



ESAP

PROCEEDINGS

20
17

THE PRIVATE SECTOR IN THE ETHIOPIAN LIVESTOCK INDUSTRY: INVESTMENT OPPORTUNITIES & CHALLENGES

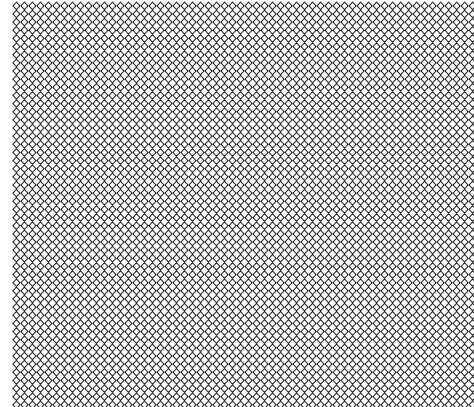


Proceedings of the 25th Annual
Conference of the **Ethiopian Society
Of Animal Production (ESAP)** Held
in **Haramaya University**,
August 24th - 26th 2017





ANIMAL BREEDING AND REPRODUCTION



WHY WE KEEP BIRTH WEIGHT RECORDS IN THE COMMUNITY BASED GENETIC IMPROVEMENT PROGRAMS OF SMALL RUMINANTS?

Temesgen Jembere¹, Kefelegn Kebede, Barbara Rischkowsky, Aynalem Haile, A.Mwai Okeyo, Bewketu Amare, Minister Brihane, Alayu Kidane, Milkias Fanta and Tadelle Dessie

¹Bako Agricultural Research Center, P.O.Box 03, West Shoa, Ethiopia

Abstract

The present study was conducted to justify that keeping birth weight (BWT) records have little or no significance in genetic improvements of market or adult weights of small ruminants while implementation of community based breeding program (CBBP). Analysis of Pearson correlation (r) between BWT and six month (6MW), BWT and nine month weight (9MW), three month weight (3MW) and 6MW and 3MW and 9MW was conducted for three indigenous Ethiopian goat breeds, namely Abergelle (AB), Central Highland (CH) and Woyto-Guji (WG). The records used for the trait combination ranged from 365 to 715 for BWT and 6MW, 271 to 543 for BWT and 9MW, 362 to 715 for 3MW and 6MW and 269 to 543 for 3MW and 9MW. The 6MW and 9MW were also regressed on BWT and 3MW for the three indigenous goat breeds. The r between BWT and 6MW, BWT and 9MW, 3MW and 6MW and 3MW and 9MW ranged from 0.099 to 0.176, 0.051 to 0.163, 0.598 to 0.706 and 0.370 to 0.546, respectively. The regression coefficients (" b ") of 6MW on BWT, 9MW on BWT, 6MW on 3MW and 9MW on 3MW ranged from 0.494 to 0.999, 0.311 to 0.996, 0.706 to 0.927 and 0.415 to 0.669, respectively. In general, BWT had weak r with 6MW and 9MW in three indigenous goat breeds of Ethiopia. The adjusted R -squared (R^2) for regressing 6MW and 9MW on BWT was less than three percent whereas the R^2 was in the range of 13 to 50% for the regression of the traits on 3MW. Literature reports also indicated weak r and genetic correlation (r_g) between BWT and adult or market weight in small ruminants. In addition, the direct heritability is smaller for BWT, compared to adult weights. For these factual, BWT could not be targeted for direct genetic improvement through selection and indirect improvement of other traits. Yet, recording BWT in the CBBP remained compulsory. We conclude that keeping BWT records in the village based breeding program of small ruminants has little or no significance.

Key words: Birth weight; Correlation; Market weight; Heritability

Introduction

Community based breeding program (CBBP) is said to be suitable for small stock keepers of small ruminants in developing countries (Mueller et al., 2015a). It is presented as an alternative to the station or government based breeding program. These days, the CBBP is being implemented in many developing countries including Ethiopia (Duguma, 2010; Duguma et al., 2011; Aynalem et al., 2011; Abegaz et al., 2014; Wurzinger et al., 2013; Mueller et al., 2015b).

The approach required record keeping, among others, for which hiring enumerators is mandatory. Recording formats that enumerators use have been developed by breeders for the implemented CBBP in Ethiopia. For instance, detailed recording formats were developed sheep (Duguma, 2010) and goat (Alemu, 2015) in Ethiopia. Growth traits at different ages including birth weight (BWT), three month weight (3MW), six month weight (6MW) and 12 month weight (12MW) in the CBBP of sheep (Duguma 2010) and BWT, 3MW, 6MW, nine month weight (9MW) and 12MW in the CBBP of goats (Alubel, 2015) are being kept in Ethiopia.

Among the growth traits, we observed that keeping accurate BWT was not easy. Under, station based breeding program, birth weights could be easily recorded within 24 hours after birth which is not the case in CBBP. Recording the BWT in CBBP rather depends on the feedback owners provide to enumerators or the activeness of the enumerators to round on all the member farmers participating in the CBBP and record new births. Unless special focus is given, for instance hiring as many enumerators as possible, accurate birth weight could not be recorded in the CBBP of small ruminants. Hiring numerous enumerators, on the other hand, could be associated with high variable costs leading to low discounted profitability of a breeding activity (Gizaw et al., 2014; Mirkena et al., 2012).

The paradox is embarking in keeping of BWT records under village breeding program where it has little or no implication for the genetic improvement programs. Meta-analysis of literature review in sheep (Safari et al., 2005) and in goats (Jembere et al., in press) showed that birth weight had weak phenotypic and genetic correlations with adult or market weights. On top, the BWT had smaller direct additive heritability and higher ratio of common environmental variances compared to the adult or market weights; which means it could not be a selection criteria. We wanted to argue the importance of recording birth weight versus its significance in the CBBP of small ruminants. To reveal that, we analyzed correlation and regression coefficients of BWT with adult or market weights. Growth data generated from three indigenous Ethiopian goat breeds namely, Abergelle (AB), Central Highland (CH) and Woyto-Guji (WG) were used. The work was also backstopped by reliable literature parameter estimates.

Materials and Methods

Description Of The Study Sites And Breeds

The data used for the correlation and regression analysis in the present work were generated from CBBPs established for AB, CH and WG. There were two villages per breed. The data were pooled from the two villages and analysed by breed. The villages were where the joint project of Biosciences for eastern and central Africa and International Livestock Research Institute (BecA-ILRI) goat project was implemented. Detailed information of the study sites were given in Table 1.

Table 1. Description of the study sites by breeds

	Abergelle		Central highland		Woyto-Guji
District	Tanqua Abergelle	Ziquala	Lay Armachiho	Meta-Robi	Konso
District's zone	Central Tigray	Wag-Himra	North Gonder	West shoa	Segen Zuria

District's city*	Yechila	Tsitsika	Tikil Dingay	Shino	Karat
Distance (km)	893	784	758	100	595
Village(s)	Dingur	Blaku	Waykaw	Tatessa	Messale and Arkisha
Altitude (m.a.s.l.)	1574	1462	2052	1200-2900	500-2200
Latitude (North)	13°22'	12°48'	12°58'	9°20'	5°17'
Longitude (East)	38°99'	38°47'	37°04'	38°10'	37°29'
Temperature (°C)**	20-28	22	17-24	23-31	12- 30
Rainfall (annual, ml)	539	255	840-1200	750-110	400-1000

*m.a.s.l. = meters above sea level; * = altitude ranges for Meta-Robi and Konso were given for the district as a whole;*

*** = mean daily temperature.*

Description of the indigenous goat breeds

The AB is kept in arid production system whereas the WG goat breed is kept in the semi-arid production system. CH is suited to crop-livestock mixed production system (Tatek et al., 2016). The description of indigenous goat breeds is given in Table 2.

Table 2. Description of the indigenous Ethiopian goat breeds

Parameters	Abergelle	Central Highland	Woyto-Guji
Distribution	South Tigray, North Wollo, eastern Gonder	Central highlands, West of the Rift-valley, Wollo, Gonder and Shoa	North and south Omo, Sidamo, and Wolyta
Production system	Arid	Crop-livestock	Semi- arid
Use	Meat, milk and skin	Meat and skin	Meat and skin
Coat color	Plain and patchy	Reddish-brown	
Facial profile	Straight to concave	Straight	Straight to concave
Horn	All horned	All horned	Most horned; there are some polled
Height at wither (cm)			
Male	71.4	76.3	72.9
Female	65	67.9	66.4

Phenotypic Correlation and Regression

Pearson correlation among growth traits in three indigenous goat breeds was made. Regression of adult or market weights on BWT and 3MW was also analyzed. The CORR and REG procedures in the SAS (2004) were used to calculate the correlation and regression coefficients, respectively. The statistical significances were tested for the coefficients. The phenotypic correlation of BWT & 3MW, BWT & 6MW, BWT & 9MW, 3MW & 6MW and 3MW and 9MW were investigated. In addition, 6mw & 9mw were regressed on BWT and 3MW and presented.

The present data analyses were reinforced by referring to the available weighted average genetic parameter estimates. The weighted average estimates included phenotypic and genetic correlations and direct genetic and direct maternal heritability estimates. The weighted average estimates are considered to be reliable and were presented based on pooled literature parameter estimates.

Results and Discussion

The present study revealed that phenotypic correlation (*r*) of BWT with the market or adult weights were small or even equal to zero in some cases. The *r* between BWT and 6MW for WG and between BWT and 9MW for CH were not different from zero (Table 3). In general, *r* of BWT with both 6MW and 9MW from the three breeds were in the range of 0.051 to 0.176 and the *r* of 3MW with both 6MW and 9MW were in the range of 0.370 to 0.706 (Table 3).

Hither *r* between 3MW and 6MW was observed compared to the *r* between BWT and 6MW (Table 3). The *r* of 3MW and 6MW was higher than *r* of BWT and 6MW by more than three, five and six folds in the cases of CH, AB and WG, respectively. In the same fashion, the 3MW and 9MW had higher *r* than BWT and 9MW where the superiority was by more than three, eight and two folds, for AB, CH and WG, respectively.

Adjacent weights had higher *r* than distant age weights. For instance, the *r* of 3MW and 6MW compared to *r* between 3MW and 9MW was higher for all the three breeds, the magnitude of superiority being 1.29, 1.40 and 1.86 folds for AB, CH and WG, respectively.

The present work indicated that BWT had weak *r* with both 6MW (0.099 to 0.176) and 9MW (0.051 to 0.163) based the data generated from the indigenous goat breeds. Rather, 3MW had higher *r*, compared to BWT, with the 6MW and 9MW traits. The *r* between 3MW and 6MW (0.598 to 0.706) was, however, higher than *r* of 3MW and 9MW (0.370 to 0.546). The weak association of birth weight with both 6MW and 9MW could be due to the fact BWT is affected by the maternal environments in the uterus compared to 3MW.

Table 3. Pearson correlation of pre and post weaning growth traits in indigenous goat breeds of Ethiopia

Traits	AB			CH			WG		
	N	R	p	N	r	p	N	r	p
BWT 6MW	715	0.135	0.0003	612	0.176	0.0001	365	0.099	0.0584
BWT 9MW	543	0.144	0.0007	402	0.051	0.3044	271	0.163	0.0073
3MW 6MW	715	0.706	0.0001	605	0.598	0.0001	362	0.690	0.0001
3MW 9MW	543	0.546	0.0001	386	0.427	0.0001	269	0.370	0.0001

AB=Abergelle goat breed; CH=Central highland goat breed; WG = Woyto-Guji goat breed; N= number of observations for the two traits; p= probability value; r = phenotypic correlation; BWT=birth weight; 6MW=six month weight; 9MW=nine month weight; 3MW=three month weight.

The regression of 6MW and 9MW on both BWT and 3MW resulted in high values of regression coefficient ("**b**") except regression of 9MW on BWT for CH and regression of 6MW on BWT for WG (Table 4). Regardless of their satisfactory "**b**" values (ranging from 0.311 to 0.996), the adjusted R-square for regressing 6MW and 9MW on BWT was considerably low, ranging from 0 % to 3 %. This means some other factors contributed to the magnitude of "**b**" which lessens the reliability of regressing 6MW and 9MW on BWT which could indicate that BWT should not be used to predict both 6MW and 9MW. This does not mean, however, keeping records of birth weight is not important. It is well known that birth weight has higher association with survival. But if accurate birth weight records could not be kept, particularly under the community based breeding programs, planning to keep birth weight records would be rather meaningless. Some other mechanisms including regressing birth weight based on the linear body measurements of kid could be developed. Once such relationship is developed, birth weights of kids, under CBBP could be generated based on the linear body measurements even at the household level of the participating farmers.

The "**b**" of 6MW and 9MW on 3MW were not always higher than the "**b**" of 6MW and 9MW on BWT (Table 4). The adjusted R-Squares for the regression of 6MW and 9MW on 3MW were considerably higher (13 to 50%) than adjusted R-Squares of regressing 6MW and 9MW on BWT.

Table 4. Regression of post-weaning growth traits on pre-weaning growth traits in indigenous goat breeds of Ethiopia

Parameters		AB		CH		WG	
		6MW	9MW	6MW	9MW	6MW	9MW
BWT	N	715	543	612	402	365	271
	b	0.968	0.996	0.999	0.311	0.497	0.850
	p	0.0003	0.0007	0.0001	0.3044	0.0584	0.0073
	Adj. R ²	0.01	0.02	0.03	0.00	0.01	0.02
	Intercept	7.892	9.953	13.509	18.799	11.83	13.857
3MW	N	715	543	605	386	362	269
	b	0.927	0.669	0.706	0.590	0.811	0.415
	p	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	Adj. R ²	0.50	0.30	0.36	0.18	0.47	0.13
	Intercept	2.921	6.958	8.357	13.271	5.024	11.570

AB= Abergelle goat breed; CH=Central highland goat breed; WG= Woyto-Guji goat breed; N= number of observations for the two traits; b=coefficient of regression; Adj. R²=Adjusted R-square; p= probability value; b = coefficient of regression; BWT=birth weight; 6MW=six month weight; 9MW= nine month weight; 3MW=three month weight.

Weighted average r among growth traits in goats, sheep and also in cattle was reported to be higher for adjacent age classes. Jembere et al (in press) reported weighted average r of 0.36 between BWT and 3MW and 0.27 between BWT and 12MW for goats; Safari et al (2005) reported weighted average r of 0.37 and 0.26 between BWT and 3MW and BWT and adult weight, respectively in sheep. Lobo et al (2000) also reported weighted average r of, in cattle, 0.46 and 0.38, between BWT and 3MW and BWT and 12MW, respectively. In all the reports, the r of BWT and 12MW/adult weight was smaller than the r of BWT and 3MW the latter has less practical implication.

On the other hand, r between 3MW and 12MW was higher by about two folds than r between BWT and 12MW in goat (Jembere et al., in press), sheep (Safari et al., 2005) and cattle (Lobo et al., 2000). This may justify that even based on the meta-analysis results BWT had weak phenotypic correlation with adult age weights or market weights.

The r is an estimate of the association between two visible characteristics and it contains genetic and environmental effects. The r could be similar with the genetic correlation (r_g) when estimates are made within the same environment (if estimates are made in similar environment, then the environmental covariance between the two traits become zero leading to equal genetic correlation with environmental correlation).

Since error variance could not be avoided, judging the genetic association of BWT with different adult weights could be more reliable than the phenotypic association of BWT with the different age weights. The weighted average r_g values in goats were 0.54, 0.32 and 0.31, between BWT and 3MW, BWT and 12MW and 3MW and 12MW, respectively in goats (Jembere et al., in press). These values were 0.47, 0.22 and 0.75, for BWT with 3MW, 6MW, and 12MW in sheep, respectively (Safari et al., 2005). Lobo et al. (2000) reported weighted average r_g values of 0.50, 0.55 and 0.81 between BWT and 3MW, BWT and 12MW and 3MW and 12MW, respectively in cattle.

In all the three reports, high r_g was reported between adjacent age classes; for instance between BWT and 3MW and between 3MW and 12MW. The weighted average r_g between BWT and 12MW or adult age weight was generally smaller than the r_g between 3MW and 12MW. This also, in addition to the r could indicate weak r_g between BWT and BWT.

The BWT of goats, sheep and cattle had smaller direct heritability than 12MW whereas the maternal heritability of BWT for the species was higher than the maternal heritability (it should be noted that maternal heritability could be base of making a trait a selection criteria, but not as important as the

direct heritability of a trait) of 12MW (Table 5). Comparing the direct heritability of BWT and 12MW (Table 5), the latter had higher values. In the case of maternal heritability, it was BWT that had higher values compared to 12MW. The lower values of direct heritability of BWT or the higher values of maternal heritability of BWT could indicate the high influence of maternal environment on the trait. From the two heritability estimates, it is the direct heritability estimates that have more implication on genetic improvement through selection. Therefore, it could be concluded that BWT might not be targeted for selection.

Table 5. Weighted direct and maternal heritability estimates of sheep and goat

Species/breed*	Birth weight	Weaning weight	Yearling weight
Direct			
Goat/dual	0.16	0.22	0.31
Sheep/wool	0.21	0.21	0.42
Sheep/dual	0.19	0.16	0.40
Sheep/meat	0.15	0.18	0.29
Cattle1	0.31	0.21	0.33
Tropical cattle	0.34	0.30	0.37
Maternal			
Goat/dual	0.12	0.08	0.05
Sheep/wool	0.21	0.16	0.04
Sheep/dual	0.18	0.10	0.06
Sheep/meat	0.24	0.10	-

*= sources are Jembere *et al* forthcoming for goat and Safari *et al* 2005 for sheep

Endeshaw *et al.* (2013) said that the market weight of Afar goat was in the range of 25 - 30 kg. According to Shija *et al.* (2013), slaughter age (years) and weight (kg) of indigenous sheep and goats in East Africa could be in the range 1.5 to 2 years and 20 to 25. Tibbo *et al.* (2006) suggested market age and market weight for sheep in Ethiopia as 12 months of and 30 kg to be considered in designing the breeding program. The average marketing age (months), for indigenous goats in Ethiopia, was reported to be 11.67 and 12.33 for males and females, respectively (Asefa *et al.*, 2015). In the present study, we could not show favorable correlations between BWT and the market weights or adult weights. The direct heritability estimates from literature, was small.

Conclusion

Birth weight had weak phenotypic correlation with 6MW and 9MW in the three indigenous goat breeds in Ethiopia. The regression of 6MW and 9MW on BWT was not reliable because of low (less than three per cent) adjusted R-square. Literature reports indicate that due to weak phenotypic and genetic correlation between BWT and adult or market weight and low direct heritability, BWT could not be targeted for genetic improvement through selection. Yet, recording BWT in the community based breeding program remained compulsory. We conclude that keeping BWT records under village based breeding program is not only of little or no significance, from field experience, but also hardly practical. Some other mechanisms, however, including regressing birth weight based on the linear body measurements of kid could be developed. Once such relationship is developed, birth weights of kids, under CBBP could be generated based on the linear body measurements even at the household level of the participating farmers.

Acknowledgment

We are grateful for the support we got from the smallholder farmers whose animals were monitored and on which the simulation of the scenarios was based. We are also thankful to the partner research

centers namely Tanqua Abergelle, Sekota Dry land, Gonder and Arbaminch for their close follow-up of data collection. The first author thanks ILRI and International Center for Agricultural Research in Dry Areas for supporting this work through the CGIAR Research Program Livestock and Fish, and a SIDA funded BecA-ILRI goat project and an International Fund for Agricultural Development (IFAD) funded SmarT (Small Ruminant value chain Transformation in Ethiopia) project.

References

- Abegaz, S., Sölkner, J., Gizaw, S., Dessie, T., Haile, A., Mirkena, T., Getachew, T., and Wurzinger, M., 2014. Optimizing alternative schemes of community-based breeding programs for two Ethiopian goat breeds. *Acta Agraria Kaposváriensis: Vol 18 Supplement 1*, 47-55.
- Alubel Alemu, 2015. On-farm phenotypic characterization and performance evaluation of Abergelle and Central highland breeds as input for designing community based breeding program. MSc. Thesis. Haramaya University, Haramaya, Pp.147.
- Aynalem Haile, Maria Wurzinger, Joaquín Mueller, Tadele Mirkena, Gemeda Duguma, Okeyo Mwai, Johann Sölkner and Barbara Rischkowsky, 2011. Guidelines for Setting up Community-based Sheep Breeding Programs in Ethiopia. ICARDA - tools and guidelines No.1. Aleppo, Syria, ICARDA.
- Belete Asefa, Kefelegn Kebede and Kefena Effa, 2015. Assessment of production and reproduction system of indigenous goat types in Bale Zone, Oromia, Ethiopia. *Academia Journal of Agricultural Research*, 3(12): 348-360.
- Duguma, G. 2010 Participatory definition of breeding objectives and implementation of community-based sheep breeding programs in Ethiopia. PhD thesis, Austria, Vienna.
- Duguma G, Mirkena T, Haile A, Okeyo AM, Tibbo M, Rischkowsky B, Sölkner J, Wurzinger M, 2011. Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits in Ethiopia: Choice model approach. *Animal*. Erbe M, Reinhardt F, Simianer H: Empirical determination of the number of independent chromosome segments based on cross-validated data. In *Proceedings of the 62nd Annual Meeting of the European Federation of Animal Science*. Stavanger; 2011.
- Endashaw Terefe, Yibra Yaqob, Kidanie Dessalegn, Abebe Tafa, Ashebir Kifle, Weldegebrel Gebregziabher and Weldegebrel Tesfamariam, 2013. Market weight and carcass characteristics of intact yearling afar goats under semi-intensive feeding management.
- Gizaw S, Rischkowsky B., Valle-Zarate A, Haile A., Arendonk J A M., Mwai A O, & Dessie T, 2014. Breeding programs for smallholder sheep farming systems: I. Evaluation of alternative designs of breeding schemes. *J. Anim. Breed. Genet.* 131: 341–349.
- Jembere, T., Dessie, T., Rischkowsky, B., Kebede, K., Mwai, A. O. and Haile, A. in press. Meta-analysis of average estimates of genetic parameters for growth, reproduction and milk production traits in goats. *Journal of small ruminant research*
- Lobo R N B, Madalena F E and Viera, A R, 2000. Average estimates of genetic parameters for beef and dairy cattle in tropical regions. *Animal breeding abstracts*. 68(6):433-462.
- Markos Tibbo, Jan Philipsson, Workneh Ayalew, 2006. Sustainable Sheep Breeding Programmes in the Tropics: a Framework for Ethiopia. 2006Tropentag. Conference on International Agricultural Research for Development. University of Bonn.
- Mueller J P, Ansari-Renani H R, Seyed Momen S M, Ehsani M, Alipour O, Rischkowsky B, 2015a. Implementation of a Cashmere goat breeding program amongst nomads in Southern Iran. *Small Rumin. Res.*, 129: 69–76. <http://dx.doi.org/doi:10.1016/j.smallrumres.2015.05.011>.
- Mueller J P, Rischkowsky B, Haile A, Philipsson J, Mwai O, Besbes B, Valle Zarate A, Tibbo M, Mirkena T, Duguma G, Sölkner J and Wurzinger M., 2015b. Community-based livestock breeding programmes: essentials and examples, invited review. *J. Anim. Breed. Genet.* 132 (2015) 155–168.
- Safari E, Fogarty N.M and Gilmour A R, 2005. A review of genetic parameter estimates for wool, growth, meat and reproduction traits in sheep. *Livestock Production Science*. 92: 271–289.
- SAS 2002, Statistical Analysis Systems for mixed models. SAS Institute Inc., Cary, NC, USA.
- Shija D S, Mtenga L A, Kimambo A E, Laswai G H, Mushi D E, Mgheni D E, Mwilawa A J, Shirima E J M and

PROCEEDING

Animal Breeding and Reproduction

Safari J G, 2013. Preliminary Evaluation of Slaughter Value and Carcass Composition of Indigenous Sheep and Goats from Traditional Production System in Tanzania. *Asian-Aust. J. Anim. Sci.* 26 (1):143 - 150.

- Tatek Woldu, André Markemann, Christoph Reiber, Girma T. Kassie and Anne Valle Zárate. 2016. Combining revealed and stated preferences to define goat breeding objectives in Ethiopia, **Livestock Science**, <http://dx.doi.org/10.1016/j.livsci.2016.08.008>.
- Wurzinger M, Escareño L, Pastor F, Salinas H, Iñiguez L and Sölkner J, 2013. Design and implementation of a community-based breeding program for dairy goats in northern Mexico. *Tropical and Subtropical Agro-ecosystems*, 16: 289 - 296.

Introduction and Growth Performance Evaluation of Washera Sheep under smallholder management systems at Aba Gerima Watershed, North western Amhara, Ethiopia

Agraw A¹, Shigdaf M¹, Molla H¹, Lisanework M¹, Eyasu L¹, Mehari A¹

Andassa Livestock Research Center, P.O.Box 27, Bahir Dar, Ethiopia

Abstract

On-farm Introduction and growth performance evaluation of Washera sheep was conducted at Bahirdar zuria district of West Gojam Zone of Amhara National Regional State. Performance data collected from 2012 to 2015 was used. The data was analyzed using general linear model procedure of Statistical Analysis System (SAS version 9.1, 2003). The least square mean birth weight, 30 days, 90 days, 180 days, 270 days, and 360 days weight was 2.63 ± 0.01 , 6.52 ± 0.3 , 12.40 ± 0.5 , 15.78 ± 0.2 , 20.25 ± 0.5 , and 23.77 ± 1.3 kg, respectively. Birth weight was significantly ($p < 0.01$) affected by birth year, birth season, dam parity, lamb sex and birth type. Birth year, birth season, dam parity, lamb sex and birth type was significantly affected ($p < 0.01$) 90 days weight. Lamb birth year was significant ($p < 0.01$) source of variation for 360 days weight. The mean average daily weight gain from birth to 30 days, birth to 90 days, 90 to 180 days and birth to 360 days was 123.18 ± 15.2 , 101.12 ± 5.4 , 40.25 ± 4.8 and 57.37 ± 3.5 gm, respectively. The effect of birth year, birth season, dam parity and birth type were significant ($p < 0.01$) for growth rates from birth to 30 days. Birth year, birth season, dam parity and birth type were significant ($p < 0.01$) for growth rates from birth to 90 days of age. The comparable growth performance of washera sheep in the study area with same breed in its home area indicated that environmental adaptation of Washera sheep to the introduced area. Different fixed effects influenced growth performance needs to be considered whenever there is a need to improve the performances of Washera sheep breeds in the area. In addition, for better productivity of the breed in the watershed, increase awareness of farmers in utilization of the developed improved forages and locally available feed sources should be considered.

Keywords: Washera sheep, Abagerima, Growth performance, on-farm management

Introduction

Sheep production is an important agricultural activity in Ethiopia which contributes very much for the livelihood of the farm households (Tesfaye *et al.*, 2010). There are a large number and breeds of sheep in the country which are maintained under the traditional low-input-low-output system of production which is estimated about 26 million heads, 9 breeds and 14 populations (CSA, 214; Solomon Gizaw, 2008). However, the current level of on-farm productivity is low; off-take rate is very low at 33% with an average carcass weight of 10 kg (Tibbo, 2006). On the other hand, the demand for livestock products is increasing from time to time (Siegmond-Schultze et al 2009). So, it is very urgent to improve their productivity to satisfy the animal product demand of the large human population.

Water and land resource center (WLRC) project had conducted research activities in different discipline in four watersheds of North Western Amhara. Before the start of the implementation, Participatory Rapid Appraisal (PRA) and Focused Group Discussion (FGD) were done in the four watersheds to assess the major livestock production constraints. The PRA and FGD result indicated that low performance of the existing sheep breed in the water shed/Abagerima is one of the identified major livestock production constraints. The local sheep breed reared in the watershed is Farta sheep breed which is one of the indigenous sheep breeds reared by the rural farmers in the mixed crop-livestock farming systems of northwestern highlands of Ethiopia and it is low productive and less preferred sheep breed in the market (Agraw *et al.*, 2014; Shigidaf *et al.*, 2012; Habtemariam *et al.*, 2012).

Therefore, there should be means of improving the genetic merit or performance of the breed. One option to improve the genetic performances of low producing animals (Tesfaye et al., 2009) is replacement that is introduction and replacing of the low performance indigenous breed by better performing indigenous/exotic breeds. With this consideration and discussion with the farmers on genetic improvement options, Andassa Livestock Research Center (ALRC) in collaboration with Water and land resource center (WLRC) project designed and implemented breed improvement program for local sheep breed in the watershed through replacement by introducing Washera sheep breed both ram and ewe.

Washera sheep is recognized as one of the promising indigenous sheep breed in Ethiopia with remarkable genetic qualities such as better genetic potential for improvement, with Known productivity characteristics such as slaughter age of 4-6 months with adequate slaughter weight and with an adaptation to a wide range of agro-climatic conditions (Mengistie et al., 2009; Solomon et al., 2010).

Therefore, this research was initiated with the objective of introducing and evaluating the growth performance of washera sheep under smallholder management systems at Abagerima watershed.

Materials and Methods

Description of the Study Area

The study was conducted at Abagerima watershed, Bahir Dar Zuria district of West Gojam zone, Amhara National Regional State, Ethiopia. The watershed is located at 23km North West of Bahir Dar city and lies within an altitude range of 1893-2120 m a.s.l. it receives an average annual rainfall of 1120 mm and covers around 900ha of land (WOARD, 2014-unpublished).

On-Farm Flock Management

Farmers in the study area keep sheep mostly separately from other livestock species and sometimes in combination with other species of animals, usually with cattle and equines. During crop harvesting times, sheep have access to grazing and crop aftermath while in dry season some farmers give supplementation for their sheep based on their physiological status. Breeding is year-round and breeding rams run with the group flock to mate with any ewe in heat during the day. Rams are selected for mating based on their conformation (body size, colour and appearance) and sometimes

based on maternal history (lamb survival, twinning rate and general health). Ram lambs born in the flock and not needed for breeding would be sold or castrated before reaching breeding age. All the farmers construct house for their sheep to protect them from sun, rain, wind, theft and wild animals. Since the start of data collection, internal and external parasite control has been carried out. For internal parasites, the animals have been de-wormed three times a year. Sheep have given ivermectin for external parasite control when external parasite infestation is high (as per the need). Vaccination against ovine pasteurellosis/every six month and anthrax/once a year was given. Sick animals were treated

Data Collection

On-farm data, collected as part of the programme on “Introduction and Performance Evaluation of Washera Sheep under smallholder management systems at Aba Gerima Watershed, North western Amhara” undertaken from 2012 to 2015, was used for the study. Animals were identified by permanent plastic ear tags applied at the beginning, birth or at purchase of the animal to facilitate recording. Performance data were collected by trained enumerators. The enumerators were supervised and data crosschecking was done by researchers of Andassa Livestock Research Centre on a two-month interval. Weights were taken every month using the Salter balance (50 kg capacity with 200 g precision) for lambs until they attained 6 months of age and on a two- month’s interval thereafter.

Data Management and Analysis

All the data collected were entered and managed using Microsoft Excel computer program. Preliminary data analysis and screening of outliers were employed before conducting the main data analysis. The data were analysed using the General Linear Model procedures of SAS (2003). Tukey Kramer test was used to separate means of effects with three or more levels which were significant in the least squares analysis of variance.

For the analysis of the growth performance of the breed, the following model was used:-

The statistical model was explained as follows:

Birth and weight at different ages

The statistical model was explained as follows:

$$Y_{ijklmn} = \mu + G_k + S_l + T_m + P_l + Y_n + e_{ijklmn}$$

Where: Y_{ijklmn} = observation on birth weight and weight at different ages

μ = over all mean

G_k = Fixed effect of lamb sex (k = male, female)

S_l = Fixed effect of lamb birth season (l = dry, wet)

T_m = Fixed effect of lamb birth type (m = single, multiple)

P_l = Fixed effect of dam parity (l = 1, 2, 3, 4)

Y_n = Fixed effect of lamb birth year (n = 2012, 2013, 2014, 2015)

e_{ijklmn} = effect of random error

Birth weight and ewe postpartum weight were included in the model as a covariate since they were not significant and removed from the model.

Average daily weight gains (ADG)

Average daily weight gains were calculated as follows:

ADG = $\frac{\text{Weight at the end of period} - \text{weight at the beginning of period}}{\text{Period in days}}$

Period in days

- 1) Average daily weight gain from birth to three months of age (ADG1)
- 2) Average daily weight gain from three month to six month of age (ADG2)
- 3) Average daily weight gain from birth to yearling age (ADG3)

Result and discussion

Birth weight

The overall least square means birth weight obtained in the current study was 2.63 ± 0.01 kg which is comparable to Gumuz sheep (Solomon et al., 2011) and Washera sheep in its home area (Mengistie et al., 2009) but higher than Washera sheep at Farta district (Shigdaf et al., 2013) and Farta sheep breed at Estie district (Agraw et al., 2014). The variation could be due to difference in breed and farmers management practice of pregnant ewes, in feed availability and quality for pregnant ewes and ewes at mating across locations. There is preferential treatment of farmers for pregnant ewes during dry season in the study area (Molla et al., 2016-inpress). The dam with good body condition at mating and during gestation fed their fetus better than others.

The analysis of variance showed that all the fixed factors considered affected birth weight significantly ($p < 0.01$). Birth year was a significant ($p < 0.01$) source of variation for lamb birth weight. Lambs born in the year 2015 were heavier than the other succeeding years. The significant effect of year on birth weight indicated that variation in the quality and quantity of feed available for the dam at mating and pre-partum where better feed availability in terms of both quality and quantity across years in the watershed.

Season of birth of lamb was found significant source of variation for birth weight where lambs born in the dry season were heavier than lambs born in the wet season (2.75 ± 0.1 kg vs. 2.49 ± 0.0 kg; $p < 0.0$). The heavier lamb birth weight born in the dry season can be explained by the better feed availability in terms of quality and quantity at ewe mating and pregnancy period in wet season

Parity of the dam affected birth weight of lambs significantly ($p < 0.01$). Ewes with higher parities produced heavier lambs. This agrees with the finding of Gardner *et al.* (2007) who reported the increase of lamb birth weight with dam age to six years of age. In contrast to the present study, Macedo and Hummel (2006) reported non-significant effect of parity on birth weight of lambs. The heavier birth weight at late parities can be explained by the heavier dam weight and larger size at later parities and physiological imprint in the uterus during the first pregnancy which will facilitate relatively greater fetal growth in the subsequent pregnancies (Gardner *et al.*, 2007). In addition, the reproductive organs of first parity ewes are also less developed to bear large foetus in which case the physiology adjusts the foetal size (Tibbo, 2006). Indeed, younger ewes are still growing and then there would have been a competition for nutrients between the fetus and the dam (Gemedo *et al.*, 2002).

The effect of type of birth was also significant. Single born lambs were heavier than their multiple contemporaries (2.75 ± 0.0 vs. 2.35 ± 0.2 , $p < 0.01$). This agrees with the results reported by Gemedo *et al.* (2002), and could be because of the finite capacity of the maternal uterine space to gestate offspring (Gardner *et al.*, 2007), as litter size increases individual birth weights decline. Sex of lamb has significant effect ($p < 0.01$) on lamb birth weight in that male lambs weighed heavier than female lambs (2.65 ± 0.01 vs. 2.50 ± 0.01). This type of effect has been reported in the literature Hassen *et al.*, (2004). The presence of a Y-chromosome and the products of *sry* gene activation have sex specific effects on fetal growth. Males appear to grow faster than respective females in utero (Loos *et al.*, 2001). However, Hassen *et al.* (2002) reported non-significant effect of sex on birth weight of lambs in the cool highlands of Ethiopia.

Weight at Specific Ages

Factors affecting weights of Washera sheep at birth and different ages (at 30, 90, 180, 270 and 360 day's age) are presented in Table 1. The least square means and standard errors of 30 days, 90 days,

180 days, 270 days and 360 days weights were 6.52 ± 0.3 , 12.40 ± 0.5 , 15.78 ± 0.2 , 20.25 ± 0.5 , and 23.77 ± 1.3 kg, respectively.

The overall three month weight is higher than Horro and Menz sheep (Kassahun, 2000) under on station and Farta sheep (Agraw et al., 2014) under on-farm but comparable with Washera sheep at its home area (Mengistie et al., 2009). The variation could be due to difference in breed, feed availability and management difference for supplementing of lactating ewes and lambs. The overall six month weight is higher than Washera sheep at Farta district (Shigdaf et al., 2013) but comparable with the same sheep breed in its home area (Mengistie et al., 2009). The variation could be due to difference in feed availability, management difference for supplementing of lactating ewes & lambs and difference in focus of farmers for the weight of the breed at this age. Farmers in the study area have a practice of selling sheep at this age as explained in the group discussion and off take data. So it is better to have good management practice to improve this marketable weight more. The yearling weight is higher than Horro and Menz sheep (Tibbo, 2004) under on station and Farta sheep (Agraw et al., 2014) under on farm but comparable with Washera sheep at its home area (Mengistie et al., 2009). The variation could be due to difference in breed and feed availability both in quantity and quality on natural pasture, difference in management practices of lactating ewes and lambs and difference in mothering ability among ewes.

Birth year was a significant source of variation ($p < 0.01$) for 30 days, 90 days and 360 days weights. There was an increasing trend in weight at all ages from 2012 to 2015; lambs born in 2015 were heavier than the other succeeding years. The significant effect of year on weight at different ages indicated that variation in the quality and quantity of feed available for the dam at mating, pre-partum and lactation where better feed availability in terms of both quality and quantity across years in the watershed. Birth season was also significant ($p < 0.01$) source of variation for 30 days, 90 days and 180 days weight of lambs. Lambs born in wet season were heavier than lambs born in dry season at the above mentioned ages. According to Tibbo *et al.* (2004), season of birth significantly affected weight at all ages consistently. The heavier weights in lambs born in the wet season can be explained by the better feed availability in terms of quality and quantity for lactating ewes to feed their lambs.

Dam parity was significant ($p < 0.01$) source of variation at 30 and 90 days weight but its effect diminished thereafter ($p > 0.01$). Lambs born from maiden ewes were the lowest in weight at 30 days and 90 days of age. This is because maiden ewes produce lambs with lower body weight and their mothering ability is poor as a result of lack of experience to care their lambs and poorly developed udder to produce and supply sufficient milk for their lambs (Gemeda *et al.*, 2002).

Sex was an important source of variation ($p < 0.01$) for only 90 days weight of lambs that males were superior over their female (12.82 ± 0.5 kg vs. 11.98 ± 0.5 kg). This result is comparable to Hassen *et al.* (2002) who reported the effect of sex after 5 months. Males appear to grow faster than respective females in uterus (Loos *et al.*, 2001) and this may be attributed to the action of sex hormones in their endocrinological and physiological functions which play a major role in accelerating growth (Tibbo et al., 2004). Type of birth had significant ($p < 0.01$) effect on 30 days and 90 days weight where single born lambs were heavier than multiple born lambs. This difference could be the singles are the sole users of the milk from their dam (Tibbo et al., 2004). Generally in this study, its effect after three month was totally weakened which might be associated with the environmental adaptation and decreasing of maternal effect. Similarly, Benyi *et al.* (2006) reported that the superiority in weight and growth rate of the single-born lambs increased only up to weaning and then declined such that after weaning multiple-born had similar weight and growth rate as singles

Generally, only lambs born during dry season have heavier birth weight than those born wet season lambs but lambs born during wet season have heavier weights at different ages (at 30, 90, 180, 270 days and yearling) which are important growth traits for meat production. Therefore when the pre-weaning survival is good, there should be a means of having all births during the wet season when there is better feed availability in terms of quality and quantity for lactating ewes and lambs.

Table 1. Least squares means and standard errors for birth weight (kg) and weight at different ages (kg)

Source of variation	Birth wt		30d wt		90d wt		180d wt		270d wt		360d wt	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	685	2.63±0.0	605	6.52±0.3	511	12.40±0.5	205	15.78±0.2	135	20.25±0.5	83	23.77±1.3
Birth year		**		**		**		**		NS		NS
2012	54	2.62±0.0c	54	5.36±0.3a	38	10.33±0.4a	20	14.94±0.4a	16	19.78±0.5a	13	20.79±1.3a
2013	225	2.69±0.1b	202	5.39±0.2b	167	11.94±.3b	68	15.21±0.3a	48	19.85±0.6a	32	21.33±1.4b
2014	312	2.70±0.2b	297	6.37±0.4b	238	13.53±0.4c	73	15.47±1.0a	51	20.25±0.7a	30	23.73±1.5c
2015	94	2.78±0.2a	82	6.46±0.5c	55	13.79±1.0d	40	15.88±1.1a	20	20.58±0.4a	11	23.89±1.2c
B season		**		**		**		**		NS		NS
Dry	278	2.75±0.1 a	259	5.53±0.2a	200	11.49±0.5a	70	14.89±.4 a	38	20.67±0.5	28	23.81±1.1
Wet	407	2.49±0.0 b	356	6.89±0.3b	311	12.93±.6b	135	15.98±.5 b	97	20.71±0.6	55	23.92±1.6
Parity		**		**		**		NS		NS		NS
1	141	2.49±0.2a	116	6.32±0.3a	93	12.21±0.3a	51	15.53±0.24	41	20.15±0.1	20	23.77±1.2
2	130	2.68±0.1b	109	6.45±0.2b	85	12.30±0.2b	38	15.68±0.34	29	20.20±0.5	15	23.77±1.3
3	165	2.70±0.0b	145	6.48±0.4b	121	12.33±0.5b	53	15.71±0.44	44	20.25±0.4	23	23.77±1.2
4	249	2.78±0.3bc	235	6.61±0.3c	215	12.48±0.2c	61	15.88±0.24	49	20.30±0.2	27	23.77±1.4
Sex		**		NS		**		NS		NS		NS
Male	371	2.65±.01 a	335	6.56±0.17	300	12.82±0.5a	155	15.80±0.46	90	21.83±0.5	45	23.09±1.29
Female	314	2.50±.01 b	270	6.48±0.16	211	11.98±0.5b	50	15.23±0.45	45	20.15±0.5	38	23.52±1.31
Birth type		**		**		**		NS		NS		NS
Single	500	2.75±0.0 a	475	6.27±.1 a	400	11.22±.4 a	115	15.95±0.4	90	20.30±0.4	55	23.82± 0.8
Multiple	185	2.35±0.2 b	130	5.78±.2 b	111	10.37±.6 b	90	15.79±0.5	45	20.20±0.8	33	23.68±2.1

*N = number of observations; Birth wt- birth weight; 30d wt- 30 days weight; 90d wt- 90 days weight; 180d wt- 180 days weight; 270d wt- 270 days weight; 360d wt- 360 days weight; NS: Not significant ($p>0.05$); ** $p<0.01$*

Growth rate

The least square means and standard errors of average daily weight gain (in grams) at different ages considered are presented in Table 2.

Pre-weaning growth rate

The growth rates from birth to 30 days and birth to 90 days of age were 123.18 ± 15.2 and 101.12 ± 5.4 gm, respectively. The pre-weaning growth rate obtained is comparable to Washera sheep in its home area (Mengistie et al., 2009) but higher than Farta sheep (Agraw et al., 2014) under on farm. The variation could be due to the difference in breed and feed availability both in quantity and quality for lactating ewes and lambs as well as management difference for supplementing of lactating ewes and lambs as the lambs depend entirely on their dam for growth.

The difference in growth rate due to year of birth was highly significant ($p<0.01$) for both ages considered. There was a yearly increasing trend in average daily weight gain from year 2012 to 2015. This difference of weight gain between years could partly be explained by the difference in the nutritional status of the dam, since up to weaning lambs are mostly dependent on their dam for their growth requirement. Season as a source of variation ($p<0.01$) for lamb growth rate from birth to 30 days and birth to 90 days; lambs born in wet season have higher average daily weight gain than those born in the dry season. Similarly, Tibbo (2004) reported that lambs born in the wet season have fast growth rate than in the dry seasons which might be because of seasonal variation in feed availability both in quantity and quality on natural pasture for the dam during lactation to produce and supply

sufficient milk for their lambs.

Dam parity affected ($p < 0.01$) pre-weaning growth rate. Lambs born from second and third parity dams grew faster ($p < 0.01$) than those from lambs born first parity dams. This is consistent with literature (Tibbo, 2004), that lambs born from the second and third parity ewes had a significantly higher growth rate than those from maiden ewes. This could be due to the difference in milk supply and maternal care, since maiden ewes produce less milk than average and lack experience to take care of their lamb. Influence of superior maternal environment of older ewes (to some age actually) is expected to be translated into better lamb performance up to weaning.

Birth type has significant effect ($p < 0.01$) on lamb pre-weaning growth rate. Single born lambs have higher average daily weight gain than multiple born lambs. The higher average daily weight gain of the singles than multiple born lambs suggested that singles are sole milk users of their dam since lambs up to weaning are mostly dependent on their dam for growth requirement. Sex had no significant effect on pre-weaning daily weight gain of lambs. Tibbo (2004) has reported a significant effect of sex on pre-weaning average daily weight gain of lambs.

Post-weaning growth rate

The least square means and standard errors of average daily weight gain from 90 to 180 days of age was 40.251 ± 4.8 gm. The post-weaning growth rate obtained is comparable with the same breed in its home area (Mengistie et al., 2009) but higher than Farta sheep (Agraw et al., 2014) under on farm. The variation could be due to difference in breed and feed availability both in quantity and quality as weaner lambs depend entirely on natural pasture, lamb management practice difference among farmers and locations.

Year of birth had significant effect ($p < 0.01$) on lamb post-weaning growth rate. Lambs born in 2015 are heavier than lambs born in 2012 (109.9 ± 4.9 gm vs. $40.5 \pm 6.8 \pm 3.2$ gm). This might be attributed to the better feed availability in terms of quality and quantity in the year 2015 in the watershed for the lambs since after weaning the lambs growth are mostly dependent on the environment factors than their dams milk. Season of birth had significant effect ($p < 0.01$) on post-weaning growth rate; lambs born in wet season have higher growth rate than dry season (42.3 ± 5.8 gm vs. 39.6 ± 4.6 gm). This might be attributed to the better feed availability in terms of quality and quantity in wet season for the lambs after weaning.

Birth type did not affected ($p > 0.01$) post-weaning growth rate. This could be due to weaner lambs have similar weight and growth rate with multiple born lambs. However, other studies found the significant influence of type of birth (Yilmaz *et al.*, 2007) and sex (Tibbo, 2004) on post-weaning growth rate. Sex did not affected ($p > 0.01$) post-weaning growth rate. Male and female lambs have similar post weaning growth rate.

Overall growth rate

The least square means and standard errors for overall growth rate i.e. birth to 360 days age was 57.37 ± 3.5 gm which is comparable with the same sheep breed in its home area (Mengistie *et al.*, 2009) and Menz and Horro male lambs (Kassahun, 2000) but higher than Farta sheep (Agraw et al., 2014) under on farm and the same sheep breed at Farta district (Shigidaf et al., 2013). The variation could be due to difference in breed and feed availability both in quantity and quality on natural pasture, lamb management practice difference among farmers and locations. All the fixed factors considered had no significant effect ($p > 0.01$) on the overall growth rate.

Generally, lambs born during wet season have faster pre-weaning, post-weaning and overall growth rate than dry season born lambs. Therefore when the pre-weaning survival is good, there should be a means of having all births during the wet season when there is better feed availability in terms of quality and quantity for lactating ewes and lambs. It is also noted that birth weight, weight and growth rate at different ages of lambs increase with increase parity (4th parity). Therefore it should be

known at what parity is the maximum birth weight, weight and growth rate at different ages of lambs obtained and also after what parity start to decline.

Table 2. Least squares means and standard errors for growth rates of Washera sheep at different ages

Source of Variation	Birth to 30 days		Birth to 90 days		90 to 180 days		Birth to 360 days	
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE
Overall	640	123.18±15.2	510	101.12±5.4	402	40.251±4.8	230	57.37±3.5
Birth year		**		**		**		NS
2012	60	115.6±8.5 ^a	38	82.0±4.6 ^a	30	36.2±3.2 ^a	36	56.6±3.5
2013	298	132.3±5.7 ^b	165	101.1±3.9 ^b	144	38.1±4.1 ^b	88	57.3±4.4
2014	192	138.5±6.3 ^b	243	120.4±4.4 ^c	230	40.2±5.8 ^c	112	57.4±4.3
2015	90	140.2±6.80 ^c	55	127.2±6.7 ^d	45	40.5±6.8 ^d		
Birth season		**		**		**		NS
Dry	256	122.8±5.7a	187	97.1±5.4a	122	39.6±4.6a	47	56.9±3.1
Wet	384	124.5±6.8b	323	104.8±6.7b	280	42.3±5.8b	180	57.2±4.4
Parity		**		**		NS		NS
1	80	115.2±15.2a	48	82.1±6.4a	40	38.8±4.9	26	56.7±4.5
2	258	120.4±11.2b	155	101.1±5.3b	134	39.5±4.3	78	57.3±3.5
3	192	121.6±12.2b	223	102.2±6.3b	210	40.1±4.6	100	57.7±3.6
4	110	130.4±18.2c	75	110.1±4.2c	65	41.2±4.9	35	58.3±2.5
Birth type		**		**		NS		NS
Single	401	125.3±4.3a	350	103.3±4.7a	300	40.6±4.2	180	58.1±2.2
Multiple	239	120.3±8.4b	160	100.2±7.8b	142	39.6±6.6	50	57.5±5.7
Sex of lamb		NS		NS		NS		NS
Male	351	123.3±5.7	281	101.2±5.6	239	40.9±6.1	130	57.7±3.6
Female	249	122.9±4.5	229	100.4±3.5	163	39.6±5.0	100	56.8±4.6

N = number of observations; ADG: Average Daily weight Gain; NS: Not significant ($p>0.01$); ** $p<0.01$

Conclusion and Recommendations

Birth season, birth year, dam parity, sex of lamb and birth type was found an important source of variation for the growth performance of the breed. The increasing productivity across year could associated with the increase of the availability of feed resources and awareness of the farmers in the watershed from year to year in utilization of the developed different feed resources on different entry points. The comparable performance of Washera sheep in the study area with same breed in its home area indicated that environmental adaptation of Washera sheep to the introduced area which can be used in similar agro-ecological condition to the study areas. Different fixed effects influenced the growth performance in the study needs to be considered whenever there is a need to improve the performances of Washera sheep breeds in the area. For better productivity of the breed in the watershed, increase awareness of farmers in utilization of the developed feed sources and locally available feeds should be considered

Acknowledgement

The field research was fully financed by Water and Land Resource Center (WLRC) project. The author is greatly indebted to thank the enumerator at the villages for their support in data collection. We are grateful to the staff of Andassa Livestock Research Centre for their interest in our research and support during the field work

References

- Agraw A, Yeshewas F, Tewodros B: 2013. **On-Farm Growth** Performance Evaluation of Farta Sheep under the Existing Farmers Management at Estie District of Amhara National Regional State, Ethiopia. Proceedings of the 21th annual conference of the Ethiopian Society of Animal Production (ESAP) Conference on Livestock and Economic Growth: Value Chains as Pathways for Development Held in Addis Ababa, Ethiopia, August 28-30, 2012
- Benyi, K., Norris, D., Karbo, N. and Kgomo, K. A. 2006. Effects of genetic and environmental factors on pre-weaning and post-weaning growth in West African crossbred sheep. *Tropical Animal Health Production*. 38, 547–554.
- Central Statistical Agency of Ethiopia (CSA). 2014. The 2014 National Statistics- Agriculture. http://www.csa.gov.et/text_files/2006_national_statistics.htm (accessed on Oct., 2014)
- Gardner, D.S., Buttery, P.J., Daniel, Z. and Symonds, M.E. 2007. Factors affecting birth weight in sheep: maternal environment. *Reproduction*. 133(1), 297–307.
- Gemedu Duguma, Schoeman S. J., Cloete S. W. P. and Jordaan G. F. 2002. The influence of nongenetic factors on early growth traits in the Tygerhoek Merino lambs. *Eth.J.Anim.Prod.* 2 (1)127-141.
- Habtemariam, Shigdaf, Agraw, Yenesew, Yeshewas, Simegne, June 2012. Impact of washera sheep on household income and livelihood of washera sheep producers in southern Gonder districts (Farta and Lai-gaint). *Global Advanced Research Journal of Agricultural Science* Vol. 1(4) pp. 090-096, June, 2012
- Hassen, Y., Sölkner, J., Gizaw, S. and Baumung, R. 2002. Performance of crossbred and indigenous sheep under village conditions in the cool highlands of central-northern Ethiopia: growth, birth and body weights. *Small Ruminant Research*. 43, 195–202
- Hassen, Y., Sölkner, J. and Fuerst-Waltl, B. 2004. Body weight of Awassi and indigenous Ethiopian sheep and their crosses. *Small Ruminant Research*. 55, 51–56.
- Kassahun, A., 2000. Comparative performance evaluation of Horro and Menz Sheep of Ethiopia under grazing and intensive feeding condition. PhD Dissertation Humboldt-University
- Loos, R.J., Derom, C., Eeckels, R., Derom, R. and Vlietinck, R. 2001. Length of gestation and birth weight in dizygotic twins. *Lancet*. 358, 560–561
- Macedo, R. and J. D.Hummel. 2006. Influence of parity on productive performance of Pelibuey ewes under intensive management in the Mexican dry tropics. *Livestock Research for Rural Development* 18(6). 8 p.
- Mengistie Taye, Girma Abebe, Solomon Gizaw, Sisay Lemma, Abebe Mekoya and Markos Tibbo 2009. Growth performances of Washera sheep under smallholder management systems in Yilmanadensa and Quarit districts, Ethiopia. *Trop Anim Health Prod*. DOI 10.1007/s11250-009-9473-x
- Molla H, Asresu Y, Agraw A, Shigdaf M, Lisanework M 2016 (inpress). Farmer's perception on introduced washera sheep breed at Abagerima watershed of western Amhara. Proceedings of the 7th Annual Regional Conference on Completed Socio economic Research Activities. Amhara Regional Agricultural Research Institute. Bahirdar. Ethiopia, Feb 16-25/2016
- SAS, 2003. SAS (Statistical Analysis System) User's Guide: Statistics. Ver.9.1. Cary, NC: Inc.
- Shigdaf, M., Zeleke, M., Mengistie, T., Asresu, Y., Habtemariam, A., Aynalem, H., 2012. Traditional management system and farmers' perception on local sheep breeds (Washera and Farta) and their crosses in Amhara Region,

Ethiopia. *Livest. Res. Rural Develop.* 24 (01).

- S. Mekuriawa, Z. Mekuriawb, M. Taye, G. Mekuriawb, A. Amanea, T. Bimrewa, A. Haile. Growth performance and linear body measurements of Washera, Farta and their crossbreed sheep under farmers management system in Western Highland of Amhara Region; *Scientific Journal of Veterinary Advances* (2013) 2(9) 132-143
- Siegmund-Schultze M, Legesse G, Abebe G and Valle Zárate A 2009 Bottleneck analysis of sheep production systems in southern Ethiopia: Comparison of reproductive and growth parameters. *Options Méditerranéennes*, A no. 91, 2009 – Changes in sheep and goat farming systems at the beginning of the 21st century
- Solomon, A., Hegde, B.P., Mengistie, T., 2011. Growth and Physical Body Characteristics of Gumuz Sheep under Traditional Management Systems in Amhara Regional State, Ethiopia. *Livest. Res. Rural Develop.* 23 (5).
- Solomon Gizaw (2008). Sheep resources of Ethiopia: Genetic diversity and breeding strategy. PhD thesis, Wageningen University, the Netherlands.
- Solomon Gizaw, Azage Tegegne, Berhanu Gebremedhin and Dirk Hoekstra 2010. Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement. *Improving Productivity and Market Success of Ethiopian Farmers Project Working Paper 23*. International Livestock Research Institute, Nairobi, Kenya. pp 58.
- Tesfaye Getachew, Aynalem Haile, Markos Tibbo, Sharma A K, Ashebir K, Endashaw Teref, Wurzinger M and Sölkner J 2009. Morphological characters and body weight of Menz and Afar sheep within their production system. *Ethiopian Journal of Animal Production* Vol. 9(1), pp. 99-115
- Tesfaye Getachew, Aynalem Haile, Markos Tibbo, Sharma A. K., Sölkner J and Wurzinger M 2010. Herd management and breeding practices of sheep owners in a mixed crop-livestock and a pastoral system of Ethiopia. *African Journal of Agricultural Research* Vol. 5(8), pp. 685-691.
- Tibbo, M., Ayalew, W., Awgichew, K., Ermias, E. and Rege, J.E.O. 2004. On-station characterisation of indigenous Menz and Horro sheep breeds in the central highlands of Ethiopia. *FAO/UNEP Animal Genetic Resources Information*. 35, 61–74.
- Tibbo, M. 2006. Productivity and health of indigenous sheep breeds and crossbreeds in the central Ethiopian highlands. Ph.D. dissertation. Department of Animal Breeding and Genetics, Faculty for Veterinary Medicine and Animal Sciences, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden. 76p.
- Woreda Office of Agriculture and Rural Development, 2014-unpublished. Bahirdar zuria district, West gojjam zone, Amhara region, Ethiopia
- Yilmaz, O., Denk, H. and Bayram, D. 2007. Effects of lambing season, sex and birth type on growth performance in Norduz lambs. *Small Ruminant Research*. 68 (3), 336–339. *Trop Anim Health Prod*

On-Farm Survival Rate Evaluation of Farta Sheep under the Existing Farmers Management System at Estie District of Amhara National Regional State, Ethiopia

Agraw Amane

Andassa Livestock Research Center, P.O.Box 27, Bahir Dar, Ethiopia

Abstract

On- farm data were collected to evaluate survival rate of Farta sheep breed raised under the existing farmer's management system at Estie district of Amhara National Regional State, Ethiopia. The data were collected from 34 household heads from 2010 to 2012 G.C and analyzed using General Linear Model Procedure (GLM) of Statistical Analysis System (SAS version 9.1, 2003). The overall least square means survival rate (%) of Farta sheep from birth to one month, three months, six months, nine months and yearling of age were 98.4 ± 0.01 , 96.6 ± 0.03 , 91.2 ± 1.1 , 87.0 ± 1.2 and $86.9 \pm 1.2\%$, respectively. The effect of different fixed factors like lamb sex, parity of dam, season of birth, year of birth, birth weight and lamb birth type on survival rate were analyzed. Except parity of dam and sex of lamb, other factors affected survival rate ($P > 0.05$). The higher survival rate indicate that the area is of low disease load and the farmer practice to decrease lamb mortality need to be encouraged and improved. the influence of different fixed factors on survival indicate that through different management and breeding practices it is possible to increase the productivity of this breed of sheep. The on-farm breeds information on survival rate need to be supplemented by on-station research to better understand the genetic variations and potential of the breed and design appropriate breeding strategies.

Key words: Estie, Farta sheep, Survival rate, on-farm management

Introduction

Ethiopia is endowed with a large number (22.3 million; CSA 2010) and breed/type (18 populations; Tibbo, 2006) of sheep due to its extremes of variable agro climatic conditions and ecological systems that support large and very diverse animal genetic resources. The majority of sheep are distributed throughout the country, and about 70% are found in the highlands (Mengistu, 2003). Farta sheep is one of the indigenous sheep breeds reared by the rural farmers in the mixed crop–livestock farming systems of north-western highlands of Ethiopia. They are an important source of cash income and manure, social and cultural functions, a means of insurance against drought and other diversities (Lemma 2002).

Locally available sheep breeds in our country are the result of natural selection for survival under feed scarcity and disease challenges (Markos *et al.*, 2006). Their productivity is low compared to temperate breeds (Kassahun, 2000). It is very urgent to improve their productivity to satisfy the animal product demand of the large human population.

Choice of breeds for improving the output from sheep should depend on the amount of information available on them. However, there is no documented information on the survival rate of the breed both on-farm and on-station management practices. In addition, within population variation under village management conditions has also not been recorded. High survival rates also help progress in the flock by making more animals available for genetic studies from which superior germplasm might be selected (Mengistie *et al.*, 2011). The good body condition and high survivability of lambs are the two main requirements for a profitable sheep industry (Purusothaman *et al.*, 2008). Lamb survival is a complex trait influenced by the lamb's own ability to survive and by its dam's rearing ability (Matika *et al.*, 2003a).

Therefore this research was initiated with the objective of evaluating the survival rate of Farta sheep under the existing farmers' management and to identify the most important factors affecting this trait to identify areas for increased research and /or extension attention under the traditional management system

Materials and methods

Description of the study area

The study was conducted at East-Estie district of South-Gondar zone, Amhara National Regional State. Estie district is situated at 11°40' N latitude and 38° E longitude and located at about 100 km north-east of Bahir Dar, Ethiopia. It lies within an altitude range of 1900-4000 m above sea level. The district receives an average annual rain fall of 900-1099 mm and a mean-range temperature of 9-25°C. The rainy season ranges from May to September (WOARD, 2010).

Animals and management

Description of the breed

Gizaw *et al.* (2007) reported that Farta sheep is found in sub-moist highland at altitude of 2000-2500m above sea level in South Gondar zone; Gondar zuria, Belesa and Dembia districts. It is characterized as short fat tailed; medium size; woolly under coat; commonly white (37.5%), brown (27.5%) and black with brown belly (15%), white/brown with brown/white patches; males are horned and reared by Amhara communities.

On-farm flock management

In the study district, farmers keep sheep in combination with other livestock species like cattle and equines. The main feed sources for sheep in the study area are natural grazing land, crop residue, improved forage, crop aftermath and concentrates. Breeding is year-round. Farmers in the study areas house their sheep throughout the year to protect them from sun, rain, wind, theft and wild animals

(Shigdaf et al., 2012).

Since the start of data collection, sheep have been de-wormed for internal parasite three times a year; at the end of rainy season, at mid dry season and at the onset of rainy season. Animals have also been sprayed for external parasites when tick infestation is high. Vaccination against pasteurellosis, anthrax and black leg has been given once a year. Mobile treatment has been given for sick sheep during flock monitoring time.

Data collection and management

On-farm data, collected as part of the programme on “On-farm monitoring of Farta sheep breed at Estie district of South Gondar Zone” undertaken from 2010 to 2012, were used for the study. The data were collected from 34 households. Plastic ear tag was used for identification of animals to facilitate recording which applied at the beginning of the monitoring study, at birth or at purchase of the animal. On-farm data were collected by trained enumerators supervised monthly by researchers from research center.

Survival data collected and recorded include animal ID, mortality date, and reason for death of the animal, date when sheep is out from the farm for different reasons as sale, gift, loss, death etc

Data management and analysis

All the data collected were entered and managed using Microsoft Excel computer program. Preliminary data analysis and screening of outliers were employed before conducting the main data analysis. Survival data were analysed using General Linear Model Procedures (GLM) of the Statistical Analysis System (SAS version 9.1, 2003).

The fixed effects considered were lamb sex (Male, Female), parity of the dam (1, 2... ≥4), season of birth (dry, wet), year of birth (2010, 2011, and 2012), lamb birth type (single, multiple), lamb birth weight (heavy, medium, light). Season of birth was defined as dry from (November to April) and wet (May to October) (South Gondar Zone BOA, 2008).. Lamb birth type was single if single and multiple if two and above. Lamb birth weight was classified as heavy – lambs >3 kg, medium – 2 to 3 kg and light <2 kg according to Mengistie *et al.* (2011). When analysis of variance declares significance, least square means were separated using adjusted Tukey-Kramer test. Tukey Kramer test was used to separate means of effects with three or more levels which were significant in the least squares analysis of variance.

The response variable analyzed was survival from birth to different ages. Survival trait coded as binary trait was determined by whether or not a lamb survived to the end of each period according to Nguti et al. (2003). Survival was studied to five different age classes; from birth to 30 days, birth to 90 days, birth to 180 days, birth to 270 days and birth to 365 days.

For the analysis of the survival rate of the breed, the following model was used:-

Model 1: For analysis of variance of survival rate

$$Y_{klmnop} = \mu + G_k + P_l + S_m + T_n + Y_o + Z_p + e_{klmnop}$$

Where: Y_{klmnop} = the observation on survival to different ages.

m = over all mean

G_k = Fixed effect of lamb sex (k = male, female)

P_l = Fixed effect of birth weight of the lamb (light, medium, heavy)

S_m = Fixed effect of birth season (m = dry, wet)

T_n = Fixed effect of lamb birth type (n = single, multiple)

Y_o = Fixed effect of year (o = 2010, 2011, 2012)

Z_p = Fixed effect of ewe parity ($p=1, 2, 3$ and ≥ 4)

e_{klmnop} = effect of random error

Result and Discussion

The analyses of variance for various factors affecting lamb survival of Farta under on farm management system has presented in Tables 1. The least squares mean showed that the overall cumulative mean survival from birth to 30 days, birth to 90 days, birth to 180 days, birth to 270 days and from birth to 365 days was 98.4 ± 0.01 , 96.6 ± 0.03 , 91.2 ± 1.1 , 87.0 ± 1.2 and 86.9 ± 1.2 respectively. In general, the overall least squares mean survival was high as compared to the reports for indigenous Ethiopian sheep breeds (Niftalem, 1990; Solomon and Gemed, 2000; Mukasa-Mugerwa et al., 2002; Solomon, 2002). But it is in line with reports by Chukwuka et al., 2010 elsewhere in Africa. The higher survival rate in the present study may be due to the genetic difference related to the environmental adaptation that is the better adaptation performance of Farta sheep breed in the study area; difference in management practices of lambs where farmers in the study area keeping newborn lambs at home in the first week of life and giving them special care; Farmers use large baskets to keep newborn lambs; allow lambs to be kept dry, clean and warm. Farmers have good management practice for lambs in the study areas since their life is mainly depend on sheep production as mentioned in the farmer's group discussion. Moreover starting from the beginning of this study, there was provision of vaccines against prevalent diseases in the area and the practice of de-worming against internal and external parasites through the study period, which could contribute ensure lambing survival as well as for health of their mothers to furnish the lamb well. Many smallholder farmers in the tropics are good at ensuring strong ewe-lamb bonding within 12-24 hours of delivery which enhances colostrums production by dams and increased intake by lambs (Mukasa-Mugerwa et al., 2000).

Year of birth, season of birth, type of birth, and birth weight had a significant ($P < 0.01$) effect on lamb survival at different ages in different ways. This result is in line with Yibrah (2008) that year of birth, season of birth, type of birth, and birth weight affected survival at different ages in different ways for Afar and Blackhead Somali sheep except parity and sex of lambs under on station management.

Effect of Year of Birth

Year of birth had significant effect ($P < 0.01$) on lamb survival at all ages considered. Lambs born in 2010 had high survival rate than the other followed years which might be due to the fluctuation of feed and rain distribution along with the decreasing of grazing land from time to time. In the same scenario, Gemed et al. (2002), Yibrah (2008) and Berhanu and Aynalem (2011) reported that the survival rate difference between years may be a reflection of differences in feed availability caused by differences in irregularity of rainfall and other climatic factors. Though no data were collected regarding causes of mortality, differences in incidence of disease outbreak between the years may also be important for the variability in survival. The effect of year of birth have significant differences in lamb survival as reported by several workers under different environmental conditions and flock management practices (Mukasa-Mugerwa et al., 2000; Abegaz et al., 2002a; Yohannes et al., 2005; Yibrah, 2008).

Effect of Season of birth

Season did not affect lamb survival to the age of 30 days but lambs born during the wet season had better survival ($p < 0.05$) at weaning (90 days), 180 days, 270 days and 365 days than lambs born in dry season. This could be due to better nutritional status of the dam in the wet season affecting milk let down to the lambs. This is in agreement with the report by Solomon (2002) for Menz sheep. It is also in line with those reported in other literatures that lambs born during the wet season had better survival than lambs born in dry season (Kassahun, 2000; Solomon, 2002; Berhan and Van Arendonk, 2006; Mengistie et al., 2011). Mukasa-Mugerwa et al. (2000), however, reported the other way round, lambs born in the dry season had better survival than lambs born in the wet season. Berhanu and Aynalem (2011) reported also lambs born during the wet season had the lowest survival rate

than dry season under on-farm management. The low survivability of lambs in wet season might be related to the occurrence of different disease due to rain that reduces survival of lambs which require better management of lambs. Berhanu and Aynalem (2011) also report that during the wet season disease challenges from infective agents is highest and that deaths attributed to parasitic gastro enteritis, mainly haemonchosis is occurring.

Effect of Dam parity

Effect of Dam parity was not significant ($P > 0.05$) at all ages considered except survival from birth to 30 and 90 days. The result obtained in the present study is somewhat in agreement with Berhanu and Aynalem, (2011) that the effect of parity on lamb survival did not bring an effect beyond four months. The significant effect of dam parity at lower age of lamb (30 and 90 days) could be due to the fully dependent of the lamb on the mother milk and dams with higher parities had better mothering ability than dams with lower parities. Lambs born from maiden ewes have lower survival rate than those from higher parity dams (Kassahun, 2000; Tibbo, 2006). According to Solomon (2002), lambs born from ewes of the first parity have lower survival rate than lambs from ewes with higher parities which could be attributed to the better mothering ability of the dams or larger birth weight of lambs at later parities.

Effect of Lamb birth type

No significant difference was observed in survival rate of lambs of single and multiple births during the first month after lambing. However, thereafter, single born lambs survived better ($p < 0.001$) than the multiple-born lambs. The lower survival in multiple-born lambs could be due to the effect of birth weight and the competition for milk especially when the dam was in poor body condition during gestation and no supplementation was given after lambing. This might be mainly attributed to higher birth weight of single lambs in this study and less competition for milk from their dams/sole user of mother milk as compared to twines (Berhanu and Aynalem, 2011).

Effect of Lamb birth weight

Birth weight of lamb had significant effect ($P < 0.01$) on lamb survival at all ages considered. Lambs having light birth weight had lowest survival at all ages followed by lambs with medium birth weight. Lamb birth weight is the single greatest factor influencing lamb survival; lambs born light had low lamb survival as compared to lambs born with medium or heavier birth weights (Sulieman *et al.*, 1990; Solomon, 2002). According to Solomon (2002), Menz sheep lambs weighing 1.5 kg and below has significantly lower survival (0.70 ± 0.02) as compared to heavier lambs ($0.83 \pm 0.01 - 0.92 \pm 0.08$). In Sudan Desert sheep, for every kg of extra birth weight mortality was reduced by 3.7% at 30 days, 6.8% at 120 days, 7.3% at 150 days and 8.2% at 365 days (Sulieman *et al.*, 1990). This is corresponding to Gameda *et al.* (2002) that increased birth weight showed an increased survival rate of lambs. Markos (2006) also report that there was a positive relationship between birth weight and lamb survival within breed at all ages. Similarly, Gameda *et al.* (2002) reported that increased birth weight showed an increased survival rate of lambs under on-station management.

Effect of Lamb sex

Sex of lamb did not significantly affect ($P > 0.05$) survival of lambs at all ages. Correspondingly, Kassahun (2000) find that male and female lambs did not have significantly different survival rates from birth up to six month. In contrast to this result, Berhanu and Aynalem (2011) find that sex had significant effect on lamb survival at all age intervals except (0-120 days) in favour of females under farmer management. The non-significant ($p > 0.05$) effect of sex on survival at all ages was in contrast to the reports by Sulieman *et al.* (1990), Solomon (2002) and Tibbo (2006) while it agrees with the investigation of Solomon and Gameda (2000) in Horro sheep except to the age of 365 days that females survived better. Tibbo (2006) associated this partly to hormone effects on immune function. On the other hand, Kassahun (2000) did not find sex effect on survival to 180 days after which

females do survive better than males and linked this to a preferential treatment of ewe lambs in preparation to mating

Table 1. Least squares means of survival (%) to different ages by sources of variations in Farta sheep

Source of variation	N	Survival from birth to:				
		30 days	90 days	180 days	270 days	365 days
Overall	220	98.4±0.01	96.6±0.03	91.2±1.1	87.0±1.2	86.9±1.2
Birth year		**	**	**	**	**
2010	55	99.8±1.4a	98.1±2.1b	93.6±2.7	89.0±3.0 ^a	89.1±3.1 ^b
2011	75	97.6±0.7b	96.6±1.1a	89.8±1.4	86.8±1.5 ^b	86.2±1.6a
2012	90	95.3±0.7c	95.3±1.0c	86.8±1.3	85.4±1.4 ^c	85.3±1.4c
Birth season		NS	*	*	*	*
Dry	106	97.8±0.6	95.4±0.9	89.5±1.2	86.6±1.2	85.5±1.3
Wet	114	98.9±0.7	97.5±1.1	92.9±1.4	88.4±1.5	87.4±1.5
Parity		*	*	NS	NS	NS
1	86	95.7±1.0	93.9±1.5	90.6±2.0	86.5±2.2	85.4±2.2
2	78	97.8±1.0	95.9±1.4	90.9±1.9	86.8±2.1	85.8±2.1
3	66	98.1±1.0	97.5±1.5	91.3±1.9	87.1±2.0	86.2±2.1
4	55	99.4±0.9	98.8±1.4	91.5±1.8	87.2±2.0	86.4±2.1
Birth type		NS	**	**	**	**
Single	176	98.5±0.6	97.9±0.9	93.9±1.2	89.3±1.3	88.0±1.3
Multiple	44	98.3±0.8	94.6±1.2	88.5±1.5	85.8±1.7	85.8±1.7
Birth weight ¹		**	**	**	**	**
Heavy	71	99.0±1.0	98.0±1.4 ^a	94.4±1.9 ^a	89.0±2.1 ^a	88.6±2.1 ^a
Medium	80	98.1±0.5	97.9±0.8 ^a	93.2±1.0 ^b	88.9±1.1 ^a	88.1±1.1 ^a
Light	69	97.2±1.1	94.9±1.7 ^b	86.0±2.2 ^c	85.3±2.4 ^b	85.2±2.4 ^b
Sex of lamb		NS	NS	NS	NS	NS
Male	105	98.7±0.6	96.8±1.0	91.5±1.2	87.6±1.4	86.7±1.4
Female	115	98.0±0.7	95.2±1.0	90.9±1.3	86.4±1.4	85.3±1.4

NS: Not significant ($p>0.05$); * $P<0.05$; ** $P<0.01$; ¹Birth weight: Heavy (>3kg), Medium (2-3kg), Light (<2kg)

Conclusion and Recommendation

Season of birth, year of birth, birth type and birth weight were found an important source of variation for the survivability of the breed. The influence of different fixed factors on survival indicates that through different management and breeding practices, it is possible to increase the productivity of this breed of sheep. Lambs with light birth weight have low survival rate than lambs with medium and heavy birth weights. Improving lamb birth weight using different management interventions such as improving pre-partum feeding of ewes, especially animals with poor body condition carrying twins may partially solve the problem (Gemedu *et al.*, 2002).

Tibbo (2006) recommended that improving the nutritional condition of the pregnant ewe would increase the birth weight of lambs which could be an effective means to improve survival of multiple lambs in difficult tropical environments. The survival rate of Farta sheep obtained in the current study was higher than the reported survival rate of other sheep breeds in Ethiopia within the respective ages. The higher survival rate indicates that better adaptability of Farta sheep breed in the study area; the area is of low disease load and the farmer practice to decrease lamb mortality need to be encouraged and improved.

The on-farm breeds information on survival rate need to be supplemented by on-station research to

better understand the genetic variations and potential of the breed and design appropriate breeding strategies. Integrated efforts combining improving feeds and feeding, health and participatory community-based breeding needed

Acknowledgement

The field research was fully financed by the Amhara Regional Agricultural Research Institute (ARARI) in Ethiopia. The author is greatly indebted to Mr. Eyasu Lakew for his support in data cross checking and data entry. The author is also interested to thank the enumerators at the villages for their support in data collection. We are grateful to the staff of Andassa Research Centre of ARARI, for their interest in our research and support during the field work.

References

- Abegaz, S., E. Negussie, G. Duguma and J. E. O. Rege. 2002a. Genetic parameter estimates for growth traits in Horro sheep. *J. Anim. Breed. Genet.* 119:35-45
- Berhan, A., Van Arendonk, J., 2006. Reproductive performance and mortality rate in Menz and Horro sheep following controlled breeding in Ethiopia. *Small Rumin. Res.*, 63, 297–303.
- Berhanu, B., Aynalem, H., 2011. Survivability of lambs under village management condition: The case around Jimma, Ethiopia. *Livest. Res. Rural Develop.* 23 (4).
- Central Statistical Agency of Ethiopia (CSA). 2010. The 2006 National Statistics- Agriculture. http://www.csa.gov.et/text_files/2006_national_statistics.htm (accessed on Oct., 2011)
- Chukwuka, O.K., Okoli, I.C., Okeudo, N.J., Opara, M.N., Herbert, U., Ogbuewu, I.P., Ekenyem, B.U., 2010. Reproductive potential of West Africa Dwarf Sheep and Goat: A Review. *Res. J. Vet. Sci.*, 3(2), 86-100.
- Gizaw Solomon, J. A. M. Van Arendonk, H. Komen, J. J. Windig and O. Hanotte. 2007. Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia. *International Society for Animal Genetics, Animal Genetics*, 38, 621–628.
- Gemed, D., Schoeman, S.J., Cloete, S.W.P., Jordaan, G.F., 2002. The influence of non-genetic factors on early growth traits in the Tygerhoek Merino lambs. *Eth. J. Anim. Prod.*, 2 (1)127-141.
- Kahsa, T.G., 2009. Estimates of economic values for important traits of two indigenous sheep breeds of Ethiopia. MSc. Thesis, BOKU – University of Natural Resources and Applied Life Sciences, Vienna, Austria.
- Kassahun, A., 2000. Comparative performance evaluation of Horro and Menz Sheep of Ethiopia under grazing and intensive feeding condition. PhD Dissertation Humboldt-University.
- Lemma Sisay, 2002. Phenotypic classification and description of indigenous sheep type in the Amhara National Regional State of Ethiopia. M.Sc. Thesis. University of Natal, Pietermaritzburg. 104p.
- Matika O., van Wyk J.B., Erasmus G.J. and Baker R.L. 2003a. A description of growth, carcass and reproductive traits of Sabi sheep in Zimbabwe. *Small Rumin. Res.* 48:119–126.
- Mengistu Alemayehu, 2003. Country Pasture/Forage Resource Profiles, Ethiopia. <http://www.fao.org/ag/AGP/AGPC/doc/Counprof/Ethiopia/Ethiopia.Htm> (Accessed on February 2007)
- Mengistie, T., Girma, A., Sisay, L., Solomon, G., Abebe, M., Markos, T., 2011. Reproductive Performances and Survival of Washera Sheep under Traditional Management systems at Yilmanadensa and Quarit Districts of the Amhara National Regional State, Ethiopia. *J. Anim. Sci. Vet. Adv.*, 10 (9), 1158-1165.
- Mukasa-Mugerwa, E., Lahlou-Kassi, A., Anindo, D., Rege, J.E.O., Tembely, S., Markos Tibbo, Baker, R.L., 2000. Between and within breed variation in lamb survival and the risk factors associated with major causes of mortality in indigenous Horro and Menz sheep in Ethiopia. *Small Rumin. Res.*, 37, 1-12.
- Mukasa-Mugerwa, E., Anindo, D., Sovani, S., Lahlou-Kassi, A., Tembely, S., Rege J.E.O., Baker, R.L., 2002. Reproductive performance and productivity of Menz and Horro sheep lambing in the wet and dry seasons in the highlands of Ethiopia. *Small Rumin. Res.*, 45, 26-271.
- Markos, T., 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. PhD dissertation. Department of Animal Breeding and Genetics, Faculty of Veterinary Medicine and Animal Sciences, Swedish University of Agricultural Science (SLU), Uppsala, Sweden. 74p.

PROCEEDING

Animal Breeding and Reproduction

- Mellado M. R. Valdez, J.E. Garcia, R. Lopez, A. Rodriguez. 2006. Factors affecting the reproductive performance of goats under intensive conditions in a hot arid environment. *Small Ruminant Research* 63:110–118.
- Nguti, R., Janssen, P., Rowlands, G.J., Audho, J.O., Baker, R.L., 2003. Survival of Red Maasai, Dorper and cross-bred lambs in the sub humid Tropics. *Anim. Sci.*, 76, 3-17.
- Niftalem Dibessa. 1990. On-farm study of the reproduction and growth performance of Menz Sheep around Debre Brhan area. M.Sc Thesis. Alemaya University of Agriculture, Dire Dawa, Ethiopia. 103 p.
- Purusothaman, M.R., Thiruvenkadan, A.K., Karunanithi, K., 2008. Seasonal variation in body weight and mortality rate in Mecheri adult sheep. *Livest. Res. Rural Develop.* 20 (9).
- Riggio, V., Finocchiaro, R., Bishop, S.C., 2008. Genetic parameters for early lamb survival and growth in Scottish Blackface sheep. *J. Anim. Sci.*, 86, 1758-1764.
- Shigdaf, M., Zeleke, M., Mengistie, T., Asresu, Y., Habtemariam, A., Aynalem, H., 2012. Traditional management system and farmers' perception on local sheep breeds (Washera and Farta) and their crosses in Amhara Region, Ethiopia. *Livest. Res. Rural Develop.* 24 (01).
- Solomon, A.K., Gemed, D., 2000. Genetic and phenotypic parameters of growth, reproductive and survival performance of Horro sheep at Bako Agricultural Research Center. Research fellowship report. Intern. Livest. Res. Instit., (ILRI), Addis Ababa, Ethiopia.
- Solomon, A.K., 2002. Genetic evaluation of production, reproduction and survival in a flock of Ethiopian Horro sheep. PhD. dissertation submitted to the Faculty of Natural and Agricultural Sciences Department of Animal, Wildlife and Grassland Sciences University of the Free State. Bloemfontein. 118p.
- South Gonder Zone Agriculture and Rural Development Office. (2008). Socio-Economic survey report from 2003-2008 (un-published).
- Sulieman, A. H., A. R. Sayers and R T. Wilson. 1990. Evaluation of Shugor, Dubasi and Watish subtypes of Sudan Desert sheep at the El-Huda National Sheep Research Station, Gezira Province, Sudan. ILCA Research Report 18. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 38 p
- SAS, 2003. SAS (Statistical Analysis System) User's Guide: Statistics. Ver.9.1. Cary, NC: Inc.
- Tibbo, Markos, 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Ph.D. dissertation. Department of Animal Breeding and Genetics, Faculty for Veterinary Medicine and Animal Sciences, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden. 76p
- Woreda Office of Agriculture and Rural Development, 2010. East Estie, North Gondar, Ethiopia
- Yibrah, Y., 2008. Environmental and genetic parameters of growth, reproductive and survival performance of Afar and Blackhead Somali sheep at Werer Agricultural Research Center, Fellowship report submitted to International Livestock Research Institute (ILRI) and Ethiopian Institute of Agricultural Research (EIAR). Ethiopia
- Yohannes, G., Kassahun, A., Thwaites, C.J., 2005. Factors Influencing Survival and Growth of the Ethiopian Horro Sheep. *Ethiop. J. Agric. Sci.*, 18, 41-51.

On-Farm Evaluations of Reproductive Performances of Fogera Cattle Breed in Selected Districts of Amhara Region, Ethiopia

Assemu Tesfa¹, Dilip Kumar, Solomon Abegaz and Getinet Mekuriaw

¹Andassa Livestock Research Center, P.O.Box 27 Bahir Dar, Ethiopia

Abstract

The current study was initiated to identify the major production constraints and evaluate the on-farm reproductive performances of Fogera cattle breed at purposively selected peasant associations (PA) of Fogera, Bahir Dar zuria and Dera districts. A total of 150 farmers, who have better knowledgeable and having at least one cattle of Fogera breed in their herd were purposively selected and interviewed. Structured questioner was used to collect the data and field observation was implemented to see the distribution and production constraints of the breed at its production area. A general linear model (GLM) procedure of SAS (2002) was used to determine the effects of fixed factors on the selected economic traits (AFS, AFC, CI and NSC). District, parity and age of the dam were used as fixed effect. As the survey result reveals, majority of the respondents are categorized in the productive age group (20-50 years) with capability of read and write. The overall mean cattle holding (both Fogera and non-Fogera breed) of the study districts were 9.73 ± 0.92 . Majority of the respondents indicates that the source of their Fogera cattle was from family (62.6%), purchased (30.6%) and own source (6.8%). The overall mean value of AFS, AFC, CI and NSC was reported to be 42.24 ± 0.05 months, 51.4 ± 0.05 months, 21.18 ± 0.70 months and 1.42 ± 0.05 , respectively. The average age of cows was reported 12.95 ± 0.33 year with average calving number of 4.49 ± 0.43 within this life time. In general, from this study it was noted that Fogera breed is well kept by its keepers and performance better by challenging the feed shortage, and diseases burden at its production environment. Therefore, improving the production environment of the breed is advised to improve the productivity of the breed.

Key words: Amhara region, Breeding practice, Fogera cattle and Reproductive performances

Introduction

Ethiopia has the largest cattle population (53.99 million heads) in Africa (CSA, 2013); of which the vast majority (98.9%) of the national herd is of indigenous zebu cattle maintained in rural areas under extensive husbandry systems. Due to the low productivity of these local breeds and to increase the demand for milk products, however, the Ethiopian government's efforts to improve productivity in the livestock sector, through intensive husbandry with exotic and cross breeds (Million and Tadelles, 2003; Firdessa, 2012). The productivity of cattle depends largely on their reproductive performance, which is an indicator of reproductive efficiency and the rate of genetic progress in both selection and crossbreeding programs (Nuraddis, 2011). Among the reproductive traits, age at first service (AFS), age at first calving (AFC), calving interval (CI) and number of services per conception (NSC), are the bases for a profitable dairy farming (Asheber, 1991; Enyew *et al.*, 1998 and Tewodros, 2008).

Fogera cattle breed, which is populated in Amhara region, is well known for its milk production that gives 1500.0 litter of milk in one lactation season (Alberro and Haile-Mariam, 1982). However, currently its productivity is declined because of different problems like genetic admixture with uncharacterized local breeds and inbreeding, shift of production system (shift of grazing lands to crop lands and crop diversification) leading shrinkage of grazing land, poor management practices (like, feed scarcity and disease prevalence), absence of well-defined breeding programs, poor selection strategy and genetic gain (Gebeyehu *et al.*, 2004; IBC, 2004 and Addisu *et al.*, 2007). These problems have coupled with the changing climate leads the breed to lose its characteristics and lowering of its productivity performance.

The on-farm productive and reproductive performance evaluation of Fogera breed had done by Addisu and his colleague during 2007 at Fogera district alone. But as Fogera breed is expected to be distributed over seven districts those surrounds Lake Tana, further studies was mandatory to understand its current performance and, therefore, this paper was initiated with the objectives; to evaluate the on-farm reproductive performances of Fogera cattle breed and to identify the major production constraints at selected districts of Amhara region.

Materials and Methods

Description of the study district

The study was conducted in three districts viz. Bahirdar Zuria, Dera and Fogera of Amhara region. The districts were selected purposively based on presence of Fogera cattle breed and their location that surrounds Lake Tana, the expected home track of the breed. Bahirdar Zuria, Dera and Fogera districts far from Addis Ababa, the capital of the country, 580; 610 and 635 km, respectively following and bounding Lake Tana in the South direction. The three districts are characterized as a mid-altitude in the Ethiopian agro-ecological classification with a mixed crop-livestock farming system.

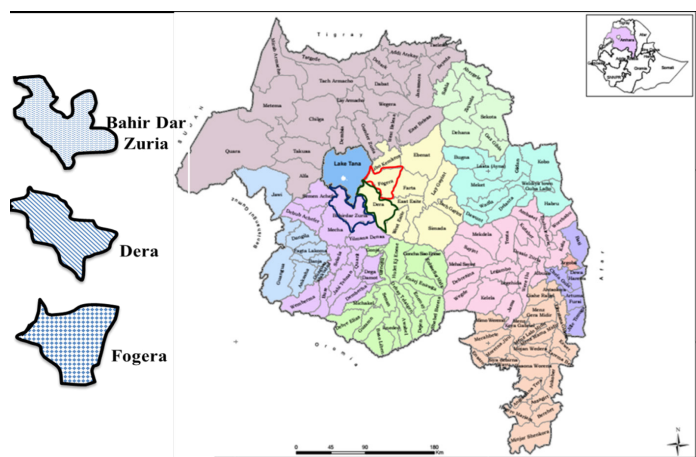


Figure 1. Map of working districts

Description of Fogera breed

Fogera breed is an intermediate Zebu-Sanga type (Alberro and Solomon Haile-Mariam, 1982) characterized and well known by its pied coat of black-and-white or black-and-grey; short, stumpy, pointed horns; hump ranges from thoracic to cervico-thoracic; dewlap is folded and moderate to large in size; docile temperament; used for draught, milk and meat (Rege and Tawah, 1999; DAGRIS 2007). Additionally, the breed is known for its tolerance to high altitudes, parasite and disease infestation, fly burden, wet soils or swampy areas, low quality of feed and other unfavorable environmental conditions (Alberro and Haile-Mariam, 1982). Fogera cattle are generally large, being tall with long legs, a massive body with solid strong bones is one of the breed's main features (DAGRIS, 2007). Farmers describe and choose Fogera breed due to its lower age at first calving and ability to plough the marshy area and better dowry (exchange value) and other social purposes.



Figure 2. Pure Fogera cows (left) and calves (right) at Andassa Livestock Research Center

Data collection

From Bahir Dar and Dera districts two Peasant Associations (PA) and one PA from Fogera district (where Fogera cattle breed conservation and improvement is practiced) were purposively selected based on the distributions of the breed. A total of 150 farmers (30 farmers from each PA), which are knowledgeable and having at least one cattle of Fogera phenotype in their herd were purposively selected and interviewed. Additionally, farmer's focus group discussion was conducted to capture the historical background of the breed at the selected areas and to understand their population and distribution.

Data management and Statistical analysis

The questioner data were screened and cross checked for reliability and consistency; questions which were not clearly addressed were removed. General linear model (GLM) procedures of the Statistical Analysis System (SAS, 2002) were used to determine the effects of fixed factors on the selected economic traits. The presence of any significant differences was checked by using TUKEY Kramer multiple comparison tests. Index method was adopted to summarize major threats of the breed at the selected districts. The fixed effects used in this study comprised of working district (1=Fogera, 2=Bahir Dar zuria and 3=Dera), parity of the dam (1, 2, 3, 4, 5 and ≥ 6) and age of the dam (1 = 3 to 6 year, 2 = 7 to 10 year and 3 = ≥ 11 years). The following GLM model was used to evaluate the reproductive performance of Fogera cattle breed (AFS, AFC, CI and NSC).

$$Y_{ijkl} = \mu + D_i + P_j + A_k + e_{ijkl}$$

Where, Y_{ijkl} = l^{th} record of i^{th} district, j^{th} parity, k^{th} age of the dam, and

μ = overall mean

D_i = effect of i^{th} working district

P_j = effect of j^{th} parity of dam

A_k = effect of k^{th} age of the dam

e_{ijkl} = random error associated with each observations

Result and Discussion

Household characteristics

The survey result revealed that majority of the interviewed farmers are categorized in the working age group (20-50 year) (Table 1), which is categorized as the working and productive age group in the agriculture system of the country. Similarly, Ethiopian scholars indicated many of the farmers participating in the agriculture sector have grouped in the same range (Tewodros, 2008; Belete *et al.*, 2010; Teshager, 2013 and Solomon *et al.*, 2014). In addition, 75%, 83% and 65% of Bahir Dar Zuria, Fogera and Dera districts, respectively, are capable to read and write through formal and non-formal educations. The younger age group of the respondents might be the main reason for better educational level found in this study. The capability of read and write is best indicator for the improvement of the agriculture production through adoption of better technologies as well as to follow applicable recommendations in the livestock sector.

Table 1. Household information

Parameters	Working districts					
	Bahir Dar Zuria		Fogera		Dera	
	Respondent (N)	Respondent (%)	Respondent (N)	Respondent (%)	Respondent (N)	Respondent (%)
Age (year)						
20-35	22	37	6	20	16	27
36-50	27	45	18	60	35	58
51-65	10	17	3	10	7	12
>65	1	2	3	10	2	3
Educational background						
Illiterate	15	25	5	17	21	35
Read and write	17	28	16	53	25	42
1-4complete	5	8	5	17	5	8
5-8 complete	14	23	4	13	5	8
9-12 complete	8	13	0	0	4	7
College	1	3	0	0	0	0

Fogera cattle production system

Fogera cattle keeping experiences

Fogera cattle keeping experience of the farmers shows significant difference across districts; Fogera district farmers had better experience in keeping of the breed which might be due to the home tract of the breed is expected to be Fogera plain (Table 2) and relative to other districts Fogera plain is known to be swampy which the breed prefers and can also obtain better feed.

As the result indicates 58%, 63% and 67% respondents of Bahir Dar zuria, Fogera and Dera district, respectively, sources Fogera cattle from their families. This indicated that the breed is accepted as productive that make it transferred from generation to generation. The respondents, additionally, indicated that while they purchase the breed from market they use selection criteria's like color, stand

(physical temperament), productivity history from other neighboring farmers of the cattle owner and its longevity.

Table 2. Fogera cattle source and experience in keeping the breed

Traits	Working districts					
	Bahir Dar Zuria		Fogera		Dera	
	Respondent (N)	Respondent (%)	Respondent (N)	Respondent (%)	Respondent (N)	Respondent (%)
Source of cattle						
Own	1	2	3	10	5	8
Purchased	24	40	8	27	15	25
From Family	35	58	19	63	40	67
Cattle keeping experience						
1-20 year	39	65	5	17	33	55
21-40 year	20	33	10	33	18	30
41-60 year	1	2	6	20	2	3
>60 year	0	0	9	30	7	12

Fogera Cattle Holding of the study Districts

The overall mean cattle holding of the study districts were 9.73 ± 0.92 ; from which 7.16 ± 0.53 of them has Fogera cattle phenotype that include the expected, mixed Fogera with other zebu breeds and the remaining 2.57 ± 0.39 is highland breed dominated in the study districts. This indicates that the respondents hold 73.58% of Fogera breeds blood on their herd composition which directs, the selected working districts are home for the Fogera breed. The higher Fogera blood cattle holding of the study districts is mainly due to the peasant associations used for the survey were selected purposively on which the breed is expected to be populated and the farmers were also selected to have Fogera breed in their herd to understand the productivity history of the breed. The result supports the assumption that Fogera breed is living at districts surrounding Lake Tana.

The total cattle holding of this study is greater than the cattle holding report of 6.7 in North Gondar zone (Sisay, 2006); 4.60 ± 1.7 (Tewodros, 2008); 9.66 ± 0.60 at Selale (Kelay, 2002); 4.16 ± 3.6 (Fisseha, 2009) in Burea district; 7.43 (Asaminew and Eyassu, 2009) in North western Ethiopia; 1.60 ± 1.49 (Adebabay *et al.*, 2011); 4.39 ± 0.23 (Shitahun, 2009) and 6.89 TLU (Zemenu *et al.*, 2014) in Debre Markos district and is lower than the report of 11.2 ± 0.48 in Oromiya region (Teshager *et al.*, 2013), 13.99 ± 1.08 in Metekel zone (Solomon *et al.*, 2014) and 21.8 cattle in East Gojjam zone (Yitay, 2008). The variation across different working districts might be due to the production system difference, forage availability, difference in total livestock population and composition and dependency in livestock and other related reasons.

Working districts had shown significant difference ($p < 0.01$) in Fogera cattle holding and farmers of Fogera district hold more number of Fogera breed followed by Bahir Dar zuria and Dera district (table 3). Significant difference of district in cattle holding was reported by Sisay (2006), Yitay (2008), and Shitahun (2009).



Figure 3. Fogera cattle breed: breeding cow at Fogera district (left) and calf at Bahir Dar Zuria district (right)

Table 3. Cattle holding of the study districts

Cattle type	Fogera cattle phenotype (Mean±SE)			Overall	Non-Fogera cattle (Mean±SE)			Overall
	B/Dar zuria district	Fogera district	Dera district		B/Dar zuria district	Fogera district	Dera district	
Milking cow	2.55±0.27	2.9±0.12	1.4±0.11	2.16±0.13	0.82±0.17	0.33±0.08	0.53±0.09	0.61±0.08
Traction oxen	1.48±0.15	1.9±0.1	0.93±0.13	1.35±0.09	0.4±0.09	0.1±0.05	0.85±0.13	0.52±0.07
Heifer	1.58±0.21	1.7±0.22	0.45±0.1	1.15±0.11	0.37±0.09	0.07±0.04	0.67±0.15	0.43±0.07
Breeding bull	0.75±0.12	1.3±0.19	0.37±0.08	0.71±0.07	0.13±0.05	0.13±0.06	0.53±0.12	0.29±0.05
Male calf	1.13±0.16	1.23±0.21	0.65±0.12	0.96±0.09	0.25±0.07	0	0.58±0.12	0.33±0.06
Female calf	1.13±0.14	0.93±0.15	0.48±0.08	0.83±0.07	0.25±0.07	0.1±0.05	0.67±0.12	0.39±0.06
Overall	8.62±1.05 ^a	9.96±0.99 ^a	4.28±0.62 ^b	7.16±0.56	2.22±0.54 ^{ab}	0.73±0.28 ^b	3.83±0.73 ^a	2.57±0.39

Breeding practices

According to the survey result, 43% of respondents use selected bull for breeding purpose. While 15% and 41% of them responds as they use unselected bull and both selected and unselected bull for breeding purpose, respectively.

Table 4. Type of breeding bull used at the study districts

District	Type of breeding bull					
	Selected bull		Unselected bull		Both selected and unselected	
	Frequency (N)	Respondent (%)	Frequency (N)	Respondent (%)	Frequency (N)	Respondent (%)
Overall	65	43	23	15	62	42
Bahir Dar Zuria	43	72	2	3	15	25
Fogera	2	7	0	0	28	93
Dera	20	33	21	35	19	32

The respondents of all the selected districts use their own, neighboring, and any one bull at the field with respective percentage of 34.4, 37.8, and 27.8% to mate their breeding cows and heifers. As the overall result indicates, there is no control mating in the breeding system followed by the

districts; which might be lack of understanding in genetic admixture (inbreeding) and its effect on the performance of their cattle. Similar result on use of uncontrolled mating via local bull sourced mainly of neighbors and own was reported by Belete *et al.* (2010); and Zemenu *et al.* (2014). This uncontrolled mating is now being the main bottleneck problem for the deterioration of Fogera breed population and performance.

Reproductive performances of Fogera cattle breed

The result of the survey data indicated that district difference, age group of the dams and parity had shown significant differences on reproductive performance traits. Additionally, the result also reveals, reproductive performance of Fogera breed had shown a declined trend (Table 5) compared to the previous results reported by Gebeyehu *et al.* (2004) and Addisu *et al.* (2007). This might be due to quality deterioration of available feed staffs, degradation/ shrinkage of grazing land and decline of Fogera population in its home tract from time to time.

Age at first service of the current study is lower than 45.7 ± 8.16 for Kereyu Sanga cattle of Oromia region (Shiferaw, 2014) and 50.72 ± 0.6 months for Horro cattle (Mekonnen *et al.*, 2012). Whereas, the average AFC recorded in this study is higher than 49.32 months and the CI is lower than 20.04 months reported by Addisu *et al.* (2007) for the same breed. Similarly, higher result for AFC was reported 54.1 ± 8.81 (Shiferaw, 2014), 55.65 months (Zemenu *et al.*, 2014) and 60.96 ± 0.7 months (Mekonnen *et al.*, 2012). Lower AFC was reported 46.06 ± 13.99 (Solomon *et al.*, 2014) and 47.46 months (Derese, 2008). Lower results for CI compared with the current study was reported 18.0 ± 3.28 months (Shiferaw, 2014), 20.16 months (Zemenu *et al.*, 2014), 20.2 months (Derese, 2008) and 15.12 months (Niraj *et al.*, 2014). Whereas, longer calving interval was reported 21.84 ± 0.4 month for Horro cattle (Mekonnen *et al.*, 2012) and 23.38 ± 13.95 months (Solomon *et al.*, 2014). Higher result for NSC (1.7 ± 0.2) was reported by Niraj *et al.* (2014). The findings of the current study shows better performance of the breed compared to AFC and NSC for other Ethiopian indigenous cattle breeds which is summarized and reported by Assemu and Dilip (2014). **Table 5. Reproductive performance of Fogera cattle breed**

Category	Reproductive performance traits							
	AFS		AFC		CI		NSC	
Overall	42.24±0.05		51.4±0.05		21.18±0.70		1.42±0.05	
CV %	18.23		14.39		34.81		51.26	
R ²	0.28		0.28		0.138		0.079	
	N	Mean ±SE	N	Mean ±SE	N	Mean ±SE	N	Mean ±SE
District	**		*		**		NS	
Fogera	91	39.48±0.11 ^b	91	50.16±0.12 ^b	91	20.64±1.34 ^{ab}	91	1.46±0.13
B/Dar	127	40.68±0.06 ^{ab}	127	51.48±0.06 ^a	99	18.55±0.91 ^b	134	1.47±0.07
Dera	97	46.08±0.11 ^a	97	55.96±0.12 ^a	85	24.27±1.38 ^a	99	1.32±0.08
Parity	***		**		NS		NS	
1	56	46.44±0.12 ^a	56	56.6±0.13 ^a	17	21.86±1.87	63	1.58±0.14
2	104	38.88±0.06 ^{bc}	104	49.16±0.04 ^{bc}	104	20.37±0.68	104	1.30±0.06
3	89	41.28±0.06 ^{bc}	89	52.08±0.06 ^{bc}	90	21.09±0.71	90	1.32±0.07
4	43	44.52±0.09 ^a	43	55.44±0.09 ^a	42	18.94±1.06	43	1.63±0.10
5	10	44.28±0.25 ^{ab}	10	55.08±0.25 ^{ab}	10	24.09±2.90	10	1.43±0.26
≥6	13	36.12±0.16 ^c	13	46.12±0.17 ^c	12	20.50±2.08	14	1.19±0.19
Age	*		*		*		**	
3-6 year	89	38.64±0.08 ^b	89	47.68±0.08 ^b	51	19.79±1.00 ^{ab}	89	1.23±0.09 ^b

7-10 year	189	40.92±0.04 ^{ab}	189	50.96±0.04 ^{ab}	187	19.77±0.51 ^b	198	1.24±0.05 ^b
>11 year	37	42.6±0.11 ^a	37	51.76±0.1 ^a	37	22.53±1.31 ^a	37	1.71±0.12 ^a

*N= number of observation; ***P<0.001; **P< 0.01; *P<0.05; NS= Not Significant. Means with the same letter are not significantly different*

District had shown a significant ($p<0.01$) effect on AFS, AFC and CI; cattle's from Dera district results higher AFS and AFC and longer CI followed by Bahir Dar Zuria and Fogera district. This difference might be attributed to the better grazing land availability and additional feed source available from rice crop residue at Fogera district. Whereas, change of production system at Bahir Dar zuria might be a reason for lower result compared to Dera district. While district difference had no significant difference on NSC which might be due to all districts follow uncontrolled natural mating at the grazing land. Similarly, Solomon *et al.* (2014) reported significant difference of district on AFC and CI.

Parity had shown a significant ($p<0.001$) effect on AFS and AFC, while non-significant ($p>0.05$) difference is observed in CI and NSC. Irregular value of AFS and AFC across parity might be due to the informative nature of respondents which related with their educational level. In a general way, there is a decreasing value of AFS and AFC as parity had increased; this might be due to variation in management practice of cattle keepers that in turn favors early maturity in physiological activity of dams. On the contrary, significant effect of parity on CI and NSC is reported by Niraj *et al.* (2014).

Age of the dam had shown significant ($p<0.05$) differences in all reproductive traits used for the study; and as the age of the dam increases all values of the reproductive performance also increases. The increased value for CI and NSC across the increased value of age might be due to the retardation of physiological activities (unable to show observable heat, inefficient functioning of the uterus and other reproductive organs), and low feed conversion efficiency in advancement of age. Additionally, the higher value of AFS and AFC across the advancement of age might be due to long living cows start to give their first calve in late age in that their physiological activities will mature enough to give birth and living longer, while early calving dams might be retarded across age due to early birth before maturing of their reproductive physiology.

Longevity

The survey result indicated that the overall mean age of the breeding cow in production is reported to be 12.95 ± 0.33 year and gives overall average of 4.49 ± 0.43 calves within this life time. There is a significant difference ($p<0.01$) in production life of cows across the three districts; and the maximum productive life is reported from Dera district (13.98 ± 0.59 years) followed by Fogera and Bahir Dar zuria districts with respective age of 13.47 ± 0.32 and 11.67 ± 0.59 years. The variation might be due to the agro ecological differences which related with feed availability, and disease occurrence. In selected kebeles of Dera district there is better feed availability around Lake Tana on which no crop diversification had been done on the edges of the Tana. Whereas in Fogera district there is crop diversification on the surrounding of the lake and in Bahir Dar zuria district there is coverage of homesteads by chat (*Catha edulis*) and plowing of the private grazing lands for irrigation.

Major production constraints of Fogera cattle breed

The survey result indicated Fogera breed is facing different problems those alone and together with other constraints lowers the productivity of the breed. Table 6, lists the major problems reported by individual respondents and by focus group discussion. Reviews indicated that the major cattle production problems are feed shortage, animal health, lack of capital, water scarcity and labour according to their severity (Solomon *et al.*, 2014 and Zemenu *et al.*, 2014).

Table 6. Major constraints for the decreasing performance and population status of Fogera breed

Major constraints	Rank (N=150)				Score	Index	Rank
	1	2	3	4			
Shrinkage of grazing land	52	14	10	8	278	0.33	1
Shortage of land for feed development and rearing of the breed	32	4	6	2	154	0.18	2
Absence of health follow up and clinic	2	26	4	2	96	0.11	3
Lack of better breeding bull	4	12	8	0	68	0.08	4
Flood on grazing land and extinction of adaptive grasses	4	10	8	0	62	0.07	5
Lack of family labour to manage the breeds	0	16	4	0	56	0.066	6
Poor management adopted for the breed	4	12	0	0	52	0.061	7
Cross breeding to upgrade the local breeds	6	4	6	2	50	0.05	8
Admixture of the breed with other highland breeds	2	4	2	0	24	0.02	9

Occurrence of feed shortage

Feed is one of the main threatening problem for cattle production; which is mainly due to shortage/ shrinkage of grazing land for crop production and due to land degradation, shortage of land for additional forage development, and over flooding of Lake Tana (mainly Fogera district) over the grazing land. As the multiple responses analysis of the data indicates the major feed shortage months were April, May and June. The main reasons for this might be due to absence of any feed staffs on the ground due to absence of rain, the conserved feeds will be consumed in the main dry season (January to March), and absence of knowledge on the development of optional feeds through irrigation at backyard, and around ages of crop production fields. Similarly, Solomon *et al.* (2014) reported that the critical months of feed shortage were between March and May (51.8%), and January and May (49.2%).

As main reason for occurrence of feed shortage, over flooding of Lake Tana in the grazing land (Figure 4, right) and staying across the summer season (August to November) was also reported by Fogera and Dera district respondents, which is due to the kebeles selected for the study are bounded by Lake Tana. Water that logged at the grazing land (Figure 4, left) also causes a disease because of formation of algae and other disease causing organisms. Additionally, amekila (*Asracantha longifolia*) and Nechi amekila weeds (Figure 5) that invade the grazing land is also a treat for shortage of feed that covers grass parts of the grazing land and the thorny nature affect the mouth and face area of the cattle while grazing under these weeds.



Figure 4. Water logged at the grazing land (left) and Lake Tana over flood at the grazing land (right) at Fogera district, Wagetera kebele



Figure 5. Invade weeds of grazing land: amekila (*Asracantha longifolia*) (left) and Nechi amekila (right) at working districts

Presence of diseases

As the survey result indicates (table 7) the major diseases in the study districts are Lymph and Skin Disease (LSD) which is due to ticks and other external parasites followed by Foot and Mouth Disease (FMD) that might be due to the swampy and water logged nature of the survey districts. Similarly, Zemenu *et al.* (2014) reported liver flucke (55%), foot and mouth disease (43.5%) and external parasites (42%) as major livestock diseases.

Table 7. Major diseases reported in the working districts (multiple response analysis)

No.	Local name of the disease	Scientific name of the disease	Number of respondents	Occurrence
1	Aba kasha, Wotetie, Yekoda besheta	Lymph and skin disease (LSD)	110	Year round, mainly during wet season of the year (June to October)
2	Meyaze	FMD	98	Sudden, September- January
3	Kureba, Mechi	Anthrax	84	Year round mainly from September –November
4	Berere, Gerefta, Yegubet tel	Fasciola	72	Year round
5	Kortem	Bovine Pasturollosis	70	July-October
6	Getchita, Gendie	Trypanosomiasis	30	September –November and April -June
7	Yewuha tel	Shistosmiassis	24	May – November
8	Wajima	Bloating	18	August- November
9	Sale, Tifena	Pneumonia	6	Year round
10	Mezeger	Tick	2	June-September

The respondents of Fogera district indicate that there is no health clinic that delivers veterinary service for their livestock; this might be due to the distance of the peasant association used for the study from the town and sub-town (*ketene*). Whereas 87% of Bahir Dar zuria and 100% of Dera district respondents indicate as they got veterinary clinic around their vicinity. The latter two districts' respondents indicate that the major sources of the veterinary service are both government and private health deliveries; additionally the respondents (78%) of these districts indicate as they prefer the government veterinary service due to its low cost and others (22%) prefer privates due to their availability throughout the day to give sudden diseases treatment and maintain damages of the livestock.

Conclusion and Recommendation

The major problem in the production of Fogera breed at the selected districts is shortage of forage that is related to the degradation and competition of the grazing land for food crop production. Additionally, lack of veterinary clinic at Fogera district and presence of newly emerging diseases followed by lack of breeding bulls are reported as production constraints at the selected districts.

The reproductive performance considered in this study viz. AFS, AFC, CI and NSC shows improvements compared to other indigenous cattle breeds of Ethiopia, which indicates the potential of the breed for milk production is high. District shows significant difference in the reproductive performance of Fogera cattle breed. As the breed is expected to live at the selected districts, the performance difference across districts might be due to feed availability, management difference and access to livestock technologies. Being better performer over other breeds makes Fogera breed to be selected by farmers to be dominant in their herd and need to expand for the future. This confidential attitude of farmers on keeping of Fogera breeds benefits for future conservation and improvement strategy adopted by research centers and other stakeholders.

Basing on the result of this study, the following recommendations are made for better future use of the breed potential.

Optional feed development strategies like backyard and farming plot surroundings and treating of bulk crop residue produced at the area should be designed and adopted as a strategy;

As the dominant breeding system in the study districts is uncontrolled mating with unselected bulls, attention should be given on implementation of selected Fogera bulls for breeding purpose that will in-turn improves the blood level of the breed;

Works on population estimation of Fogera breed should be addressed to develop appropriate conservation as well as improvement strategies.

Acknowledgements

The author's acknowledge Amhara Regional Agricultural Research Institute (ARARI) and CASCAP, capacity building for scaling up of evidence-based best practices in agricultural production in Ethiopia, for financing this survey work. Additionally, the author's extend their gratitude to Shiwangezaw Addisu and Gizachew Teshome for feeding and clearing the data and Taddess Getu, Mulat Lakew and Eyasu Lakew for their help in collecting the primary data.

Reference

- Addisu Bitew, Adebabay Kebede, Bewuket Siraw, Solomon Gizaw and Tewodros Bimerow, 2010. *Conservation-Based Breeding Program for Fogera Cattle*. Working Document. Amhara Regional Agricultural Research Institute Andassa Livestock Research Center (unpublished papers).
- Addisu Bitew, Getinet Mekuriaw and Tezera M. 2007. *On-farm evaluation of management practices and productivity of Fogera cattle in Northwest Ethiopia*. Proceedings of the 2nd annual regional conference on completed livestock research activities, Amhara Regional Agricultural Research Institute (ARARI), Bahir Dar, Ethiopia.
- Adebabay Kebede, Firew Tegegne, Zeleke Mekuriaw and Azage Tegegne, 2011. *Characterization of Milk Production Systems in Bure District, Ethiopia*. The IUP Journal of Life Sciences, Vol. V, No. 2, 2011.
- Alberro, M. and Solomon Haile-Mariam. 1982. *The indigenous cattle of Ethiopia*. Part-I. World Animal Review, No. 41: 2-10
- Asaminew Tasew and Eyassu Seifu, 2009. *Smallholder Dairy Production System and Emergence of Dairy Cooperatives in Bahir Dar Zuria and Mecha Woredas, Northwestern Ethiopia*. World Journal of Dairy and Food Sciences 4 (2): 185-192, 2009. 185-192pp.
- Asheber Sewalem. 1991. *Evaluation of the reproductive and pre-weaning growth performance of Fogera cattle and their F1 Friesian cross at Andassa cattle breeding station, Ethiopia*. MSc. Thesis. Alemaya University, Dire Dawa, Ethiopia.

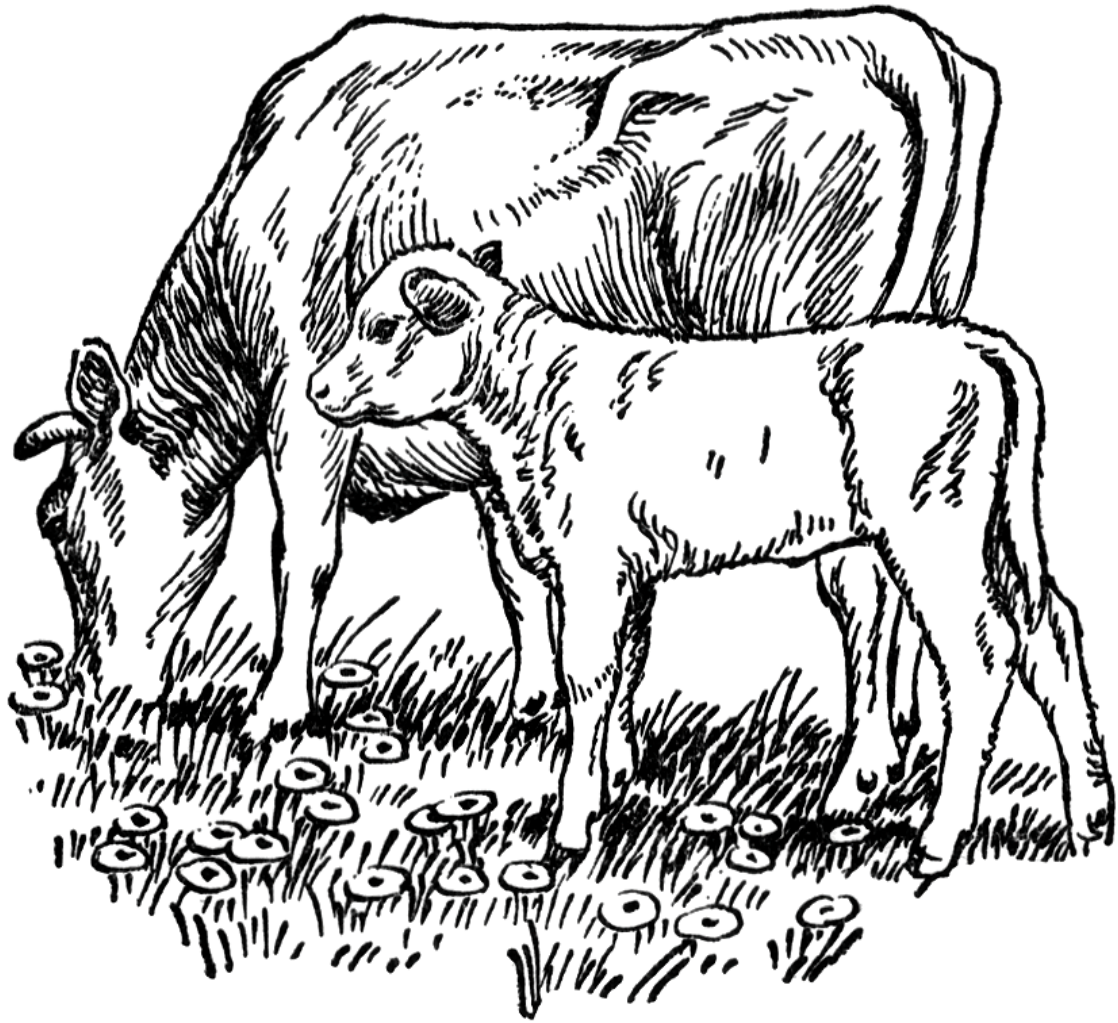
PROCEEDING

Animal Breeding and Reproduction

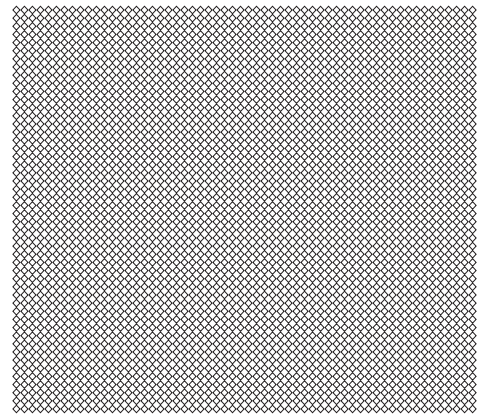
- Assemu Tesfa and Dilip K.G., 2014. Genetic and non-genetic parameter estimates of dairy cattle in Ethiopia: A review. *Online J. Anim. Feed Res.*, 4(3): pp. 83-90.
- Belete Anteneh, Azage Tegegne, Fekadu Beyene and Berhanu Gebremedhin. 2010. Cattle milk and meat production and marketing systems and opportunities for market-orientation in Fogera woreda, Amhara region, Ethiopia. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 19. ILRI (International Livestock Research Institute), Nairobi, Kenya. 65 pp.
- DAGRIS 2007. Domestic Animal Genetic Resources Information System (DAGRIS). (eds. S. Kemp, Y. Mamo, B. Asrat and Tadele Dessie). International Livestock Research Institute, Addis Ababa, Ethiopia. <http://dagris.ilri.cgiar.org>
- Derese Teressa, 2008. Present situation of urban and peri-urban Milk Production and quality of raw Milk Produced in West Shoa Zone, Oromia Region, Ethiopia. Haramaya University. MSc thesis. Pp 101.
- Enyew Nigussie, Brannang E., Kebede B. and Rottmann O. J. 1998. Reproductive performance of dairy cattle at Asella livestock farm, Arsi, Ethiopia. I: Indigenous cows versus their F1 crosses. *J. Anim. Breed. Genet.* 115, 267-280.
- FAO (Food and Agriculture Organization of the United Nations). 2003. Smallholders and community-based management of farm animal genetic resources, by W. Bayer, W., von Lossau, A. & Feldmann, A. In Community-based management of animal genetic resources. Proceedings of the workshop held in Mbabane, Swaziland, 7-11 May 2001, pp. 1-12. Rome.
- Firdessa R., Tschopp R., Wubete A., Sombo M., Hailu E., Erenso G., Kiros T., Yamuah L., Vordermeier M., Hewinson R.G., Young D., Gordon S.V., Sahile M., Assefa A., Berg S. 2012. High prevalence of Bovine Tuberculosis in dairy cattle in central Ethiopia: implications for the dairy industry and public health. *PLoSOne*, 2012; 7(12): e52851.
- Firew Tegegne and Getinet Assefa. 2010. Feed Resource assessment in Amhara National Regional State. Ethiopia Sanitary and Phytosanitary Standards and Livestock and Meat Marketing Program (SPS-LMM), Texas A & M University System. Addis Ababa, Ethiopia.
- Fisseha Moges, 2009. Studies on Production and Marketing Systems of Local Chicken Ecotypes in Bure Woreda, North-West Amhara. MSc. Thesis. Hawassa University, Awassa, Ethiopia. Pp 187.
- Gebeyehu Goshu, Azage Tegegne, Tezera Mulugeta and Aklilu Agdie. 2004. Preliminary report on the distribution of Fogera cattle around Lake Tana, Ethiopia. Addis Ababa, ESAP. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia, 2004, 203-207.
- IBC (Institute of Biodiversity Conservation). 2004. The State of Ethiopia's Farm Animal Genetic Resources: Country Report. A Contribution to the First Report on the State of the World's Animal Genetic Resources. IBC. May 2004. Addis Ababa, Ethiopia.
- IBC (Institute of Biodiversity Conservation). 2012. Domestic animal diversity, Some of Ethiopia's domestic animal diversity.
- IPMS (Improving Productivity and Market Success of Ethiopian Farmers). 2005. Fogera Woreda Pilot Learning Site Diagnosis and Program Design.
- Kelay Belehu. 2002. Analyses of Dairy Cattle Breeding Practices in Selected Areas of Ethiopia. PhD Dissertation. Pp 117.
- Niraj Kumar, Kbrom Tkui and Abraha Bisrat. 2014. Reproductive performance of dairy cows under farmer's management in and around Mekelle, Ethiopia. *Livestock Research for Rural Development* 26 (5) 2014.
- Nuraddis Ibrahim, Ashebir Abraha and Shiferaw Mulugeta. 2011. Assessment of reproductive performance of crossbred dairy cattle (Holstein Friesian X zebu) in Gondar town. *Global Veterinaria* 6(6): 561-566, 2011.
- Rege J.E.O. and Tawah L.C. 1999. The state of Africa cattle genetic resource II. Geographical distribution, characteristics and uses of present-day breeds and strains. International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia
- Rege J.E.O., Kahi A., Okomo-Adhiambo M., Mwacharo J. and Hanotte O. 2001. Zebu cattle of Kenya: Uses, performance, farmers' preference, measures of genetic diversity and options for improved use. *Animal Genetic Resources Research* 1. ILRI (International Livestock Research Institute), Nairobi, Kenya. 103 pp.
- Shiferaw Garoma. 2014. Reproductive and productive performance of Kereyu Sanga cattle in Fentalle District

of Oromia Region, Ethiopia. *Journal of Cell and Animal Biology*: Vol. 8(2), pp. 28-33, February 2014.

- Shitahun Mulu, 2009. *Feed Resources Availability, Cattle Fattening Practices and Marketing System in Bure Woreda, Amhara Region, Ethiopia*. MSc.thesis, Mekele University. Pp 120.
- Sisay Amare, 2006. *Livestock production systems and available feed resources in different agro-ecologies of North Gonder zone, Ethiopia*. MSc. Thesis. Alemaya University. Pp 111.
- Sisay Asmara. 2010. *Characterization of Sheep Production System and Fattening Practices in Bahir Dar Zuria Woreda*. M.Sc. Thesis. Pp 111.
- Solomon Zewdu Altaye, Binyam Kassa, Bilatu Agza, Ferede Alemu and Gadisa Muleta. 2014. *Smallholder cattle production systems in Metekel zone, Northwest Ethiopia*. *Res. J. Agric. Environ. Manage*, Vol. 3(2), pp. 151-157.
- Teshager Ayalew, Belay Duguma and Taye Tolemariam, 2013. *Socio-economic and Farm Characteristics of Smallholder Cattle Producers in Ilu Aba Bora Zone of Oromia Regional State, South Western Ethiopia*. *Global Veterinaria* 10 (5): 607-613, 2013. 607-613pp.
- Tewodros Bimerew. 2008. *Assessment of Productive and Reproductive Performance of Indigenous and Cross-bred Cattle under Smallholder Management System in North Gondar, Amhara Region*. MSc. Thesis; Mekele University, Ethiopia. Pp 136.
- Yitaye Alemayehu Ayenew, 2008. *Characterization and analysis of the urban and peri-urban dairy production systems in the North eastern Ethiopian highlands*. BOKU – University, Austria. PhD thesis. Pp 120.
- Zemenu Yayeh, Mekonen Hailemariam, Kelay Belhu and Bimrew Asmare, 2014. *Characterization of dairy cattle production systems in Debreworkos district, Amhara Regional State, Ethiopia*. *Pacesetter J. Agric. Res*. Vol. 2(4), pp.42-51, April 2014.



Feeds and Nutrition



Effect of Supplementation of Water Hyacinth on Feed Intake, Digestibility and Growth Performance of Washera Sheep around Lake Tana, Blue Nile Basin, Ethiopia

Shigdaf Mekuriaw^{1,2}, Firew Tegegne^{1,3}, Atsushi Tsunekawa¹, Toshiyoshi Ichinohe⁴, Nobuyuki KOBAYASHI¹ and Sawako HORAI⁵

¹Arid Land Research Center, Tottori University, Japan

²Andasa Livestock Research Center, Bahir Dar, Ethiopia

Abstract

The study was carried out at Zenzelma Campus College of agriculture, Bahir Dar University, Ethiopia. The objective of this experiment was to determine effects of supplementation of different level of water hyacinth on feed and nutrient intake, digestibility, and growth performance of washera sheep. Twenty intact male sheep with initial body weight of 24.1 ± 1.68 kg (mean $\pm$ SD) were used in both the 90 days of feeding and 7 days of digestibility trials. The experimental animals were arranged into four blocks of five animals based on the initial body weight. The four treatments were assigned to each animal in a block. The dietary treatments used in the experiment were rice straw fed ad libitum and 100% water hyacinth (T1), 75% WH and 25% Concentrate (T2), 50% WH and 50% Concentrate (T3), and 100% Concentrate (T4). The crude protein (CP) content of water hyacinth stem, leaf, entire and whole without root is 6.1, 14.4, 7.5 and 5.6 respectively; while 24.1 for concentrate mix and 3.9 for rice straw. Total DM intake was 687.4, 723.1, 763.4 and 787.6 in the order of T1, T2, T3 and T4 respectively. Digestibility of CP was lower for T1, but similar among T2, T3 and T4; DM digestibility was greater ($p < 0.05$) for T4 and T3 than T2 and T1, and values were similar ($p > 0.05$) for T3 and T2. Daily BW gain (ADG) was 14.9, 53.6, 69.1 and 96.3 g/day in the order of T1, T2, T3 and T4. Net return and marginal rate of return increased with increasing supplemental level of SS. Therefore, T2 and T3 were best in terms of both biological and economic performance of animals from the feeding regime employed in this study.

Key words: Water hyacinth leaf, rice straw, chemical composition, body weight and Lake Tana

Introduction

Because the ever increasing human population has resulted in a demand for protein food, particularly from livestock products in the Third World countries (Rajib and Balen, 2004). Research results indicate that aquatic legumes have superior nutritive value compared to other species of fodder trees. Its value when used as a protein supplement for sheep fed cereal crop residues can be equivalent to alfalfa hay, vetch hay, and several oil seed meals (Khalili and Varvikko, 1992; Siaw et al., 1993; Karachi et al., 1997; Woodward and Reed, 1997).

Investigation of water hyacinth was conducted in 2011 by interdisciplinary expedition groups in Lake Tena (Dereje, 2013). Several efforts have been done to control and eradicate the weed manually from the infected areas of the lake; unfortunately it was not successful because the surrounding community was not cooperated due to less awareness about the invasive weed. Due to its fast expansion rate, it brought regional attention; as a result researchers should work to elicit solutions for the problem by bringing collaborating with different expertise and citizens who can contribute in terms of knowledge and experience in the world to develop best strategies to overcome the problem of this weed.

On the other hand, when looked from a resource angle, it appears to be a valuable resource with several unique properties. Livestock in the tropics are still facing the challenges of poor nutrition, as the available crop residues or by-products are of low nutritive value (Babayemi et al 2004). The grass is low in crude protein and insufficiently available during the dry season (Bamikole Feed scarcity vs poor nutrition so Water Hyacinth (WH) fills this gap. One way to help alleviate this feed shortage would be the development of new technology for the utilization of aquatic plants as livestock feed. Water hyacinth could provide an easily accessible feed resource for livestock while at the same time it's harvesting contribute to its control. Rajib and Balen (2004) also reported that Water hyacinth which is a widely prevalent enormously fast-growing aquatic weed can be an inexpensive source of animal feed.

Accordingly, use of water hyacinth for animal feed in developing countries could help solve some of the nutritional problems that exist in these countries (Jafari, 2010). Proper and large-scale utilization could serve as a positive approach to the control of water hyacinth (Anushree, 2007). Moreover, utilization of water hyacinths as an animal feed has been reported (Baldwin et al., 1975). Cattle have been observed grazing floating water hyacinths when land forages were limited (Little, 1968). In addition, Wassie et al. (2014) reported that some cattle graze on the water hyacinth when there is no grass around Lake Tana.

Therefore, this study aims to determine feed intake, digestibility and live weight change of Washera sheep fed rice straw as a basal diet supplemented by water hyacinth and concentrate mixtures at different level.

Material and Methods

Description of the study area

The feeding trial was conducted at Zenzelma Campus in College of Agriculture and Environmental science of Bahir Dar University, around Lake Tana, Ethiopia. Lake Tana is geographically located in the north-western part of Ethiopia, between latitude 10°58'–12°47'N and longitude 36°45'–38°14'E (Figure 1). It has a surface area of 3,200 sq km, a mean depth of 8 meters and maximum depth of 14 meters with fluctuations due to increasing siltation levels. It is the largest freshwater body in the country, contributing about 50% of the water resource of the nation. The lake lies at higher altitude in the range of 1,840 meter above sea level compared to Lake Victoria at 1,134 meters above sea level and is considered the highest lake in Africa. Due its altitude it is characterized by cold waters with mean temperature of 21.7°C. The Lake Tana watershed consists of 347 **Kebeles** (the lowest administrative units) and 21 **Woredas** (districts) in four administrative zones (IFAD, 2007). The lake catchment covers an area of 16,500 sq km (Wassie et al., 2014).

Feeds Preparation

Water hyacinth was harvested from Lake Tana in the shore line of Gonder Zuria district of Lemba and Mitirha Aba Warka Peasant associations (Figure 1). The concentrate was formulated and purchased from Aba Wengele feed processing enterprise in Bahir Dar Town. The basal diet, rice straw, was purchased from the farmers around Lake Tana in Fogera Plain. Rice straw was offered *ad libitum* at 25 % in excess of daily consumption determined based on the previous seven days average intake. There is free access of water to experimental sheep. The water hyacinth and concentrate mix, and their mixture were offered as feed base.

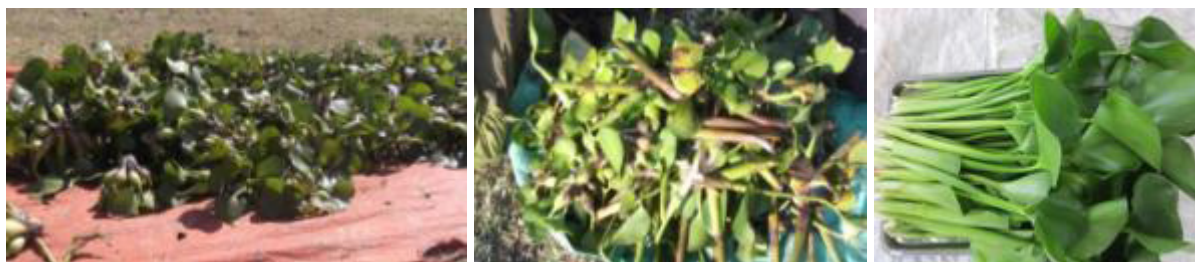


Figure 1. *Water hyacinth collected from Lake Tana*

Experimental animals and their management

Twenty yearling intact Washera sheep with mean BW of 24.1 ± 1.68 kg (mean $\pm$ SD) were purchased from Adet Market. The age of the sheep was determined by dentition and information from the owners. The experimental sheep were identified with ear tag. The animals were quarantined for two weeks at the site of the experiment in order to observe any disease situation. The animals were vaccinated Oxy 20%, ovine pasteurellosis and anthrax. The sheep were also dewormed against internal and external parasites using albendazole (300 mg/head), Tetramizole tablet and diazinon (60 %), respectively.

The experimental animals were housed in an individual pens in a ventilated shade that was built for this purpose in Zenzelma Campus of Bahir Dar University. The pens were equipped with feeding trough for water hyacinth, concentrate mix and rice straw; plastic buckets for watering trough (Fig. 2).



Figure 2. *Individual feed barn in Zenzelma Campus of Bahir Dar University.*

Experimental design and treatments

The experimental design was a randomized complete block design with four treatments and five replications. Experimental sheep were blocked based on their initial body weight into five of four animals each. The initial body weight was determined as a mean of two consecutive body weight measurements after overnight fasting. And then, the treatments were then randomly assigned to the sheep in each block. The treatment diets were T1 = 100% wilted water hyacinth, T2 = 75% wilted water hyacinth + 25% Concentrate Mix, T3 = 50% wilted water hyacinth + 50% Concentrate Mix and T4 = 100% Concentrate Mix. The Concentrate Mix (CM) consisted of Noug Seed Cake (NSC) - 50%, Wheat bran (WB) - 20%, Maize grain - 29% and Common salt - 1%; which was formulated using win feed software 8. Rice straw has been given *ad libitum*.

Experimental animals were allowed to adapt for two weeks to experimental diets before the

commencement of actual feeding trial. The feeding trial lasted for 90 consecutive days. Supplemented sheep were offered the supplement in two equal portions at 1000 and 1600 hours in a separate feeding trough. Water was available for the experimental sheep all the time. The amounts of feed offered and refused were recorded daily for each sheep.

Feed intake

Daily feed offer and refusals of each sheep were recorded. Daily mean feed intake was measured as differences between offered and refused feeds. Samples of feed offer from all diets and refusals from hay were collected and bulked throughout the experiment. Subsamples were taken and prepared for chemical analysis.

Digestibility and feeding trial

Each sheep was fitted with fecal collection bags (Fig.3) for 4 days of acclimatization period to carrying of the fecal collection bags prior to total collection of feces for seven consecutive days. Feces voided by each sheep over 24h were weighed and recorded every day, mixed, and 20% of representative samples were taken and frozen at -10°C . The daily collected fecal samples were pooled over the collection period for each animal. At the end of the collection period, samples from each sheep were mixed and dried at 60°C to a constant weight. The digestibility of nutrients was determined as the difference between nutrients intake and that recovered in feces expressed as a proportion of nutrients intake.

Apparent D coefficient= $\frac{\text{Nutrient intake}-\text{Nutrient excreted in faeces}}{\text{Nutrient intake}}$

Nutrient intake



Figure 3. Nylon bag digestibility trial and the fecal sample.

Body weight change and Feed Conversation Efficiency (FCE)

The initial and final body weights were obtained by weighing sheep on two consecutive days before feeding and watering using suspended weighing scale. Experimental sheep were subsequently weighed at 10-day intervals during the feeding trial after overnight fasting. The daily BW gains were calculated as the difference between final BW and initial BW divided by the number of feeding days. Feed conversion efficiency was calculated as average daily gain (ADG) divided by feed intake.

Chemical analysis

Representative samples of feeds offered and refusals were collected for chemical analysis.

The DM, OM and CP concentration were analyzed according to the procedures of AOAC (1990). Neutral detergent fiber (NDF) concentration was analyzed according to the procedures of Van Soest and Robertson (1985). OMD and ME concentration was estimated by the method of Menke and Steingass (1988). The value of VI was estimated by the equation of Khazaal *et al.* (1993). The water hyacinth chemical analysis was done in Shimane University, Japan while the fecal sample analysis is in Poli Campus of Bahir Dar University Feed Nutrition laboratory.

Data collection

In the laboratory analyses, the nutritive value of Water hyacinth was recorded. Feeds offered were weighed before giving them to the animal. Feed refusals was also collected each morning prior to offering fresh feed and weighed to measure the feed intake throughout the experimental period. Live body weight of the experimental animals was measured using Salter balance (50kg).

Statistical analysis

The analysis of variance (ANOVA) of data on feed intake, body weight change and digestibility were run using the general linear model procedure of SAS (2008). Differences between treatment means were separated using Duncan's multiple range tests when values of the means were significant ($P < 0.05$).

The statistical model used for the analysis of body weight (Model 1) and intake (Model 2) was:

$$\text{Model: } Y_{ij} = \mu + T_i + B_j + E_{ij}$$

Where: Y_{ij} = observation of body weight in the j^{th} block and i^{th} treatment;

μ = the overall mean;

T_i = the i^{th} treatment effect;

B_j = the j^{th} block effect;

E_{ij} = the random error.

$$\text{Model 2: } Y_{ijk} = \mu + T_i + B_j + P_k + E_{ijk}$$

Where: Y_{ijk} = observation of feed intake in the i^{th} treatment, j^{th} block, and K^{th} periods;

μ = the overall mean;

T_i = the i^{th} treatment effect;

B_j = the j^{th} block effect;

P_k = the k^{th} block effect;

E_{ijk} = the random error.

Partial budget analysis

The partial budget analysis involved the calculation of the variable cost of sheep, feeds, and benefits gained from sale of sheep at the end of the feeding period. In the partial budget analysis, the total return (TR) was determined by the difference between the selling and purchasing price of sheep. The total variable costs (TVC) included feed, labor, and animal costs. The net income (NI) was calculated as $NI = TR - TVC$.

Results and Discussion

Chemical composition of treatment feeds

The results of the chemical composition analysis of the experimental and basal diet feeds are shown in Table 1. The observed 14.4% CP content of water hyacinth in the current study was higher than the report of Mako and Akinwande (2010) which is 10.42% CP but similarly to Adejoke (2013) that

reported about 14 CP of water hyacinth. Differently, Abo Bakr et al. (1984) found that leaf protein isolate from water hyacinth (*Eichorniacrassipes*) contained 49.6% protein and Adejoke (2013) also reported that the leafy parts of water hyacinth from nutrient enriched waste water usually contain 25 - 35 percent crude protein on a dry weight basis. The level of CP in the whole plant without root is higher than the critical level of 7.0 g /100 g DM below which feed intake will be depressed (Minson 1990).

In this study, the water hyacinth leaves have high CP content than the other part of the plant followed by the whole without root. Similarly, Abdelhamid and Gabr (1991) also reported that the nutrient content is lower in the stem and root compared with leaves. Supported to this finding, a study on potentials of water hyacinth as feed for ruminants, El-Serafy et al (1981) and Aboud et al. (2005) showed that water hyacinth leaves and stem contain as much as 18% crude protein. This level is comparable to common leguminous fodder and greater than the grass available in Africa (Shayo, 1992). Likewise, Adejoke (2013) reported that the nutritive value of water hyacinth appeared to be higher than that of Guinea grass, as assessed by higher crude protein and lower cell wall contents. It has been also stated that CP value ranging from 7-7.5% is required to satisfy maintenance requirement of ruminant animals (Van Soest, 1982) and may be considered as a valuable supplement for animals fed on low quality crop residues such as rice straw. Mako et al (2011) emphasize that due to good nutrient profile, water hyacinth can be used to supplement the low nutrient value of tropical grasses. In an advantage, all of the essential amino acids were present at high levels in the leaf protein isolate (Abo Bakr et al., 1984).

The NDF content of water hyacinth leaf and the entire in the current study are lower than reported by (Aboud et al., 2005). Pond *et al.* (1995) noted that NDF portion of feed is only partially digestible by any species of animals, but can be used to greater extent by such animals as ruminants which depend on microbial digestion for utilization of most fibrous plant components.

Table 1. Chemical Composition of Water Hyacinth, Concentrate Mix and Rice straw

Parameter	Parts of Water hyacinth						Concentrate Mix	Rice straw
	Root	Petiole	Stem	Leaf	Whole/R	Whole		
DM (% ADM)	94.9	89.6	90.4	92.1	92.4	94.0	91.6	89.3
OM (% DM)	92.1	86.9	87.1	88.1	88.8	90.9	78.8	86.3
CP (% DM)	4.0	4.6	6.1	14.4	7.5	5.6	24.1	3.9
NDF (% DM)	64.7	48.3	47.1	42.0	60.5	52.7	33.4	69.7

DM -dry matter; ADM- air dry matter; CP-crude protein; NDF-neutral detergent fiber; CM-Concentrate Mix (NSC, WB and Maize).

Feed and nutrient intake

Feed and nutrient intakes of the experimental animals are presented in Table 2. A highly significant ($P < 0.001$) difference was recorded in total dry matter intake within treatment group with the highest consumption recorded in sheep assigned for T4 followed by T3 and T2 except it is lower for the T1 feeding 100% water hyacinth. The low intake of water hyacinth in Treatment T1 postulated that associated with the presence of high percentage of moisture.

Similarly, Dolberg et al. (1981) reported that the intake of water hyacinth on a DM basis was very low as water hyacinth only contains 5 to 10% DM. Adejoke (2013) reported that in diets based on Guinea grass the maximum level of sun-cured water hyacinth in diets for growing goats is 30%. Since dietary requirements for these elements are provided when aquatic plants are used as approximately 10 - 20% of the diet, a mineral imbalance may result if this level is exceeded (Sciences, N. A, 1975).

In this study, supplementation of different level of water hyacinth and concentrate mix resulted in significantly higher ($P < 0.001$) total DM, OM and CP intake. Islam et al. (2009) reported that daily CP intake in 50% wilted water hyacinth supplemented diets showed significantly higher CP consumption. In addition, Dolberg et al. (1981) also reported that the addition of an oil cake (220g/d), to the second

diet (water hyacinth, straw mix) increased the gain in weight to 5.9 kg and DM intake to 109% over the control group on water hyacinth alone. To support this result Aboud et al. (2005) explain that because of its high moisture content, pre-wilting and addition of molasses during ensiling appear to be the most practical way of improving the utilization of the plant, a form that would be a significant contribution to dry-season feeding along the Lake shores.

The rice straw DM intakes of T1 and T2 are significantly higher than T3 and T4. This may be due to an effort of the animal to extract more nutrients by consuming additional rice straw in the supplementation of more water hyacinth. Intake of DM as % BW was lowest for T1 and greater for the other three treatments that were similar among each other. This appears to be a result of differences in daily body weight (Table 2). Values for the total DM intake expressed by metabolic body weight was significantly higher ($P < 0.05$) in the order of $T4 > T3 > T2 = T1$, which could be attributed to variations in CP content of the supplements especially water hyacinth and concentrate as well as differences between treatments in DM intake.

The dry matter intake of water hyacinth shows increasing trend as shown in Fig. 4. As well, Aboud et al. (2005) reported that the intake increased linearly with the increasing levels of wilted water hyacinth.

Table 2. Daily feed and nutrient intake of Washera sheep fed on water hyacinth, concentrate mix and rice straw.

Intake g/day	Treatments				SEM	SL
	T1	T2	T3	T4		
WH DM intake	445.6	213.5	116.3	-	0.68	
CM DM intake	-	274.5	384.7	549.6	0.63	
RS DM intake	281.8 ^a	275.1 ^a	220.1 ^b	228.8 ^b	1.2	***
Total DM intake	687.4 ^c	723.1 ^b	763.4 ^{ab}	787.6 ^a	1.6	***
DM intake (% BW)	2.4 ^c	2.8 ^b	3 ^{ab}	3.3 ^a	0.4	***
DM intake (g/ kg W ^{0.75})	34.6 ^c	44.3 ^b	53.5 ^{ab}	64.4 ^a		***
Total OM intake	577.4 ^c	607.4 ^b	641.3 ^{ab}	661.6 ^a	2.6	***
Total CP intake	68.7 ^c	79.5 ^b	84.0 ^{ab}	86.6 ^a	1.4	***
Total NDF intake	302.5 ^c	347.1 ^b	366.4 ^{ab}	378.0 ^a	0.8	***

a, b, c means within a row having different superscripts are significantly different at *** = ($p < 0.001$); WH = Water Hyacinth; CM= Concentrate Mix; RS= Rice straw; DM= Dry mater; BW = body weight; OM = organic matter; CP = crude protein; NDF = neutral detergent fiber; SEM = standard error mean; SL= significant level.

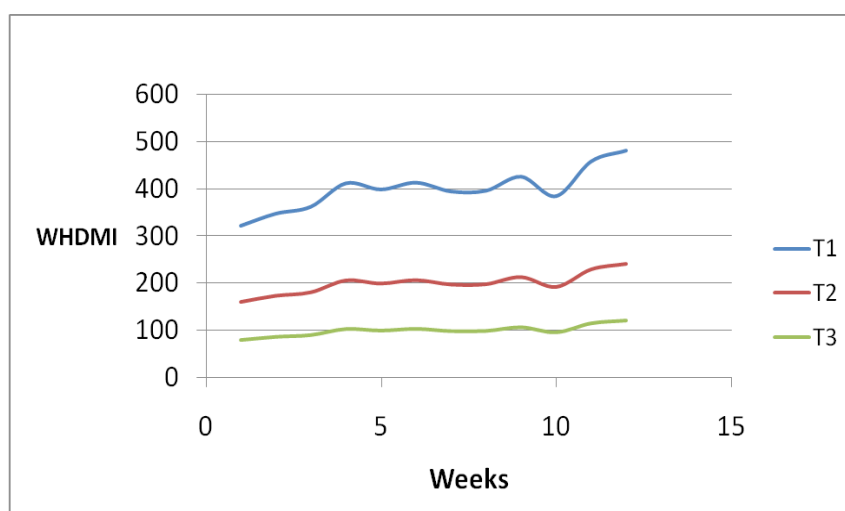


Figure 4. Water Hyacinth Dry Mater Intake across different weeks.

In vitro digestibility of water hyacinth

The *in vitro* digestibility of water hyacinth is presented in Table 3. Higher values were shown for water hyacinth stem, leaf, petiole and entire than root and whole without root respectively.

The values for digestibility were substantially equivalent for leaf and stem while greater for the entire values reported by Aboud et al. (2005) findings on potential of water hyacinth in ruminant nutrition in Tanzania.

Table 3. Feeding value estimates of water hyacinth by *in vitro* gas production technique

Parameter	Parts of Water hyacinth					
	Root	Petiole	Stem	Leaf	Whole/R	Whole
OMD (%)	50.6	55.0	58.0	57.8	45.6	53.8
ME (MJ/kg DM)	7.8	8.8	8.5	8.7	7.7	8.2
VI (g DM/kg ^{0.75})	14.5	34.0	26.1	24.8	17.3	25.1

OMD, organic matter digestibility; ME, Metabolizable energy;

VI, voluntary feed intake expressed as metabolic body size (kg BW^{0.75}).

Apparent digestibility of DM and nutrients

The DM and nutrient digestibility of washera sheep fed rice straw as a basal diet and supplemented with water hyacinth, concentrate and their mixtures is shown in Table 4. There were no refusals of Concentrate Mix in any treatments. As shown in Table 4, there were clear effects of treatment on DM, OM, CP and NDF digestibility, all of which increased with decreasing the level of water hyacinth and increasing the concentrate feed. The values for digestibility were substantially higher than values reported for forages available around Lake Victoria (Kakengi et al 1999). This further supports the need for inclusion of 75 % and 50% of water hyacinth with concentrate proportion into potential feed resources in Eastern Africa like rice straw and could form an important feed base for smallholder farmers (Aboud et al., 2005).

Table 4. Apparent digestibility coefficients of nutrients of Experimental diets

Digestibility	Treatments				SEM	SL
	T1	T2	T3	T4		
DM	59.6 ^c	69.6 ^b	72.8 ^{ab}	78.6 ^a	2.10	***
OM	63.4 ^c	71.9 ^b	73.2 ^{ab}	75.8 ^a	1.14	***
CP	58.4 ^c	70.2 ^b	79.2 ^{ab}	86.2 ^a	1.56	***
NDF	64.4 ^c	69 ^b	71.8 ^b	76.8 ^a	1.98	***

a, b, c Means within a row not bearing a common superscript letter are significantly different; *** = ($P < 0.001$), CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; SEM = standard error of mean; SL = significant level.

Body weight and Feed Conversation Efficiency (FCE)

The effect of supplementation of Washera sheep fed rice straw with water hyacinth and concentrate and their mixtures on body weight change and average body weight gain data are presented in Table 5. Final BW, ADG and FCE were significantly affected ($P < 0.05$) by treatment and had similar trend across treatments. Animals in T1 had lower ADG, because of the low intake of water hyacinth supplementation as compared to the concentrate fed. This is due to its high moisture content. The other reason may be due to less efficient utilization of the CP in water hyacinth. But when the level of water hyacinth decreases with the supplementation of concentrate, it appeared that there was an increasing trend for ADG and FCE in T2 and T3. The difference in ADG and FCE among treatments

in this study is consistent with differences in intake of DM and nutrients observed in this study. Islam et al. (2009) reported that wilted water hyacinth supplementation also significantly improved the protein conversion efficiency of growing bullocks. Kahn (1977) also found that green water hyacinth alone was insufficient for the maintenance of bullocks as the animals lost 23 g/day of live weight during a period of 60 days.

The reason why the growth performance of the water hyacinth feeding treatment is because when I formulated the feeding ration I used the CP of water hyacinth (leaf plus stem) 16.2% (Cheat *et al.*, 2010) while the actual value after the analysis was 14.4. Adejoke (2013) conclude that water hyacinth foliage should never be fed as the sole diet of ruminants but may be fed at up to 25% of the diet DM along with protein-rich supplements.

Islam et al. (2009) also reported that total as well as daily live weight gain was significantly higher in wilted water hyacinth supplemented groups. Some experimental results Gupta et al (1975) observed that water hyacinth hay alone was not well accepted by bullocks, but when the diet offered on a DM basis consisted of 2.7 kg water hyacinth, 0.3 kg ground nut cake and 2.3 kg rice straw, the bullocks gained 10 ± 4.6 kg over a period of 32 days.

The finding result of Islam et al. (2009), indicated that supplementation of wilted water hyacinth in straw-based diet had significant effect on nutritive value of the diet and growth of animals. Kahn (1977) also found that green water hyacinth alone was insufficient for the maintenance of bullocks as the animals lost 23 g/day of live weight during a period of 60 days. However, when rice straw was given together with the water hyacinth (1:1 ratio) the bullocks increased their DM intake by 67% and gained 68g/day of live weight. On the basis of proximal analysis, rice straw has a much lower nutritive value (less crude protein and more cell wall compounds) than water hyacinth. In this case, the positive effects from adding a feed of lower nutritional value could be due to the diluting effect of the rice straw on the anti-nutritional compounds in water hyacinth (Leonardo Lareo and Ricardo Bressani. 2013).

Table 5. Body weight parameters and feed conversion efficiency

BW Parameters	Treatments				SEM	SL
	T1	T2	T3	T4		
Initial BW (kg)	23.92	23.22	23.88	24.2	0.17	ns
Final BW (kg)	25.26 ^c	28.0 ^b	30.1 ^{ab}	32.8 ^a	0.36	***
ADG (g/d)	14.9 ^c	53.6 ^b	69.1 ^b	96.3 ^a	4.27	***
FCE	0.03 ^c	0.08 ^b	0.10 ^{ab}	0.12 ^a	0.02	***

a, b, c letters in the same row having different superscripts are significantly different;

*BW = Body weight; ADG = average daily body weight gain; *** ($P < 0.001$); SEM = standard error of mean; SL = significance level.*

The overall trends of body weight changes across the feeding trial period are presented in Fig. 5. In the current study, there was inconsistency change in weight gain for T1 with decline trend in the final period weight. This is because of the sickness of one animal in this treatment group which has decreasing in last time weights. According the Veterinarian diagnosis report, it is difficult to relate the disease with the toxicity of water hyacinth because the other animals in the treatment group have no such cases.

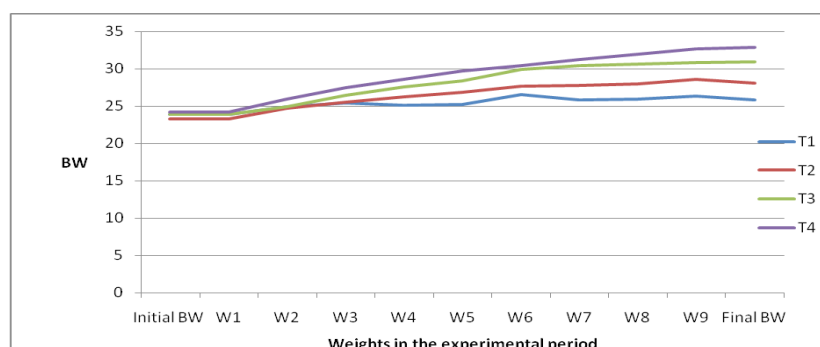


Figure 5. Growth curve of yearling Washera sheep in the experimental period

Partial Budget Analysis

The partial budget analysis of experimental feed on Washera sheep is given in Table 6.

Partial budget analysis of the present study showed that net return per animal was higher for T3 followed by T2 than T4 and T1. Among the treatments, T3 and T2 are more profitable considering the net return of 895 and 735 ETB respectively. In this study, inclusion of 75 and 50% water hyacinth with similar proportion of concentrate in the reverse way improved body weight change of sheep and correspondingly increased the net income from the sale of sheep at the end of the feeding trial respectively.

Generally, sheep which had a better nutrient intake had superior average body weight gain and had a higher sale price to earn higher net return except T4 which has increased the input cost that reduces its net benefit. Hence, in the present study, it can be concluded that the equal proportion of water hyacinth and concentrate mix (T3) improves nutrient utilization, reduced cost of body weight gain and maximized economic returns from feeding of sheep.

Table 6. Partial budgeting and Sensitivity analysis for fattening practice.

Parameter/variables	Treatment 1	Treatment 2	Treatment 3	Treatment 4
A. Benefit (selling price of sheep)	6100	7010	7700	8040
costs				
Purchasing price of sheep	4970	5165	5325	5235
Water hyacinth harvesting cost	640	480	320	0
Concentrate Purchase	0	550	1100	2200
Medication cost	130	80	60	50
B. Total variable cost	5740	6275	6805	7485
Net benefit (A-B)	360	735	895	555
benefit cost ratio A/B	1.06	1.12	1.13	1.07
MRR (Marginal Rate of Return)		0.7	0.3	-0.5
Sensitivity analysis				
-20% selling price (Birr/head)	860	667	645	1053
+20% fattening cost (Birr/head)	1580	2137	2435	2163
Gross return (Birr/head)	1220	1402	1540	1608
Net benefit (Birr/head)	72	147	179	111

Conclusion and Recommendation

This paper has demonstrated the potential feed value of water hyacinth. The result showed that water hyacinth leaves has high CP which is available all year round and could provide nutrients to be

utilized as fodder for ruminant. Basically, deliberate production of water hyacinth is not recommended because water hyacinth can easily turn into a serious environmental hazard if critical care is not taken. But, currently, massive amounts of water hyacinth already exist in Lake Tana. It would be far-sighted to suggest additional form of utilization which may compliment the current efforts of controlling the plant. The finding of this result shows that because of its high moisture content, pre-wilting and addition of concentrate mixture with rice straw come out to be the most practical way of improving the utilization of water hyacinth. Supplementation of water hyacinth, concentrate and their mixtures (as treatment 2 and 3) to the basal rice straw diet improved feed conversion ratio, total DM intake, CP intake and CP digestibility and it also improved BW gain with similar trend for all supplemented Washera sheep over the treatment 1. Therefore, T2 and T3 are cost effect and suitable for improving the body weight of Washera sheep. However, as this experiment is the first of its kind in Ethiopia which was done under experimental station further on-farm evaluations under farmers' condition has to be done.

Acknowledgement

The first author would like to thank the UNSCO/JAPAN Young Research Fellowship Award Program for 2015, France, Paris, for the financial support of this research work. I have also especial thank to the Arid Land Research Center Tottori University in Japan for hosting to do this research (in particular for Prof. Atsushi Tsunekawa). I want to extend my gratitude to Shimane University, Japan, for analysis of the water hyacinth chemical composition. Thanks also for Bahir Dar University that allowed to use the feeding experimental barn. Great thank to Andassa Livestock Research Center to give leave of study for this research work. Lastly, I want to acknowledge Mr Gezu Sendek and Melkamu for supporting us in the water hyacinth and data collection respectively.

References

- Aboud, A. A. O., Kidunda, R. S. and Osarya, J. 2005. "Potential of water hyacinth (*Eicchornia crassipes*) in ruminant nutrition in Tanzania." *Livest. Res. Rural Dev.* 17(8).
- Abo Bakr T. M., El-Shemi N. M. and Mesallam A. S. 1984. Isolation and chemical evaluation of protein from water hyacinth. *Plant Foods for Human Nutrition*. Volume 34, Issue 1, pp 67-73.
- Abdelhamid, A. M., & Gabr, A. A. (1991). Evaluation of water hyacinth as a feed for ruminants. *Archives of anim. Nutri.* 41(7-8), 745-756.
- Adejoke Adeneye Mako. 2013. Performance of West African Dwarf goats fed graded
- Levels of sun-cured water hyacinth (*Eichhornia crassipes* Mart. Solms-Laubach) replacing Guinea grass. *Livestock Research for Rural Development* 25 (7).
- Anushree Malik. 2007. Environmental challenge vis a vis opportunity: The case of water
- Hyacinth, Review article: *Environment International* 33 (122-138).
- AOAC 1990 *Official Methods of Analysis*, 15th edition. Association of the Official Analytical
- Chemists. Washington D.C.
- Babayemi, O.J., Demeyer D. And Fievez, V., 2004. "In vitro rumen fermentation of tropical
- Browse seeds in relation to their content of secondary metabolites." *J. Anim. Feed Sci.* 13(Suppl. 1): 31-34.
- Baldwin J. A. , Hentges J. F., BagnaU L. O. and Shirley R. L. 1975. Comparison of pangolagrass and water hyacinth silages as diets for sheep. *Journal of animal science*, vol. 40(5).
- Cheat Sophal, Khieu Borin and Preston T R. 2010. Effects of supplements of water hyacinth and cassava hay on the performance of local "Yellow" cattle fed a basal diet of rice straw. *Livest. Res. Rural Dev.* 22 (9).
- Dolberg F, Saadullah M and HaqueM. 1981. "A short review of the feeding value of water plants." *Trop. Anim. Prod.* 6: 322-326.
- El-Serafy, A. M. ; Soliman, H. S. ; Ashry, M. A. El; Allam, S. M. ; Goering, H. K., 1981. Comparative intake and digestibility of water hyacinth hay and silage by water buffalo steers and sheep. *J. Anim. Sci.*, 51 (supplement

1): 235-236

- IFAD (2007): *Community-Based Integrated Natural Resources Management Project in Lake Tana Watershed-Ethiopia*. IFAD Project Document (Third Draft: 31. August 2007), Government of the Federal Republic of Ethiopia & International Fund for Agricultural Development.
- Islam, S.; Khan, M. J.; Islam, M. N. 2009. Effect of feeding wilted water hyacinth (*Eichhornia crassipes*) on the performance of growing bull cattle. *Indian Journal of Animal Sciences* Volume: 79 Issue: 5 Pages: 494-497.
- Lareo, L. and R. Bressani (1982). "Possible utilization of the water hyacinth in nutrition and industry." *Food Nutri. Bulletin* 4(4): 60-64.
- Little, E. C. S. (1979). *Handbook of utilization of aquatic plants. A review of world literature*.
- Jafari, N., 2010. Ecological and socio-economic utilization of water hyacinth (*Eichhornia crassipes* Mart Solms). *J Appl Sci Environ Manag* 14:43-49.
- Khanna, S., Santos, M. J., Ustin, S. L., & Haverkamp, P. J. (2011). An integrated approach to a biophysiological based classification of floating aquatic macrophytes. *International Journal of Remote Sensing*, 32(4), 1067-1094.
- Khazaal K, Dentinho MT, Ribeiro JM, Ørskov ER. 1993. A comparison of gas production during incubation with rumen contents and nylon bag degradability as predictors of the apparent digestibility in vivo and the voluntary intake of hays. *Animal Production* 57: 105-112.
- Menke KH, Steingass H. 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. *Animal Research and Development* 28: 7-55.
- Rajib Mukherjee, Balen Nandi. 2004. Improvement of in vitro digestibility through biological treatment of water hyacinth biomass by two *Pleurotus* species. *International Biodeterioration & Biodegradation* 53 (7) - 12. www.elsevier.com/locate/ibiod.
- Statistical Analysis System (SAS). 2003. *SAS User's Guide: Statistics. Ver.9.1*. Cary, NC:Inc.
- Sciences, N. A. (1975). *Aquatic Weed Management: Some Prospects for the Sudan and the Nile Basin: Reports of a Workshop Held 24-29 November 1975*, Khartoum, Sudan, Agricultural Research Council.
- Wassie Anteneh, Minwuyelet Mengist, Ayalew Wondie, Dereje Tewabe, Woldegebrael W/Kidan, Addisalem Assefa and Wondie Engida (2014). *Water hyacinth coverage survey report on Lake Tana, Technical Report Series 1*.
- Van Soest PJ, Robertson JB, Lewis BA. 1991. Methods of fiber, neutral detergent fiber and non-starch carbohydrates in relation to animal nutrition. *Journal of Dairy Science* 74:3583-3597.

The potential of alfalfa production using organic fertilizer and supplementary irrigation in Sidama highlands of Southern Ethiopia

Birhanu Biazin^a, Tesfaye Shewage, Yoseph Mekasha, Azage Tegegne, Dirk Hoekstra Amare Haileslassie, Shiferaw Boke

^a International Livestock Research Institute P.O. Box, 5689, Addis Ababa, Ethiopia;

Abstract

Alfalfa (Medicago sativa L.) is one of the leading forage crops in the world because of its high nutritive value, yield, and good adaptation to various agro-climatic and soil conditions. However, its adoption and wider dissemination in Ethiopia is very meager. The objective of this study was, therefore, to examine the potential of alfalfa production using organic fertilizer and supplementary irrigation in the highlands of Sidama Zone, southern Ethiopia. Improved alfalfa production techniques were introduced in a participatory manner with 22 voluntary households at Bensa, Bona Zuria and Arbegona districts of the Zone. This paper reports the outcome of this field experimentation to monitor alfalfa biomass yield in response to different production interventions and agro-meteorological analyses to determine supplementary irrigation requirements. The dry matter yield was determined by sampling from 12 field sites during December-February and May-June, 2016 which represented the dry and wet seasons, respectively. The result of this study indicated that there is a potential to produce 18-22 tons/ha/year dry matter yield using farmyard manure and supplementary irrigation during the dry season only. There were no significant ($\alpha > 0.05$) differences in dry matter yield between the study districts that represent medium and high altitude areas. The monthly dry matter yield was not also significantly ($\alpha > 0.05$) different between the dry (1.56 ± 0.1) and wet (1.7 ± 0.1) seasons implying that proper application of supplementary irrigation could enable continued harvesting of optimum biomass yield throughout the year. The Sidama highlands being endowed with a sufficient and well-distributed precipitation, supplementary irrigation is required only during the period from December to March under normal rainfall conditions (50% probability of exceedance). The study implied that there is a good potential of alfalfa production through proper applications of farmyard manure and supplementary irrigation from shallow wells and rainwater harvesting structures. Further research is being undertaken as follow up to determine the benefits of alfalfa production as feed for dairy and poultry production. Access to true-to-type seeds, being a prime constraint against scaling out alfalfa production, research and extension support is required for farmer-based seeds production and supply system.

Keywords: Dry matter yield; Farmyard manure; Net irrigation requirement; Shallow wells

Introduction

Alfalfa (*Medicago sativa* L.) is one of the most important forage crops in the world because of its high nutritive quality, yield, and good adaptation to various agro-climatic conditions (Russelle, 2001; Mengistu, 2002; Li et al., 2007). It is considered as the 'Queen of forages' (Russelle, 2001). Alfalfa (also known as lucerne) is a long-lived perennial legume that grows over a wide range of altitudes and is tolerant to a wide range of temperatures (Mengistu, 2002; Russelle, 2001). Although the crop is suited to a wide range of well-drained soils, best production is on neutral to slightly alkaline soils. Beyond its proven and superior importance as a forage crop, alfalfa has a substantial contribution for soil and water conservation and nitrogen economy in the soil through symbiotic nitrogen fixation (Kelner et al., 1997; Li et al., 2002). It also helps protect surface and groundwater quality by acting as a great sponge for excess nitrate and water (Russelle, 2001). Alfalfa fiber, especially abundant in the stems, can be used to make paper, or, using the appropriate enzymes, it can be broken down and fermented to yield ethanol or lactic acid, a feedstock for biodegradable plastics. One new alfalfa already produces phytase, the enzyme that improves phosphorus availability in mono-gastric animals, such as swine and poultry.

In Ethiopia, there have been some efforts to develop irrigated and rainfed alfalfa as part of the endeavors in improving livestock feed quality and quantity. Alfalfa productivity and yield potentials in a given area can be affected by various management efforts encompassing proper use of fertilizers, crop water management, cutting frequency and tending operations such as weeding and disease management among others (Asseng, 2000; Ventroni et al., 2010). However, given the meager experiences in growing alfalfa as a forage crop in Ethiopia, there have been few studies towards understanding the improved agronomic and irrigation management strategies on biomass production and productivity (Kebede, 2010; Geleti et al., 2014). Hence, site-specific studies focusing on agronomic and irrigation management are required before wider dissemination. Therefore, given the diverse agro-climatic and soil conditions in Ethiopia, the effect of organic soil amendments and supplementary irrigation on alfalfa yield should be studied for wider use in Ethiopia.

The Sidama highlands, in Southern Ethiopia, being endowed with well-distributed and sufficient rainfall, ample water resources potential and deep soils, it is suitable for the development of both irrigated and rainfed forage crops such as alfalfa. As part of its development-oriented applied research, the Livestock and Irrigation Value chains for Ethiopian Smallholders (LIVES) project has introduced improved alfalfa production techniques under rainfed and irrigated systems in participatory processes. This paper reports the outcome of a three-year development effort to grow alfalfa using improved production and irrigation management techniques in the highlands of Bensa, Bona Zuria and Arbegona districts in southern Ethiopia that represent medium and high altitude areas. The objective of the study was, therefore, to evaluate the production and productivity of alfalfa under high and medium altitude areas of Sidama zone in southern Ethiopia in response to organic fertilizer uses and supplementary irrigation. The study tried to examine the irrigation water requirement of alfalfa in Bona Zuria and Arbegona district that represent medium and high altitude areas of the Sidama highlands, respectively.

Materials and Methods

Descriptions of the study area

This study was undertaken at Arbegona and Bona Zuria districts of Sidama zone. Arbegona (6°57'N latitude and 38°83'E longitude) and Bona Zuria (6°62' N latitude and 38°78'E longitude) are located at a distance of about 78 and 105 km, respectively, south east of Hawassa city, the capital of Southern Nations Nationalities Peoples Regional (SNNPR) State. The mean altitudes of the study sites in Arbegona and Bona districts that represent the high and medium altitudes are 2550 and 2000 meters above sea level, respectively. The mean maximum and minimum daily temperature values of Bona district ranges between 24-28 °C and 12-13 °C, respectively (Figure 1). Similarly, the corresponding values for Arbegona district ranges between 17-21 °C and 7-9 °C, respectively (Figure 1). Generally, Bona district has slightly higher mean monthly reference evapo-transpiration and lower mean monthly precipitation than Arbegona district (Figure 2). The long-term mean monthly

precipitation is greater than the mean monthly reference evapotranspiration during April-November at both Bona Zuria and Arbegona districts.

The soils of the study area range between clay and loam soils. Table 1 presents the physico-chemical properties representing the medium altitude areas. Although the organic carbon contents of the soils are not very low, the slightly acidic nature of the soils could cause lower availability of phosphorus. Hence, phosphorus is a limiting nutrient for crop production in the Sidama highlands in general. The area has generally a huge surface and ground water resources potential and it is an important headwater source for the Genale river that drains to the Somali lowlands and ultimately to the Indian ocean. However, the rugged and undulating topographic setting implies the need for proper watershed management for sustainable soil and water resources utilization (Van den Bout, 2015).

Enset (*Ensete ventricosum*) is the dominant food crop commonly grown by producers across the 3-districts. Coffee and avocado are important commercial crops in the medium altitude areas such as Bona zuria district while shallots and Ethiopian cabbage are important cash crops in the high altitude areas of Arbegona district. Maize, teff, wheat and barley are also grown in the study area. Mixed crop-livestock system is the dominant production system in the study area, and livestock production is a very important means of livelihoods. The major feed resources for livestock in the study area encompass grazing lands and crop residues (Mekasha et al., 2016). Moreover, trees such as *Arundinaria alpine* (mountain bamboo), *Croton macrostachys*, *Milletia ferruginea*, *Cordia africana*, *Ficus sur* (*F. capensis*), *Erythrina abyssinica* and *Hagenia abyssinica* are commonly grown in the study districts. Most of these trees are being used as sources of livestock feed.

Table 1. Physico-chemical characteristics of the soils at Bensa representing mid altitude areas of the stud area in Sidama zone, Southern Ethiopia

Soil depth	PH	Ec (H ₂ O ms)	Organic carbon (%)	Available phosphorus (ppm)	Available K (Meq/100g)	Soil texture (%)			Texture class
						Sand	Clay	Silt	
0-15	5.7(0.9)	0.18(0.06)	3.8(0.2)a	11.0(0.6)a	0.8(0.3)	46(3)	20(2)	34(2)	Loam
16-30	5.9(0.1)	0.08(0.02)	2.2(0.2)b	8.8(0.6)b	1.5(0.6)	40(6)	25(3)	35(6)	loam
Mean	5.8(0.1)	0.12(0.10)	3.0(0.3)	9.9(0.6)	1.10.4)	43(3)	23(2)	34(3)	loam

Values followed by dissimilar letters (a-b) along a column are significantly different. Data was adopted from Seble Bekele (MSc thesis under preparation).

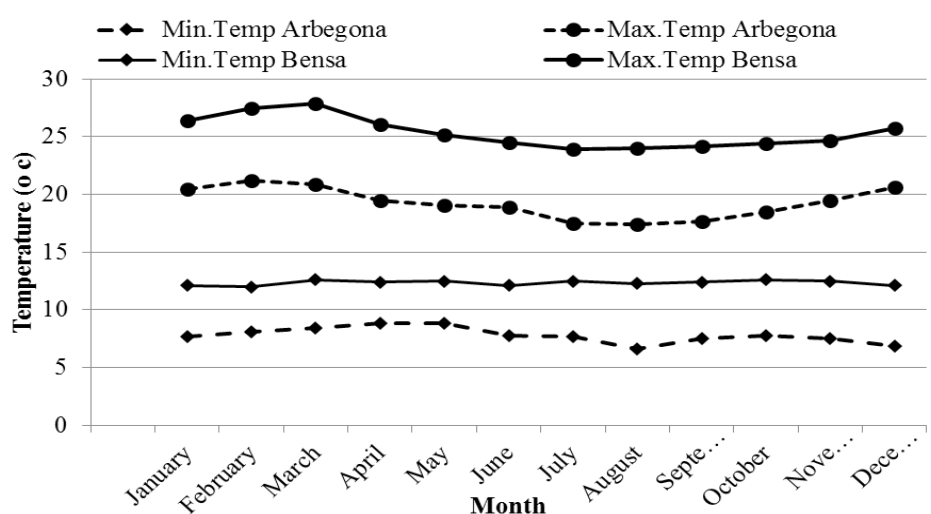


Figure1. Mean monthly maximum and minimum temperature at Bona Zuria and Arbegona districts, representing medium and high altitude areas of the Sidama highlands, respectively.

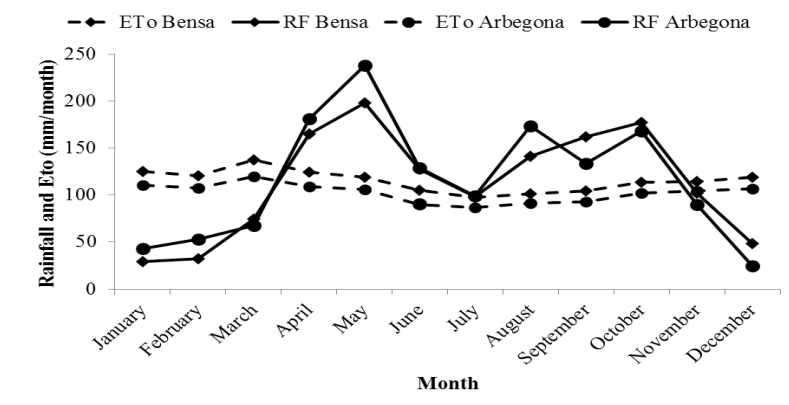


Figure 2. Mean monthly reference evapotranspiration and precipitation at Bona Zuria and Arbegona districts, representing medium and high altitude areas of the Sidama highlands, respectively.

Sampling technique

As part of the development-oriented action research process by the Livestock and Irrigation Value chains for Ethiopians Smallholders (LIVES) project, pilot intervention households were selected to introduce irrigated alfalfa using improved production techniques. These households were selected in a participatory process based on their ownership of crossbred dairy cows for which they should feed the alfalfa, their access to irrigation water and voluntariness to cooperate in the action research process. Hence, 22 households were selected and true-to-type alfalfa seed was provided for all them to start managing the crop using improved production techniques. This study reports the outcome of 12 alfalfa producing households, six of whom were selected from mid altitude (2000 meters above sea level on average) areas of Bona Zuria district and the other six households from high altitude (2500 meters above sea level) areas of Arbegona district.

Agro-meteorological analyses and supplemental irrigation need for alfalfa

Long-term meteorological data (1998-2013) of Bensa and Arbegona stations, representing medium and high altitude areas, respectively were obtained from the Ethiopian Meteorological Agency, Hawassa center. The dry, normal and wet years were determined based on 80%, 50% and 20% probabilities of exceedance. Accordingly, the mean daily and monthly reference evapo-transpiration and crop water demands were calculated for dry, normal and wet years following the FAO Penman-Monteith equation (Allen et al., 1998). The FAO Cropwat8 program was employed to estimate the net irrigation water requirement along the year (FAO, 2009). The crop parameters that were used as input data for the program are presented in Tables 3 and 4. The lengths of the different alfalfa developmental stages were adopted from FAO irrigation and drainage paper 56 (Allen et al., 1998) and modified based on field observations (Table 3). Table 5 presents the soil characteristics that were used as inputs for the program. Accordingly, the mean daily, dekadal (10 days) and monthly net irrigation requirement were determined for the medium altitude areas (Bensa district) and high altitude areas (Arbegona district). Finally, the amount of irrigation water required for supplementary irrigation during the dry season was estimated using the following equation.

$$V = (I \cdot A \cdot E \cdot 0.001)$$

Where, V is the volume of water required for supplementary irrigation in m³ for a given year, I is the net irrigation required for a given year in mm, A is the area of the land to be irrigated in m² and E is the irrigation efficiency in %. The irrigation efficiency was estimated to be 80% as the farmers are commonly using bunch system. Hence, the above equation was used to estimate the volume of water required for full (100% ETc) and deficit (75% ETc) irrigation techniques in the study districts.

Table 3. Crop developmental stages for various cutting cycles of alfalfa

Crop characteristics	Crop development stage			
	Initial	Developmental	Mid	Late
Alfalfa stage days, first cutting cycle	10	20	20	10
Alfalfa stage days, other cutting cycles (second above)	5	10	10	5

Table 4. Alfalfa crop water characteristics used as inputs for Cropwat8

Crop characteristics	Value
Kc	0.5-1.0
Critical depletion	0.5
Yield response factor	1.10
Maximum rooting depth (meters)	1.10

Table 5. Soil characteristics used as inputs for Cropwat8

Soil Characteristics	Values
Total available moisture (FC-WP)	140mm/meter
Maximum rain infiltration	240mm/day
Maximum rooting depth	110cm
Initial soil moisture depletion	50%

Field experimental layout, crop management and data collection techniques

Introduction of alfalfa was undertaken to the selected 12 households mostly in backyards with plot areas ranging between 100 m² and 300 m². All the pilot households have undertaken proper land preparations to ensure suitable seed beds by removing the soil peds. Alfalfa (CV: *Hunter river*) seeds were sown at the rate of 8 kg/ha in a row with spacing between rows of 50 cm. Seeds were sown following rainfall events that could satisfy the field capacity of the soils during June – July, 2013.

In the mixed crop-livestock farming systems of the Sidama highlands, there is ample opportunities to use organic fertilizer in the form of dry farmyard manure for alfalfa production. The physico-chemical characteristics of the dry farmyard manure in the study areas were analyzed after taking composite samples from different farms in September 2015 (Table 2). Phosphorus being the most limiting nutrient in the area (Table 1), and considering the potential of alfalfa in fixing nitrogen once it is established and produced nodules, the amount of manure to be applied was estimated based on the available phosphorus content in the soil and dry farmyard manure. Previous studies have also indicated that Alfalfa doesn't require N but removes large amounts of P from the soil and thus often responds to P fertilization (Norton, 2008). Dry farm yard manure obtained from cattle could have 0.35-0.70% available phosphorus and 1.7-2.3% available potassium (FAO, 2005). Accordingly, the optimum amount of dry farmyard manure that had to be applied to the soil annually could be 150-200 quintals. Hence, the farmers were advised to properly incorporate the manure with the soil before sowing and monthly application following every harvest at the rate of 10 quintals per hectare. The farmers applied the dry farmyard manure after harvesting and removing the weeds on the soil thus reducing the contact with the leaves that would otherwise cause salt burning due to release of ammonia gas. Farmers were continuously coached and mentored for proper management of the alfalfa plantation.

The intervention households were advised to apply supplementary irrigation during the months of December-March. On average, they were applying 5 mm every other day which could represent

about 70-75% of the irrigation water requirement (assuming 80% irrigation efficiency in the bunch irrigation technique) during the months of December – March. The intervention households were using mainly shallow wells as main sources of water. About 30% of the households used rope and washer pumps to lift water from the shallow wells (Figure 3) while the rest used manual fetching.

The farmers have started harvesting the alfalfa after an average of two months since establishment for the first cycle. The farmers were advised to undertake the cutting of alfalfa at an average of 30 days intervals at 15-20 cm above the ground continuously throughout the year. However, there were slight differences in the cutting frequency varying between 25 and 30 days. Fresh biomass yield was determined two times per year representing the wet (May-June, 2016) and the dry (Jan-Feb, 2016) seasons. Measurements of fresh harvest were determined using a sensitive balance by sampling 5-6 quadrants (0.5 m²) from each of the 12 farms, 6 at medium altitude areas (Bensa and Bona Zuria districts) and another 6 at high altitude areas (Arbegona district). The dry biomass yield was determined by taking 150-200 gm fresh samples from each farm and oven drying it at 105°C for 24 hours at the SNNPR regional soil laboratory.

Table 2. Physico-chemical properties of dry farmyard manure at Arbegona district, Southern Ethiopia

Parameters	units	Method of analyses	Value
pH	no	(1:2.5 soil to water ratio)	7.11
Total Nitrogen	%	Kjeldahl digestion	1.08
Organic Carbon	%	Walkley-Black oxidation	11.38
Moisture on dry weight basis	%	17	Oven drying

Data was adopted from Tsegaye Girma (MSc thesis under preparation).



Figure 3. Alfalfa produced using dry farmyard manure and supplementary irrigation associated with low-cost rope and washer pump in Arbegona district, Sidama highlands (Photo by Birhanu Biazin, June, 2016)

Data analyses

Statistical differences were tested using Univariate analysis of variance (ANOVA) following the generalized linear model (GLM) procedure of SPSS version 17 for Windows (Julie, 2007). Differences were considered significant at the $P < 0.05$ level. Mean separations were done using Tukey's Honest Significance Difference (HSD) test for equal variances and Dunnet's test for not equal variances. The normality of the distribution of the data was analyzed using the Shapiro-Wilk normality test (Shapiro and Wilk, 1965). Moreover, data are summarized in descriptive statistics and results are presented in graphs and tables.

Results and Discussion

Dry matter yield of irrigated alfalfa

Figure 4 presents the mean monthly dry matter yield of irrigated alfalfa during wet and dry seasons. The annual dry matter yield of alfalfa in the study area ranged from 18 to 22 tons/ha. This is in agreement with a previous study that reported around 22 tons/ha per annum in southern Ethiopia (Geleti et al., 2014). However, our results are much higher than several research findings elsewhere in Ethiopia (Befekadu and Yunus, 2015; Walie et al., 2016). The average monthly dry matter yield was not significantly ($\alpha > 0.05$) different between the medium and high altitude areas of the Sidama highlands (Figure. 4). The lack of differences in the biomass yield between the different altitudes could be attributed to the fact that the crop is well-adapted to a wider agro-climatic condition (Russelle, 2001; Mengistu, 2002). Average dry matter percentage varied between 14 and 21%, with an overall mean value of 15%. This is slightly lower than a previous study that reported 20% dry matter in Southern Ethiopia (Duguma et al., 2014). The slightly lower percentage of dry matter could be due to the relatively shorter cutting interval.

There was no significant seasonal variation in the mean monthly dry matter yield of irrigated alfalfa (Figure 4). This implies that the yield of alfalfa would not be affected by season if it is properly irrigated during the dry months. A study elsewhere in the world revealed that change in precipitation between years could account for up to 50% alfalfa yield variability under rainfed conditions (Jefferson and Cutforth, 1997). A severe reduction in alfalfa biomass yield during dry seasons can be associated with a decrease in transpiration due to water deficits (Sammis, 1981). Hence, this study implied that proper application of supplementary irrigation during the dry season could enable to harvest consistent amount of biomass yield throughout the year in the Sidama highlands.

Given the fact that the soils of the study area have lower available phosphorus content, proper application of dry farmyard manure could enable to harvest sufficient amount of alfalfa yield. Previous studies reported that at low to medium phosphorus levels of soils, proper application of phosphorus fertilizer can significantly improve alfalfa dry mass yield (Berg et al., 2009; Understander et al., 2011). Proper incorporation of manure and composts with soils can substantially enhance the phosphorus levels of soils thus making it easily available for alfalfa plantations (Martin et al., 2006). This indicates that in the face of ever increasing price for chemical fertilizers, proper use of farmyard manure can compensate for chemical fertilizers probably making positive contributions to the adoption of alfalfa production by smallholder farmers.

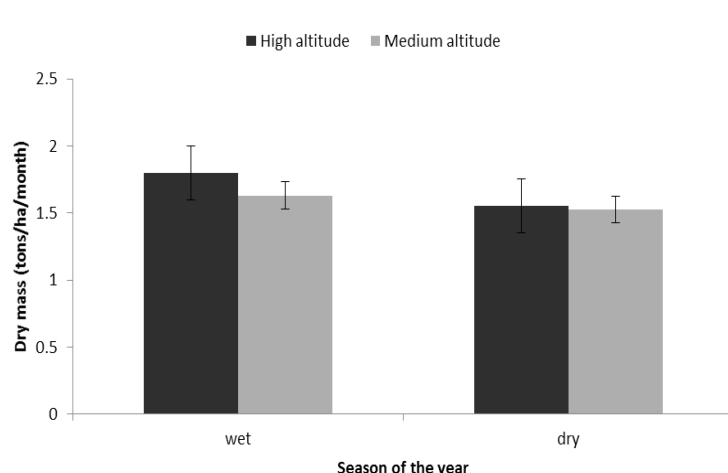


Figure 4. Dry matter yield of alfalfa in dry and wet seasons at high and medium altitude areas of Sidama highlands, respectively. The error bars represent the standard error of the mean.

Irrigation water requirement and the potential of micro-irrigation techniques

Figures 5a and 5b present the net irrigation water requirement of alfalfa during dry, normal and

wet years. Generally, there is no any net irrigation water requirement during the months of April – October in normal rainfall years that represent 50% probability of exceedance (Figures 5a & 5b). About 90% of the net irrigation water is required during the months of December-March under a normal rainfall year in all the study districts. However, during dry years (80% probability of exceedance), the annual net irrigation requirement and the number of months when irrigation is required could be substantially increased. Generally, the mean annual net irrigation requirement for alfalfa (310mm) is lower than the estimated annual groundwater recharge in the study area (Di Gier, 2015). This implies that there is a good opportunity to use supplementary irrigation for intensive alfalfa production in the predominantly dairy-based farming system in the Sidama highlands. Having the huge potential of shallow ground water and the common tradition of shallow wells in the study districts, it could be possible to apply full and deficit supplementary irrigation from shallow wells. In the western states of the USA, ET normally ranges from 900 mm to 1200 mm, but it can reach up to 1800 mm in desert areas (Grismer, 2001). It could also be possible to irrigate 300 m³ alfalfa field using low-cost rope and washer pumps that can be aptly integrated with shallow wells.

Beyond using the shallow wells, there is also a huge opportunity to harvest rainwater during the rainy seasons and use that for supplementary irrigation either during the dry season, mostly during December – February or when there are long dry spells during the rainy seasons. Table 6 presents the volume of water required to satisfy 100% crop water requirement (full) and 75% crop water requirement (deficit) water requirement of alfalfa grown in 300m² plot under dry, normal and wet years. It could be possible to harvest up to 120 m³ of water using underground and sub-surface rainwater harvesting structures (Biazin et al., 2012).

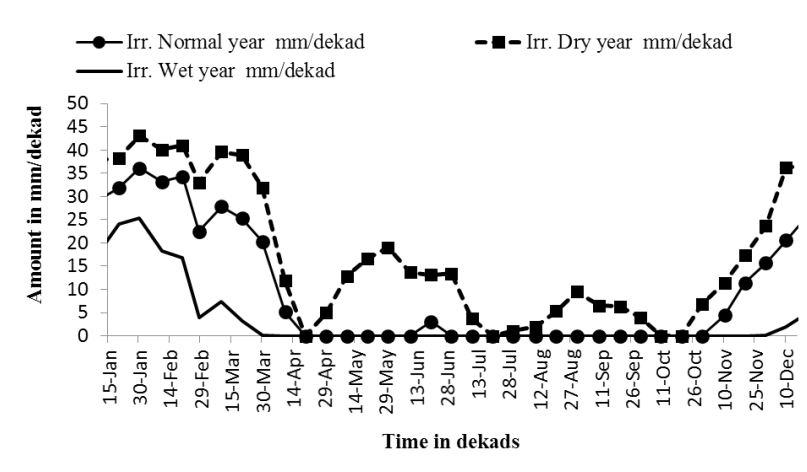


Figure 5a. Dekadal (10-days) irrigation water requirement at Bona Zuria districts, both representing the medium altitude areas, in response to high, normal and low rainfall years

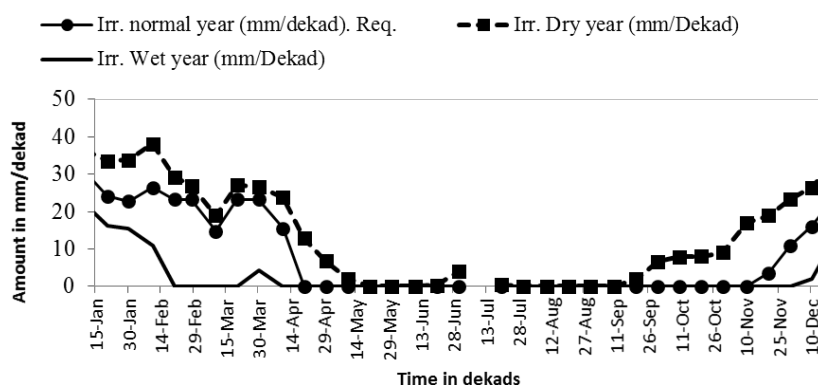


Figure 5b. Dekadal (10-days) irrigation water requirement at Arbegona district, representing the high altitude areas, in response to high, normal and low rainfall years

Table 6. Net irrigation water requirement for alfalfa, volume of water required for supplementary irrigation for full and deficit irrigation in medium and high altitude areas of Sidama zone, Southern Ethiopia

Rainfall condition (probability of exceedance)	Annual rainfall (mm) [#]		Net irrigation requirement (mm/year)		Volume of water (m ³) required to irrigate 300 m ² alfalfa plot (100% ET _c)		Volume of water (m ³) required to irrigate 300 m ² alfalfa plot (75% ET _c)	
	High altitude	Medium altitude	High altitude	Medium altitude	High altitude	Medium altitude	High altitude	Medium altitude
Dry year (80%)	905	828.1	510	660	191	248	115	186
Normal year (50%)	1402	1357	310	378	116	142	87	106
Wet year (20%)	2247	2187.0	104	139	39	52	29	39

[#]High altitude =Arbegona district; Medium altitude=Bona zuria and Bensa districts

Conclusion and Recommendations

Alfalfa is a newly introduced forage crop in the Sidama highlands of southern Ethiopia. This study showed that there is a huge potential to grow alfalfa through proper application of dry farmyard manure and supplementary irrigation only during the dry season in the study area. In the mixed crop-livestock farming system of Sidama highlands where there could be ample opportunities to use dry farmyard manure, there is a huge opportunity to scale out manure-based irrigated alfalfa production. Given the sufficient and well-distributed precipitation, supplementary irrigation is needed only for a maximum of four months. Therefore, use of low-cost water lifting devices such as rope and washer pumps could support the development of irrigated alfalfa production in the study areas. Further studies are required to optimize cutting frequency and examine socio-economic performances of alfalfa as supplementary feed for dairy cows in the study area. Access to true-to-type seeds of alfalfa continued to be a prime constraint for scaling out of improved alfalfa production through supplementary irrigation. Hence, future research should also focus on farmer-based alfalfa seed production and supply system.

Acknowledgements

This study was financially supported by the Department of Foreign Affairs, Trade and Development of Canada (DFATD) through the Embassy of Canada at Addis Ababa, Ethiopia. The authors are thankful to the Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) project of ILRI and to the smallholder farmers who voluntarily supported the research. The authors are also thankful to the laboratory assistants at SNNPR regional soil laboratory, in Hawassa.

References

- Allen, R.G., Periera, L.S., Raes, D., Smith, M., 1998. *Crop Evapo-transpiration: Guidelines for computing crop water requirement*. FAO Irrigation and Drainage Paper No. 56. FAO, Rome.
- Asseng, S., Hsiao, Th.C. 2000. *Canopy CO₂ assimilation, energy balance, and water use efficiency of an alfalfa crop before and after cutting*. *Field Crops Research* 67, 191-206.
- Berg, WK., Cunningham, S.M., Brouder, S. M., Joern, B.C., Johnson, K.D., Volenec, J.J. 2009. *Influence of Phosphorus and Potassium on Alfalfa Yield, Taproot C and N Pools, and Transcript Levels of Key Genes after Defoliation*. *Crop science* 49, 974-982.
- Biazin, B., Sterk, G., Temesgen, M., Abdulkedir, A., Stroosnijder, L., 2012. *Rainwaterharvesting and management in rainfed agricultural systems in sub-SaharanAfrica–A review*. *J. Phys. Chem. Earth* 47–48, 139–151.

- De Gier, p. 2015. The impact of coffee-based agroforestry on the hydrology of the upper Genale River basin, Sidama Zone, Ethiopia. MSc thesis, Wageningen University, the Netherlands.
- Duguma, B., Eshete, G., Zewdu, T., Tolera, A.d.2014. Comparison of Nutritive Value of Alfalfa, Rhodes Hay, Cynodon Pasture and Linseed Cake –Maize Mixture at Hawassa College of Agriculture, Ethiopia. *Academic Journal of Nutrition* 3 (2), 19-21.
- Kebede, F. 2010. Some Legume Crops Effect on Soil Nitrogen Recovery in the Degraded Soils of North Ethiopia. *Journal of American Science* 6(10), 867-870.
- FAO, 2009. ETo Calculator version 3.1. **Land and Water Digital Media Series No 36**. FAO, Rome, Italy. <<http://www.fao.org/land-water/databases-and-software/eto-calculator/en/>>
- FAO, 2005. Fertilizer use by crops in Ghana.
- Fereres, E., Soriano, M.A. 2007. Deficit irrigation for reducing agricultural water use. *Journal of Experimental Botany*, 58, (2) 147–159.
- Geleti, D., Hailemariam, M., Mengistu, A., Tolera, A. 2014. Biomass yield potential and nutritive value of selected Alfalfa (**Medicago sativa L.**) cultivars grown under tepid to cool sub-moist agro-ecology of Ethiopia. *Journal of Agricultural Research and Development* 4(1), 007-014.
- Grismer ME. 2001. Regional alfalfa yield, etc, and water value in the western states. *Journal of Irrigation and Drainage Engineering* 127, 131–139.
- Julie, P. 2007.SPSS Survival manual: A step by step guide to data analysis using SPSS for Windows Version 15. 3rd edition. Open University Press, UK.
- Li, X., Su, D., Yuan, Q. 2007. Ridge-furrow planting of alfalfa (**Medicago sativa L.**) for improved rainwater harvest in rainfed semiarid areas in Northwest China. *Soil & Tillage Research* 93, 117–125.
- Martin, E. C., Slack, D. C., Tanksley, K. A., Basso, B. 2006. Effects of Fresh and Composted Dairy Manure Applications on Alfalfa Yield and the Environment in Arizona. *Agron. J.* 98:80–84.
- Mekasha, Y. Zewdie, T., Biazin, B., Yoseph, Shewage, T., Dubale, T., Tegegne, A., G/Medhin, B., Hoesketra, D. 2016. Assessment of Livestock Feed Resources & Feed-agri-business in Gamogofa and Sidama Zones of Southern Ethiopia (under preparation).
- Mengistu, A., 2002. Forage production in Ethiopia: A case study with implications for livestock production. Ethiopian Society of Animal Production Addis Ababa, Ethiopia.
- Norton, J. 2008. Alfalfa Fertility and Manure Management. Wyoming Society for Range Management Annual Meeting, Cheyenne, WY, November 19, 2008.
- Russelle, M.P., 2001. Alfalfa: after an 8000-year journey, the “Queen of Forages” stands poised to enjoy renewed popularity. *Am. Sci.* 89, 252–261.
- Sammis, TW. 1981. Yield of alfalfa and cotton as influenced by irrigation. *Agronomy Journal* 73, 323–329.
- Shapiro, SS.Wilk, MB.1965. An analysis of variance test for normality (complete samples). *Biometrika* 52: 591–611.
- Van den Bout, B. 2015. The influence of land use change on soil erosion in the Genale catchment, Southern Ethiopia. MSc thesis, Utrecht University, the Netherlands.
- Ventroni, L.V., Volenec, J.J., Cangiano, C.A. 2010. Fall dormancy and cutting frequency impact on alfalfa yield and yield components. *Field Crops Research* 119, 252–259.

Cattle fattening and marketing system in Bonke woreda of Gamo Gofa zone, southern Ethiopia: Practices, challenges and opportunities for improvement

Guayo Demisse¹, Ajebu Nurfeta, Yoseph Mekasha and Azage Tegegne

¹Office of Livestock & Fisheries, Bonke Woreda of Gamogofa zone, Southern Ethiopia

Abstract

The study was carried out to assess cattle fattening and marketing system in Bonke Woreda of Gamo Gofa Zone, southern Ethiopia. The woreda has three agro-ecologies, Dega, Woina Dega and Kola. Two kebeles per agro-ecology were selected purposively based on the practice and potential for cattle fattening. The study involved interviewing 120 cattle fattening households purposively selected from six kebeles in three agro-ecologies. From each kebele, 20 households (10 men and 10 women) engaged in cattle fattening were selected. Thus, a total of 120 households were interviewed in the survey. Focus group discussions and key informants interview was employed to enrich the data. The data were analyzed using the General Linear Model (GLM) Procedure of Statistical Package for Social Science (SPSS 16). The result showed that indigenous cattle breeds are used for fattening, and the major source of cattle for fattening was through purchasing from the local market (69.1%). The most common criteria used while purchasing fattening cattle included frame size, heath, body condition, coat color and price of animals. Almost all fatteners in the Dega (95%) and Woina Dega (100%) agro-ecologies are engaged in cattle fattening castrated male cattle. Most of the producers (83%) use matured and old oxen for fattening. The majority (90%) of the respondents indicated that the most common criteria used to decide duration of fattening was body condition of the animals. Most of the respondents in the Dega, Woina Dega and Kola agro-ecologies fatten cattle for six months, three months and five months, respectively. The major types of feed resources used for fattening are natural pasture, crop residues, stubble grazing and grass hay supplemented with a handful of on-farm produced maize grain. Existence of large cattle population, long experience in cattle fattening, diverse and suitable agro-ecology, availability of crop residues, high irrigation potential, and cheap labor force reveals the potential of the study area for improved cattle fattening. However, poor feed conservation practices, lack of knowledge in feeding systems, high prevalence of diseases, poor access for credit service and market information and underdeveloped cattle marketing are the major constraints that hinder the improvement of cattle fattening practices. Hence, capacity development of producers and extension staff on improved cattle fattening and marketing system, improved access to market information, introduction of improved fattening packages such as improved feed production, conservation and utilization, introduction of short cycle fattening, improved management and disease control are instrumental to improve fattening system and thereby transform the system from traditional to market-oriented.

Key words: smallholder cattle fattening, feed resource & feeding, marketing system

Introduction

Ethiopia holds the largest livestock population in Africa, which is estimated to be 56.7 million heads of cattle, 29.3 million sheep, 29.1 million goats, 1.16 million camels, 56.8 million chicken, 2.03 million horses, 7.3 million donkey and 0.4 million mules (CSA, 2015). Livestock play vital role in Ethiopian economy where it is a source of livelihood for many smallholder farmers, pastoralists and agro pastoralists. It also serves as a source of cash income, household security, accumulating capital and fulfilling various socio-cultural obligations (Ayele *et al.*, 2003; Sere *et al.*, 2008). Livestock contributes to about 12-18 % of the total GDP, 35 - 49% of agricultural GDP and 23.8% of export earnings (Beruk, 2014; IGAD, 2011, 2013). Even though, livestock has vital contributions to socio- economic development of the country, its production and productivity and the income generated from the sector is low due to many factors (Belete et al., 2010). Documentation of the existing production & marketing practices, identification of the major constraints and opportunities are preconditions for designing suitable livestock development strategies (Herrernan, 2004).

Bonke woreda of Gamo Gofa zone is known for its high cattle population and diverse agro – ecology suitable for cattle fattening. Cattle production in general and cattle fattening in particular is an important component of the farming system. There is also cheap labor, better experience in cattle fattening, and increasing demand for fattened cattle in the local market. However, despite the potential, cattle fattening system has remained unimproved. Assessment of the existing practices, challenges and opportunities along the value chain are important to understand the existing system and prioritize interventions through the involvement of stakeholders. Thus, the current study was designed to assess smallholder cattle fattening and marketing practices, and challenges & opportunities for improvement in Bonke woreda of southern Ethiopia.

Materials and Methods

Description of the Study Area

The study was carried out in Bonke woreda of Gamogofa zone, Southern Ethiopia. Bonke is one of the 15 woredas, which lies between 5°55'N latitude and 37°15'E longitude with an altitude range of 600-4200 m.a.s.l. The land area of the Woreda is estimated to be 85,940 km². The woreda has three agro-ecology: Dega (46%), Woina Dega (30%) and Kola (24%). The mean annual average rainfall and the mean annual average temperature of the woreda are 1400 mm and 13.05°C, respectively (BoARD, 2015; BoFED, 2015).

Sampling of targets

Two kebeles were selected from each of the three ecologies purposively based on the potential of high value livestock commodities by the livestock and irrigation commodities value chain for Ethiopian smallholders (LIVES) project and active participation of farmers in cattle fattening practice. Twenty households (10 Men and 10 Women) who had better experience in cattle fattening were selected from each kebele. Thus, a total of 120 households were interviewed in the survey. To generate gender disaggregated data both female headed households and women's within male headed households were considered.

Methods of data collection

The study considered data from both secondary and primary sources. Primary data were collected through semi - structured questionnaires, key informant interviews, focus group discussions and field observations. Secondary data were collected from zonal and woreda livestock and fisheries offices, and marketing and cooperative departments. The data were collected by enumerators with close follow up and monitoring by the researcher. The procedures employed for data collection for survey part are described below.

Statistical Analysis

Data collected from the study were managed using MS Excel computer program. The data were analyzed using SPSS (Statistical Package for Social Science; version 16) software. Descriptive statistics and chi-square test were employed to describe and compare the various qualitative variables while ANOVA and Tukey were used for analysis of quantitative variables with respect to cattle fattening practices and marketing systems.

Results

Livestock ownership of the households

The average number of indigenous cattle and poultry per household (HH) in TLU was higher ($p < 0.05$) for lowland and mid-altitude agro-ecology compared to highland (Table 1). However, the average numbers of crossbred cattle and exotic chicken holding per HH was higher ($p < 0.05$) for highland compared to mid-altitude and lowland agro-ecologies. The average number of sheep per HH was higher ($p < 0.05$) in highland and mid-altitude than in lowland agro-ecology whereas the average number of goat holding per HH was higher ($p < 0.05$) for low land compared with highland and mid-altitude.

Table 1. Type and number (mean $\pm$ s.e.) of livestock owned by the sampled households

Livestock species	Number of livestock by agro-ecology (TLU)			
	Highland	Mid-altitude	Lowland	Over all
Cattle				
Indigenous	1.21 $\pm$ 0.23 ^b	6.15 $\pm$ 0.55 ^a	6.2 $\pm$ 0.56 ^a	4.52 $\pm$ 0.34
Cross bred	3.8 $\pm$ 0.71 ^a	0.08 $\pm$ 0.05 ^b	0.0 $\pm$ 0.0 ^b	1.29 $\pm$ 0.28
Total	5 $\pm$ 0.74	6.23 $\pm$ 0.58	6.2 $\pm$ 0.56	5.81 $\pm$ 0.36
Sheep	0.41 $\pm$ 0.07 ^a	0.33 $\pm$ 0.08 ^a	0.05 $\pm$ 0.02 ^b	0.26 $\pm$ 0.04
Goat	0.003 $\pm$ 0.003 ^b	0.03 $\pm$ 0.01 ^b	0.11 $\pm$ 0.03 ^a	0.05 $\pm$ 0.01
Chicken				
Indigenous	0.01 $\pm$ 0.003 ^b	0.04 $\pm$ 0.004 ^a	0.05 $\pm$ 0.01 ^a	0.03 $\pm$ 0.003
Exotic	0.02 $\pm$ 0.07 ^a	1 $\times$ 10 ⁻³ $\pm$ 9 $\times$ 10 ^{-4b}	1 $\times$ 10 ⁻⁴ $\pm$ 9 $\times$ 10 ^{-5b}	1 $\times$ 10 ⁻³ $\pm$ 2 $\times$ 10 ⁻³
Equine*	0.35 $\pm$ 0.09	0.23 $\pm$ 0.07	0.39 $\pm$ 0.11	0.32 $\pm$ 0.05
Bee hive				
Traditional (n)	0.2 $\pm$ 0.1 ^b	1.43 $\pm$ 0.32 ^{ab}	1.23 $\pm$ 0.48 ^a	0.95 $\pm$ 0.2
Modern (n)	0.2 $\pm$ 0.14	0.05 $\pm$ 0.03	0.05 $\pm$ 0.03	1 $\pm$ 0.05
Average total livestock	5.73 $\pm$ 0.84	6.86 $\pm$ 0.66	6.79 $\pm$ 0.63	6.46 $\pm$ 0.41

n = number of respondents; TLU=Tropical Livestock Unit; SE = standard error; ^{a-b} means with different superscript within a row are significantly different ($p < 0.05$); *equine included horse, mule and donkey

Purposes of keeping livestock

The purpose of keeping livestock as ranked by the respondents in the study area is presented in Table 2. Livestock producers ranked milk and milk products followed by income and draught power as a major driving force for keeping livestock in the area. The purpose of keeping livestock as a source of meat is low compared to other traits described above. Farmers sell their animals whenever they need cash for food, seed and other family requirements.

Table 2. Importance of livestock rearing as ranked by sampled households in the study area

Parameters (%)	Rank						Index
	1 st	2 nd	3 rd	4 th	5 th	6 th	
Milk and milk product	49.17	12.50	23.33	15.00	-	-	0.24
Income source	35.83	22.50	35.0	6.67	-	-	0.23
Draught	14.17	35.83	30.83	18.33	0.83	-	0.21
School fee	0.83	28.33	10.83	60.0	-	-	0.18
Meat	-	0.83	-	-	99.17	-	0.10
Skin and hide	-	-	-	-	-	100.0	0.05

Index=sum of all single purpose rank [(6 for 1) + (5 for 2) + (4 for 3) + (3 for 4) + (2 for 5) + (1 for 6)] divided by sum of all weighed purposes of livestock rearing mentioned by respondent

Source and type of fattening cattle

According to focus group discussants, the dominant cattle breed used for fattening in the study area is indigenous. Although there are few numbers of crossbreds, they are used for breeding and milk production. The major source of fattening cattle in the study area was through purchasing from market (69.1%) followed by raising at home (24.2%; Table 3). Although this was consistent across the three agro-ecologies, the proportion of fatteners who raise cattle for fattening at home was higher for mid-altitude compared to highland and lowland agro-ecology. This study also showed that majority of the smallholder producers (56.7%) use purchased animals for cultivation of cropping land before commencement of the fattening in the study area. However, majority of the producers (42.5%) in highland fatten cattle immediate after the purchase.

Most of the cattle fatteners (86.7%) in the study area use castrate for fattening compared to non-castrates. However, fatteners in lowland agro-ecology combine fattening castrate (65%) with non-castrate (35%). Moreover, most of the producers (83%) in the study area use matured & old oxen while the use of younger animal is less common. This study also revealed that cattle fattening in the highland agro-ecology partly depends on culled cows (32.5%).

Table 3. Source and type of cattle used for fattening by the sampled households in the study area

Variable (%)	Agro-ecology			Overall (n = 120)
	Highland (n = 40)	Mid-altitude (n = 40)	Lowland (n = 40)	
Source of fattening cattle				
Raised at the farm	20.0	42.5	10.0	24.2
Purchased from market	70.0	47.5	90.0	69.1
Culled cattle at the farm	10.0	10.0	-	6.7
Use of purchased cattle before fattening				
Let them plough cropping land	32.5	77.5	60.0	56.7
Fatten immediately	42.5	12.5	37.5	30.8
Keep them for some months	25.0	10.0	2.5	12.5
Type of fattening cattle				
Castrated	95.0	100.0	65.0	86.7

Non castrated	5.0	-	35.0	13.3
Physiological stage of preferred cattle				
Old oxen	30.0	15.0	10.0	18.4
Matured oxen	27.5	85.0	82.5	65.0
Young bull	10.0	-	7.5	5.8
Culled cow	32.5	-	-	10.8

Criteria for terminating and duration of fattening

The criteria used for terminating fattening cattle was significantly ($p < 0.05$) different among agro-ecological zones. Thus, majority (90%) of the respondents indicated that the most common criteria used to decide fattening period was body condition of the animals. According to this study, smallholder producers fatten cattle especially during the months of May to September targeting Meskel holiday. However, there is variation in the duration of fattening among the agro-ecologies. Consequently, majority of the respondents in the highland, mid altitude and lowland fatten cattle for six months, three months and five months, respectively (Table 5).

Table 5. Criteria for terminating and duration of fattening period in the study area

Variables (%)	Agro ecology			Overall (n = 120)
	Highland (n = 40)	Mid altitude (n = 40)	Lowland (n = 40)	
Criteria for terminating finishing period				
Feeding length	10.0	10.0	-	6.7
Body condition	80.0	90.0	100.0	90
Anticipated price	10.0	-	-	3.3
Duration of fattening				
Three month	5.0	40.0	25.0	23.3
Four month	7.5	25.0	15.0	15.8
Five month	17.5	10.0	52.5	26.7
Six month	50.0	20.0	7.5	25.9
> Six month	20.0	5.0	-	8.3

Feed resources and feeding system of fattening cattle

The major type of feed resources for the fattening animal in the study area were natural pasture, crop residues, stubble grazing, grass hay and feed supplements. The availability of feed resources varied depending on the seasons with respect to quality, quantity and type of feed (Table 6). The dominant dry season feed resource are crop residues (maize and sorghum stovers, straws from barley and teff, and haulms of haricot bean, faba bean and peas), stubble grazing and feed supplements (parts of sweet potato, banana and enset), atella, boiled maize grain and bole (salty soil lick). Grazing natural pasture (private and communal land), feeding on weeds and tillers of field crops are the major feed resources during the wet season. Moreover, cattle fatteners provide Amole chewu (salt lick) as mineral supplements.

Table 6. Major feed resources used by cattle fatteners in the area.

Variables (%)	Major feed resources	
	Dry season (n = 120)	Wet season (n = 120)
Natural pasture	12.3	69.8
Crop residues	55.7	15
Stubble grazing	13.3	7.7
Hay	5.2	-
Feed supplements	10.8	7.5
Browse trees	2.7	-

There was significant ($p < 0.05$) difference in cattle feeding practices among the agro-ecologies (Table 7). In the highland agro-ecology, around 67.5% of the households' use combination of tether grazing and stall feeding for cattle fattening. However, majority of the households in lowland (82.5%) and mid-altitude (72.5%) agro-ecology use stall feeding. This study also revealed that free grazing was less common (2.5%) while tether feeding (19.2%) was the second common form of feeding system of fattening cattle in the study area.

Table 7. Feeding system and mineral supplementation for fattening

Variable (%)	Agro ecology			Overall (n = 120)
	Highland (n = 40)	Mid-altitude (n = 40)	Lowland (n = 40)	
Feeding system				
Free grazing	7.5	-	-	2.5
Tether grazing	20	22.5	15	19.2
Stall feeding	5	72.5	82.5	53.3
Tether grazing and stall feeding	67.5	5	2.5	25.0
Mineral supplementation				
Yes	65	100	47.5	70.8
No	35	-	52.5	29.2

3.6. Housing of fattening cattle

Smallholder cattle fatteners use three types of houses/enclosures for the cattle in the study area (Table 11). The dominant housing types commonly employed in the area was that they keep their animals in the living room (Table 11). According to the focus group discussion and field observation cattle houses were constructed by using locally available materials such as grasses, wheat straw, bamboo tree and woods.

Table 11. Type and importance of housing for cattle in the study area

Variable (%)	Agro-ecology			Overall (n = 120)
	Highland (n = 40)	Mid-altitude (n = 40)	Lowland (n = 40)	
Do you provide Housing for cattle				
Yes	100.0	100.0	87.5	95.8
No	-	-	12.5	4.2
Type of house				

PROCEEDING
Animal Breeding and Reproduction

Corrals	22.5	10	65	32.5
In living rooms	65	90	25	60.0
Barn	12.5	-	10	7.5

Water practices

The major source of water for cattle in the study area included rivers, pond and spring. According to the sampled households, only 22.5% and 15% of the households in lowland and mid-altitude agro-ecology, respectively, face water shortage while majority of the others do not face the problem (Table 12). Similarly, majority of the households across all the agro ecology travel < 1 km to provide water for their animals.

Table 12. Watering practices of fattening cattle source and watering frequency of fattening cattle

Variable (%)	Agro ecology			Overall (n = 120)
	Highland (n = 40)	Mid-altitude (n = 40)	Lowland (n = 40)	
Do you face shortage of water				
Yes	-	15	22.5	12.5
No	100.0	85	77.5	87.5
Distance travelled for watering				
Watered at home	30.0	55.0	7.5	30.8
< 1 km	70.0	40.0	87.5	65.8
1 - 5 km	-	5.0	5.0	3.4
Watering frequency				
Once in a day	17.5	30.0	47.5	31.7
Twice in a day	82.5	70.0	52.5	68.3

Major diseases and veterinary services

According to focus group discussion, disease & parasite was one of the major problems hindering cattle production in general and cattle fattening in particular in the study area. The prevalence was higher in lowland (62.5%) and mild-altitude (67.5%) compared to highland (55%; Table 13) agro-climate. The major diseases of cattle included *Trypanosomosis* (local name: *wotsale*), anthrax (local name: *Aba senga*), blackleg (local name: *Aba gorba*), pasteurillosis and Foot & Mouth Disease (*Didme*). The major external and internal parasites prevalent in the stidu area included ticks, mites and flies, and gastro-intestinal nematodes and liver fluke, respectively.

Availability of credit service for cattle fattening

In this study, most of the respondents reported that they do not have access to any sort of credit service for cattle fattening in the Woreda (Table 14). Although there are micro-finance institutions established at woreda level, they do not have a program to support cattle fattening.

Table 14. Availability and access of credit service for beef fattening activity

Variable (%)	Agro ecology			Overall (n = 120)
	Highland (n = 40)	Mid-altitude (n = 40)	Lowland (n = 40)	
Availability of credit for cattle fattening				
Yes	2.5	2.5	-	1.7

No	97.5	97.5	100.0	98.3
Access for credit access				
Yes	2.5	2.5	-	1.7
No	97.5	97.5	100.0	98.3

Cattle marketing places and market channel

There are about 6 cattle marketing places on Bonke woreda of Gamogofa zone. These are **Geressie** (woreda town), **Danible Ottora**, **Dhimale Fusse**, **Chosha**, **Beza** and **Tsadho** markets. However, these markets are undeveloped and characterized by poor market infrastructures. With the exception of **Geressie**, all the other cattle marketing places are open and not fenced. In addition all markets are set once in a week except **Geressie** which is held twice in a week. The major fattened cattle marketing channel of the study area is described below:

Cattle fattener/producer è Local consumer

Cattle fattener/producer è Trader è Consumer (e.g. butchers at Arbaminch city)

Cattle fattener/producer è Small Trader è Big Trader è Consumer (Informal market; e.g. Moyale)

Cattle fattener/producer è Small trader è Big traders è Consumers (Domestic market; e.g. Addis Ababa)

Selection criteria for fattening cattle

Different criteria were used to select cattle for fattening in the study area (Table 16). The major criteria used for selection was frame size (index 0.165) followed by health (index 0.148), body condition (index 0.138) and coat color (index 0.116). Besides, age, adaptation, horn size/type and breed of animals were among the identified criteria used to choose cattle for fattening by the sampled households.

Table 16. Selection criteria of fattening cattle as ranked by smallholder cattle fatteners

Criteria of selection (%)	Rank									Index
	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	
Frame size	30.83	22.5	28.33	8.33	0.83	8.33	-	0.83	-	0.165
Health	27.50	15.0	24.17	10.83	3.33	5.83	4.17	8.33	0.83	0.148
Body condition	10.0	25.0	11.67	23.33	10.83	6.67	9.17	0.83	2.5	0.138
Color	15.0	8.33	8.33	7.5	15.83	18.33	15.0	10.83	0.83	0.116
Price	1.67	5.83	10.0	20.0	24.17	15.83	6.67	12.5	3.33	0.107
Age	2.5	18.33	14.17	14.17	6.67	4.17	5.0	4.17	30.83	0.101
Adaptation	0.83	2.5	0.83	7.5	21.67	20.83	25.0	20.0	0.83	0.085
Horn size/type	9.17	2.5	0.83	5.0	7.5	8.33	17.5	15.0	34.17	0.072
Breed	2.5	-	1.67	3.33	9.17	11.67	17.5	2.5	26.67	0.068

Index= sum of all single selection criteria rank [(9 for 1) + (8 for 2) + (7 for 3) + (6 for 4) + (5 for 5) + (4 for 6) + (3 for 7) + (2 for 8) + (1 for 9)] divided by sum of all weighed selection criteria

Access to market information

This study showed that about 85.8% of respondents had no access to market information (Table 17).

However, about 56.7% of the producers received assistance on cattle marketing from development agents. The selling and buying price of the cattle in the market is determined through negotiations between producers and traders (63.3%), through brokers (24.2%), sellers (11.7%) and least by buyers (0.8%). It was noted that negotiations between producers and buyers were always based on visual estimations of the physical characteristics of the animal by traders.

Table 17. Market information and marketing system of fattening cattle

Variable (%)	Agro ecology			Overall (n = 120)
	Highland (n = 40)	Mid-altitude (n = 40)	Lowland (n = 40)	
Access for market information				
Have access	92.5	77.5	87.5	85.8
No access	7.5	22.5	12.5	14.2
Access for advise on marketing				
Have access	72.5	45.0	52.5	56.7
No access	27.5	55.0	47.5	43.3
Decision on selling fattened cattle				
Relative advantage of price	85.0	100.0	97.5	94.2
Proximity of the market	15.0	-	2.5	5.8
Price determination at the market				
Seller	10.0	5.0	20.0	11.7
Buyer	-	2.5	-	0.8
Broker	2.5	7.5	62.5	24.2
Negotiation between seller and buyer	87.5	85.0	17.5	63.3

Opportunities and constraints of fattening

There are huge opportunities for cattle fattening in the study area. These included the availability of large number of cattle in the area, experience of cattle fattening, diverse and suitable agro- ecology for fattening, availability of agricultural by-products, high irrigation potential for improved forage development, initiation of the introduction of improved forage species and cheap labor force.

Even though, cattle fattening has contributions to socio-economic development of producers, the participation of smallholder farmers in the fattening activity is yet traditional and hindered by many challenges. Thus, this study indicated that cattle production and productivity were very low and producers may not get reasonable benefits from their fattening activity (Table 18). According to the interviewed producers, shortage of feed is the major constraint ranked as 1st followed by shortage of land (2nd), disease (3rd) and knowledge and extension gap (4th).

Table 18. Rank of constraints of cattle fattening in the study area

Constraints	Respondents' rank (%)										Index
	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th	
Shortage of feed	37.5	35.8	7.5	10.8	2.5	3.3	0.8	-	1.6	-	0.158
Shortage of land	42.5	11.6	5.8	3.3	8.3	5.8	5.0	5.8	1.6	10.0	0.133
Disease	11.6	15.0	23.3	6.6	3.3	9.1	5.0	7.5	11.6	6.6	0.113
Credit service	3.3	15.0	13.3	18.3	15.0	6.6	17.5	5.8	0.8	4.1	0.113
Shortage of grazing land	-	4.1	15.0	16.6	19.1	21.6	12.5	7.5	2.5	0.8	0.105

Marketing	3.3	6.6	10.8	15.0	20.8	11.6	8.3	3.3	9.1	10.8	0.098
Road access	0.8	1.6	5.8	23.3	10.8	14.1	29.1	13.3	0.8	-	0.096
Drought	0.8	-	4.1	-	15.0	18.3	9.1	25.8	21.6	5.0	0.070
Knowledge and extension gap	-	3.3	8.3	1.6	5.0	5.8	10.0	27.5	25.8	12.0	0.064
Breed	-	6.1	5.8	4.1	-	3.3	2.5	3.3	24.1	50.0	0.049

Index=sum of all single constraint rank [(10 for 1) + (9 for 2) + (8 for 3) + (7 for 4) + (6 for 5) + (5 for 6) + (4 for 7) + (3 for 8) + (2 for 9) + (1 for 10)] divided by sum of all weighed constraint.

Discussion

Small holder cattle fattening practices

The mean total livestock holding per household (HH) in the current study (6.46 ± 0.41 TLU) was higher than 3.77 ± 0.12 TLU reported for Chiro district of west Hararghe zone (Bezahegn, 2014), 3.47 - 4.44 TLU reported for highland and mid-altitude areas of Dale district of Sidama zone (Endeshaw, 2007), but lower than 10.82 TLU reported for lowlands of Dale district of the same zone (Endeshaw, 2007). The importance of cattle keeping in the study area was consistent with literature (Seid and Berhan, 2014). Improved capacity (knowledge, skill and attitude) of the producers, access for inputs/ services supply and market information are instrumental for improved cattle fattening. However, in this study, most of the respondents did not receive any kind of training on improved cattle fattening system. Consequently, traditional fattening practice is the dominant form of cattle fattening in the area. Consistent with the current study, Ahmed *et al.* (2010) reported that most of the fatteners in rural areas of Bangladish did not take any training on improved cattle fattening system.

The current study illustrated that the source of fattening cattle for majority of the respondents' in the study area was through purchasing from market which is inconsistent with Teshager (2013). Moreover, previous works (Takele and Habtamu, 2009; Shitahun, 2009) showed that cattle fatteners use purchased animals for cultivation of cropping land for a season or long before the fattening in Wolaita zone and Bure worda, respectively, which is in agreement with the current study. According to Shewangizaw *et al.* (2014) castration of fattening cattle was common for fattening in south region, which is in agreement with the current findings. Castration of cattle before the fattening is believed to enable the animals put more body weight and minimizes aggressive behavior (make them docile). In line with the current study, Shewangizaw *et al.* (2014) reported that farmers in central part of southern Ethiopia commonly fatten mature and older animals. This might be attributed to the demand of the society for fat carcass and better fattening efficiency of the animal than bulls. Contrary to the current study, Fikru (2015) reported that cattle fatteners in Harshin districts of Somali region prefer to fatten steers and bulls than castrate.

Consistent with the current study, most of the producers in Wolaita area fatten cattle two times per year (Takele and Habtamu, 2009) while others in Illu Aba Bora area fatten once a year (Teshager, 2013). Similarly, Takele and Habtamu (2009) reported that majority of the households fatten one cattle per fattening cycle. Contrary to this, Umar *et al.* (2008) and Sarma and Ahmed (2011) reported that fatteners hold five cattle on average per fattening cycle in Borno State of Nigeria and Rajbari district of Bangladsh, respectively. The difference in number of cattle fattened per fattening cycle might be due to difference in working capital, feed availability, capacity gap of fattener and market demand.

The long duration of cattle fattening without or with minimum supplementary feed was consistent with several studies reported earlier (MoA, 1996; UNDP, 2003). Habtemariam (2000) also reported that producers could take more than one year for fattening cattle in western and eastern parts of the country. Discordant with the preceding report and findings of the current study, the duration of cattle fattening in Wolaita area was 4 months (Takele and Habtamu, 2009) and 3 – 4 months in central southern region of Ethiopia (Shewangizaw *et al.*, 2014). Differences in cattle fattening length

may be due to variation in type and quantity of feed ingredients used, agro ecology of the area, type of fattening animal, market demand and capacity gap of the producers. Similar to the current study Estefanos *et al.* (2014) reported that the duration of cattle fattening is determined by anticipating future market price, rate of live weight change of the animal and cost of feed.

Feed resources and feeding practice of fattening cattle

Consistent with the current study, Takele and Habtamu (2009) and Belete *et al.* (2010) reported that crop residue and natural pasture are the major feed resources used for fattening cattle in southern Ethiopia and Amhara National Regional State, respectively. Moreover, Adugna *et al.* (2012) reported that natural pasture and crop residue are the major feed resources of livestock in the highlands of Ethiopia. On the other hand, in agreement with current findings, Alemayehu (2005) indicated that the contribution of agro – industrial by – products is minimal/or in accessible for rural smallholder producers and restricted to some urban and pre – urban farms. Takele and Habtamu (2009) and Shewangizaw *et al.* (2014) also noted that supplementation of concentrate feed for fattening cattle is the growing practice in Wolaita Zone of southern region. The feeding system practiced by households in the study area agreed with Shewangizaw *et al.* (2014) who indicated that most of the producers in central southern region use stall feeding, while few households use both stall feeding and grazing. With respect to mineral supplementation, Seid and Berhan (2014) reported that smallholder producers in Burji area provide Amole chewu/salt and Bole as a mineral supplement for the cattle. In addition, Daniel (2008) indicated that smallholder producers in Borena zone strongly believed that supplementation of salt is useful to condition fattening cattle.

Major diseases and veterinary services

Disease was one of the major hindrances for cattle production in the study area. Similar to the present study blackleg, anthrax, Trypanosomosis, Pasteurellosis, FMD (foot and mouth disease), LSD (Lumpy Skin Disease) and CBPP (contagious bovine pluro pneumonia) were found to be the major diseases occurred in West Hararghe zone of Oromia regional state (Abdi *et al.*, 2013). Moreover, ticks, mites and flies were reported as major external parasites while gastro-intestinal nematodes and liver fluke were the major internal parasites causing considerable loss of animals in the same area. The veterinary health services provided to overcome these diseases and parasites in the area was inadequate. Currently, veterinary health assistants are providing health service to the community through mobile service bases (one health assistant assigned to 2-3 villages). On the other hand, it was reported that, farmers access veterinary service within 5 km distance in Bure area (Shitahun, 2009). It is, therefore, important to improved access for veterinary service in the study area through establishment of health centers and assignment of health assistants taking into account livestock population and disease prevalence of the area. Equally important, encouraging & incentivizing private veterinary health service providers to operate in rural areas where there is potential for cattle fattening should be looked into.

Availability of credit service for fattening package

Access and availability of credit service have a great role in promoting market oriented fattening system. According to Feder (1985), adoption of new technologies is associated with availability of credit. However, majority of producers in the study area have no access for any sort of credit service for cattle fattening, which was consistent previous reports (Gurmessa and Daniel, 2013; Abdi *et al.*, 2013).

Cattle marketing practices

According to different scholars livestock markets are categorized into primary, secondary, and terminal markets based on types of major market participants, volume of supply per unit of time and the purpose of buying (Yacob, 2002; Ayele *et al.*, 2003; Abbey, 2004; ACDI/VOCA, 2006b). Consistent with the current findings, Fikru (2015) reported that, marketing system in Harshin district was undeveloped and characterized by inadequate market infrastructures. In agreement with the

same author, cattle marketing places in the study area were open place/not fenced (except in district town) for a mixture of livestock species including finished cattle. Concerning cattle marketing route, two main livestock marketing routes were noted in the study area where one goes up to Moyale border market while the other extends up to Addis Ababa terminal markets.

The current study indicated that majority of the fatteners purchase fattening animals from local market and sell in the same market. The findings was consistent with Fikru (2015) for marketing fattening in Harshin area. On the other hand, many scholars' authors (Ayele *et al.*, 2003; Teshager *et al.*, 2013 and Fikru, 2015) reported that the mode of transportation for fattened cattle was trekking on foot, which is in agreement with the current findings.

The selection criteria for purchasing fattening cattle in the current study were similar with Shitahun (2009) who reported that price, health, body size/frame, age and adaptability were the major selection criteria employed by cattle fatteners in descending order in Bure worda, Ethiopia. Moreover, Mekonnen *et al.* (2012) reported that farmers give better attention for traits like body size, physical appearance, coat color and hump size in western Oromia. According to earlier reports cattle fatteners select fattening animals based on color, sex, height, body condition, and hump size in Wolaita (Takele and Habtamu, 2009), west Hararge (Abdi *et al.*, 2013) and central southern region of Ethiopia (Shewangizaw *et al.*, 2014), respectively. Besides, Teshager *et al.* (2013) reported that breed type (local) was one of the preferred criteria for purchasing fattening cattle in Ilu Aba bora area. However, almost all traders in Amhara region of Ethiopia do not take coat colour as criteria for selection of fattening animals (Belete *et al.*, 2010).

Access to market information

Market information is crucial and required by fatteners to make fair and proper decisions and strengthen their negotiating ability during transaction with buyers and consequently prevent possible exploitation by better informed traders. However, in the current study most of the smallholder producers do not have access to market information before selling their cattle. Consequently, fattener's are forced to sale conditioned animals with low price, which could not enable them to fetch profit from fattening practice and expand their business. On the other hand, Daniel (2008) and Teshager *et al.* (2013) reported that most of the producers get market information before taking their livestock to market in Borena and Ilu Aba bora area of Ethiopia.

Conclusion

Cattle fattening is an important component of livestock production in Bonke district of Gamogofa zone. However, the production system was traditional and cattle fatteners in areas such as the highlands of Gamogofa fatten cattle once a year. The most common criteria used to terminate the duration of cattle fattening period was body condition of the animals. The available feed resources used for cattle fattening were crop residues, green grass and natural pasture without any supplementary feed resources. In the study area, cattle marketing system was undeveloped (traditional) and characterized by inadequacy of market infrastructural facilities. Although there are huge opportunities for cattle fattening, the system was hindered by many factors such as shortage of feed and grazing land, disease and parasites, knowledge and extension gap and lack of credit service in the study area. Hence, capacity development of producers and extension staff on improved cattle fattening and marketing system, improved access for market information, introduction of improved fattening packages such as improved feed production and utilization, improved management and diseases control are instrumental to improve fattening system and thereby transform the system from traditional to market oriented production.

Acknowledgements

The authors would like to acknowledge the Department of Foreign Affairs, Trade and Development of Canada (DFATD) through the Embassy of Canada at Addis Ababa, Ethiopia and the Livestock and Irrigation Value chain for Ethiopian Smallholder (LIVES) project of the International Livestock

Research Institute (ILRI) for supporting this research. The authors are also grateful to Office of Livestock and Fisheries of Bonke Woreda of Gamogofa zone for granting study leave for the first author and facilitating implementation of the field work.

Reference

- Abbey, A. 2004. *Red Meat and Poultry Production and Consumption in Ethiopia and Distribution in Addis Ababa*: Borlaug-Ruan World Food Prize Intern and national Livestock Research Institute Addis Ababa, Ethiopia.
- Abdi, E., Kamal, K., Yassin, E. and Muleta, D. 2013. Cattle production in west Hararge and opportunity and constraints assessments in Darulabou, Gemechis and Chiro districts of Oromiya regional state, Ethiopia. *International Journal of Livestock Production Research*, 1(1): 1- 15.
- Adugna, T., Assefa, G., Geleti, D., Gizachewe, L., and Mengistu, A. 2012. *Feed Resource Availability and Quality*: In: Adugna, T., Yami, A. and Alemu, D. (Eds). *Livestock and Feed Resources in Ethiopia: Challenges, Opportunities and the need for transformation*. Addis Ababa, Ethiopia: Ethiopian Animal Feed Industry Association, pp.5-36.
- Agricultural Cooperative Development International/Volunteers in Overseas Cooperative Assistance (ACDI/VOCA), 2006b. *Baseline Information for Key Indicators*. Pastoralist Livelihood Initiative Livestock Marketing Project.
- Ahmed, T, M. A. Hashem, M. Khan, M. F. Rahman and M. M. Hossain. 2010. *Factors Related to Small Scale Cattle Fattening in Rural Areas of Bangladesh*. *Journal of Animal Science*, 39(1&2): 116 – 124.
- Alemayehu, M. 2005. *Feed resources: status, limitations and opportunities for integrated development*. pp: 410. In: *Proceeding of the 12th Annual Conference of the Ethiopian Society of Animal Production*, 14-14 August 2004. Ethiopian Society of Animal Production, Addis Ababa, Ethiopia.
- Andualem, T., Berhan, T. and Gebeyehu, G. 2015. *Assessment of Cattle Feed Resources; Chemical Composition and Digestibility of Major Feeds in Essera District, Southern Ethiopia*. *Science, Technology and Arts Research Journal*, 4 (2): 89-98 20.
- Ayele, S., Assegid, W., Jabbar, M.A., Ahmed, M.M and Belachew, H. 2003. *Livestock marketing in Ethiopia: A review of structure, performance and development initiatives*. Socio-economic and Policy Research Working Paper 52. ILRI (International Livestock Research Institute), Nairobi, Kenya.
- Ayenew, H. 2012. *Risk analysis in cattle fattening in North West Ethiopia: Empirical evidence form two limit Tobit model*. *International Journal of Development and Sustainability*, 1(2): 240– 254.
- Belete, A., Azage, T., Fekadu, B., and Berhanu, G. 2010. *Cattle and Meat Production and marketing systems and opportunities for market orientation in Fogera Woreda, Amhara Region, Ethiopia*. IPMS (Improving Productivity and Market Success of Ethiopian Farmers) Project, International Livestock Research Institute (ILRI), Nairobi, Kenya. Working Paper 19, 65 pp.
- Beruk, Y. 2014. *Grain Production as Contribution to Animal Feed in Ethiopia*. Ethiopian Animal Feed Industry Association (EAFIA): March 27, 2014. Nairobi, Kenya.
- Bezahegn, A. 2014. *Small Scale Beef Cattle Fattening Practices, On-Farm Performance Evaluation and Opportunities for Market Orientation in Western Hararghe Zone, Chiro District*. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.
- BoARD (Bureau of Agricultural and Rural Development). 2015. *Annual livestock extension report, Bonke Woreda, Gamo Gofa Zone*.
- BoFED (Bureau of Finance and Economic Development). 2015. *Annual Statistical Bulletin, Bonke Woreda, Gamo Gofa Zone*.
- CSA (Central Statistical Agency of Ethiopia). 2015. *Agricultural sample survey: Report on livestock and livestock characteristics*, 2 (573): 23.
- Daniel, T. 2008. *Beef Cattle Production System and Opportunities for Market Orientation in Borena Zone, Southern Ethiopia*. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.
- Denis, M., E. Zziwa, S. K. Mugasi and G. H. Laswai. 2015. *Characterizing beef cattle value chains in agro – pastoral communities of Uganda’s Lake Victoria Basin*. *Frontiers in science*, 5 (1): 1 – 8.
- Endeshaw, A. 2007. *Assessment on production system and marketing of goats at Dale district (Sidama Zone)*.

M.Sc. Thesis. Hawassa University, Hawassa, Ethiopia.

- Estefanos, T., Tesfaye, A., Feyisa, H., Gashaye, W., Tatek, W., Tesfaye, K. and Osho, T. 2014. Traditional cattle production in the highlands of Hararge: Case study of East and West Zones of the high lands of Harerge, Eastern Ethiopia. *Basic Research Journal of Agricultural Science and Review*, 3(12): 122-130.
- Feder, G. 1985. The Relationship between Farm Size and Farm Productivity: The Role of Family Labor, Supervision and Credit Constraints. *Journal of Development Economics*, 18(2-3):297- 313.
- Fikru, S. 2015. Assessment of Cattle Fattening and Marketing Practice in Harshin District of Somali Regional State, Ethiopia. *Journal of Advances Dairy Research*, 3 (2):137.
- Getahun, K. 2006. Effect of Urea Treatment and *Leucaena* (*Leucaenaleucocephala*) Supplementation on the Utilization of Wheat Straw by Sheep. M.Sc. Thesis, Haramaya University of Agriculture, Ethiopia.
- Gezu, T., Haftu K. and Sefa, S. 2014. Feed Resources and Constraints for Cattle Fattening in Lemo and Soro Woredas, Hadya Zone, Southern Ethiopia. *Global Journal of Animal Science, Livestock Production and Animal Breeding*, 2 (4): 119-125.
- Gurmessa, U and Daniel, T. 2013. Determinations of Agro-Pastoralists Participation in Cattle Attending Package at Fentale Woreda: The case of East Showa Zone, Ethiopia. *American Journal of Research Communication*, 1(8): 205 - 226.
- Habtemariam, K. 2000. Livestock Production, Household Food Security and Sustainability in Smallholder Mixed Farms: A case study from Kombolcha Woreda of Eastern Ethiopia. M.Sc. Thesis. Swedish University of Agriculture sciences, Uppsala.
- IGAD (Intergovernmental Authority on Development), 2011. The Contribution of Livestock to the Ethiopian Economy-Part II, IGAD Livestock Policy Initiative, Roy Behnke, Odessa Centre, Great Wolford, United Kingdom.
- Mekonnen, A., Haile, A., Dessie, T. and Mekasha, Y. 2012. On farm characterization of Horro cattle breeding production systems in western Oromia, Ethiopia. *Livestock Research for Rural Development*, 24 (100).
- MoA (Ministry of Agriculture of Ethiopia). 1996a. Fattening extension manual. MoA, Animal and Fishery Resource Main Department, FLDP (Fourth Livestock Development Project), Addis Ababa, Ethiopia. 83 pp.
- P. K. Sarma and J. U. Ahmed. 2011. An economic study of small scale cattle fattening enterprise of Rajbari district. *J. Bangladesh Agricultural University*, 9(1): 141–14.
- Seid, G. and Berhan, T. 2014. Assessment of Cattle Husbandry Practices in Burji Woreda, Segen Zuria Zone of SNNPRS, Ethiopia. *International Journal of Technology Enhancements and Emerging Engineering Research*, 2 (4):2347 - 4289.
- Sere, C., Ayantunde, A., Duncan A., Freeman, A., Herrero, M., Tarawali, S. and Wright, I. 2008. Livestock production and poverty alleviation-challenges and opportunities in arid and semi- arid tropical rangeland based systems. In: the proceedings of multi-functional grasslands in a changing world. pp: 19-29, XXI International Grassland Congress and VII International Rangeland Congress, China.
- Shewangizaw, W., Zekarias, B. and Tesfaye, A. 2014. Assessment of Cattle Fattening and Marketing System and Constraints Affecting Cattle Fattening in Central Southern Region of Ethiopia. *African Journal of Agriculture Research*, 9(41): 3050 – 30 55.
- Shitahun, M. 2009. Feed Resources Availability, Cattle Fattening Practices and Marketing System in Bure Woreda, Amhara Region, Ethiopia. M.Sc. Thesis. Mekelle University, Mekelle, Ethiopia. pp: 120.
- Takele, T. and Habtamu, L. 2009. Traditional Backyard Cattle Fattening in Wolaita: Systems of Operation and the Routine Husbandry Practice.
- Teshager, A., Belay, D. and Taye, T. 2013. Traditional Cattle Fattening and Live Animal Marketing System in Different Agro Ecologies of Ilu Aba Bora Zone, Oromiya, Ethiopia. *Global Veterinarian*, 10(5): 620-625.
- Umar, A.S.S., J.F. Alamu and O.B. Adeniji. 2008. Economic Analysis of Small Scale Cow Fattening Enterprise in Bama Local Government Area of Borno State, Nigeria. *Economic Journal*, 4(1):1–10.
- UNDP (United Nations Development Program). 2003. Oecussi–Ambeno Community Activation Program (OCAP). UNDP Timor–Leste Annex 8, August 2003.

Evaluation of the Effects of Concentrate Supplementation on Carcass Merits of Farta Sheep

Lemma gulilat¹, Endalew Walelign and Agraw Amane

¹Debre Tabor University, Department of Animal Science, P.O. Box 272

Abstract

The experiment was conducted at Debre Tabor University research center with the main objective of to evaluate the carcass merits of Farta sheep and to evaluate the effect of concentrated feed on carcass quality of Farta sheep fed on different concentrated mixture and hay as basal diet. The experiment was conducted using a randomized complete block design (RCBD) with five treatments and five replications. Blocking was based on the initial body weight of sheep. Twenty five Farta sheep with yearling age and average initial was 21.45 kg used for the feeding trial were randomly assigned to five treatments. The treatments were hay allow (T1), 100% wheat bran +basal hay (T2), 67% wheat bran and 33% NSC +basal hay (T3), 67% NSC and 33% wheat bran +basal hay(T4) and 100% NSC + basal hay. Feed offers and refusals for feeding trials were recorded daily, while body weight change of sheep during the feeding trial was recorded every fifteen days. The chemical compositions of the experimental feeds indicated that the NSC allow with basal diet was highest than (30.57%) other treatments and 66.7% wheat bran and 33.3% NSC (23.83%), 33.3% wheat bran and 66.7% NSC (29.20%) CP contents, respectively. Feeding of Farta sheep cows with NSC resulted in significantly ($p < 0.05$) lower daily dry matter intake (1.85kg/sheep, but higher daily weight gain (57.4g/day) when compared with those sheep fed on basal hay. Dressing percentage as proportion was greater ($P < 0.05$) for animals supplemented with 67.3% NSC and 33.7% (48.04%) of wheat bran with hay as basal diet (35.51%). The juiciness score of loin samples from NSC and wheat bran fed the 90% was higher ($p < 0.05$) than fed others treatments. Hence, according to the results of this study feeding of yearling Farta sheep with feed 66.7% wheat bran and 33.3% NSC and 33.3% wheat bran and 66.7% NSC was efficient for both biologically as compared to other treatments. For farther research we recommended that to determine the level of concentrated feed added in basal diet of yearling farta sheep for maximum body conformation.

Key words: yearling weight, ripe eye area, quality meat, carcass

Introduction

The domestic meat demand is believed to increase with increasing literacy and family income. Meat consumption is often an indicator of the economic status of a country or an individual. People with a higher social or economic status demand a greater amount of high-quality meat products. The per capita consumption of meat in developed/industrialized countries is much higher as compared to developing countries. Countries whose population consumes the least amount of meat are located in Africa and Asia (Ameha, 2008). In Ethiopia, the average annual meat consumption per capita is estimated to be 8 kg/year. Consumption of meat in the USA is 124 kg per capita per year (340 g/day) (Ameha, 2008).

Ethiopia has about 25.5 million sheep and meat production is the most important function of these animals in the country (CSA, 2013). There is high demand for live animals as well as meat from small ruminants by consumers in the Middle East and North and West African countries. There is also a high domestic demand for small ruminant meat, particularly during religious festivals (Tsedeke, 2007). The country exported 12,000 tons of small ruminant meat in 2005/6. The goal for ruminant meat export in 2008 is 30,000 tons, of which 33% is expected to be from small ruminants (Ameha, 2008).

The annual national mutton meat production is 77 thousand metric tons and about 30% is high average off-take rates estimated from sheep (Workneh, 2006). Sheep contribute some 21% of the total ruminant livestock meat output (Ameha, 2008). While contributing significantly to meat production in Ethiopia, present production levels of sheep are far below their potential. A major cause contributing to such low meat yield is that animals are commonly slaughtered at immature body weights, 18–20 kg for sheep and 16–18 kg for goats (Ameha, 2008).

The proximity of Ethiopia to consumers in Middle Eastern countries and their taste preference for our indigenous animals are advantageous for the Ethiopian meat export market (Ameha, 2008). However, the international market for meat is becoming increasingly competitive and meat traders must adopt improved practices in production, processing and packaging of meat to maintain and grow market share. Strict quality control measures to meet specific export-market demands also need to be implemented. Hence, considerable training and extension will be essential in assisting various stakeholders to meet market requirements and maximize the foreign exchange generated from the growing meat industry.

Hay is usually made from mixed pasture by farmers from September up to November in order to feed the animals including sheep at the time of feed scarcity from March up to July (BoARD, 2005). Hay in the central highlands of Ethiopia was harvested after the crude protein (CP) content of the pasture passed peak production and the protein content on dry matter (DM) basis was usually less than 5% (Kidanie, 1993). This was below the level of maintenance requirements for ruminants (Van soest, 1994). Then chemical compositions of hay harvested at North Gondar Wegera woreda was characterized by low CP (4.21%), high NDF (76.75%), and ADF (52.04%) on DM basis (Mulu, 2005). Thus, to improve the utilization of poor quality feed resources in ANRS, it is important to develop supplementation strategy using available agro-industrial by products.

Wide variability exists among Ethiopian small ruminant breeds with respect to potential growth rates and mature weight. Further, most Ethiopian breeds have undergone little selection for improved meat production and true breed potentials are not known. Horro rams have shown capability for post-weaning growth rates of approximately 150 g/day, which would enable them to reach a mature body weight of 45–50 kg at one year of age. Afar rams attain average mature body weights of approximately 40 kg, but post-weaning growth rates have been reported to be less than 100 g/day with supplementary feeding. The maximum post-weaning growth rate of Menz (small-sized breed) ram lambs under improved on-station management appears to be less than 100 g/day. The Awassi × Menz crossbred ram, however, was 40% heavier in yearling body weight under supplementary feeding than purebred Menz (Ameha, 2008). There are opinions that highland sheep meat is black in color but not supported by research and there is no any study about Farta sheep carcass. Hence, this study will be filling the gap of this and to generate full documents about this Farta sheep.

Objective of the study

To evaluate the carcass merits of Farta sheep

To evaluate the effect of concentrated feed on carcass quality of Farta sheep

MATERIAL AND METHODS

Description of the Study Area

The Experiment was conducted in Debre Tabor university research center, which is found in ANRS, South Gondar Administrative Zone. The site is situated at 11°40' North latitude and 38°00' East longitudes and at 2650 meter above sea level. The mean annual rainfall is 1570 mm and the mean minimum and maximum annual temperatures are 9.6 and 21.5°C, respectively (DoPED, 1997).

Experimental Ration and Ingredients

The feed ingredients was used in the formulation of the different experimental rations of the present study was wheat bran, noug seed cake, salt and hay. Chemical analysis was taking from representative samples of the ingredients and based on the analysis results, five treatment rations was formulated.

Experimental Animal Management

Age of the animals and breed was determined by looking their dentations and asking the information from the owners and phenotypic characteristics, respectively. The animals were adapted for 15 days at the site of the experiment in order to let the animals get accustomed to the specific environment and to observe their health situations. Health precautions and diseases control measures was taking throughout the experimental period. Before the commencement of the actual experiment, the experimental pens, watering and feeding troughs were thoroughly cleaned. A total of twenty five (25) yearling sheep similar body weight was randomly distributed to five dietary treatments. Animals were fed experimental diets for 90 experimental days. The sheep were fed *adlibitum* in individual pen and feeds were offer twice a day at 08:00 and 16:00 hours and water was available at all times throughout the experimental period.

Experimental Design and Treatments

The experiment was conduct in randomized complete block design (RCBD) for consisting five treatments. The experimental animals were blocked into five blocks of five animals based on initial live weight, which was determined by two consecutive weightings after overnight fasting. The animals were randomly assigned in each experimental treatment. The five dietary treatments that consist of different levels of concentrated feeds are shown as follow,

Table 1. Five dietary treatments that consist of different levels of concentrated feeds

T1 = grass hay alone
T2= Grass hay + 300gm wheat bran
T3= Grass hay+ 200 gm wheat bran +100 gm NSC
T4= Grass hay + 100 gm wheat bran + 200 gm NSC
T5= Grass hay+300 gm Noug Seed Cake

Measurement and Observation

Chemical analysis of feed ingredients and experimental rations

Representative Samples of treatment rations offered was taking at each mixing weighing in each day, bulked over throughout the experimental period for each treatment and sub-sample taken at the end

of the experiment. After weighing the ort for each replicate was mixed thoroughly and bulked per treatment, then small amount of samples was take every day, bulked over the experimental period for chemical analysis. Feed samples was analyzed for dry matter (DM), nitrogen (N), ether extract (EE), crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF) acid detergent lignin (ADL) and ash by employing the procedure of AOAC (2000).

Feed intake

A weighed amount of feed was offered twice daily 8:00 Am in the morning and 4:00 pm in afternoon. Orts were collect the next morning and weighed after removing external contaminants by visual inspection. For each replicate, the feed offered and refusal was recorded. The amount of feed consumed was determined as the difference between the feed offered and refused on DM basis.

Body weight measurement

The body weight measurement was taking at the beginning and with interval of 15 days up to end of the experiment weighed by balance for individual sheep. The mean daily body weight gain was determined at the end of the experiment as a difference between the final and initial body weight divided by number of feeding days.

Feed conversion ratio

Feed conversion ratio was determined as a ratio of the weight of feed consumed per carcass weight. The formula is as follows:

$$\text{Feed conversion ratio} = \frac{\text{Weight of feed consumed (g)}}{\text{Carcass weight (g)}}$$

Carcass evaluation

At the end of the feeding trial half of the experimental sheep were fasted for 12 hours and slaughtered. Animals were weighed immediately before slaughter. The blood were drained in to bucket and weighed. The head were detached from the body. The skin was flayed, fore and hind legs were trimmed off at the carpal and tarsal joints and weighed. After that internal contents of the gut were emptied and weight of the empty gut was recorded. The empty body weight was then determined as slaughter weight less gut contents. The hot carcass weight was estimated after removing weight of the head, thorax, abdominal and pelvic cavity contents as well as legs below the hock and knee joints. Rib eye muscle area was traced on transparency paper after cutting the vertebrae between the 12th and 13th ribs. The weights of both the edible and non-edible carcass components were recorded.

For sensory panel test (Smell, tenderness, juiciness and taste) meat from each cut was cooked for 70 minutes in a circulating water bath at 70°C temperature, then was cut in to small cubes, and offered to a panel of 6 evaluators. Each evaluator will score for each of the above parameters on their scale.

Partial budget analysis

The partial budget analysis involved the calculation of the variable cost of sheep, feeds and benefits gained from the result. Market prices of sheep was assess in Debre Tabor town animal market before the experimental sheep was purchase. In the analysis, the total return (TR) was determined by the difference between selling and purchasing price of sheep in each treatment after and before the experiment. The change of net income (ΔNI) was calculated by subtracting change of total variable cost (ΔTVC) from the change of total return (ΔTR):

$$\Delta NI = \Delta TR - \Delta TVC$$

The change in net income (ΔNI) was calculated as the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC):

$$\Delta NI = \Delta TR - \Delta TVC.$$

The marginal rate of return (MRR) measures the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC):

$$MRR = (\Delta NI) / (\Delta TVC).$$

Methods of data analysis

Analysis of variance (ANOVA) in using SAS 9.1.3 version of statistical software package used to analyze the data.

Result and Discussion

Chemical composition of experimental feeds

The chemical composition of different experimental feeds is shown in Table 2. The dry matter of basal diet in this experiment was contradictory to the DM content of 93.42% reported by Fentie Bishaw (2007). But it was in line with Aschalew and Getachew (2013) that reported 91.06%. The CP content of basal diet in this experiment disagrees with the CP content of 3.56% reported by Fentie Bishaw (2007) but was similar with Aschalew and Getachew (2014) reported 6.70% and Brihanu and Getachew (2013) reported 6.23%. The ADF of basal diet used in the current experiment was similar that reported by Aschalew and Getachew (2013) but less than 53.48 that reported by Fentie (2007) and greater than 45.33 that reported by Brihanu and Getachew (2013). But the ADL was almost similar that reported by Aschalew and Getachew (2013) and brihanu and Getachew (2013) and greater than Fentie (2007) repot 5.6.

Table 2. Chemical composition of different concentrated mixture in treatments

Chemicals composition of Offered feed	Treatment diet				
	T1	T2	T3	T4	T5
DM (%)	91.3	90.2	91.6	91.5	92.4
Ash (%)	6.34	5.34	6.62	7.96	7.91
CP (% DM)	7.2	17.16	23.83	29.20	30.57
NDF (% DM)	55.88	46.57	67.99	72.04	88.19
ADF (% DM)	48.95	28.93	28.12	28	31.66
ADL (% DM)	10.27	4.04	5.06	5.23	6.51

ADF= acid detergent fiber; NDF= neutral detergent fiber; ADL = acid detergent lignin

Dry matter intake

Dry matter intake (DMI) of yearling Farta sheep fed diet containing hay basal diet and different concentrate supplementation is presented in Table 2. The daily dry matter intake of yearling Farta sheep fed 100% NSC with basal hay was significantly ($P < 0.05$) lower than basal hay. This daily intake is shows as the basal diet because the concentrate neither was nor refused. Therefore, the intake of basal diet was reduced when concentrate added in the ration of yearling sheep. The intake of basal diet in the current experiments agrees with the report of Fentie Bishaw (2007). In the current experiment, the daily dry matter intake of basal diet was significantly lower than 540.5 g/h/day that reported by Fentie Bishaw (2007).

Table 3. Feed intake of Farta sheep fed different mixture of ingredients

Body weight	Treatment					Mean	P value
	T1	T2	T3	T4	T5		
Total Hay intake (kg/head)	177.79 ^a	175 ^{ab}	174.14 ^{ab}	169.42 ^b	166.9 ^b	172.65	0.03
Hay intake (kg/head/day)	1.97 ^a	1.94 ^{ab}	1.9 ^{ab}	1.88 ^b	1.85 ^b	1.908	0.04
Supplement intake (g/h/day)	0.00	300	300	300	300	240	0.76
Total DDMI (g/h/day)	394 ^c	688 ^a	680 ^{ab}	676 ^b	670 ^b	621.6	0.02

^{a, b} Means within a row with different superscripts are significantly different; Ns = no significant; * = significant at (P<0.05); TDMC = Total Dry Mater Consumed; DDMI = Daily Dry Matter Intake

Body weight change

The effect of concentrate supplementation on body weight change of Farta sheep is represented in Table 4. According to Ascalew and Getachew (2013) and Brihanu and Getachew (2013) for Farta and Ogaden sheep the daily body weight gain is increases when the concentrated level increased. In the current experiment was also increased when the concentrate level increased. There was significance difference in initial body weight and final body weight among treatments, and mean daily body weight gain of sheep fed diet consisting hay as basal diet was significantly (P<0.05) lower than other treatments. The result indicated that the daily body weight gain and feed conversion efficiency was increased when yearling sheep were fed concentrated feeds accordingly.

Table 4. Yearling sheep body weight change and feed conversion efficiency

Body weight	Treatment					Mean	P value
	T1	T2	T3	T4	T5		
Initial body weight (kg)	20	21.67	21.56	21.72	21.83	21.32	0.26
Final body weight (kg)	21.08 ^b	25.40 ^{ab}	25.83 ^{ab}	26.7 ^a	27 ^a	24.45	0.009
MDBWG (g)	1.2 ^c	41.4 ^b	47.4 ^{ab}	55.3 ^{ab}	57.4 ^a	23.45	0.04
FCE	0.93 ^b	1.1 ^a	1.12 ^a	1.04 ^{ab}	1.07 ^{ab}	1.03	0.001

^{a, b} Means within a row with different superscripts are significantly different; Ns = no significant; * = significant at (P<0.05); MDBWG = Mean Daily Body Weight Gain in Gram; FCE = Feed conversion efficiency

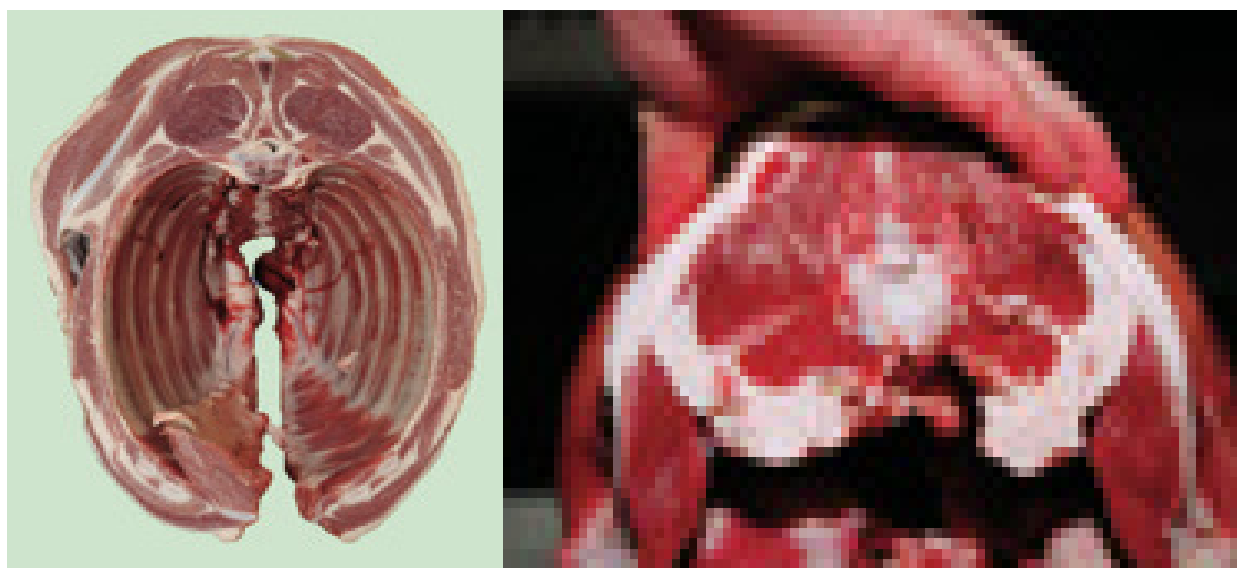
Carcass Components

In the current experiment the dressing percentage of the supplemented yearling sheep was greater numerically than the non-supplemented ones (Table 5) below. The pre-slaughter weight, hot carcass weight, and gut fill in this study appeared to be of no different among treatments but rib eye area was significantly different. Among the supplemented groups, there was no significant (P>0.05) difference in empty body weight, ribeye muscle area and dressing percentage as a proportion of slaughter weight. Dressing percentage as proportion was greater (P<0.05) for animals supplemented with 67.3% NSC and 33.7% of wheat bran with hay as basal diet.

Table 5. Carcass characteristics of Farta sheep fed on hay and different concentrated level

Carcass characteristics	Treatment					Mean	P value
	T1	T2	T3	T4	T5		
Pre-slaughter weight (kg)	22.5	26	26.5	26.25	27	25.65	0.196
Hot carcass weight (kg)	7.99	12	11.5	12.51	11.5	9.9	0.241
Dressing percentage (%)	35.51	46.15	43.4	48.04	42.59	38.48	0.406
Rib eye area (cm2)	11.25 ^b	12 ^{ab}	14.75 ^a	11 ^b	12.25 ^{ab}	12.25	0.027
TEOC (kg)	2.66	2.28	3.31	2.62	2.73	2.72	0.16

TNEOC (kg)	6.44	7.44	7.35	6.04	7.92	7.04	0.34
^{a, b} Means within a row with different superscripts are significantly different; Ns = no significant; * = significant at ($P < 0.05$); TEOC = total edible organ component; TNEOC = total none edible organ component							



Meat quality

Panelists rated their samples in well ventilated, partitioned booths, under red lighting. Panelists cleansed their palate between each sample with apple juice diluted 50% with filtered water, unsalted crackers and filtered room temperature water. Attribute ratings were electronically collected using eight-point descriptive scales for initial and overall tenderness (8=extremely tender; 1=extremely tough), juiciness (8=extremely juicy; 1=extremely dry), lamb flavour intensity (8=extremely intense lamb flavor; 1=extremely bland lamb flavor), off flavor intensity (8=extremely bland or none, 1=extremely intense off flavor). Flavor desirability and overall palatability were rated on an eight point hedonic scale, (8=extremely desirable; 1=extremely undesirable).

Initial tenderness was rated on the first bite through the cut surface with the incisors, juiciness was rated after eight chews with the molars, and flavor desirability was evaluated after 10 to 15 chews, lamb flavor and off flavor intensity between 10 to 20 chews and overall tenderness after 25 chews. At the end of each ballot, all panelists had the opportunity to comment on any off flavors or texture characteristics that were found in the samples.

High sensory scores (7 on a scale of 0 to 10) were recorded for all treatments (Table 6). These scores correspond well with previous sensory scores obtained by the same taste panel for bran with NSC fed normal feedlot diets (Webb *et al.*, 1997; 1999). The juiciness score of loin samples from NSC and wheat bran fed the 90% was higher ($p < 0.05$) than fed others treatments. Ilian *et al.* (1988) recorded the highest juiciness scores in meat from sheep fed a diet.

Table 6. Mean sensory attributes of yearling Farta sheep meat obtained from different feeds

Meat characteristics	Treatments					Mean
	T1	T2	T3	T4	T5	
Juiciness	80%	60%	60%	60%	60%	64
Tenderness	20%	20%	20%	20%	20%	20
Salty	0%	20%	20%	20%	20%	16

Partial budget analysis

The partial budget analysis for the feeding trial is presented in Table 7. The result of the partial budget analysis indicated that the gross financial margin or total return obtained in this trial was 272, 292, 306, 400 and 480 ETB/sheep for yearling Farta sheep fed on T1, T2, T3, T4 and T5 diets, respectively.

As it is indicated from the partial budget analysis in Table 7, yearling farta sheep fed on 100% of NSC (T5) returned a higher net income (251.9 ETB/sheep) as compared to the other treatments.

The net return from each treatment was 183.11, 102.4, 95.95, 181.44 and 251.9 ETB/head for T1, T2 T3, T4 and T5 respectively. The percent of marginal rate of return (MRR) was 61 and 133 for T4 and T5, respectively. Thus, it indicated that each additional unit of one ETB per body weight of sheep cost increment resulted in one ETB and additional 0.61 and 1.33 ETB benefit for T4 and T5, respectively. Yearling farta sheep fed on rice straw treated by effective micro- organism (T5) had the highest net income and MRR value (118.79 and 133%, respectively) as compared to the other treatment groups. Therefore, feeding of noug seed cake for yearling farta sheep had better economic benefits as compared to feeding of other diets.

Table 7. Partial budget analysis for Farta sheep and feed

Parameter	Treatments				
	T1	T2	T3	T4	T5
Purchasing price of sheep ETB/head	850	850	850	850	850
Hay consumed (kg/head)	177.79	175	174.14	169.42	166.9
Concentrate feed consumed (kg/head)	0.00	27	27	27	27
Total feed consumed (kg/head)	177.79	203	201.14	196.42	193.9
Cost of hay (ETB/head)	88.89	87.5	87.17	84.86	83.6
Cost of concentrate (ETB/head)	-	62.1	72.9	83.7	94.5
Total feed cost (ETB/head) (TVC)	88.89	149.6	160.07	168.56	178.1
Gross income (R) (ETB/head)	1122	1142	1156	1250	1330
Total return (TR) (ETB/head)	272	292	306	400	480
Net income (NI) (ETB/head)	183.11	142.4	145.93	231.44	301.9
Change of net income (Δ NI)	-	-40.71	-37.18	48.33	118.79
Change of total variable cost (Δ TVC)	-	60.71	71.18	79.69	89.21
MRR (Δ NI/ Δ TVC)	-	-0.67	-0.52	0.61	1.33

TVC = Total variable cost; TR = Total return; NI = Net income; Δ TVC = change of total variable cost; Δ NI = change of net income; MRR = marginal rate of return; ETB = Ethiopian birr's NR = net return

Conclusions and Recommendations

The chemical composition of the experimental feeds indicated that the basal diet of hay low CP (7.2%) content which is below the maintenance requirement of animals. The concentrate level of ration added in the basal diet increases its CP content. The NSC allows and hay had 30.57% of Cp as compared to T2, T3 and T4; this was increases the dressing percentage as compared to sheep fed hay allows. The daily mean body weight gain of animals fed on hay allows (23.1 g/h/day) was significantly lower ($p < 0.05$) than animals fed concentrated feed. The result of the feeding trial indicated that animals fed NSC allow with hay was higher ($p < 0.05$) daily dry matter intake (57.4g/h/day) as compared to other treatments. Hence, according to the results of this study feeding of yearling Farta sheep with feed 66.7% wheat bran and 33.3% NSC and 33.3% wheat bran and 66.7% NSC was efficient for both biologically as compared to other treatments. For farther research we recommended that to determine the level of concentrated feed added in basal diet of yearling Farta sheep for maximum body conformation.

Reference

- Ameha Sebsibe. 2008. *Sheep and Goat Meat Characteristics and Quality*. In: Alemu Yami and R.C. Merkel (Eds). *Sheep and Goat Production Handbook for Ethiopia*. Ethiopian Sheep and Goats Productivity Improvement Program (ESGPIP), Addis Ababa, Ethiopia. Pp. 323-328.
- ANRS (Amhara National Regional State), 2003. Rural household socio-economic survey of 56 Woredas in Amhara Region. Volume VIII. Livestock production February 2003. Bahir Dar. 46p.
- AOAC (Association of Official Analytic Chemistry), 1990. *Official Methods of the Analysis* 15th Ed. AOAC. Arlington, USA. 1298p.
- Aschalew Asefa and Getachew Animut, 2013. *Supplementation of Raw, Malted and Heat Treated Grass Pea (**Lathyrus Sativus**) Grain on Body Weight Gain and Carcass Characteristics of Farta Sheep*
- BoARD (Bureau of Agriculture and Rural Development), 2005. *Animal feeding strategy*. Amhara National Regional State. Bahir Dar. Ethiopia.
- BoARD (Bureau of Agriculture and Rural Development), 2005. *Sheep breeding improvement strategy*. ANRS .Bahir dar. CSA 2013. Central Statistical Agency of Ethiopia (CSA): the 2013 National Statistics.
- Brihanu Tessema and Getachew Animut, 2013. *Effect of Green **Prosopis juliflora** pod and noug seed cake (**Guizotia obissynica**) Cake Supplementation on digestibility and Performance of Blackhead Ogaden Sheep Fed Hay as a Basal Diet*
- Department of Planning and Economic Development, 1997. *Annual monitoring and evaluation report for South Gondar* (Unpublished).
- Girma A., Merkel, R. C. and Sahlu, T. 2000. *Enhancing food security and income generation potential of families in Southern Ethiopia through improved goat production and extension*.
- Kidanie Gebre Mariam, 1993. *Effects of cutting date on botanical composition and nutritive value of pasture in the central highlands*. An MSc Thesis presented to AU, Ethiopia. 105p
- Mulu Moges, 2005. *Effects of feeding different levels of breweries dried grain on live weight gain and carcass characteristics of Wogera sheep fed on hay basal diet*. An MSc Thesis submitted to the Department of Animal Science, School of Graduate Studies. Alemay University. June, 2005. Alemaya. 54p
- Tsedeke K. 2007. *Production and marketing of sheep and goats in Alaba, SNNPR*. Msc thesis, Hawassa University. Hawassa, Ethiopia.
- Van Soest, p. J., 1994. *Nutritional Ecology of Ruminants*. 2nd ed. Cornell University press. London. 476p.
- Workneh Ayalew. 2006. *Getting the Incentives Right: Concerns Associated with Expansion of Cattle Export Markets in Ethiopia*. *Eth. J. Anim. Prod.* 6(2): 99-103.

Evaluation of milk production performance of lactating Fogera cows fed with urea and effective micro-organisms treated rice straw as basal diet

Lemma Gulilat¹ and Endalew Walelign

¹Debre Tabor University, Department of Animal Science, P.O. Box 272

Abstract

The experiment was conducted at Andassa Livestock Research Center with the main objective of evaluating the milk production performance and feed intake of Fogera cows fed on rice straw treated by urea and effective micro-organisms (EMO) as basal diet. The experiment was conducted using a randomized complete block design (RCBD) with three treatments and three replications. Blocking was based on the initial body weight of cows. Nine Fogera cows with average age, parity, initial body weight and stage of lactation was 9.3 year, 4.4, 262.7kg and 53.1 days, respectively used for the feeding trial were randomly assigned to three treatments. The treatments were 67% wheat bran and 33% NSC from 2kg concentrate + untreated rice straw (T1), 67% wheat bran and 33% NSC from 2kg concentrate +urea treated rice straw (T2) and 67% wheat bran and 33% NSC from 2kg concentrate + rice straw treated by effective micro-organism (T3). Feed offers and refusals for feeding trials were recorded daily, while body weight change of cows during the feeding trial was recorded every fifteen days. The chemical compositions of the experimental feeds indicated that the untreated, urea treated and EMO treated rice straws had low (3.46%), highest (5.51%) and intermediate (4.48) CP contents, respectively. Feeding of Fogera cows with EMO treated rice straw resulted in significantly ($p<0.05$) higher daily dry matter intake (8.52 kg/cow, higher daily weight gain (27.7 g/day) and higher daily milk yield (2.82l/day) when compared with those cows fed on untreated rice straw. Furthermore, cows fed with EMO treated rice straw yielded the highest net income and marginal return rate (MRR) (82.6 and 194%, respectively). Hence, according to the results of this study feeding of lactating Fogera cows with EMO treated rice straw is efficient for both biologically and economically compared to urea treated rice straw.

Key words: effective microorganism, lactating cows, rice straw, milk yield, urea treatment

Introduction

Livestock in Ethiopia provide draught power; serve as source of income for farming communities, means of investment and important source of foreign exchange earnings. Of the total household cash income of farming community, livestock account for 37 to 87% in different parts of the country (Ayele *et al.*, 2003). The livestock population in Amhara National Regional State (ANRS) is estimated at 10.5 million cattle, 8.2million sheep and 5.1 million goats. Of the cattle population in the region, about 25,744 are believed to have indigenous and exotic blood (Eshete, 2007), which is only 0.25% of the population is exotic blood and the remaining vast cattle population of the country (99.75%) belongs to indigenous/local breed.

The Fogera cattle found in Fogera Woreda, South Gondar Zone, is used for milk, meat and draft power by smallholder farmers. They are known to have better performance in terms of milk yield, growth rate and tolerance to heat, parasitic burden and adaptability to marshy areas (Gebeyehu, *et al.*, 2004). The Fogera cattle is one of the 27 identified indigenous breeds (a Zebu x Sanga breed) in the country and is distributed in a plain around Lake Tana, northwestern Ethiopia (Gebeyehu, *et al.*, 2004). However, the population and productivity of Fogera cattle breed is declining due to shifting of grazing land in to rice cultivation, damage of grazing land by flood and lack of adequate feeds (Firew and Getnet, 2010).

In Fogera Woreda, rice straw is the most abundant livestock feed resource. But this straw has high fiber content and low digestibility and protein content (3.35%) (Teshome Derso, 2009). The treated low quality roughages have higher digestibility and crude protein than untreated roughages. According to AlemuYami (2008), farmers feed their high nutrient requiring animals, such as lactating or fattening animals treated low quality roughage by using different mechanism. Therefore, rice straw can be improved by using different treatment methods like urea and effective micro-organisms. The protein content of feed treated by mixing of different treatment; the mixture of EM contained treatment had highest protein content as compared to the others (Nassia.B. *et al.*, 2013). All the available evidences tend to indicate that EMO could safely and economically be included into animal feed. There is no environmental and public health hazard reported from the use of EM technology in animal feeding. There are experiments done on dairy cows using urea treated rice straw but no work is yet done using effective micro-organism. Hence this study was conducted with the objectives of evaluating the milk production performance and feed intake of Fogera cows provided with rice straw treated by urea and EMO and to compare the nutritive value and the economic benefits of urea and EMO treated rice straw.

Material and Methods

The study was conducted at Andassa Livestock Research Center which is located 11°4' N and 37°3' E and is located 19km from BahirDar. The minimum and maximum temperature was 22° and 30°, respectively with annual rainfall of 1300 mm. Before commencement of the experiment, all animals were dewormed for internal parasites and nine lactating cows with parity 4 and 5 and two weeks after calving were selected. The experimental cows were assigned to each treatment based on their initial body weight randomly and experimental cows were given experimental diets for 45 days including 15 days of adaptation and milk yield and feed intake was taken from each treatment for one month.

Experimental feed preparation

The urea treated rice straw was ensiled in polythene sheet with a capacity of 50-100 kg of urea treated rice straw. The ratio of water: urea: straw used was 100:5:100 kg as per the recommendation of Chenost (1995). The solution of urea and water was uniformly sprayed and mixed to properly incorporate the solution into the straw on batch bases with 100 kg of straw and water each with 5 kg of fertilizer grade urea. The duration of rice straw treatment was for 21 days. After 21 days, urea treated rice straw was provided for the cows based on their requirements (Misra *et al.* (2006).

For the preparation of effective micro-organism treatment, adequate quantities of an inert form of EM

(EM-1) packed in plastic bottles was obtained from Bahir Dar its branch of Weljijie PLC (Debrezeit). The procedure was chopped the rice straw within the 2-3cm length, prepared 1litter of inactive EM and molasses and 18 litter of water. Then the molasses, EM1 and water were thoroughly mixed to activate the microorganism. After stirring, the mixture (one liter of EMO) was inoculated into or sprayed over (50-70 kg) of rice straw. The mixed solution was finally incubate in an airtight container for microbial fermentation and multiplication and stored for 10 days in dark room with room temperature (Higa and Wididana, 2007).

Experimental design and treatments

The experiment was conducted by a randomized complete block design (RCBD) involving three treatments. The three treatment combinations were the following;

T1: 2kg of concentrate+ 3% their body weight untreated rice straw per day/head

T2: 2kg of concentrate+ 2.5% their body weight rice straw treated by urea per day/head

T3: 2kg of concentrate + 2.5% their body weight rice straw treated by EMO per day/head

Data Collection

Chemical composition of feeds

All samples of feed offered and refusals were analyzed for DM, N (Kjeldahl-N) and ash content according to AOAC (1990) procedures in Bahir Dar University, Engineering Faculty, and school of Food Technology. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by the methods of Van Soest *et al.*, (1991) in laboratory of international livestock research institute (ILRI) in Addis Ababa.

Milk yield and composition analysis

Half of the experimental cow's teat were hand milked twice a day (at 8:00 am in the morning and 4:00 pm in the evening), the left teat for the first fifteen days and right teat for the next fifteen days and the average daily milk yield per cow was calculated by multiplying the daily milk yield from half of the teat by two and milk yield measurements were taken by using graduated cylinder every day throughout the study period. The average daily milk yield of the individual lactating cow was determined dividing the total milk yield of experimental cow by the number of experimental days. Every fifteen days interval, 100 ml of milk samples were taken using a glass measuring cylinder for each cow after the completion of the adaptation period for chemical analysis. The milk samples were used to determine percentage of fat, protein and ash. Fat content of the milk was estimated using the Gerber analytical method and the formaldehyde titration method was used to determine the total protein content of milk (Van Soest *et al.*, 1991).

Animal's body weight

The body weights (BW) of animals were measured by using heart girth at fifteen days intervals throughout the experiment to determine BW change. Body weights were recorded for each lactating cow against its identification number on a weight registration notebook. The body weights of lactating cows were taken within fifteen days interval by overnight fasting. Body weight changes were determined as a difference between the final and initial body weight, where both measurements were taken as a sum of two consecutive weightings. The daily body weight gains (DBWG) were calculated as the difference between final BW and initial BW divided by number experimental days. The feed conversion efficiency of experimental animals was determined as the ratio of daily body weight gain to the amount of feed consumed for the total experimental days.

Feed intake

A weighed amount of feed was offered twice per day at 8:00 am in the morning and 4:00 pm in the afternoon. Orts were collected for the next morning and weighed after removing external contaminants by visual inspection. For each replicate, the feed offered and refusal were recorded. The amount of feed consumed was determined as the difference between the feed offered and refused on dry matter (DM) basis.

Partial budget analysis

The partial budget analysis was performed to evaluate the economic advantage of the different treatments by using the procedure of Upton (1979). The analysis involved the calculation of the variable costs of experimental milk, feeds and benefits gained from the result. At the end of the experiment, experienced milk dealers from Bahir Dar market estimated the selling price of experimental lactating Fogera cow's milk. In the analysis, the total return (TR) was determined by calculating the difference between selling and purchasing price of lactating Fogera cow's milk in each treatment at the beginning and the end of the experiment. The cost of feeds was computed by multiplying the actual feed intake for the whole feeding period with the prevailing prices. The partial budget method measures profit or losses, which are the net benefits or differences between gains and losses for the proposed change and includes calculating net return (NR), i.e., the amount of money left when total variable costs (TVC) are subtracted from the total returns (TR).

$$NR = TR - TVC$$

Total variable costs include the costs of all inputs that change due to the change in production technology. The change in net return (ΔNR) was calculated as the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC), and this is to be used as a reference criterion for decision on the adoption of a new technology.

$$\Delta NR = \Delta TR - \Delta TVC$$

The marginal rate of return (MRR) measures the increase in net income (ΔNI) associated with each additional units of expenditure (ΔTVC). This is expressed in percentage as:

$$MRR (\%) = (\Delta NR) / (\Delta TVC) \times 100.$$

Methods of data analysis

ANOVA for Feed intake, milk yield and composition was done using the GLM or Mixed model procedure in SAS or SPSS software version 9.0 and differences were considered statistically significant at either $\alpha=0.05$ or 95% confidence interval.

Results and Discussion

Chemical composition of experimental feeds

The chemical composition of different experimental feeds is shown in Table 1. The dry matter of rice straw treated by urea in this experiment was contradictory to the DM content of 95.5% and 69.1% reported by Teshome (2009) and Promma *et al.* (1993), respectively. But similar with Hany (2000) reported 91.5% DM content of rice straw. The CP content of rice straw in this experiment disagrees with the CP content of 7.6 reported by Promma (1993); this disagreement is may be due the stage of rice harvested and the time and season differences. But agree with the Cp content of 3.35% and 3.5% reported by Teshome (2009) and (Yuangklang *et al.*, 2009), respectively. The CP content of rice straw used in the current experiment is greater than the Cp content of 2.76% and 4.99% that reported by Parnich (1983) for untreated and urea treated rice straw, respectively. But the ADF of rice straw used in the current experiment was less than that reported by Parnich (1983) but the ADL was greater in the current finding. The fiber content of rice straw treated by effective micro- organisms was low as compared to untreated rice straw.

Table 1. Chemical composition of rice straw treated by EMO, urea and untreated

Chemicals composition of Offered feed	Treatment diet		
	T1	T2	T3
DM (%)	91.9	92.8	92.8
Ash (%)	18.2	23.3	21.3
CP (% DM)	3.46	5.51	4.98
CF (% DM)	32.1	15.7	10.5
NDF (% DM)	69.1	68.0	56.3
ADF (% DM)	43.7	46.1	41.0
ADL (% DM)	4.1	6.4	4.9

ADF= acid detergent fiber; NDF= neutral detergent fiber; ADL = acid detergent lignin

Dry matter intake

Dry matter intake (DMI) of lactating Fogera cows fed diet containing rice straw treated by effective microorganism and urea is presented in Table 2. The daily dry matter intake of lactating cows fed rice straw treated by EMO was significantly ($P<0.05$) higher than untreated rice straw. The intake of rice straw in the current experiments agrees with the report of Wanapat *et al.*, (2013). In the current experiment, the daily dry matter intake of urea treated and untreated rice straw was significantly greater than 5.65 kg and 4.91kg per day, respectively that reported by Parnicch (1983). But daily dry matter intake of urea treated rice straw reported by Wanapat (2013) was in line with the findings of this experiment.

Feed intake is a very important factor that determines the production of milk and body weight, in cows (McAinsh and Riise, 2005). The result of the present study indicates that the feed intake as well as milk production of lactating Fogera cows increased when the rice straw was treated by urea and effective micro-organism as compared to untreated rice straw.

Table 2. Feed intake and milk yield of Fogera cows fed untreated rice straw and treated by EMO and urea

Body weight	Treatment			SEM	SL
	T1	T2	T3		
TDMC (kg/cow)	190.2	239.33	255.47	13.4	Ns
DDMI (kg/cow/day)	6.34b	7.98ab	8.52a	0.15	*
MY (lt/Cow/day)	2.34 b	2.4ab	2.82a	0.007	*

^{a, b} Means within a row with different superscripts are significantly different; Ns = no significant; * = significant at ($P<0.05$); TDMC = Total Dry Matter Consumed; DDMI = Daily Dry Matter Intake; MY = milk yield

Milk production and composition

As we observed from the table 3 milk composition of lactating cow for feeding of urea treated rice straw had good protein content as compared to the remaining treatments. As we absorbed from the table the protein content of milk when an animal's fed urea treated rice straw was also high as compared to other treatments. This is the reason urea has nitrogen rich compound which contribute protein for milk and feed. The nitrogen content of lactating cow's milk for the current experiment was higher than 3.2% and 3.3% animals that fed untreated and urea treated rice straw, respectively reported by Wanapat (2013) and Thaintip (2013). The fat content of the current experiment was similar with the study of Hart (1992). However, the fat and protein content of milk which animal's fed urea treated and untreated rice straw was lower than that reported by Wanapat *et al.* (2013) and Hart (1992), on Holstein crossbred dairy cattle in Thailand and Buffalo in Australia, respectively.

Table 3. Chemical composition of milk used for different experimental treatments

Chemical composition	Milk		
	T 1	T 2	T 3
DM (%)	13.12	15.61	13.56
CP (% DM)	3.42	3.77	3.48
CF (% DM)	3.50	3.63	3.33
Ash (% DM)	0.70	0.73	0.75

DM = Dry Mater; CP = Crude Protein; CF = Crude fat;

Milk composition and production are the interaction of many elements within the cow and external environments (O'Connor, 1994). High milk yield of satisfactory composition is the most important factor ensuring high economic returns. If the composition of milk varies widely, its implication is that feed value and its availability as a raw material will also vary. Feeding of urea treated rice straw alone had given an extra milk yield of 1.16 kg in lactating animal per day in the study area, which is similar to 1-1.5 kg milk per day reported by Khan and Davis (1981) and Pedock *et al.* (1982). Similar results were also reported by Mesfin *et al.* (2009), and Getu (2006) indicating that cows fed urea treated teff straw and wheat straw respectively had significantly higher milk yield than non-supplemented crossbred cows. In the current experiment there was significant difference ($P < 0.05$) between the cows fed on treated and untreated rice straw taking groups of cows in milk yield. The effect of inclusion of effective micro-organism treated rice straw in lactating Fogera cow's daily milk yield is depicted in Table 2 and Figure 1. Milk yield of lactating Fogera cows that fed rice straw treated by effective micro-organism was significantly ($P < 0.05$) higher than untreated rice straw. Milk production in all treatments of the current experiment is similar with Teshome (2009). Different experiments showed that cows fed urea treated rice straw produced higher daily milk yields compared to cows fed untreated rice straw (Wanapat, 2013). The milk production depends on the intake of feed. Therefore, this experiment also indicated that the milk yield increased with the increment in dry matter intake of Fogera cattle.

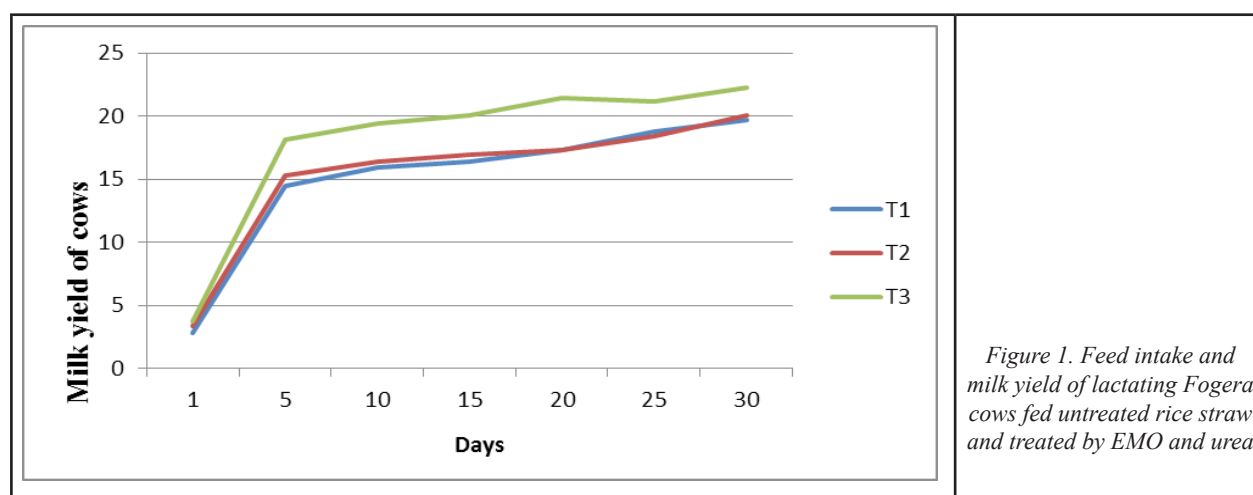


Figure 1. Feed intake and milk yield of lactating Fogera cows fed untreated rice straw and treated by EMO and urea

Body weight change

The effect of inclusion of rice straw treated effective micro-organism on body weight change of Fogera cows is represented in Table 4. According to Mukassa-Mugerwa (1989), lactating cows will probably lose weight after calving, but weight loss should be minimized through good feeding to allow them to start cycling again and to allow annual calving. During the early lactation (first three months after calving) all cows in the current study lost body weight, with a declining trend with advance in lactation. Requirements for the observed daily mean milk yield (2.31 kg/day) from this trial were not met at all levels of supplementation; but the estimated MEI requirement (63MJ/day) for maintenance and milk production of lactating dairy cow weighing 250 kg (average body weight of the experimental animals) and producing 4-6kg/day milk of 4.5% butter fat (ARC, 1990). The finding from this trial clearly supports this idea suggested by Preston and Leng (1986) that molasses or alkali treated straw

based diets are more digestible, but they support little improvement in animal productivity unless they are supplemented with bypass nutrients. There was no significance difference in initial body weight and final body weight among treatments, but mean daily body weight gain of cows fed diet consisting rice straw treated by EMO was significantly ($P<0.05$) higher than T1. The result indicated that the daily body weight gain and feed conversion efficiency was increased when lactating cows were fed rice straw treated by urea and effective micro-organism accordingly. The findings of this experiment contradicts with the findings of Teshome (2009), who reported reduced growth rate of lactating cows when fed with untreated rice straw unlike urea treated rice straw. This discrepancy could be due to the supplementation of 2 kg concentrate feed in this experiment for lactating cows which were fed on untreated rice straw. The other reason in this experiment could be the short experimental period; 30 days is not enough to evaluate the change in weight of the experimental animals.

Table 4. Animal body weight and feed conversion efficiency of different treatments

Body weight	Treatment			SEM	SL
	T1	T2	T3		
Initial body weight (kg)	262.0	245.33	254.67	11.1	Ns
Final body weight (kg)	262.4	245.95	255.5	11.1	Ns
MDBWG (g)	13.3 ^b	20.7 ^{ab}	27.7 ^a	4.7	*
FCE	0.069	0.086	0.108	0.02	Ns

^{a, b} Means within a row with different superscripts are significantly different; Ns = no significant; * = significant at ($P<0.05$); MDBWG = Mean Daily Body Weight Gain in Gram; FCE = Feed conversion efficiency

Partial budget analysis

The partial budget analysis for the feeding trial is presented in Table 5. The result of the partial budget analysis indicated that the gross financial margin or total return obtained in this trial was 411, 419, and 493 ETB/cow for lactating Fogera cows fed on T1, T2 and T3 diets, respectively.

As it is indicated from the partial budget analysis in Table 5, lactating Fogera cows fed on effective micro-organism treated rice straw(T3) returned a higher net income (234.33 ETB/cow) as compared to the other treatments .

The net return from each treatment was 194.25, 132.79 and 234.33 ETB/head for T1, T2 and T3, respectively. The percent of marginal rate of return (MRR) was 11 and 194 for T2 and T3, respectively. Thus, it indicated that each additional unit of one ETB per liter of milk cost increment resulted in one ETB and additional 0.11 and 1.94 ETB benefit for T2 and T3, respectively. Lactating Fogera cows fed on rice straw treated by effective micro- organism (T3) had the highest net income and MRR value (82.6 and 194%, respectively) as compared to the other treatment groups. Therefore, feeding of rice straw for lactating cows treated by urea and effective micro- organism had better economic benefits as compared to feeding of untreated rice straw.

Table 5. Partial budget analysis for lactating Fogera cows fed urea treated rice straw and EMO

Parameter	Treatments		
	T1	T2	T3
Purchasing price of milk ETB/cow	11.16	11.16	11.16
Feed consumed (kg/cow)	255.47	224.53	251.50
Rice straw consumed (kg/cow)	255.47	220.13	239.33
Total supplement consumed (kg/cow)	-	4.4	11.97
Labor cost ETB	25.5	27.70	31.48
Total feed cost (ETB/cow)(TVC)	216.99	286.37	259.51

Cost of rice (ETB/cow)	216.99	186.77	189.88
Cost of supplements (ETB/cow)	-	99.10	69.63
Gross income (R) (ETB/cow)	422.4	432.6	508.44
Total return (TR) (ETB/cow)	411.24	419.16	493.84
Net return (NR) (ETB/cow)	194.25	132.79	234.93
Change of net income (Δ NI)	-	7.92	82.6
Change of total variable cost (Δ TVC)	-	69.38	42.52
MRR (Δ NI/ Δ TVC)	-	0.11	1.94

TVC = Total variable cost; TR = Total return; NI = Net income; Δ TVC = change of total variable cost; Δ NI = change of net income; MRR = marginal rate of return; ETB = Ethiopian birr's NR = net return

Conclusions and recommendations

The chemical composition of the experimental feeds indicated that the untreated rice straw had low CP (3.46%) content which is below the maintenance requirement of animals. The urea treated had higher CP (5.51%) contents as compared to T1 and T3; this increases the production of milk as compared to untreated rice straw numerically. The daily mean body weight gain of animals fed on EMO treated rice straw (27.7g/ day) was significantly higher ($p < 0.05$) than animals fed untreated rice straw, but no significant difference was observed between the urea treated and untreated rice straw. The result of the feeding trial indicated that animals fed rice straw treated by effective micro-organism had higher ($p < 0.05$) daily dry matter intake (8.52 kg/cow/day) as compared to untreated rice straw. The total milk yield and daily milk yield of cows was significant differences ($P < 0.05$) higher in (T3) than (T1).

Lactating Fogera cows fed rice straw treated by effective micro-organism (T3) had the highest net income and MRR value as compared to the other treatment groups. Therefore, feeding of rice straw for lactating cows treated by effective micro-organism had better economic benefits as compared to feeding of untreated and urea treated rice straw. Hence, we recommended that, rice straw treated by effective micro-organism is higher than urea treatment in many aspects, like its effect on milk production, feed intake, and the aroma of the treated straw is also acceptable by the animals. In addition to this it is also economically profitable and hence we recommend effective micro-organism treated rice straw as an efficient way of treating rice straw. However, further on farm trial has to be conducted to verify the on-station findings of this experiment.

Reference

- Alemu Yami, 2008. *Nutrition and feeding of sheep and goat. Ethiopia sheep and goat productivity improvement program.*
- AOAC (Association Cofficial Analytic Chemists), 1990. *Official methods of analysis 15th ed, AoAC, inc. Arlington, Virginia, U.S.A. 1298p.*
- ARC (Agricultural Research Council), 1990. *The nutrient requirement of ruminant livestock. Common Wealth Agricultural Bureaux. Slough, England. UK.*
- Ayele Solomon, Assegid Workalemahu, Belachew Hurrisa, M. A. Jabbar and M. M. Ahmed, 2003. *Livestock*

marketing in Ethiopia: A review of structure, performance and development initiatives. Socio-economic and Policy Research Working Paper 52. ILRI (International Livestock Research Institute), Nairobi, Kenya. 35pp.

- Chenost, M. 1995. Optimizing the Use of Poor Quality Roughage through Treatments and Supplementation in Warm Climate Countries with Particular Emphasis on Urea Treatment. First Electronic Conference on tropical Feeds with Particular Emphasis on Urea Treatment. FAO, Rome.
- Eshete Dejen, 2007. Assessment of dairy beef development potential in Amhara region (presented at a workshop organized by SPS-LMM and Amhara Region Agricultural Research Institute). Bahir Dar, Ethiopia.
- Gebeyehu G, A .Tegegne, T. Mulugeta, A. Agide, 2004. Preliminary report on the distribution of Fogera cattle around Lake Tana, Ethiopia. Addis Ababa, ESAP. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia, 2004, 203-207.
- Getu Kitaw, 2006. Replacement of Formulated Concentrate Mix with Vetch (**Viciadasycarpa**) Hay to Lactating Crossbred Dairy Cows Fed on Urea Treated Wheat Straw. M.Sc. Thesis, Alemaya University.
- Hart.F.J, 1992. Physiology of digestion of urea treated rice straw in Swamp Buffalo. AJAS, 1992 Vol.5 (No.4) pp617-622
- Higa, T and G.N. Wididana, 2007.The Concept and theory of Effective Microorganism.
- Khan A K M N and Davis C H, 1981. Effect of treating paddy straw with ammonia on the Performance of local and cross bred lactating cows; In: Jackson et al (editors): Maximum livestock production from minimum land. Pp168
- Mesfin D, Seyoum B, Aemiro K, Getu K and Kedir N, 2009. On-farm evaluation of lactating crossbred (**Bostaurus x Bosindicus**) dairy cows fed a basal diet of urea treated teff (**Eragrostistef**) straw supplemented with escape protein source during the dry season in crop-livestock production system of north Shoa, Ethiopia. **Livestock Research for Rural Development Volume 21, Article 61**. Retrieved April 5, 2009,from <http://www.lrrd.org/lrrd21/5/deje21061.htm>
- Misra A K, Mehra U R and Dass R S, 2006. Assessment of feeding urea ammoniated wheat straw on growth performance feed intake and nutrient utilization in cross bred calves reared under stall fed or grazing condition. Livestock research for rural development. Volume, 18 No.11. Retrieved November 1, 2008, from <http://www.lrrd.org/lrrd18/11/misr18164.htm>
- Mukasa-Mugerwa, E., 1989.A review of reproductive performance of **Bosindicus** cattle. ILCA Monograph No. 6, Addis Ababa, Ethiopia
- Nasia Batool, Imtiaz Ahmad, Imdad Hussain and Muhammad Fateh, 2013. Mixing less palatable grasses with urea, molasses and effective microorganisms and its effect on chemical composition and digestibility in goats.
- O'Connor CB.1994. **Rural Dairy Technology**. ILRI Training Manual 1. ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. Pp133ParnichTinnimi, 1983.Urea-ensiledrice straw as a feed for cattle
- Perdock, H. B., M. Thamothaaram, J. J. Bloom, H. Van Den Born and C. Van Veliw,1982. Practical Experiences with Urea Ensiled Straw in Sirilanka. Maximum Livestock Production from Minimum Land. Pp. 123-134. Proc. of the Third Seminar Held at Bangladesh Agricultural Research Institute.
- Preston, T. R. and A. R. Leng, 1986. Supplementation of diets based on fibrous residues and byproducts. Pp.373-413. In: F. Sundstøl and E. Owens (eds.), Straw and Other Fibrous Byproducts as Feeds. Development in animal and veterinary sciences (The Netherlands), No.14.Elsevier science publisher BV, Amsterdam, The Netherlands.
- Promma, S. Jeenklum P.and Indratula T., 1993. Production responses of crossbreeding Holstein milking cows fed urea treated rice straw at three different fiber levels.
- Teshome Derso, 2009. On-farm Evaluation of Urea Treated Rice Straw and Rice Bran Supplementation on Feed Intake, Milk Yield and Composition Of Fogera Cows, North Western Ethiopia.
- Thaintip Kraiprom, Somkiert Prasanpanich, Phongthorn Kungmun1, Sour Sivijchai and Sornthep Tumwasorn, 2013. Effect of Fermented By-Product and Rice Straw on Milk Yield and Fatty Acid Composition in Dairy Cows
- Upton, M., 1979. Farm Management in Africa. The principles of production and planning.Oxford University Press, Great Britain. pp. 282-298.
- Yuangklang, C., Patipan, C., Wongnen, C., Vasupen, K., Wongsuthavas, S., Bureenok, S., Panyakaew P.and Khot-sakdee, J., 2009. Effect of rice straw type on nutrient digestion and rumen fermentation in buffalo.

PROCEEDING

Animal Breeding and Reproduction

- Van Soest, P.J., B.J. Robertson and B.A. Lewis, 1991. Methods For Dietary Fiber, Neutral Detergent Fiber, And Non-starch Polysaccharides In Relation To Animal Nutrition. *Dairy, Science* 74:3583-3597.
- Wanapat, M., Kang, S., Hankla, N. And Phesatcha, k., 2013. Effect of rice straw treatment on feed intake, rumen fermentation and milk production in lactating dairy cows. *African journal of agricultural research*

Evaluation of different feeding options for growing Fogera bulls to attain export market weight at Andassa Livestock research center

Tewodros Bimerow¹, Tekeba Eshetie, Asresu Yitayew, Mekonnen Tilahun, Zelalem Asmare, Tesfaye Alemu

¹ Andassa Livestock Research Center, P.O.box 27, Bahir Dar, Ethiopia.

Abstract

This study was conducted at Andassa Livestock Research Center. A total of twenty one Fogera growing bull at the age of two year with average initial body weight of 194.38 ± 6.20 were used for the study. All experimental bulls were randomly assigned to one of the three dietary treatments groups. For each three dietary treatments groups (T1, T2 and T3), two years old Fogera bulls were assigned throughout the experimental period until the animals were attained export market on average weight of 300kg. All experimental animals were individually fed with their corresponding rations for 21 days of adaptation period followed by a 150 days of experimental period. The amount of feeds provided for the experimental bulls were slightly increased based on the weight change of the bulls. On average 2.42 kg, 2.33kg and 2.41kg of mixed feeds were offered for animals kept under T1, T2 and T3, respectively. The result of the feeding trial shows that there is no statistically significance difference ($P > 0.05$) among the three dietary treatment groups (T1, T2 & T3) in final body weight gain of fattened bulls at 150 days of experimental periods. The result of the feeding trial shows that there is statistically significance difference between T3 and the rest of two treatments (T1 and T2) in average daily weight gain. Animals fed with T1 and T2 attained more average daily weight gain than animals fed with T3. On the other hand T2 attained 300kg of export market weight at 120 experimental periods where as T1 and T3 attained at 150 experimental periods. This shows that the feed conversion efficiency of animals categorized under treatment 2 is higher than treatment 1 and 3 groups. In this trial there is no significance difference in hot carcass and cold carcass weight among the three treatment groups fed with difference type of concentrate feeds. The net benefit of treatment 3 is the highest which is followed by T2 and T1, respectively. From this trial it was concluded that even if there is a significance difference in average daily gain of T1 and T2 with T3 there is no significance difference in final body weight (FBW) and total weight gain (TWG) among treatments. There is also no significance difference in all treatment groups in hot carcass weight, cold carcass weight, in primal cuts and carcass traits. Hence any fattener (commercial farmer or private investor) can use one of the three treatments groups based on the availability of feeds for fattening of growing Fogera bulls for export market weight gain of 300kg. But for better economic return any beef cattle fattener can use dietary treatment 3 and 2 for export market weight gain of 300kg.

Key Words: Fogera bulls, Basal diets, , Final body weight gain, carcass composition, net profit

Introduction

Ethiopia has the largest cattle population in Africa with an estimated of 52.1 million heads of animals (CSA, 2014/15). With their large number and diversity of products, cattle contribute more to the national economy than any other livestock species. They provide about 45% of all domestic meat consumption with small surplus which generates export income mainly from the sale of live animals. However, the earning from export of live animals and processed meat is very small as compared to the potential of the country.

To improve this scenario, various research activities have been undertaken in different parts of the country. The recent study on evaluation of feedlot performance of Fogera breeds at Andassa Livestock Research Center indicated that the Fogera cattle breeds have a better potential than High land zebu cattle breeds (Adebabayet al.). Looking for different feeding options for Fogera breeds to attain the desired market weight and carcass quality for growing bull age was not still studied. Cognizant of this fact, this study was carried out to generate feasible technologies to meet the required international market weight for Fogera grower bulls.

Objectives:

To evaluate different feeding options for grower bulls of Fogera cattle to attain the required market weight of 300kg.

To identify the most economical feeding system for grower bulls of Fogera cattle to attain the target weight

To evaluate the carcass characteristics of grower bulls of Fogera cattle under different feeding options

Materials and Methods

Location and Study Area Description

This study was conducted at Andassa Livestock research center. The center is found about 22 km south of Bahir Dar city on the road to Tis Abay. It is located 11°29'N latitude and 37°29'E longitude with an elevation of 1730 m above sea level. The area receives about 1434 mm of rainfall annually. The mean annual temperature vary from a maximum of 29.5°C in March to a minimum of 8.8°C in January.

Experimental animals and feeds

A total of twenty one Fogera growing bull at the age of two year were used for the study. Among these, ten Fogera growing bulls were selected from Andassa livestock research center's existing flock and the remaining eleven were purchased from farmers around Andassa. The purchased bulls from the farmers were entered at Andassa Livestock research center and then each experimental animal was kept in quarantine for about 15 days and treated for internal parasites by using Albendazole and for external parasite with accarcide. All experimental bulls were randomly assigned to one of the three dietary treatments groups. For each three dietary treatments groups (T1, T2 and T3), two years old Fogera bulls were assigned throughout the experimental period until the animals were attained export market on average weight of 300kg. However, due to health problems, one bull was died from treatment two at the middle of the experiment period. All experimental animals were individually fed with their corresponding rations for 21 days of adaptation period followed by a 150 days of experimental period.

The dietary feeds offered for experimental bulls during the whole experimental period were T1=Grazing +molasses 20% + wheat bran 55%+Noug seed cake23% +salt 2%; T2= Grazing + maize grain20% + wheat bran 60% +Noug seed cake 18% +salt 2%; T3= Grazing, molasses 15% +wheat bran 63% +Noug seed cake 20% +salt 2%. The chemical composition of each dietary treatment group is indicated in table 1.

Feeding of experimental animals

All 21 experimental growing bulls were randomly assigned for three dietary rations. After 21 days of adaption period, the amount of feeds provided for the experimental bulls were slightly increased based on the weight change of the bulls. On average 2.42 kg, 2.33kg and 2.41kg of mixed feeds were offered for animals kept under T1, T2 and T3, respectively. The ration was formulated to furnish 9.96 MJ of energy per kg of feed and to contain 18.2% total protein. Each dietary treatment was offered twice daily for the respective groups of animals, half in the morning and half in the afternoon, after 8 hours grazing. Refusal feeds from each treatment group were collected and weighed every morning before the daily feed allowance was provided for the bulls. Each animal assigned for three treatment groups were kept under treatment groups and supplemented with the respective dietary rations for a maximum of 150 days and then feeding of bulls were stopped when the experimental bulls attained the required export market live weight of 300kg. After three weeks of adaptation period, each animal was weighed using heart-girth measurement at the beginning of the experiment and fortnightly thereafter up to the end of the fattening period. Average daily gains (g/d) were calculated as differences between final and initial body weights divided by the total days of feeding period.

Carcass parameter evaluation

At the end of the experimental period, two fattened Fogera growing bulls were randomly selected from each treatment group and slaughtered at export abattoir at Bahir Dar town, ASHRAF. After the animals were slaughtered and skinned, all important internal organs of each bull such as kidney, heart, liver, lung, spleen, empty gut, heart fat, kidney fat, mesenteric and omental fat were eviscerated and measured. The rest hot carcass of the slaughtered bulls were dissected equally into right and left parts with the help of modern carcass cutting machine and weight of each right and left parts of entire carcass were taken before putting in to cold chill room at -4°C for about 24 hours. After this, the cold carcass of the bulls were taken out and weighted again to see the difference in weight between the hot and cold carcass of each treatment group. To evaluate the chilled carcass characteristics of bulls, the right parts of entire animals' carcass were cut between 12th and 13th ribs. Then the chilled carcass was cut into five major carcass parameters such as Leg, Loin, Rack, Breast & Shank, Shoulder & neck. Then to evaluate the difference in primal carcass cut, all the parameters were separately measured. From each primal carcass cut, muscle and fat were manually trimmed from the bone using knife. Finally all the carcass traits/ parameters of trimmed muscle and fat were separately measured.

Financial analysis of different feeding trials

All financial data used to calculate the profitability of fattening of Fogera bulls by using different feeding options were collected. Accordingly, all cost items used to conduct this experimental trial during the whole 150 days of fattening periods were collected. All variable costs such as purchase of experimental animals (animals used in the center for the trial current cost were initially estimated by the help of five professional people), feeds cost, labor and veterinary cost incurred to conduct this fattening trial for the above mentioned fattening periods were calculated. The gross output/ revenues of fattened bulls using three different treatment groups were estimated at the end of the fattening periods by the help of five professional people who had enough knowledge on marketing of fattened bulls.

In this cost items calculation, only gross margin of fattened grower Fogera bulls using different dietary treatment groups were calculated. Because of fixed cost did not include in this cost benefit analysis, the profit calculated here does not indicate net profit/ net loss. It only indicates gross margin of each fattened bulls using different feed trials. However, the opportunity costs of fattening these bulls were considered.

Statistical analysis

All live weight and carcass parameters of each fattened and slaughtered of bulls data was analyzed

using general linear model (GLM) of Statistical Analysis System (SAS 2000). The estimated least squares means were separated by the Duncan's Multiple Range Test at $P < 0.05$.

Result and Discussion

Growth performance

An experimental trial on two year age Fogera bulls fed with different feeding trials to attain 300kg of export market weight for a maximum of 150 days of fattening period was conducted at Andassa Livestock Research Center (ALRC). The weight change or gain of bulls during this period was recorded and the results were explained as flow. Growth performance or weight change of experimental bulls categorized under each three treatment groups and fed with different feeding trial for period of 21 weeks (150days) of fattening period was determined. Final body weight gain of experimental bulls for T1, T2 and T3 was indicated in table 1.

The result of the feeding trial shows that there is no statistically significance difference ($P > 0.05$) among the three dietary treatment groups (T1, T2 & T3) in Final body weight gain of fattened bulls at 150 days of experimental periods. This implies that the dietary treatment offered for all experimental bulls have similarity in nutritional value and had played the same roles to bring the animals to attain the required 300kg of export market weight.

Even if almost all experimental bulls had attained similar weight gain during the above listed fattening periods, animals fed with T1 (Grazing, molasses, wheat bran and Noug seed cake and salt) attained more total body weight gain than animals fed with T2 (Grazing, maize grain, wheat bran, Noug seed cake and salt) and T3 (Grazing, molasses, wheat bran, Noug seed cake and salt). Animals fed with treatment 2 also gained higher average daily weight gain than animals fed with treatment 3 (Figure1).

Table 1. Least squares means (+SE) and tests of significance of Growth performance experimental 2 years of Fogera bulls at 150 days fattening periods

Growth performance across experimental period	Treatments								Sig	CV
	Overall		T1		T2		T3			
	N	LSM±SE	N	LSM±SE	N	LSM±SE	N	LSM±SE		
IBW	21	194.38±6.20	7	188.57±10.74	7	192.71±10.74	7	201.86±10.74	ns	14.62
FBW 30 days	21	214.67±6.29	7	218.14±10.89	7	210.86±10.89	7	215.00±10.89	ns	13.43
FBW 60 days	21	235.00±5.61	7	235.57±9.71	7	234.86±9.71	7	234.57±9.71	ns	10.93
FBW 90 days	21	261.57±5.72	7	263.00±9.91	7	259.14±9.91	7	262.57±9.91	ns	10.02
FBW 120 days	20	288.50±9.47	7	278.00±16.01	6	304.17±17.80	7	285.57±16.01	ns	14.68
FBW 150 days	20	309.8±8.57	7	312.57±14.45	6	312.67±15.61	7	304.57±14.45	ns	12.34
TBWG	20	114.20±4.33	7	124.00±7.32	6	116.17 ±7.91	7	102.7±7.32	ns	16.96
ADWG	20	728.47±6.20	7	833.59±39.33 ^a	6	743.38±40.62 ^a	7	608.06±39.33 ^b	***	14.62

T1= Treatment one, T2= Treatment two, T3= Treatment, N= number of observation, FBW= final body weight, TBWG= total body weight gain, ADWG= average daily weight gain. Mean bearing different superscript letters with in the same row differ significantly ($P < 0.05$), SE=standard error

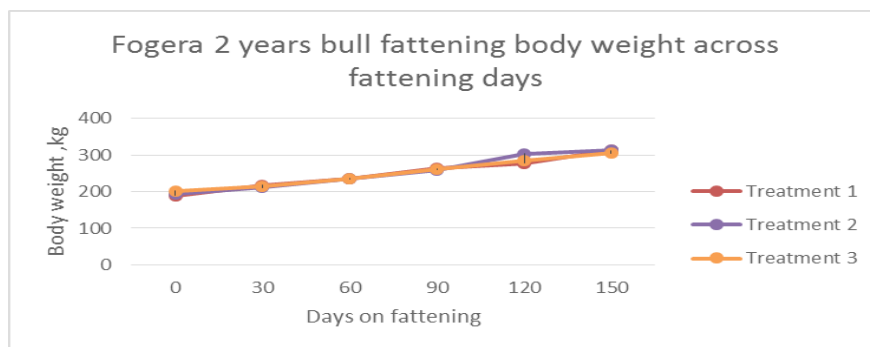


Figure 1. Final body weight gain of 2 year Fogera bull across the experimental period

The result of the feeding trial shows that there is statistically significance difference between T3 and the rest of two treatments (T1 and T2) in average daily weight gain (Table 1). Animals fed with T1 (Grazing, molasses, wheat bran and Noug seed cake and salt) and T2 (Grazing, maize grain, wheat bran, Noug seed cake and salt) attained more average daily weight gain than animals fed with T3 (Grazing, molasses, wheat bran, Noug seed cake and salt). This is due to that T3 has highest initial average body weight than T1 and T2 and also T1 and T2 had higher feed conversion than T3. On the other hand T2 attained 300kg of export market weight at 120 experimental period where as T1 and T3 attained at 150 experimental period. This shows that the feed conversion efficiency of animals categorized under treatment 2 is higher than treatment 1 and 3 groups.

In this experiment, animals fed with T1 groups had attained highest average daily weight gain at 30 days of fattening periods than 90,150, 60 and 120 days of fattening period, respectively. However, animals fed with T2 and T3 groups had attained highest average daily weight gain at 120 days of fattening periods than 150,90,60 and 30 days of fattening period, respectively (Figure2).

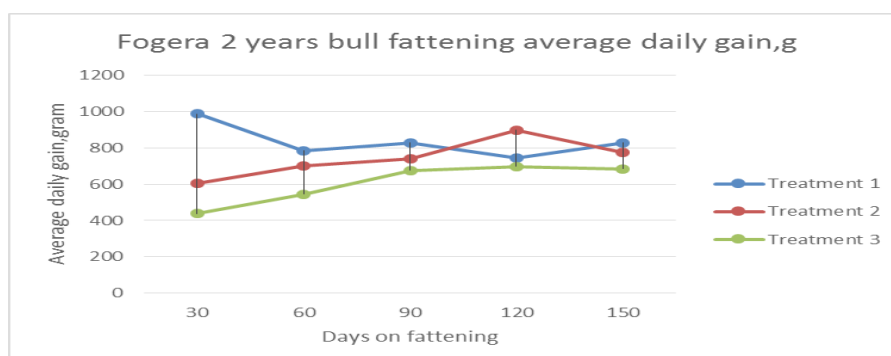


Figure 2. Average daily body weight gain of 2 year Fogera bulls across the experimental period

Dietary effects on carcass components

Mean carcass trait of Fogera growing bulls fed with three dietary treatment groups were indicated table 3. In this trial there is no significance difference in hot carcass and cold carcass weight among the three treatment groups fed with difference type of concentrate feeds. However, bulls received T1 had slightly higher hot carcass (78 kg) than animals fed with T2 (68.5 kg) and T3 (63.41kg). Similar trends were observed for heart, kidney, omental and mesenteric fat, fat thickness, rib eye area, hump and scrotal fat weight. This is similar to the findings of Mieso Guru et al. (2013) which indicated absence of significant difference in carcass component variables among Boran yearling bulls.

Table2. Least square mean $\pm$ SE of carcass yield traits and carcass composition for Fogera growing bulls

Traits	Treatments		
	T1	T2	T3
Hot carcass weight (kg)	78 ^a $\pm$ 9.9	68.5 ^a $\pm$ 2.12	63.85 ^a $\pm$ 2.12
Cold carcass weight (kg)	79.5 ^b $\pm$ 7.78	71 ^b $\pm$ 4.24	71.5 ^b $\pm$ 3.54

Heart fat (kg)	0.39 ^c ±0.07	0.37 ^c ±0.007	0.35 ^c ±0.007
Kidney fat	1.65 ^d ±0.35	1.45 ^d ±0.78	1.33 ^d ±0.58
Scrotal fat	1.02 ^e ±0.18	0.93 ^e ±0.18	0.9 ^e ±0.212
Omental& mesenteric fat (kg)	3.56 ^f ±0.18	2.03 ^f ±0.53	2.45 ^f ±1.27
Hump (kg)	3.98 ^g ±0.74	3.9 ^g ±0.35	3.7 ^g ±1.48
Back fat thickness(cm)	0.35 ^h ±0.07	0.3 ^h ±0.00	0.16 ^h ±0.06
Rib eye area (mm2)	57.5 ⁱ ±2.12	54 ⁱ ±0.00	46.5 ⁱ ±14.85

T1= Treatment one, T2= Treatment two, T3= Treatment. Mean bearing different superscript letters with in the same row differ significantly (P<0.05), SE=standard error.

Dietary effects on carcass primal cuts

Primal carcass cuts of yearling age of Fogera growing bulls fed with different feeding options are presented in table 3.

Table 3. Primal cuts of Fogera Growing bulls

Traits	Carcass part	Treatments		
		T1	T2	T3
Leg (Kg)	Bone	4.84 ^a ±.042	3.92 ^a ±0.31	4.12 ^a ±0.56
	Meat	19.86 ^b ±1.33	15.06 ^b ±2.01	14.17 ^b ±2.9
	Fat	2.16 ^c ±0.14	1.98 ^c ±0.34	2 ^c ±0.11
Loin (Kg)	Bone	1.11 ^a ±0.042	1.01 ^a ±0.13	0.85 ^a ±0.27
	Meat	2.86 ^b ±2.43	3.97 ^b ±0.89	2.76 ^b ±0.28
	Fat	1.05 ^c ±0.3	1.18 ^c ±0.3	1.21 ^c ±0.21
Rack (Kg)	Bone	2.75 ^a ±0.19	2.05 ^a ±0.44	1.38 ^a ±0.17
	Meat	6.12 ^b ±0.76	4.61 ^b ±0.35	4.79 ^b ±1.26
	Fat	1.21 ^c ±0.41	1.31 ^c ±0.75	1.52 ^c ±0.54
Breast & Shank (kg)	Bone	2.83 ^a ±0.42	2.75 ^a ±0.95	2.39 ^a ±0.18
	Meat	4.83 ^b ±0.33	4.36 ^b ±0.48	4.27 ^b ±0.042
	Fat	1.09 ^c ±0.27	1.69 ^c ±0.33	1.73 ^c ±0.24
Shoulder & neck (Kg)	Bone	4.83 ^a ±1	4.14 ^a ±0.113	3.36 ^a ±0.17
	Meat	16.12 ^b ±2.04	13.35 ^b ±0.014	12.18 ^b ±0.96
	Fat	1.78 ^c ±0.622	1.95 ^c ±0.24	1.5 ^c ±0.17

Although slight variations were observed among bulls fed different rations for bone weight, there was no significant difference for other different primal cuts of Fogera grower bulls. These results are similar to the report of Tesfaye Lemma et al. (2007) who indicated that there are no significant different among the bone proportion of Boran oxen fattened on different feeding management. Fat and lean meat weights for different primal cuts (legs, loin, rack, breast and shank and, shoulder and neck) did not differ among rations (Table 3). This result is similar to that reported by Tesfaye and Tesfa (2006) and Tesfaye Lemma et al. (2007), which indicate that there was no significant difference among beef quality parameters of Kereyu and Boran bulls respectively, finished on the similar rations for 90 days. Primal cuts of bulls finished on T1 had higher contents of bone, meat and fat. The lowest contents were observed for T3. This shows that there is positive relationship between rib eye area and amount of muscle in carcass.

Cost- benefit analysis of fattening of growing Fogera bulls

Adebabay et al. (2012) conducted study on Fogera breed beef fattening to determine profitable fattening

duration targeting local beef market. Export market, however, sets beef quality standards that could vary across destination countries. Young bull in a specific weight threshold is the necessary standard of the export market in most export destination countries. To attend the minimum slaughtered animal weight, the live weight of beef should not be less than 300 kg. The study had three treatments and the time taken to reach 300kg was different; animals under T2 reached 300kg within 120 days while the other two treatments took extra 30 days to reach 300kg live weight. The Partial budget is therefore analyzed by considering the benefit and cost of fattened beef exactly when it weighed 300kg. A gross benefit is the benefits generated from selling of fatten animal. The net benefits of cattle fattened using different feed composition was computed as gross benefits subtracted by total variable cost. Fogera growing bull can reach the required export market weight using the three feed rations without significant body weight gain variation. The net benefit among the three treatments is quite different. This is due to the variation of feed ingredients cost. Conducting treatment comparison based on net benefit is appropriate for feed treatment as long as the time horizon is the same. In this study, two time horizons were considered. Therefore, net profit is more informative than net benefit but it is difficult to capture all costs and benefits. The net benefit of treatment 3 is the highest which is followed by T2 and T1, respectively. It is straight forward that keeping young Fogera bull for 150 days by supplementing T3 feed ingredient has relatively large benefit but it does not show the level of profitability. If we consider the interest rate and capital depreciation for the extra 30 days and fattening rotation per year (4 times when they followed 120 days fattening duration), of course, the net benefit does not show change, while in terms of profitability T2 might have the chance to come first. The result implies that how two time horizon in partial budget analysis is puzzle to come up with a specific recommendation. The result tells that fattening operators can supply young Fogera bull beef by supplementing T2 feed ingredients for 120 days and T3 feed ingredients for 150 days to export market. Further study should be held to determine which fattening duration can generate more profit using a minimum one year on farm panel data in two groups (120 days fattening duration Vs 150 days fattening duration).

Table 4. Partial budget analysis of finishing Fogera growing bulls fed with three dietary feeds in (ETB).

Items	T1	T2	T3
Body weight	312.57	304.17	304.57
Gross benefits	5026.00	4808.29	5568.86
Total cost that vary	3621.56	3294.55	3533.34
Initial purchasing price	1985.71	1733.33	1885.71
Feed cost	1277.35	1256.90	1281.87
Labor cost	326.00	260.80	326.00
Veterinary cost	32.5	43.52	39.75
Net benefits	1404.44	1513.74	2035.52

Conclusion and Recommendation

From this trial it was concluded that even if there is a significance difference in average daily gain of T1 and T2 with T3 there is no significance difference in final body weight (FBW) and total weight gain (TWG) among treatments. There is also no significance difference in all treatment groups in hot carcass weight, cold carcass weight, in primal cuts and carcass traits such as heart fat, kidney fat, scrotal fat, omental & mesenteric fat, hump, back fat thickness and rib eye area. This implies that all the three dietary treatment groups had the same effect on growing Fogera bulls to gain 300kg of export market weight and carcass traits at 150 days of fattening periods. The economic analysis of different dietary treatment groups showed that all the three treatment are profitable for fattening growing Fogera bulls to obtain the required export market weight of 300kg at 150 days of fattening periods. Hence any fattener (commercial farmer or private investor) can use one of the three treatments groups based on the availability of feeds for fattening of growing Fogera bulls for export market weight gain of 300kg. But for better economic return any beef cattle fattener can use dietary treatment 3 and 2

for export market weight gain of 300kg.

Acknowledgement

We want to thank Ethiopia Institute Agricultural Research (EIAR) for funding this experiment. Lastly, also Yehanewe Agaze contributed in animal management and data record.

Reference

- AdebabayKebede, AddisuBitew, TewodrosBimrew, YihalemDenekew, AsresuYitayew, YeshwasFeredeand GetinetZelege, 2011. Comparative evaluation of the fattening potential of some selected cattle breeds of Amhara Region, Ethiopia. *Int. J. Pharm. Med. & Bio. Sc.* 2013. Vol. 2, No. 4
- CSA (Central Statistical Agency) (2014/15). Report on Livestock Resources of Amhara Region.
- Tesfaye Lemma, Tesfa Geleta, Amsalu Sisay and Tekle Abebe, 2007. Effects of four different basal diets on the carcass composition of finishing Borana bulls *Journal of Cell and Animal Biology* Vol. 1 (2), pp. 015-018, September 2007
- Tesfaye L, Tesfa G (2006). Carcass quality of Kereyu bulls on different finishing rations, 2006. In proceedings of 14th national conference of Ethiopian Society of Animal Production held 5-7 September, 2006, Addis Ababa, Ethiopia. (In press).
- SAS (2000). Users' Guide: Statistics (Version 8). SAS Institute Inc., Cary, NC

Effect of feeding thyme (*Thymus schimperi*) on feed intake, digestibility, carcass characteristics and sensory quality of meat of Arsi-Bale sheep fed a basal diet of barley straw

Mekuanent Baye ¹, Ajebu Nurfeta and Sandip Banerjee

¹Agarfa ATVET College

Abstract

The experiment was carried out using twenty-four male intact yearling Arsi-Bale sheep with average body weight of 17.61 (± 1.2) kg to evaluate the effect of supplementing thyme (*Thymus schimperi*) leaves on feed intake, digestibility, body weight gain, carcass traits and meat quality characteristics of Arsi-Bale sheep. The experiment consisted of ninety day growth experiment followed by a seven-day digestibility trial. Carcass traits and meat quality attributes of the experimental rams were evaluated at the end of the digestibility experiment. The experimental design was randomized complete block design, and animals were blocked based on their initial body weights and randomly assigned to the treatment diets. Dietary treatments comprised of 300g concentrate mix (33% linseed cake and 67% wheat bran) (T1), 250 g concentrate mix + 50 g thyme leaf (T2), 225 g

concentrate mix + 75 g/d thyme leaf (T3), and 200 g concentrate mix + 100 g thyme leaf (T4). Barley straw was offered *ad libitum*. The highest ($P<0.05$) total DM and organic matter (OM) intake of rams were observed for T2, while the lowest ($P<0.05$) was for T1 diets. Total DM and OM intake decreased with increased amount of thyme across the treatments ($T2<T3<T4$). The total CP intake decreased ($P<0.05$) with increasing levels of thyme leaf. The highest ($P<0.05$) DM digestibility was for T1, while the lowest ($P<0.05$) was for T4. The apparent digestibility of OM, CP and NDF was lower ($P<0.05$) for supplemented treatments compared with T1. Dressing percentage was higher ($P<0.05$) for T1, T2 and T3 compared with T4, but the values for T1, T2 and T3 diets were similar ($P<0.05$) among each other. Larger ($P<0.05$) rib eye muscle area was observed for T1 and T2 diets, while the lowest ($P<0.05$) was for T4 diet. There was no significant difference ($P>0.05$) in cooking loss and cooking yield of mutton between T1 and supplemented groups. The length of myofibril fragment of mutton was highest ($P<0.05$) for T2 and T3, whereas it was lowest ($P<0.05$) for T4, but the values for T2 and T3 were similar ($P<0.05$). The values of aroma and flavour intensity scores were higher ($P<0.05$) for supplemented treatments (T2, T3 and T4) compared with those fed on T1 diet. The highest ($P<0.05$) aroma intensity score was obtained for T4, while the lowest ($P<0.05$) was for T1. Mutton from the sheep fed on T1 diet had the highest ($P<0.05$) scores for tenderness and juiciness (4.3 and 4.3), respectively. Thus it can be concluded that, inclusion of dried thyme leaf at the levels of 50 g/d to barley straw basal diet to be better in terms of animal performance and nutrient utilization.

Keywords: Digestibility; carcass traits; meat quality characters; *Thymus schmperi*; Barley straw; Arsi-Bale sheep.

Introduction

Sheep production plays a vital role among all the livestock reared in Ethiopia. They are reared mainly important as source of income (from the sales of live animals) and also as a source of meat for household consumption. It was estimated that 29.33 million heads of sheep exist in Ethiopia (CSA, 2014). These are reared entirely under extensive production system which characterized by low productivity of the animals due to lower input in form of feed and other allied factors associated with the production system. The productivity of sheep is very low as mentioned by annual off-take rate of 33% and average carcass weight of 10 kg/head (CSA, 2010). The productivity is further influenced by scarcity of feed (inadequate amount and quality), genetic makeup of the animals and periodic occurrence of disease. According to Markos (2006), among the environmental factors, the major problem associated with poor animal (sheep) production in Ethiopia are inadequate supply both and quality and quantity of feed.

The major feed sources for sheep in Ethiopia are forage obtained from natural pasture, crop residues and stubble grazing (Solomon *et al.*, 2008). From the total supply of livestock feeds in Ethiopia, most of it are obtained from natural pasture, followed by crop aftermath and miniscule amount obtained from agro industrial by- products (CSA, 2010). Cereal crop residues play a major role in the feeding of sheep under different production systems (Jayasuriya, 1984). However, these feedstuffs are characterized by high content of indigestible fibre due to increased lignifications of cellulose. Fermentable energy and protein deficiencies in crop residues coupled with their low digestibility impair the ruminal functions, intake and ruminant productivity (Sarwar *et al.*, 2004).

Supplementing concentrates with poor-quality tropical forages is known to improve the feed intake and digestibility of roughages. However, the use of concentrates are limited especially under small-scale livestock production systems which is attributable to unreliable supply of concentrates which are in most of the times too expensive to be procured by the small holder farmers. Consequently, prospect for using cereal grains as a livestock feed by smallholder farmers are quite limited (Ajebu, 2010). Therefore, it is important to find alternative source of supplement which could easily obtained by local farmers without incurring additional cost. One such source of feed supplement could be inclusion of the leaves of thyme (*Thymus schimperi*) to the regular diet of the sheep especially reared in areas where the plant is easily available.

Thyme is a type of medicinal herb grouped under the *Lamiaceae* family (Mikaili *et al.*, 2010). Many species of the plant are classified under different genera of the family *Lamiaceae* and have been reported from different parts of the world. However, the two commonly available species endemic to Ethiopia are *Thymus schimperi* Ronniger and *T. serrulatus Hochst.ex Benth* while *Thymus vulgaris* is a species native to southern Europe (Asfaw, 2000). Thyme oil that has been reported to be grouped under top 10 of the essential oils accepted globally (Letchamo, 1995). The composition and amount of this essential oil is influenced by the season of harvesting (Atti-Santos *et al.*, 2004) and also several non genetic factors besides other agronomical reasons (Jordan *et al.*, 2006; Naghdi *et al.*, 2004). Thyme oil can be added in the diets of livestock to improve or alter rumen function as the naturally occurring compounds have a synergistic effect on the rumen micro flora (Paulson, 2008). The herb can also help in stimulating appetite and digestion in the animals besides it can also influence several other physiological functions that help to sustaining good health and welfare of the animals and thereby help in improving the performance of the animals (Afshar *et al.*, 2012).

In the study area, sheep are raised on natural pasture, fallow lands and crop residues, which are not quite sufficient to meet even the basic physiological/maintenance requirements and this often results in poor growth and production (Solomon *et al.*, 2008). Thyme naturally grows in the areas and thus the sheep are often seen to consume this plant alongside the conventional feed. It is conventionally said that the mutton from the locally reared Arsi-Bale sheep raised around the thyme growing area have some desirable flavour. As perceived by the residents of the area this unique and desirable flavour of meat is believed to be associated with the consumption of the thyme leaves by animals. Results from a study in the northern Ethiopia indicated that feeding thyme leaves promoted the feed intake, digestibility, growth performance and meat quality of the local sheep (Tewodros, 2011).

However, the supplementary value of this herb as a supplementary feed has not been well studied. Besides the effect of the supplementation of thyme leaves on the performance of sheep and its effect on the quality of the products obtained thereof too are yet to be studied. Therefore, this study was designed to assess the effects of supplementing thyme (*Thymus schimperi*) leaf on intake, body weight gain, and digestibility and carcass characteristics of Arsi-Bale sheep fed barley straw basal diet of barley straw

Materials and methods

Preparation of experimental feeds

The study was conducted at Agarfa ATVET College, Ethiopia. The experimental feed consisted of a basal diet of barley (*Hordeum vulgare*) straw linseed (*Linum usitatissimum*) cake, and wheat (*T. aestivum*) bran and thyme leaf as supplement. The concentrate consisted of 33 % of linseed seed cake, and 67 % of wheat bran on a DM basis, which were purchased from the local market and Robe flour milling factory, respectively. Barely straw was obtained from Agarfa ATVET college farm. The thyme leaves were hand plucked at the flowering stage. Branches and twigs were carefully removed manually and the leaves were dried under shade. The dried leaves were stored in sacks before mixing with concentrates.

Animals and their management

A total of twenty six yearling Arsi-Bale rams with an average initial body weight of 17.61 ± 1.2 kg were purchased from local market. Age of sheep was determined based on dentition. The animals were allowed an adaptation period of two weeks. During the adaptation period the animals were drenched with a broad spectrum anti-helmenthic (Albendazole) against internal parasites and sprayed with accaricide (diazinole) against external parasites. The experimental animals were placed in individual pens that were equipped with feeding trough and watering bucket. Animals were adapted to the experimental feed for 14 days before the commencement of the trials. The experiment consisted of growth phases of 90 days of feeding followed by 7 days of digestibility trial.

Experimental design and treatments

A randomized complete block design was used for the experiment. At the end of the acclimatization period, the animals were grouped in to three blocks of eight animals each according to their initial body weights and randomly assigned to the four treatment diets. The treatments comprised of different levels of concentrate mixes formulated according to the growth requirements of the sheep based on the recommendations of Agricultural Research Council (ARC, 1980) by considering their body weight and the expected weight gain. The concentrate mixture was comprised of wheat bran and linseed cake with the ratio of 2:1 on DM basis, respectively. The supplement feed was offered in two equal portions twice a day at 08:00 h and 16:00 h. The basal diet (barley straw) was offered *ad libitum* ($\approx 20\%$ refusal). The daily total supplements were limited to 300g DM. Thyme leaf supplement was incorporated with the amount of 33.3 %, 25% and 16.7 % of the total concentrate supplement for T2, T3 and T4, respectively. The treatments were as indicated in Table 1.

Table 1. Experimental treatments

Treatments	Barley straw (g/d)	Concentrate (g/d)	Thyme leaf (g/d)
T1	Ad libitum	300	-
T2	Ad libitum	250	50
T3	Ad libitum	225	75
T4	Ad libitum	200	100

Feed intake

The daily feed offered and refusal of each treatment diet was measured and recorded throughout the experimental period to assess the daily feed intake. Daily feed intake of the individual sheep was recorded as a difference between the feed offered and refusal. Samples of feed offered were collected from each treatment diets, samples of the refusals were taken for each individual sheep over the experimental period. Then the refusal feed were pooled over the experimental period and sub-sampled for analysis.

Weight change and feed conversion efficiency

Averages of two consecutive live weights were taken after overnight fasting to determine the initial weight of the animals. Body weight (BW) measurements were taken every 14 days after overnight fasting and daily BW gain was determined as a difference between final and initial BW divided over the feeding days. The feed conversion efficiency (FCE) was calculated as ratio of daily body weight gain to daily feed consumed.

Digestibility trial

After the completion of ninety days of feeding trial, a digestibility trial was initiated with the same animals and rations of the feeding trials. The digestibility experiment was conducted by keeping the animals in an individual pen permitting separate collection of faeces and equipped with feeders and water supplies. The animals were placed in their individual pen to which animals were adapted to the faecal bags for three days. Faeces voided were collected in the faecal bags over 24 hours period and for seven days the collected faeces were weighed every morning for each sheep. Ten percent of the voided faeces was sampled and pooled for each animal over the collection period. The faecal samples were stored at -20 °C over the seven days of collection period. After the seventh day, faecal samples were thawed at room temperature thoroughly mixed and sub-sampled and dried in an oven at 60 °C for 72 h and ground in Wiley mill to pass 1 mm sieve screen and kept in airtight containers until chemical analysis.

Carcass evaluation

At the end of the feeding and digestibility trial, three experimental animals from each treatment were fasted overnight. Slaughter weight (SW) was taken 30 minutes prior to slaughter. The animals were slaughtered following the standard procedures of USDA (1982). On slaughtering, the animals were killed by severing jugular vein and carotid artery with knife. The weight of the blood was estimated as a difference between the live weight and weight after bleeding. The oesophagus was tied to prevent the back flow of rumen content while suspending the animals for skinning. The skin was flayed carefully to avoid adherence of fat and muscle tissue to the skin, and was weighed. The empty body weight (EBW) was calculated as the difference between slaughter weight (SW) and gut content. Hot carcass weight (HCW) was determined by excluding contents of the thoracic, abdominal and pelvic cavities, head, skin, feet and tail of the animal. Dressing percentage (DP) was calculated based on the hot carcass weight (HCW) divided by SW and/or HCW divided by empty body weight (EBW). The rib-eye muscle area of each animal was determined by cutting perpendicular to the backbone between 11th and 12th ribs and tracing the left and right rib-eye muscles on butter paper Galal *et al.* (1979). The area was measured using portable leaf area meter (model LI- 3000 A). The mean of the right and left cross sectional areas were taken as a rib-eye muscle area measurement.

Mutton quality attributes

Meat samples of each treatment were collected after removing bone from flesh, cut into pieces of an average of 40 g and labelled for identification. Then the meat samples were cooked in distilled water at 65°C for 30 minutes (Fasae *et al.*, 2010). Cooking loss percentage was calculated as the difference between weight of meat sample before cooking and after cooking divided by pre-cooked weights of meat multiplied by 100 according to Fasae *et al.* (2010). The myofibril fragment length of mutton was assessed under a digital microscope with 40x magnification (Gallo *et al.*, 2009).

Sensory analysis of meat

Meat sample was taken from *L. dorsi* muscle and front leg for sensory analysis of their flavour, aroma, juiciness and tenderness. The analysis was made on cooked ram meat without salt or spices addition. For the attributes tenderness and juiciness, the foreleg was used whereas for all other sensory attributes the muscle *longissimus dorsi* (loin) was used. The meat was cooked over an electric oven at 165°C. The samples were immediately sliced into pieces of uniform dimensions (=50 g) labelled with 3-digit random numbers and randomly offered to the trained panel. The sensory quality of mutton was determined by developing sensory questionnaires to measure the intensity based on a 9-point hedonic scale (like extremely as 9, dislike extremely as 1) for the flavour and aroma and 5-point hedonic scale (very tender as 5, not tender as 1) for the tenderness and juiciness of cooked mutton meat as described by AMSA (1978).

The test panellist consisted of eight persons chosen from the college community who are familiar with meat characteristics and familiar with the consumption of mutton and were trained according to ISO 8586-1 (2012). There was training sessions using descriptors of flavour, aroma, tenderness and juiciness of cooked meat as reference. In the two first sessions, the tenderness, flavour, aroma and juiciness descriptors of raw and cooked lamb meat were studied; the next two sessions were concerned with identifying, selecting and quantifying attributes to evaluate the meat. The panellists were given orientation and instructed to rinse their mouth with clean water prior to testing each sample so as to avoid sensory bias. The panellists were asked to rate the meat samples based on their degree of likeness (acceptance of the meat samples) for each sensory attribute by giving scores ranging from 1- 9 for flavour and aroma and 1-5 for tenderness. Each panellist evaluated each meat sample from the different treatments for the described sensory attributes. Rating of meat samples for flavour, and aroma were done by giving numerical values as follows: like extremely (9), like very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2) and dislike extremely (1). Rating of tenderness and juiciness were done by giving numerical values as follows: very tender/juicy (5), moderately tender/juicy (4), just tender/juicy (3), less tender/juicy (2), not tender/juicy (1) (AMSA, 1978).

Chemical analysis

The samples were partially dried in forced draft oven at 60°C to constant weight for 48 hours. The dried samples were grounded to pass 1mm Wiley mill sieve size and labelled for easy identification. The chemical analysis was run in three replicates. Finally, dry matter (DM), ash and crude protein (CP) were determined according to the procedure of A.O.A.C. (1990). The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined using the detergent extraction method developed by Van Soest *et al.* (1991) with an ANKOM® 200 fibre Analyzer (ANKOM Technology Corp., Fairport, NY, USA).

Statistical analysis

Data generated on feed intake, digestibility, weight gain and carcass parameters were analyzed using the General Linear Model (GLM) procedure of the SAS (SAS, 2002). Treatment means were separated Duncan's multiple-range test. The statistical model used for the analysis of growth, feed intake digestibility and carcass parameters were:

$Y_{ijk} = \mu + t_i + b_j + e_{ijk}$, where Y = response variable; μ = the overall mean; t_i = i^{th} treatment effect (1, 2, 3, 4); b_j = j^{th} block effect (1, 2, 3); e_{ijk} = the random error.

The sensory score data was analyzed by the analysis of variance technique for CRD using the general linear model procedure of SAS (2002). Means separation was done using the least significant difference test when ANOVA showed presence of significant difference between treatment means. The model used for the analysis of sensory score data was $Y_{ij} = \mu + \alpha_i + e_{ij}$ where Y_{ij} = response variable; μ = the overall mean; α_i = the treatment effect; e_{ij} = the random error.

Results

Chemical composition of treatment feeds

The CP content of thyme was lower compared with that of wheat bran (Table 2). Linseed cake had the highest content of CP followed by wheat bran and thyme leaf meal. The cell wall content (NDF and ADF) was higher in both linseed cake and wheat bran compared to the thyme leaf meal. Among the supplement ingredient wheat bran contained the highest NDF and ADF.

Table 2. Chemical composition (% DM unless specified) of feed ingredients

Ingredients and treatments	Chemical composition				
	DM %	Ash	CP	NDF	ADF
Barley straw	94.4	10.1	4.8	77.1	50.1
Linseed cake	97.4	8.0	46.8	44.0	11.7
Wheat bran	95.6	3.6	18.5	47.4	12.6
Thyme	96.0	5.0	14.0	41.1	10.2

DM=dry matter; CP = crude protein; ADF = acid detergent fiber; NDF= neutral detergent fiber; T1= Straw ad libitum + 300g concentrate; T2= straw ad libitum + 250g concentrate + 50 g thyme leaf; T3= Straw ad libitum + 225g concentrate + 75g thyme leaf; T4= Straw ad libitum +200g concentrate +100g thyme leaf.

Dry matter and nutrient intake

The DM and nutrient intakes of Arsi-Bale sheep during the feeding trial are summarized in Table 3. Barley straw DM intake was significantly ($P<0.05$) lower for T1 than the supplemented groups. On the other hand, there was a declining trend in barley straw DM intake with increasing levels of thyme ($T2>T3>T4$) among supplemented group. Concentrate mix as well as the supplemental thyme leaves were readily consumed by all animals with no left over. The highest ($P<0.05$) total DM and OM intake of rams were observed for T2, while the lowest ($P<0.05$) was for T1 diets. Total DM and OM intake decreased with increased amount of thyme across the treatments ($T2<T3<T4$). The total crude protein intake decreased ($P<0.05$) with increasing levels of thyme leaf.

Table 3. Daily dry matter and nutrient intakes of Arsi-Bale sheep fed barley straw supplemented with different levels of thyme (*Thymus schimperi*)

	Treatments					
Parameter	T1	T2	T3	T4	SEM	SL
Dry matter intake (g/d)						
Straw	377.5 ^d	475.5 ^a	445.5 ^b	436.5 ^c	50.8	***
Supplement	288.6	288.6	288.3	287.4	2.71	NS
Total dry matter	666.1 ^d	764.1 ^a	733.8 ^b	723.9 ^c	50.8	***
Total nutrient intake (g/d)						
Organic matter	635.4 ^d	719.6 ^a	693.4 ^b	684.6 ^c	43.3	***
Crude protein	101.4 ^a	99.2 ^b	94.3 ^c	89.0 ^d	2.21	***
Neutral detergent fiber	399.2 ^c	474.3 ^a	445.1 ^b	440.9 ^b	42.2	***
Acid detergent fiber	434.7 ^a	283.2 ^b	260.4 ^c	254.5 ^d	31.0	***
Estimated ME (MJ/head/d)	8.25 ^b	8.10 ^b	8.74 ^a	8.02 ^b	4.52	***

^{a-d} means with different lowercase letters in the same row are significantly different *** $P < 0.001$; * $P < 0.05$; ** $P < 0.01$; SEM = standard error of mean; SL = significance level; ME (MJ/Kg) = $0.016 \times \text{DOMD}$; ADF=acid detergent fiber; NDF = neutral detergent fiber; ME = metabolizable energy; T1= Straw ad libitum + 300g concentrate; T2= straw ad libitum + 250g concentrate + 50 g thyme leaf; T3= Straw ad libitum + 225g concentrate + 75g thyme leaf; T4= Straw ad libitum +200g concentrate +100g thyme leaf.

Body weight change and feed conversion efficiency

The mean initial body weights (BW), final BW, average daily body weight gain (ADG) and feed conversion efficiency (FCE) are given in Table 4. The daily weight gain for T1 was greater ($P<0.05$) than T3 and T4, whereas T2 had an intermediate value. The highest ($P<0.05$) feed conversion efficiency was obtained for T1, while the lowest ($P<0.05$) was for T3 and T4, but the values between T3 and T4 were similar ($P<0.05$).

Table 4. Body weight gain of Arsi-Bale sheep fed barley straw supplemented with different levels of thyme (*Thymus schimperi*)

Parameter	Treatments				SEM	SL
	T1	T2	T3	T4		
Initial body weight (kg)	17.50	17.67	17.67	17.60	1.20	NS
Final body weight (kg)	24.33	24.17	23.33	23.20	1.46	NS
Total weight change (kg)	6.83 ^a	6.50 ^{ab}	5.67 ^b	5.6 ^b	0.82	*
Average daily gain (g)	75.93 ^a	72.22 ^{ab}	62.96 ^b	62.22 ^b	9.14	***
FCE (g BWG/ g DMI)	0.114 ^a	0.095 ^b	0.086 ^c	0.087 ^c	0.01	***

^{a-c} means with different lowercase letters in the same row are significantly different *** $P < 0.001$; * $P < 0.05$; ** $P < 0.01$; SEM = standard error of mean; SL= significance level; NS = not significant level; FCE=Feed conversion efficiency; BWG=Body weight gain; DMI=Dry matter intake; T1= Straw ad libitum + 300g concentrate; T2= straw ad libitum + 250g concentrate + 50 g thyme leaf; T3= Straw ad libitum + 225g concentrate + 75g thyme leaf; T4= Straw ad libitum +200g concentrate +100g thyme leaf.

Dry Matter and Nutrient Digestibility

The apparent digestibility coefficients of DM and nutrients for Arsi-Bale sheep fed barley straw as a basal diet supplemented with thyme leaf at different level are given in Table 5. The highest ($P<0.05$) DM digestibility was for T1, while the lowest ($P<0.05$) was for T4. The apparent digestibility of OM, CP and NDF was lower ($P<0.05$) for supplemented treatments compared with T1. The NDF and ADF digestibility for T1 was greater ($P<0.05$) than T3 and T4, but the values for T3 and T4 were similar ($P<0.05$) among each other.

Table 5. Dry matter and nutrient digestibility coefficient of Arsi- Bale sheep fed barley straw supplemented with different levels of thyme (*Thymus schimperi*)

Digestible coefficients	Treatments				SEM	SL
	T1	T2	T3	T4		
Dry matter	0.65 ^a	0.63 ^{ab}	0.61 ^{bc}	0.60 ^c	0.05	***
Organic matter	0.72 ^a	0.70 ^b	0.69 ^b	0.69 ^b	0.04	**
Crude protein	0.89 ^a	0.87 ^b	0.82 ^d	0.83 ^c	0.02	***
Neutral detergent fiber	0.66 ^a	0.62 ^b	0.59 ^c	0.59 ^c	0.04	***
Acid neutral detergent	0.63 ^a	0.60 ^{ab}	0.59 ^b	0.57 ^b	0.08	**

^{a-c} means with different lowercase letters in the same row are significantly different *** $P < 0.001$; * $P < 0.05$; ** $P < 0.01$; SEM = standard error of mean; SL= significant level; T1= Straw ad libitum + 300g concentrate; T2= straw ad libitum + 250g concentrate + 50 g thyme leaf; T3= Straw ad libitum + 225g concentrate + 75g thyme leaf; T4= Straw ad libitum +200g concentrate +100g thyme leaf.

Carcass Characteristics

The mean values for pre-slaughter weight (SLW), empty body weight (EBW), hot carcass weight (HCW), dressing percentage and rib-eye area of the experimental sheep are given in Table 6. The pre SW and EBW were similar ($P>0.05$) among treatments. Hot carcass weight (HCW) and dressing

percentage on SW and EBW base were higher ($P<0.05$) for T1, T2 and T3 compared with T4, but the values for T1, T2 and T3 were similar ($P<0.05$) among each other. Larger ($P<0.05$) rib eye area was observed for the rams reared on T1 and T2 diets, while the lowest was for those fed on T4 diets.

Table 6. Main carcass characteristics of Arsi-Bale sheep fed barley straw basal diet supplemented with different level of thyme (*Thymus schimperi*)

Parameters	Treatments				SEM	SL
	T1	T2	T3	T4		
Slaughter body weight (kg)	23.33	24.00	22.67	22.33	1.12	NS
Empty body weight (kg)	17.03	17.40	16.76	17.80	0.44	NS
Hot carcass weight (kg)	9.72 ^a	9.85 ^a	9.48 ^a	7.92 ^b	1.63	**
Dressing percentage						
Slaughter weight Basis (%)	41.76 ^a	41.06 ^a	41.80 ^a	35.47 ^b	0.50	**
Empty weight Basis (%)	57.07 ^a	56.61 ^a	56.50 ^a	53.52 ^b	1.34	*
Rib eye area (cm ²)	10.74 ^a	10.78 ^a	9.73 ^b	8.23 ^c	0.002	***

^{a-c} means with different lowercase letters in the same row are significantly different *** $P < 0.001$; * $P < 0.05$; ** $P < 0.01$; SEM = standard error of mean; SL= significance level; NS = not significant level; T1= Straw ad libitum + 300g concentrate; T2= straw ad libitum + 250g concentrate + 50 g thyme leaf; T3= Straw ad libitum + 225g concentrate + 75g thyme leaf; T4= Straw ad libitum +200g concentrate +100g thyme leaf.

Mutton quality and sensory attributes

The cooking loss, cooking yield, fiber fragment length and sensory attributes of meat of sheep supplemented with different levels of dried thyme leaf are given in Table 7. The values of aroma and flavour intensity scores were higher ($P<0.05$) for supplemented treatments (T2, T3 and T4) compared with those fed on T1 diet. The highest ($P<0.05$) aroma intensity score was ($P<0.05$) obtained for T4, while the lowest ($P<0.05$) was for T1. On the other hand, the values increased with the increased level of thyme leaf in the diets. The lowest ($P<0.05$) flavour intensity score was observed for T1, while the highest ($P<0.05$) was for T3 and T4, but the values for T3 and T4 were similar ($P<0.05$) among each other.

The values of tenderness intensity score was ($P<0.05$) highest for T1, while it was lowest ($P<0.05$) for T3. Mutton tenderness intensity score decreased ($P<0.05$) with the increasing level of thyme leaf in the diets. The highest ($P<0.05$) values of juiciness intensity score was observed for T1 and T2, while the lowest ($P<0.05$) was for T3, but the values for T3 and T4 were similar ($P<0.05$) among each other.

There was no significant difference ($P>0.05$) in cooking loss and cooking yield of sheep meat between control and supplemented groups. However, the length of myofibril fragment of mutton was highest for T2 and T3, whereas it was lowest ($P<0.05$) for T4, but the values for T2 and T3 were similar ($P<0.05$).

Table 7. The effect of Thyme (*Thymus schimperi*) supplementation on mutton quality sensory attributes of meat of Arsi-Bale sheep

Parameters	Treatments				SEM	SL
	T1	T2	T3	T4		
Aroma	6.1 ^c	7.3 ^b	7.8 ^{ab}	8.1 ^a	0.77	***
Flavour	5.9 ^c	7.0 ^b	8.0 ^a	8.3 ^a	0.77	***
Tenderness	4.3 ^a	3.5 ^b	3.3 ^{bc}	2.6 ^c	0.68	**

Juiciness	4.3 ^a	4.3 ^a	3.4 ^b	2.5 ^c	0.78	**
Cooking loss (%)	20.73	15.28	25.26	28.42	16.3	NS
Cooking yield (%)	79.27	84.72	74.74	71.58	16.3	NS
Myofibril diameter	0.770 ^{ab}	0.944 ^a	0.833 ^a	0.543 ^b	0.12	*

^{a-c} means with different lowercase letters in the same row are significantly different *** $P < 0.001$; * $P < 0.05$; ** $P < 0.01$; SEM = standard error of mean; SL= significance level; NS = not significant level; T1= Straw ad libitum + 300g concentrate; T2= straw ad libitum + 250g concentrate + 50 g thyme leaf; T3= Straw ad libitum + 225g concentrate + 75g thyme leaf; T4= Straw ad libitum +200g concentrate +100g thyme leaf.

Discussion

Chemical composition of experimental feeds

The observed CP content of barley straw in the current study was lower than the values (5.4 % CP) reported by FAO (1977). However, the CP content of barley straw in the present study was higher than the results (4.4%) of Seyoum and Zinash (1989). However, the CP content of barley straw in the current study was comparable with the findings (4.66%) of Neamn *et al.* (2014). The difference as observed can be attributed to the varietal differences as have been stated by Mc Donald *et al.*, (1995). The CP content of barley straw in the current experiment was not quite sufficient to support the optimum activity of microorganism in the rumen as have been noted by Van Soest (1994). Therefore, in order to meet the basic maintenance requirements concentrate supplementation is required (McDonald et al., 2002). Similarly, Hadjipanayiotou and Morand-Fehr (1991) reported that feeding energy concentrates with barley straw cover the maintenance requirement of Awassi sheep.

According Lonsdale (1989), the CP content of wheat bran varies from 13.3 to 17.0 %. The result of the current study was comparable at the higher end of the above mentioned ranges, which may be ascribed to the method of processing and also to the varietal differences as noted by Haska *et al.* (2008). Moreover, the CP content of wheat bran used in this experiment was comparable with the results (17.5 % and 16.9 %) of Neamn *et al.* (2014) and Mulugeta and Gebrehiwot (2013), respectively.

The study showed that the results of CP contents of thyme (*Thymus schimperi*) in the current experiment was higher compared with the result (7.2 %) of Tewodros (2011) for *Thymus serrulatus* and the result (9 %) of Ali (2014) for *Thymus Vulgaris*, However, the results of ash (5.0 %), NDF (41.1 %) and ADF (10.2 %) contents of thyme (*Thymus schimperi*) in the current study were lower than the results (ash 10.4 %, NDF 65.8 % and ADF 52.0 %) reported by Tewodros (2011). The difference in the two studies might be due to difference in the season and method of harvesting and drying method of the supplement. Results of chemical analysis revealed that the CP values of the ration decreased as the level of thyme in concentrate mix increased. This is because of the lower CP contents of thyme compared to that of the concentrate mix.

Dry matter and nutrient intake

The higher DM intake of barley straw for sheep receiving thyme supplemented ration (T2, T3, and T4) might be attributed to the lower nutrient content of thyme compared with concentrate feed. This may be attributed to a natural habit of increasing the intake of feed to meet the basic nutrient requirements, the observation was in accordance with those of Firisa *et al.* (2013) who reported that the DM intake was higher (in comparison to the non supplemented group) in Horro lambs supplemented with *Vernonia amygdalina* leaves. Contrary to the current study, Takele and Getachew (2011) indicated that there was no significant difference on DM intake of hay between supplemented and non supplemented groups of sheep, which may be attributed to the type of feed offered and the quality of the hay in the basal supplement. While, the others noted that basal DM intake was highest in diets without any supplementation when compared to the sheep receiving *Acacia alibidae* and *Acacia seyal* leaves as supplements Neamn *et al.* (2014).

Tewodros (2011) reported that the total DM and OM intake of sheep which received the thyme supplements were higher than those of the non-supplemented group which is consistent with the current experiment. The higher DM and OM intake of sheep reared on T2 diet could be associated with synergistic effect of feeding the thyme leaf supplements with that of the basal diet and concentrate,

the observations are in close accordance with those of Khamisabadi *et al.* (2015) who concluded that addition of thyme and peppermint at a concentration of 3% of forage per diet increased the feed intake of lambs, while at a higher dosage the palatability of the supplementary feed may have decreased which adversely influence the intake of the feed as a whole. Similar observations too have been reported by Lital *et al.* (2004) where they observed decreased intake of feed with increased inclusion of thyme leaves in the diet which they ascribed to a relatively higher content of thymol which may give an unpleasant taste and flavour to the feed thereby desisting the sheep from consumption of the feed. Similarly, Michiels *et al.* (2012) stated that while inclusion of thymol can stimulate feed intake at lower dosage and its bitter and chemo-receptor activation may depress feed intake at higher levels of inclusion in the feed (Westerhold, 2013).

In the current study, the decrease in CP intake with the increase in thyme level in the ration might be due to the lower CP content of the thyme leaves compared to those of the concentrate, the finding was in close accordance with those of Tewodros (2011) who reported that the CP intake was higher in Menz sheep supplemented with concentrate mix when compared to those receiving the supplementary feed. Consistently, in another study Manh *et al.* (2012) observed that when the levels of eucalyptus (*Camaldulensis*) leaf meal supplementation increase across the treatment, the CP intake decreased. Contrary to the current result, the level of CP intake among the supplemented sheep was positively correlated with the level of supplementation (Bahrn, 2014, Kefyalew, 2013).

Body weight change and feed conversion efficiency

Performance of animal is the effects of several synergistic factors and also depend on the type of feed it receives and also on the combination and concentration of the different nutrients. These influence the overall intake, digestibility, and metabolic efficiency of absorbed nutrients (Minson, 1990). The higher average daily gain and feed conversion efficiency for T1 might be due to the higher CP intake compared with supplemented groups. The findings are in consonance with the work of Tewodros (2011) who reported that the total average daily weight gain (ADG) of Menz sheep receiving 300g/d concentrate were higher than the sheep receiving *ad libitum* hay alone, 200g/d concentrate + 100g/d thyme and 100g/d concentrate + 200g/d thyme. Contrarily, to the present findings the findings of Feleke *et al.* (2011) indicated that the total ADG of sheep receiving control diet were lower than sheep fed in graded levels of moringa (*Moringa stenopetala*) leaf meal. The average daily gain results of the current study was comparable with the results (60.60 - 63.67 g) of Bahrn (2014) for Horro yearling lambs supplemented with 60 % cassava leaf meal and 40 % concentrate mix at 300 g DM/d. However, average daily gain in the current study was higher than the results (29.6 - 46. 4 g) of Dereje (2014) for sheep fed in tagasaste (*Chamaecytisus palmensis*) forage.

Dry matter and nutrient digestibility

In the current study, the lower apparent DM digestibility coefficient for T4 could be due to the lower CP content of the ration and the presence of thyme leaf at higher level in the ration. This could be due to the existence of thyme oil which might have antagonistic property on the rumen microflora. The observations were in close accordance with those of Evans and Martin (2000) who noted that thymol influences energy metabolism of rumen bacteria which can reduce the overall nutrient digestion and also total volatile fatty acid (VFA) production when added at higher doses. Findings of a result by Alsaht *et al.* (2014) indicated that digestibility of fiber decreased by 35 % at higher dose (1,600 mg/d) of thymol added to the diet of growing lamb fed concentrates vis-a-vis those of lambs raised on non-supplemented diet. The findings from the current study are also in consonance with the work of Tewodros (2011) who reported lower DM digestibility among the lambs reared on 100 g thyme and 200 g concentrate ration when compared to the lambs fed in 200g thyme and 100 g of concentrate ration. However, the findings of the present study are not in accordance with those of Neamn *et al.* (2014) who reported that the dry matter and nutrient digestibility improved after the inclusion of *Acacia albidiae* and *Acacia seyal* leaf meal. Consistently, Firisa *et al.* (2013) also observed that DM digestibility of Horro sheep improved with the increased levels of *Vernonia amygdalina* leaves and sorghum grain (33% *vernonia amygdalina*; 67% sorghum grain).

The DM digestibility for the feeds used in the present study decreased linearly with increasing levels of thyme leaves which is in accordance with the findings of Manh *et al.* (2012) for cattle fed with eucalyptus (*Camaldulensis*) leaf meal with rice straw as basal diet. However, the results of DM digestibility in the current study was higher than the results (57.3- 58.3 %) of Bahrn (2014) for sheep fed cassava leaf meal and significantly higher than the results (46.0 - 60.0 %) of Berhanu *et al.* (2014) for Washera sheep supplemented with *Millettia ferruginea* leaf meal fed on natural pasture grass hay, while it was lower than the results (68.58 - 77.75 %) of Sultana *et al.* (2014) for goat fed different levels of Moringa foliage (*Moringa oleifera*). The variation of apparent DM digestibility among different experiments might be associated with the presences of limiting factor that hinders DM digestibility as have been noted by Berhanu *et al.* (2014).

The higher apparent CP and NDF digestibility for T1 compared with the rest of supplemented group in the current study might be the higher CP content of the diet. The observation was not in close accordance with those of Berhanu (2014) who reported that the CP digestibility was lower in non - supplemented group compared with the rest of *Millettia ferruginea* (Birbra) supplemented groups. In the present study, the higher digestibility of NDF for T1 compared to those fed on supplemented ration which is not consistent with the finding of Gerencser *et al.* (2003) who observed no significant differences on the digestibility of ADF and NDF by substitution of 3% thyme leaves for rabbits fed on alfalfa meal. This may be attributed to the species of thyme used in the preparation of the leaf meal. The study by Manh *et al.* (2012) too indicated that supplementation of eucalyptus (*Camaldulensis*) leaf meal had no significant effect on apparent digestibility of NDF and ADF among dairy cattle fed on rice straw as a basal diet. The differences as observed may be due to the effect of thymol which depresses the intake of feed because of it being less palatable and also that it may disrupt the normal rumen micro flora thereby depressing growth.

Carcass characteristics

In the current study, the higher carcass weight observed for T1, T2 and T3 diets may be due to the higher carcass and the lower empty body weight obtained for each corresponding treatments. Similar observations were reported by Berhanu *et al.* (2014) who indicated that the high dressing percentage was observed for those sheep fed on 450 g/d of concentrates when compared to the sheep raised on similar amount of *Millettia ferruginea* (Birbra) supplementation. However, the results were not similar to those of Bahrn (2014) who observed lack of significant differences among the treatment groups when the sheep were reared on cassava supplemented diet. Moreover, the results of this study were also not in line with those of Kefyalew (2013) who observed that the hot carcass weight and dressing percentage were lower among the sheep receiving tomato pomace supplemented diet.

In the present study, the decrease in hot carcass weight and dressing percentage with increasing thyme level in ration could be associated with the lower CP content of thyme when compared to the concentrate diet. The observations are in agreement with those of Papi *et al.* (2011) who reported improvement in dressing percentage with increasing levels of concentrate in the diet of different animal species. The improvement in dressing percentage may be attributed to better muscular development among the sheep reared on high protein diet. The observations are in close accordance with those of Pittroff *et al.* (2006) who noted that weight change and organ mass of finishing lambs improved when they are fed on high protein diet. Studies by Jabbar and Anjum (2008) also indicated that high level of concentrate in the diet also improved dressing percentage in lambs. Tewodros (2011) observed that hot carcass weight and dressing percentage were higher for sheep receiving lower dosages of thyme (100 g thyme + 200 g concentrate) diet when compared with sheep fed on diet containing 200 g thyme + 100 g concentrate.

The higher dressing percentage observed for sheep receiving T1, T2, and T3 diets compared to those reared on T4 diet might be due to the higher carcass weight which may be associated with the higher nutrient digestibility. This might have resulted in higher ADG and HCW among the sheep receiving T1, T2 and T3 diets as compared to those reared on T4 diet. McDonald *et al.* (2002) stated that, nutrition, age, sex, genetics, season and other related factors affect the growth and carcass traits of animals. The mean dressing percentage on slaughter weight and empty body weight observed in the current

study is comparable with the result (33.3 - 42.0%) of Tewodros (2011) for sheep fed different levels of thyme. The dressing percentage in the current experiment is higher than the result (31.7 - 33.9%) of Berhanu *et al.* (2014) for sheep fed in *Millettia ferruginea* foliage supplementation but lower than the result (44.21- 44.76 %) of Bahran (2014) for sheep fed in cassava leaf supplementation. The lower dressing percentages as observed may be attributed to the lower slaughter weight of sheep which is in agreement with those of Preston and Willis (1974) who stated that dressing percentage increased with live weight increase till a point at which it tended to cease.

Rib eye muscle area is related to development of muscle (*L dorsii*) in the carcass and higher lean/bone ratio (Wolf *et al.*, 1980). In the present study, The larger Rib eye muscle area as observed for sheep raised on T1 and T2 diets might be attributed to the higher CP content of ration compared with other thyme leaf supplemented ration. Consistently, Yilkal *et al.* (2014) observed that lower value of Rib eye muscle area was obtained in non-supplemented sheep probably be due to the lower CP and higher NDF value of the hay. The observed Rib eye muscle area in the current study was higher than the results (4.9-10.7 cm²) of Tewodros (2011) when Menz sheep was fed a basal diet of hay supplemented with dried thyme leaf but lower than the results (10.57-10.89 cm²) of Bahran (2014) in Horro sheep supplemented with cassava leaf.

Mutton quality and sensory attributes

In the current study, the non significant differences in cooking loss and cooking yield of mutton across all dietary treatments could be due to relatively similar water - holding capacity of mutton. The observations agreed with those of Osório *et al.* (2009) who stated that the amount of juices that is released from cooked meat depends on water holding capacity, pre-concentration of collagen at 65-70°C and denaturation of protein. Findings by Asslyng *et al.* (2003) too indicated that water is probably lost due to denaturation of heat sensitive protein during cooking of meat, which causes less water to be trapped within the protein structures held by capillary force. Consistently, Abdel - aal and Suliman (2008) also reported that lack of difference in cooking loss and cooking yield of mutton for sheep supplemented with different levels of *leucaena* hay and Bello and Tsado (2014) for sheep supplemented with varying levels of dried poultry dropping.

The greater length of myofibril fragments of mutton for sheep receiving T2 and T3 diets might be due to the greater myofibril sizes of muscle obtained from those lambs. This indicates mutton from the sheep raised on T2 and T3 diets was less tender than those reared on T1 diets. This might be because meat tenderness is inversely related with muscle myofibril length; the finding was in close accordance with those of Hopkins *et al.* (2005) who noted that meat tenderness varies mainly due to changes of the myofibrillar protein structure of muscle in the period between animal slaughter and meat consumption. Similarly, Gallo *et al.* (2009) reported that myofibril length of lambs was greater for those fed in concentrate diet than pasture supplemented diet.

The pleasant aroma and intensified flavour of mutton obtained from sheep reared on supplementary diet may be attributed to the deposition of aromatic constituents of thymol in the muscles. The findings are in accordance with those of Naser (2007) who reported that most of the plants having aromatic and medicinal properties imbibe their flavour in the meat and also within intramuscular fat. Consistently, studies by Young *et al.* (1997) indicated that the intensity of flavours in mutton may be attributed to the smell of volatile compounds that are found in fat. The results also agreed with that of Tewodros (2011) who also reported that the intensity of aroma and flavour enhanced with an increase in the levels of supplementation of thyme. The levels of tenderness and juiciness were low in thyme supplemented group and lowest in lambs which received the highest supplementation. This may be attributed to higher fat deposition inside the muscle (marbling) resulted from higher nutrient concentration of concentrate compared with supplemental leaf meal as noted by Turner *et al.* (2003). Consistently, Ameha (2008) who also stated that deposition of fat among the muscle fibers (marbling) as the animal grows and matures on a high energy ration can improve tenderness.

Similarly, Priolo *et al.* (2002) pointed out that meat tenderness could be affected either through direct effect of the fat which is softer than lean and/or by an indirect effect of reduced muscle fiber length. Contrarily, to the present findings, Arsenos *et al.* (2002) reported lack of significant difference

in tenderness score values of mutton between lambs reared based on pasture and concentrate diets. Moreover, findings of a study by Bello and Tsado (2014) observed lack of significant difference in meat tenderness score between the sheep fed on sorghum stover and those supplemented with dried poultry dropping.

The higher Juiciness scores in the mutton of sheep raised on T1 and T2 diets compared to those receiving T3 and T4 could be associated with a relatively higher firmness and intramuscular fat deposition (marbling) of mutton resulted from higher concentration of nutrients among those treatment diets. The observation are in close accordance with those of Carpenter (1962) who noted that firmness in meat is associated with a rigid structure, high juice retention, and limited losses of fluid during processing or cooking. However, the presence of intramuscular fat deposits can increase apparent firmness without actually influencing fluid retention. Similarly, Hocquette *et al.* (2010) also stated that that intramuscular fat positively influences flavour, juiciness, tenderness and/or firmness and the overall acceptability of meat.

Thus it can be concluded that inclusion of *Thymus schimperi* at 50 g as part of concentrate mix can be recommended for sheep feeding.

Acknowledgement

The first author thanks Agarfa Agricultural, Technical Vocational, Educational and Training College for providing facilities necessary for the research work.

References

- Aaslyng, M. D., Bejerholm, C., Ertbjerg, P., Bertram, H. C., Andersen, H. J. 2003. Cooking loss and juiciness of pork in relation to raw meat quality and cooking procedure. *Food Quality and Preference* 14: 277-288.
- Abd El-aal1, H.A., Suliman, A.I.A., 2008. Carcass traits and meat quality of lamb fed on ration containing different levels of leucaena hay (*Leucaena leucocephala* L.). *Biotechnology in Animal Husbandry* 24 (3-4): 77-92.
- Afshar, M., Syed, A.S. and Hasan, F., 2012. Some of thyme (*Thymus vulgaris*) properties in ruminant's nutrition. *Annals of Biological Research* 3(2):1191-1195.
- Ajebu Nurfeta. 2010. Feed intake, digestibility, nitrogen utilization and body weight change of sheep consuming wheat straw supplemented with local agricultural and agro-industrial by-products. *Tropical Animal Health and Production* 42:815-824.
- Ali, H. H. 2014. Productive performance and immune response of broiler chicks as affected by dietary thyme leaves powder. *Egyptian Poultry Science Journal* 34 (1):71-84.
- Alsaht, A.A., Bassiony, S.M., Abdel-Rahman, G.A. and Shehata, S.A. 2014. Effect of cinnamaldehyde thymol mixture on growth performance and some ruminal and blood constituents in growing lambs fed high concentrate diet. *Life Science Journal* 11(3).
- A.O.A.C. 1990. Official Method of Analysis. 15th ed., Association of Official Analytical Chemist, Washington, DC. USA.
- AMSA.1978. Guidelines for cooking and sensory evaluation of meat. American meat science Association in Co-operation with National Livestock and meat Board, **Chicago** 33.
- Ameha, S., 2008. Sheep and goats meat characteristics and quality. Pp.325-340. In: Alemu Yami and R.C. Merkel (eds.). *Sheep and Goats Production Handbook of Ethiopia*. ESGPIP (Ethiopian sheep and goat productivity improvement program).
- Arsenos, G., Banos, G., Fortomaris, P., Katsaounis, N., Stamataris, C., Tsaras, L. and Zygoiannis, D. 2002. Eating quality of lamb meat: Effects of breed, sex, degree of maturity and nutritional management. *Meat Science* 60: 379-387.
- ARC (Agricultural Research Council).1980. *The Nutrient Requirements of Ruminant Livestock*. Technical Review by an Agricultural Research Council Working party published on behalf of the Agricultural research council by the commonwealth Agricultural London. 351pp.
- Asfaw, N., Storesund, H.J., Skattebol, L., Tonnesen, F., Aasen, A.J. 2000. Volatile oil Constituents of two *Thymus*

species from Ethiopia. *Flavour and Fragrance Journal* 15:123-125.

- Atti-Santos, A.C., Pansera, M.R., Paroul, N., Serafini, A. and Moyna, P. 2004. Seasonal variation of essential oil yield and composition of **Thymus vulgaris L.** (Lamiaceae) From South Brazil. *Journal of Essential Oil Research* 16:294-295.
- Bahran Fikrae. 2014. Effect of Cassava Leaf meal Substitution on Feed Intake, Digestibility, Body Weight Gain and Carcass Parameters in Horo Yearling Sheep. MSc Thesis Presented to The School of Graduate Studies of Haramaya University.
- Bello, A. A. and Tsado, D.N. 2014. Quality And Sensory Evaluation of Meat From Yankasa Rams Fed Sorghum Stover Supplemented With Varying Levels of Dried Poultry Droppings Based Diet. *International Journal of Agriculture and Food Science Technology* 5(2):1-8.
- Berhanu Alemu, Getachew Animut and Adugna Tolera. 2014. Effect of **Milletia ferruginea** (Birbra) foliage supplementation on feed intake, digestibility, and body weight change and carcass characteristics of Washera sheep fed natural pasture grass hay basal diet. *Springer Plus* 3:50.
- Carpenter, Z. L., Abraham H. C. and King G. T.1968. Tenderness and cooking loss of beef and pork. Relative effects of microwave cooking, deep fat frying and oven broiling. *Journal of the American Dietetic Association* 53:353.
- CSA (Central Statistics Agency of Ethiopia), Agricultural Sample Survey. 2010: Report on Livestock and Livestock Characteristics (Private Peasant Holdings). Vol. II, pp. 94.
- CSA (Central Statistic Authority) of Ethiopia. 2014. Agricultural sample survey Report on livestock and livestock characteristics (Private peasant holdings). Vol.II.194p.
- Dereje Kebede. 2014 Evaluation of tagasaste (**chamaecytisus palmensis**) forage as a substitute for concentrate in diets of sheep fed natural pasture hay. MSc Thesis Presented to The School of Graduate Studies of Haramaya University.
- Evans, J. D., and S. A. Martin. 2000. Effects of thymol on ruminal microorganisms. *Current Microbiology* 41:336-340.
- FAO.1977. New feed resources. Proceedings of a technical consultation held in Rome, 22-24 November 1976. FAO Animal Production and Health Paper, No. 4. FAO, Rome. 300 pp.
- Fasae, A., Adu, I.F., Aina, A.B.J. and Dipeolu, M.A. 2010. Growth performance, carcass characteristics and meat sensory evaluation of West African Dwarf sheep fed varying levels of maize and cassava hay. *Tropical Animal health and Production* 43:2.
- Feleke Gebregiorgis & Tegene Negesse & Ajebu Nurfeta, 2011.Feed intake and utilization in sheep fed graded levels of dried moringa (*Moringa stenopetala*) leaf as a supplement to Rhodes grass hay. *Tropical Animal Health and Production* 44: 511-517.
- Firisa Woyessa, Adugna Tolera and Diriba Diba, 2013. Feed intake, digestibility and growth performance horro lambs fed natural pasture hay supplemented graded levels vernonia **amygdalina** leaves and sorghum grain mixture. *Science, Technology and Arts Research Journal* 2(2):30-37.
- Galal, E.S.E., Tesfazgy, A., Awgichew, K. 1979. A study on fattening Ethiopian sheep: Performance of Adal lambs on supplemented grazing. *Ethiopian Journal of Agricultural Science* 1(2): 99-107.
- Gallo, S.B., Siqueira, E.R.D., Delgado, E.F., Silva, M.D.P., Rosa, G.T.D. 2009. Influence of feeding regime and finishing system on lamb muscle fiber and meat quality. *Revista Brasileira De Zootecnia-Brazilian* 38(11): 2204-2210.
- Gerencser, Z., Szendrő, Z., Matics, Z., Radnai, I., Kovacs, M., Nagy, I., Cullere, M., Dal Bosco, A., Dalle, Z.A. 2014. Effect of Dietary supplementation of *Spirulina* (**Arthrospira platensis**) and Thyme (**Thymus vulgaris**) on apparent digestibility and productive performance of growing rabbits. *World Rabbit Science* 22:1-9.
- Hadjipanyiotou, M. & Morand-Fehr, P.1991. Intensive feeding of dairy goats. In: P. Morand- Fehr ed., *Goat nutritio3n*, EAAP Publication No.46, Pudoc, Wageningen, the Netherlands, pp.197-208.
- Haska, L., Nyman, M., Anderson, R. 2008. Distribution and characterization of fructan in wheat milling fractions. *Journal of cereal Sciences* 48:768-774.
- Hocquette, J., F. Gondret, E. Baéza, F. Médale, C. Jurie, and D. Pethick. 2010. Intramuscular fat content in meat-producing animals: development, genetic and nutritional control, and identification of putative markers.

Animal 4:303-319.

- Hopkins, D.L., Walker, P.J., Thompson, J.M., Pethick, D.W. 2005. Effect of sheep type on meat and eating quality of sheep meat. *Australian Journal of Experimental Agriculture* 45(5): 499–507.
- ISO (international Standard Organization) 8586. 2012. *Sensory analysis - General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors*, Switzerland.
- Jabbar and Anjum, M.I. 2008. Effect of diets with different forage to concentrate ratio for fattening of Lohi lambs. *Pakistan Veterinary Journal* 28:150-152.
- Jayasuriya, M.C. 1984. Potential for the better utilization of crop residues and agro-industrial by-products in animal feeding in the Indian sub-continent.
- Jordan, M.J., Martinez, R.M., Goodner, K.L., Baldwin, E.A. and Sotomayor, J.A. 2006. Seasonal variation of *Thymus hyemalis* Lange and Spanish *Thymus vulgaris* L. essential oils composition. *Journal of Industrial Crops and Products* 24: 253-263.
- Kefyalew Gebeyew. 2013. Effect of feeding dried tomato pomace, concentrate mix and their mixture on feed intake, digestibility, body weight change and carcass parameter on Hararghe highland sheep fed natural pasture hay. MSc Thesis Presented to the School of Graduate Studies of Haramaya University.
- Khamisabadi H., kafilzadeh F., Charaien B. 2015. Effect of thyme (*Thymus vulgaris*) or peppermint (*Mentha piperita*) on performance, digestability and blood metabolites of fattening sanjabi lambs. *Biharean Biologist* (online first): art 151408.
- Laitat, M., de Jaeger, F., Vandenheede, M. and Nicks, B. 2004. Factors influencing feed ingestion and performance of weaned pigs: perception and characteristics of diets. *Annales de Medecine Veterinaire* 148:15–29.
- Letchamo, W., H.L. XU, A. Gosselin. 1995. Variations in photosynthesis and essential oil in thyme. *Journal of Plant Physiology* 147: 29–37.
- Lonsdale, C. 1989. Raw materials for Animal Feed Compounders and Farmers. Straights. (Book) Chalcombe publications, Great Britain. 17-47pp.
- Manh, N.S., Wanapat, M., Uriyapongson, S. Khejornsart, P. and Chanthakhoun, V. 2012. Effect of eucalyptus (*Camaldulensis*) leaf meal powder on rumen fermentation characteristics in cattle fed on rice straw. *African Journal of Agricultural Research* 7(13) 1997-2003.
- Markos Tibbo. 2006. Productivity and health indigenous sheep breed and cross breed of in central Ethiopia highlands. PhD thesis presented to Department of Animal Breeding and Genetics, Sweden .Pp75.
- McDonald, P., R.A. Edwards., J.F.D. Greenhalgh and C.A. Morgan. 1995. *Animal Nutrition* (5th ed). John Wiley and Sons, New York. Pp451-464.
- Mc Donald, P., Edwrad, R.A., Green, H. J.F.D. and Morgan, G.A. 2002. *Animal Nutrition* 6th pearson Educational limited. Edinburgh, Great Britain. Pp544.
- Michiels, J., Missotten, J., Ovyin A., N. Dierick, N., Fremaut, D., De Smet, S. 2012. Effect of dose of thymol and supplemental flavours or camphor on palatability in a choice feeding study with piglets. *Czech Journal of Animal Science* 5 (2): 65–74
- Mikaili, P., Mohammad Nezhady, M.A., Shayegh, J. and Asghari, M.H. 2010. Study of Antinociceptive Effect of *Thymus vulgaris* and *Foeniculum vulgare* Essential Oil in Mouse. *International Journal of Academic Research* 2: 374-376.
- Minson, DJ. 1990. Forage in ruminant nutrition. Academic Press, San Diego, CA 482:403-461.
- Mulugeta, Fitwi and Genrehiwot, Tadesse. 2013. Effect of sesame cake supplementation on feed intake, body weight gain, feed conversion efficiency and carcass parameters in the ration of sheep fed on wheat bran and teff (*Eragrostis teff*) straw. *Ethiopian Journal of Science* 5(1): 89-106.
- Naser, A. 2007. Antimicrobial and antioxidant properties of spices. *Bulletin of Pharmaceutical Sciences* 30(1):8187.
- Neamn Gebreselassie, Getachew Animut and Mengistu Urge, 2014. Effect of Supplementation with Dried Leaves of *Acacia albida*, *Acacia seyal* and their Mixture on Feed Intake and Digestibility of Local Sheep Fed Barley Straw as a Basal Diet. *Journals of Fisheries and Livestock Production* 3:125.
- Naghdi, B.H., Yazdani, D, Ali, S.M. and Nazari, F. 2004. Effects of spacing and harvesting time on herbage yield

and quality/quantity of oil in thyme, **Thymus vulgaris L.** *Journal of Industrial Crops and Products* 19: 31-236.

- Osório, J.C.S.; Osório, M.T.M.; Sañudo, C. 2009. Sensory characteristics of mutton. *Revista Brasileira de Zootecnia* 38:292-300.
- Papi, N., Mostafa-Tehrani, A., Amanlou, H. and Memarian, M. 2011. Effects of dietary forage-to-concentrate ratios on performance and carcass characteristics of growing fat-tailed lambs. *Animal Feed Science and Technology* 163:93-98.
- Paulson, J. 2008. Essential oils as dietary supplements for dairy cattle, *Dairy Extension*.
- Pittroff, W., Keisler, D.H., Blackburn, H.D. 2006. Effects of a high-protein, low-energy diet in finishing lambs: Weight change, organ mass, body composition, carcass traits, fatty acid composition of lean and adipose tissue, and taste panel evaluation.
- Preston, T.R. and Willis, M. B. 1974. *Intensive Beef Production* 2nd ed. Pergamon Press, London, p 566.
- Priolo, A., Micol, D., Agabriel, J., Prache, S., and Dransfield, E. 2002. Effect of grass or concentrate feeding systems on lamb carcass and meat quality. *Meat Science* 62:179-185.
- Sarwar, M., M. A. Khan and M. Nisa. 2004. Effect of organic acids or fermentable carbohydrates on digestibility and nitrogen utilisation of urea-treated wheat straw in buffalo bulls. *Australian Journal of Agricultural Research* 55:223-228.
- SAS (Statistical Analysis System). 2002. *SAS/STAT guide to personal computers-Version 7*. Statistical Analysis System Institute Inc. Cary, NC.
- Solomon Abegaz, Girma Abebe and Kasahun Awgichew. 2008. Sheep and Goat production systems in Ethiopia. In: *Sheep and Goat Production Handbook for Ethiopia*. Alemu Yami and R.C. Merkel (Eds). Addis Ababa, Ethiopia.
- Sultana, N. Alimon, A.R, Huque, K.S Baba, M. and Hossain, J. 2015. Evaluation of Moringa Foliage (**Moringa oleifera**) as Goat Feed. *Iranian Journal of Applied Animal Science* 5(4) :865-871.
- Seyoum Bediye and Zinash Sileshi. 1989. The composition of Ethiopian Feedstuffs, Research Report No. 6. Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia. pp. 33.
- Takele Feyera and Getachew Animut. 2011. Digestion, Intake and Live Weight Changes of Horro Lambs Fed Vetch (**Lathyrus sativus**) Haulm Basal Diet Supplemented with Sole Wheat Bran, **Acacia albida** Leaf Meal or Their Mixture. *Pakistan Journal of Nutrition* 10 (11): 1013-1021.
- Tewodros Eshete. 2011. Effect of inclusion of different proportions of thyme (**thymus serrulatus**) in concentrate mix supplement on feed intake, digestibility, and body weight change and carcass parameters of Menz sheep fed grass hay. MSc Thesis Presented to The School of Graduate Studies of Haramaya University.
- Turner, K.E., McClure, W.P., Weiss, R. J., Borton, and J. G. Foster. 2003. Alpha tocopherol concentrations and case life of lamb muscle as influence by concentrate or pasture finishing. *Journal of Animal Science* 80: 2513-2521.
- USDA. 1982. Official united state standards for grades of lamb, yearling mutton and mutton carcass. Agricultural marketing service USDA, Washington, DC, 1.
- Van Soest, P.J., Roberston, J.B., and Lewis, B.A. 1991. Methods for dietary fiber and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74:3583-3597.
- Van Soest, P.J. 1994. *Nutritional Ecology of Ruminants*. 2nd Ed. Cornell University Press, London. 476p.
- Westerhold, M.C. 2013. Essential Oil Effects On Rumen Fermentation, Animal Performance, And Meat Quality Of Beef Steers. MSc Thesis presented to the faculty of graduate school of Missouri university, Columbia.
- Wolf, B.T., C. Smith and D.I. Sales. 1980. Growth and carcass composition in the cross bred progeny of six terminal sire breeds of sheep. *Journal of Animal Production* 31(5):307-313.
- Yilkal Tadele, Yoseph Mekasha and Firew Tegegne. 2014. Supplementation with different forms of processed Lupin (**Lupinus albus**) grain in hay based feeding of Washera sheep: Effect on feed intake, digestibility body weight and carcass parameters. *Journal of Biology, Agriculture and Healthcare* 4 (27):213-231.
- Young, O.A., Berdague, J.L., Viallon, C., Rousset-Akrim, S. and Theriez, M. 1997. Fat-borne volatiles and sheep meat odour. *Meat Science* 45:183-200.

Feed Intake, Milk Yield and Milk Composition of Crossbred Dairy Cows Fed on different levels of Napier and Concentrate Mixture

Misganew Walie

Abstract

An experiment was conducted at Andassa Livestock Research Center in Amhara National Regional State (ANRS), Ethiopia, to evaluate the effect of different levels of fresh Napier grass and concentrate mixture feed supplements on feed intake, milk yield and milk composition of crossbred dairy cows. Five second parity crossbred dairy cows with similar stage of lactation were selected from farmers nearby Andassa. The experiment had five treatments with four periods using crossover design. The treatments were; Grass hay + 100% concentrate mix (positive control) T1, Grass hay + 50% napier grass + 50% concentrate mix T2, Napier grass ad libitum T3, Grass hay + 25% napier grass + 75% concentrate mix T4 and grass hay + 25% concentrate mix + 75% napier grass T5. There were significant ($P \leq 0.001$) differences between treatment groups in their grass hay, Napier and concentrate mix dry matter intake. The overall milk yield (kg/cow/day) was 4.72; while fat, protein, solid-not-fat, lactose and fat to protein ratio composition of milk (%) were, 4.82, 3.04, 8.35, 4.56 and 1.61, respectively. Milk yield was significantly different ($P < 0.01$) between T5 as compared to T3 and T4 but not significantly different with that of T1 and T2 treatment groups. Except fat and fat to protein ration all the milk compositions analyzed was not affected by different levels of Napier and concentrate mixture. Supplementation of crossbred dairy cows with different levels of Napier and concentrate mixture fed on natural grass hay has an effect on feed intake, milk yield and milk fat and fat to protein ratio.

Key words: Crossbred cows, dry matter intake, milk composition, Napier grass

Introduction

Feed scarcity in qualitative and quantitative dimensions is one of the major impediments to livestock production in Ethiopia. The quality and quantity of feed resources available to the animals in most parts of the country is mainly affected by seasonal fluctuation of rainfall. Zinash and Seyoum (1989) reported that the crude protein (CP) and metabolizable energy (ME) content of natural pasture showed seasonal variations which correspond closely to the seasonal pattern of rainfall. According to the results reported by same authors peak CP and ME content of 11.2% and 8.2 MJ/kg observed in July declined steadily to 3.3% and 7.1MJ/kg in March. In contrast, neutral detergent fiber (NDF) content increased from 61% in July to its peak of 80% in March. This shows that during the long dry season, animals are prone to nutritional deficiency and need to be supplemented.

Inadequate and unbalanced nutrient supply is one of the major technical constraints of urban and peri-urban dairy production systems in Ethiopia (Abaye *et al.*, 1991; Goshu and Mekonen, 1997). Productivity of ruminants is influenced primarily by feed intake which in turn determined by feed digestibility and the capacity of the diet to supply the correct balance of nutrients required by animals in different productive stages (Van Soest, 1994). Feeding crude protein in excess amounts increases energy requirements for the synthesis and excretion of urea from the body and deficiencies of crude protein reduces digestibility of the diet (Cheek, 2005).

Grazing systems typically increase productivity by increasing the number of heads and the land area used. However, currently expansion of cropping at the expense of grazing lands being triggered by increase in human population has led to further deterioration of grazing areas with the consequent erosion of biodiversity and disappearance of palatable pasture species (Alemayehu, 2002). Mixed farming also faces limitations as innovations in crop production are reducing crop residues and non-grain biomass available for feeding. Moreover, the contribution of agro-industrial by-products in animal production has been minimal due to high cost, unreliable supply and poor access (Tessema *et al.*, 1995).

Improved forage crops play an important role in sustaining the livelihoods of small and medium scale farmers, mainly as a result of their positive effects on livestock production and contribution to economic and environmental sustainability. On the other hand, indigenous forage species in Ethiopia have low productivity or low digestibility, which reduces their usefulness for livestock nutrition (Alemayehu, 2002).

A strategy for feed resource development would incorporate different options for improvement of feed availability and quality, and improvement in the efficiency with which feed supplies are used. Among the strategies developing improved forage species is the one which have been currently practiced in different parts of the country. Though the practice is many made by resourceful (particularly land) and improved breed livestock holding farmers, there is a gap of determining the effect of these improved forages for productivity.

In connection with this Andassa Livestock research center is undertaking promising research activities in aspects of improved forage and nutrition. The Center introduced different forage crops in various areas. Among the improved forage Napier grass is one of widely adopted and gained reputation by farmers hence giving considerable contribution in feeding of milking crossbreds. As part of its unreserved effort, the center has succeeded in establishing an improved dairy producer village group at Koga Irrigation command area. In October, in its field day demonstrations, the dairy farmers and other stakeholders appraised the need for linking the improved forage with the animal by developing appropriate feeding package is indispensable.

Therefore in cognizant of this fact, this experiment was initiated to tailor made the gaps that the farmers are practically facing by developing proper feeding package based on the available feed resources.

Objective of the study

To evaluate the effect of feeding different levels of Napier and concentrate mixture on feed intake, milk yield and major milk composition in crossbred milking cows

Materials and Methods

Description of study area

The study was conducted at Andassa Livestock Research Center (ALRC), located in Amhara National Regional State (ANRS), Ethiopia. It is far from 22 km south of Bahir Dar on the way to Tis Abay. The center is situated 11°29' N latitude and 37°29' E longitude at an altitude of 1730 meter above sea level. The mean annual rainfall is 1434 mm and the mean maximum and minimum temperature ranged from 27.9 to 13.1°C and humidity ranged from 95% throughout the rainy season to 35% during the dry season. The topography of the area varies from river valley plain to gentle slope grassland. In general, the area is characterized by dark clay soil, which is seasonally water logged (Yihalem, 2005).

Experimental feeds and feeding

Hay was harvested from grazing land and given *ad libitum* to cows. The dominant grasses in Andassa Livestock Research Center include *Cynodon*, *Hyperhenia*, *Andropogon*, *Paspalum*, *Cetaria*, *Elusin*, *Eragrostis*, *Sporobulus* and *Trifolium* species (Yihalem, 2005). Napier grass was collected from Andassa Livestock Research Center medebit trial site. During March 2015 Napier from completed trials and multiplication has been cut to uniform height and irrigated once per week for better biomass production. The height of Napier during the first time of harvest might be on average one meter even though, fresh Napier was harvested daily. The fresh Napier after transported to the experimental house then chopped to appropriate size for ease of consumed by dairy cows. Concentrate mix (soybean meal 33%, wheat bran 10%, maize 53%, calcium carbonate 2% and salt 2%) was purchased from Merkeb union, Bahir Dar town before the start of feeding trial. Treatment feeds were offered by dividing in to two equal portions two times a day at 8:00am and 4:00pm after weighing refusal feeds. The experimental animals were given water three times a day. Basal diet (hay) was offered *ad libitum* adjusted daily by allowing 20% of refusal from previous day's intake. However, periodic adjustment of treatment feeds offer was made for each cow as per the average milk produced before the beginning of the next period. The level of % of feeding the treatments was adjusted half kilogram of concentrate with one liter of milk and one kilogram of Napier for one litter of milk in dry matter base.

Experimental design and Animal Management

Cross over design was used for the experiment. Five cows with approximately two months lactation and having second parity were selected from farmers nearby Andassa and contractual agreement was made between Andassa Livestock Research Center and Farmers. The experimental animals were examined their health status by Veterinarians and two times sprayed with Diazinol 60% for external parasite control. Moreover, experimental animals were given Fascinox 900mg for the treatment of fasciolosis and Tetraclozan 3400mg for the control and prevention of internal parasites during the beginning of the experiment. The experimental cows were kept in individual pens. During the end of each period and before the beginning of the next period experimental animals given fifteen days of adaptation to the experimental feeds. Each treatment randomly assigned to each cow in every period without repetition. In addition animals were given fifteen days of adaptation to the experimental house and feeds.

Treatments were:

T1= Grass hay + 100% concentrate

T2= Grass hay + 50% napier grass + 50% concentrate

T3= Napier grass *ad libitum*

T4= Grass hay + 25% napier grass + 75% concentrate

T5= Grass hay + 25% concentrate + 75% napier grass

Milk composition analysis

Milk samples were taken on average two times per period in morning and evening milking using graduated bottle throughout the study period. 100 ml of milk from each cow was taken and analyzed using Lacto scan after the instrument adjusted using distilled water at Andassa Livestock Research Center health laboratory room.

Partial budget analysis

Price of hay is deducted from the price of 1 belled hay (weighted 18 kg), which valued 50 birr accordingly 1 kg hay has been valued 2.75 birr. Napier grass have no market price so we obliged to use proxy price. Proxy price of Napier grass is the price of natural grass market of Deber Tabor. However, the price of concentrate taken from purchased price of Merkeb union feed processing (5.80birr/kg).

Data collection and Statistical analysis

Feed offer and refusal of basal and supplement was weight daily. All the cows were hand milked twice a day (in the morning at 7:00 am and in the evening at 5:00 pm). Milk yield measurements were taken using graduated bottles during the entire study period. Feed and nutrient intakes, milk yield and milk composition were subjected to the General Linear Model (GLM) procedure of Statistical Analysis System (SAS, 2002). Least significance difference (LSD) test was used to determine any significant difference between means. The model used for data analysis was:

$$Y_{ij} = \mu + T_i + B_j + e_{ijk}$$

Where;

Y = the observation on feed intake, milk yield or milk composition

μ = the overall mean

T_i = effect of i^{th} treatment

B_j = effect of the j^{th} period

e_{ijk} = random error.

Results and Discussion

Feed intake

Summary of the mean dry matter intake (DMI) (kg/day) of crossbred cows fed on different levels of Napier and concentrate mixture are presented in table 1. Dry matter intake significantly ($P \leq 0.001$) varied between treatment groups in their grass hay, Napier and concentrate intake. The significant variation recorded in cows given T2, T4 and T5 as compared to T1 might be due to the substitution effect of grass hay by Napier grass. Moreover, those group of cows given different levels of Napier showed highly significant variation between each other. This could be due to difference in the treatment levels of offer. The low total dry matter intake recorded in cows given napier *ad libitum*, which had higher moisture content, than those given grass hay and concentrate mixture might be attributed to the lower dry matter content of napier which limit cows intake. Moreover, the difference in terms of dry matter intake in cows given concentrate mixture also expected, because of difference in the levels of those diets given.

Experimental cows during period 4 and 5 recorded significantly ($P \leq 0.001$) lower grass hay intake. This might be related to cows became on heat and then their grass hay intake decline within that time. In addition, cows given concentrate mixture in period 4 and 5 showed significantly ($P \leq 0.001$) lower as compared to period 1 and 2, this could be associated with adjustment of concentrate given with that of milk yield.

Table1. Least squares mean of dry matter intakes (kg/day) of cross breed cows fed on different levels of Napier and concentrate mixture

Variables	N	HI	N	NI	N	CI
Overall mean		7.70±0.07		3.97±0.07		1.44±0.03
Treatment		***		***		***
T1	35	8.42±0.13 ^a	-	-	35	2.21±0.06a
T2	35	7.31±0.13 ^b	35	2.34±0.15 ^c	35	1.30±0.06c
T3	-	-	35	8.73±0.15 ^a	-	-
T4	34	7.58±0.13 ^b	35	1.01±0.15 ^d	35	1.62±0.06b
T5	33	7.44±0.14 ^b	35	3.82±0.15 ^b	35	0.65±0.06d
Period		***		**		***
1	28	7.79±0.15 ^a	28	3.59±0.16 ^b	28	1.53±0.07ab
2	28	8.19±0.15 ^a	28	3.73±0.16 ^b	28	1.69±0.07a
3	28	8.01±0.15 ^a	28	4.35±0.16 ^a	28	1.49±0.07b
4	28	7.21±0.15 ^b	28	4.11±0.16 ^{ab}	28	1.33±0.07c
5	25	7.24±0.16 ^b	28	4.09±0.16 ^{ab}	28	1.19±0.07c
CV		10.20		21.65		26.36

^{abcd} means with different superscripts with in columns are significantly different; *** = significant at $P < 0.001$; N= number of observation; HI = Grass hay intake; NI = Napier intake; CI = Concentrate mix (soybean meal 33%, wheat bran 10%, maize 53%, calcium carbonate 2% and salt 2%) intake T1= Grass hay + 100% concentrate, T2= Grass hay + 50% napier grass + 50% concentrate, T3= Napier grass ad libitum, T4= Grass hay + 25% napier grass + 75% concentrate and T5= Grass hay + 25% concentrate + 75% napier grass.

Milk yield and Milk composition

The overall least square mean milk yield (MY) and composition (%) of crossbred dairy cows fed on different levels of Napier and concentrate mixture is presented in table 2. The relatively lower milk yield in cows given T3 and T4 recorded might be related to lower dry matter content in Napier and relatively higher proportion of roughages with lower concentrate level in T4. On the other hand, cows given 100% concentrate with that of replaced by 50% and 75% napier showed no significant ($P > 0.05$) difference in their milk yield, This could be taken as good opportunity for small holder farmers engaged in development of napier in their back yard. The mean milk yield in the present study range from 4.16 to 5.28 liters/day. The value was comparable with (Belay *et al.*, 2012) in which the average daily milk yield, was 7.01, 5.55 and 3.50 liters for the 1, 2 and 3 stage of lactations, respectively in Jimma town, Ethiopia. However, the result of this study is lower than that of (Adebabay, 2009) who reported 10.96, 9.12 and 5.04 liters for first, second and third lactations, respectively in Bure district, western Ethiopia.

Crossbred dairy cows given 100% and 75% concentrate mixture recorded significantly ($P < 0.05$) lower fat percentage as compared T2, given 50% concentrate mixture but no significant ($P > 0.05$) difference was observed between cows given concentrate 50% with that of 25% and also napier *ad libitum*. In line with this study, Adebabay *et al.* (2009) reported the lowest fat composition of milk samples from treatment groups fed on noug seed cake and concentrate (comprising of 74% maize grain, 25% noug seed cake and 1% salt). This agrees with the generally accepted literature that cows fed low roughage rations yield milk of lower fat content compared to cows fed higher proportion of roughage diets.

The reason behind relatively lower milk yield in the present study might be related to quality of napier and grass hay used in the experiment, which was associated with relatively higher fat to protein ratio recorded and also the stress due to confinement of the animals during the experiment period as the crossbred dairy cows practice free grazing and partly in barn during mid day and night time in the farmers management system. The crude protein content of Napier may vary according to variety and stage of harvest. For instance at 30cm height the CP content 9.2% but when it reaches greater than 2m the CP% declines to 5% in Kenya (Lukuyu *et al.*, 2012). The same author reported using Napier grass only, the expected milk production is 7 kg/day but in the present study 4.32litres/day was lower. The reason might be difference in Napier variety, stage of Napier harvest and blood level breed used.

Fat to protein ratio recorded in T1 and T4 was relatively near to optimum but in T2 and T3 which was higher, this indicates the former taken relatively higher roughage feeds. Alphonsus *et al.*, (2013) calculate the fat-protein ratio (FPR) as well as the energy corrected milk (ECM) using milk analysis results and conclude that it is possible to estimate major problems in dairy cow nutrition, predict and prevent possible nutritional and metabolic disorder. In terms of evening and morning milking, fat and fat to protein ratio showed significant difference but other milk composition did not show significant difference. The higher in fat percentage in morning milking than evening milking might be attributed to relatively longer time interval between milking in the former. Differences among individuals are often greater than differences within breeds, such differences are due to partly genetic and partly to environmental factors (O'Connor, 1994).

Table 2. Least squares mean milk yield (kg/day) and milk composition (%) of cross breed cows fed on different levels of Napier and concentrate mixture

Variables	MY	Milk composition (%)					
		Fat	SNF	Protein	Lactose	Salt	FTPR
Overall mean	4.72±0.11	4.82±0.09	8.35±	3.04	4.56±0.06	0.68±0.007	1.61±0.03
Treatment	**	*	ns	ns	ns	ns	**
T1	4.93±0.25 ^{ab}	4.73±0.20 ^b	8.54±0.21	3.13±0.08	4.67±0.14	0.69±0.02	1.59±0.07 ^a
T2	4.93±0.25 ^{ab}	5.36±0.20 ^a	8.15±0.21	2.97±0.08	4.44±0.14	0.66±0.02	1.85±0.07 ^b
T3	4.32±0.25 ^b	5.22±0.20 ^{ab}	8.18±0.21	2.98±0.08	4.46±0.14	0.66±0.02	1.77±0.07 ^b
T4	4.16±0.25 ^b	4.54±0.21 ^b	8.23±0.22	3.00±0.08	4.29±0.15	0.67±0.02	1.53±0.07 ^a
T5	5.28±0.25 ^a	5.20±0.20 ^{ab}	8.61±0.21	3.10±0.08	4.71±0.14	0.69±0.02	1.72±0.07 ^{ab}
Period	ns	**	***	***	***	***	***
1	5.12±0.25	4.21±0.20 ^b	9.63±0.21 ^a	3.53±0.08 ^a	5.28±0.14 ^a	0.80±0.01 ^a	1.59±0.07 ^a
2	4.96±0.25	5.01±0.18 ^a	7.94±0.19 ^b	2.86±0.07 ^b	4.37±0.13 ^b	0.64±0.02 ^b	1.79±0.06 ^b
3	4.58±0.25	5.21±0.22 ^a	8.09±0.24 ^b	2.93±0.09 ^b	4.46±0.16 ^b	0.65±0.02 ^b	1.80±0.08 ^b
4	4.59±0.25	5.59±0.30 ^a	8.11±0.32 ^b	2.95±0.12 ^b	4.07±0.22 ^b	0.65±0.03 ^b	1.92±0.11 ^b
5	4.36±0.25	5.04±0.17 ^a	7.94±0.18 ^b	2.89±0.07 ^b	4.39±0.12 ^b	0.64±0.01 ^b	1.76±0.06 ^b
Time		***	ns	ns	ns	ns	***
Evening		4.60±0.11 ^b	8.44±0.12	3.09±0.04	4.56±0.08	0.69±0.01	1.49±0.04 ^a
Morning		5.42±0.18 ^a	8.24±0.19	2.98±0.07	4.47±0.13	0.66±0.02	1.89±0.06 ^b
CV	31.24	18.33	11.2	11.7	13.98	11.23	19.74

^{ab} means with different superscripts with in columns are significantly different; *** = significant at $P<0.001$; **= significant at $P<0.01$; *=significant at $P<0.05$; ns= non significant difference; MY = milk yield (kg/day); SNF = solid not fat; FTPR = fat to protein ratio; CV= coefficient of variation, T1= Grass hay + 100% concentrate, T2= Grass hay + 50% napier grass + 50% concentrate, T3= Napier grass ad libitum, T4= Grass hay + 25% napier grass + 75% concentrate and T5= Grass hay + 25% concentrate + 75% napier grass.

Forage diets high in cellulose give rise to acetic acid, while concentrate diets give rise to propionic acid, and the proportion of acetic acid falls (McDonald *et al.*, 1995). Propionic acid in the rumen promotes partition of energy towards synthesis of body fat instead of milk fat synthesis, resulting

in a decrease in milk fat content (Randby, 1996). In agreement with this author, cows given T1 and T4 (100% and 75% concentrate) recorded relatively lower fat content as compared to cows given relatively higher fibrous feeds.

In addition, milk composition depends greatly on ration composition, changes in concentration and ratio of fiber and energy in ration affect milk fat percentage and protein percentage (Tammimga, 2001) and milk fat to milk protein ratio (FPR), thus making this milk component a possible indicator of ration composition. Reduced milk fat %, probably due to decreased fiber intake, can lead to such health problems as acidosis and laminitis (Heuer *et al.*, 1999). In their study on milk composition characteristics, Kuterovac *et al.*, (2005); Banik *et al.* (2004) suggested that a milk fat-protein- ratio of 1.1-1.5 could be taken as optimal and the ratio greater than 1.5 could indicate energy deficiency and fiber surplus in ration, while the milk fat protein- Ratio less than 1.1 indicates fiber deficiency and energy surplus.

Table 3. Correlation coefficient between milk yield and milk composition in crossbred dairy cows fed on different levels of Napier and concentrate mixture

	Milk yield	Fat%	Protein%	Lactose%	SNF%	Density%
Milk yield	1.00	0.453	0.611	0.841	0.689	0.559
Fat%		1.00	-0.307	0.249	-0.173	-0.431
Protein%			1.00	0.841	0.966	0.974
Lactose%				1.00	0.874	0.731
SNF%					1.00	0.953
Density%						1.00

SNF= solid not fat

Correlation coefficient between milk yield and milk composition in crossbred dairy cows fed on different levels of Napier and concentrate mixture is presented in table3. The positive and higher correlation of milk yield with protein and lactose in the present study indicates the degree of association, as the milk yield increases the higher percentage of protein and lactose in the milk increases. Lactose, solid not fat (SNF) and density were highly and positively correlated with Protein while protein, SNF and density were negatively correlated with fat content. In addition, SNF and density were highly and positively correlated with lactose.

Partial budget analysis

Partial budget analysis result is presented in Table 4. The net benefits of crossbred dairy cows using different levels of Napier and concentrate mixture was computed as gross benefits subtracted by total variable cost. The net benefit among the five treatments is quite different. This is due to the variation of levels of Napier and concentrate mixture. Conducting treatment comparison based on net benefit is appropriate for feed treatment as long as the time horizon is the same. In this study we considered two time horizon therefore net profit is more informative than net benefit but it is difficult to capture all costs and benefits. The net profit of T1 is highest which is followed by T5, T2, T4 and T3, respectively. The result showed that farmers involved in dairy production can supply milk by supplementing T1 feed ingredients in nearby urban and T5 and T2 in rural areas to milk consumers and home consumption.

Table 4. Partial budget analysis of crossbred milking cows fed on different levels of Napier and concentrate mixture

Variables	T1	T2	T3	T4	T5
Benefit	2070	2070	1813.2	1746	2216.4
Milk selling	2070	2070	1813.2	1746	2216.4
Variable costs	1420.63	1508.895	1554.58	1361.45	1611.11

Cost of hay	921.25	799.425	-	820.05	796.95
Cost of Napier	-	409.9	1527.8	176	668
Cost of concentrate	499.38	292.32	-	365.4	146.16
Labor cost*	-	7.25	27.04	5.28	11.82
Net benefit	649.37	561.105	258.36	384.55	605.29

* Napier chopping and harvesting, T1= Grass hay + 100% concentrate, T2= Grass hay + 50% Napier grass + 50% concentrate, T3= Napier grass ad libitum, T4= Grass hay + 25% Napier grass + 75% concentrate and T5= Grass hay + 25% concentrate + 75% Napier grass.

Conclusion and Recommendation

The milk yield in the present study vary from 4.16 to 5.28 liters/cow/day. From the present study, it could be concluded as without greater effect on milk yield and major composition the amount of concentrate required could be substituted until 50% to 75% Napier grass. Except fat content and fat to protein ratio all the milk compositions analyzed were not affected by different levels of Napier and concentrate mixture. The value of fat to protein ratio in the present study is higher which indicates cows fed more roughage feeds. Based on the biological data and partial budget analysis depending on the availability of Napier and concentrate mix, the result could be demonstrated as 100% concentrate mix with grass hay (T1), 75% Napier and 25% concentrate mix with grass hay (T5) or 50% napier and 50% concentrate mix (T2) for optimum milk yield in areas where dairy is practice. Further study is required on different Napier variety and stage of harvest on milk yield and major milk composition.

Acknowledgements

The authors would like to thank ARARI (Amhara Region Agricultural Research Institute) for their financial support and participant farmers nearby Andassa Livestock Research Center for their valuable contribution in the accomplishment of the study.

References

- Abaye T, Tefera GM, Alemu GW, Bruk Y, Philip C. 1991. Status of dairying in Ethiopia and strategies for future development, pp. 25–36. In Proceedings of 3rd National Livestock Improvement Conference, 24-26 May 1989. Institute of Agricultural Research (IAR), Addis Ababa, Ethiopia.
- Adebabay Kebede. 2009. Characterization of Milk Production Systems, Marketing and On-farm Evaluation of the Effect of Feed Supplementation on Milk Yield and Milk Composition of Cows at Bure District, Ethiopia. M. S thesis submitted to Bahir Dar University, pp: 54.
- Alemayehu Mengistu. 2002. Forage production in Ethiopia. A case study with implications for livestock production. Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia. P. 93.
- Alphonsus, C., G. N., Akpa, B. I Nwagu. P. P Barje, M. Orunmuyi, S. M.Yashim, M. Zanna, A. E. Ayigun, and Opoola E., 2013. Evaluation of Nutritional Status of Friesian x Bunaji Dairy Herd Based on Milk Composition Analysis. *J AnimSciAdv*, 3(5): 219-225.
- Babnik D, Verbic J, Podgorshek P, Jeretina J, Perpar T, Logar B, Sadar M, Ivanovic B., 2004. Handbook for the management of nutrition of dairy cows the assistance of the mammary inspection results. Agricultural Institute of Slovenia, Ljubljana.
- Belay Duguma, Yisehak Kechero and Janssens G.P.J., 2012. Productive and Reproductive Performance of Zebu X Holstein-Friesian Crossbred Dairy Cows in Jimma Town, Oromia, Ethiopia. *Global Veterinaria* 8 (1): 67-72, 2012.
- Chock P.R. 2005. *Applied Animal Nutrition Feeds and Feeding*. 3rd Edn. Pearson Education, Inc., N.Y., USA
- Goshu M, Mekonnen HM. 1997. Milk production of Fogera cattle and their crosses with Friesian at Gonder, northern Ethiopia. *Ethiopian J. Agric. Sci. (EJAS)* 16(2):61–74.
- Heuer C, Schukken YH, Dobbelaar P. 1999. Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and culling in commercial dairy herds. *J. Dairy Sci.* 82:295–304.

PROCEEDING

Animal Breeding and Reproduction

- Kuterovac K, Balas S, Gantner V, Jovanovac S, Dakic' A. 2005. Evaluation of nutritional status of dairy cows based on milk analysis results *Ital. J. Anim. Sci.* 4 (suppl. 3), 33-35, and 2005.
- Lukuyu B, Gachuri CK, Lukuyu MN, Lusweti C and Mwendia S (Eds). 2012. **Feeding dairy cattle in East Africa.** East Africa Dairy Development Project, Nairobi, Kenya.
- Tamminga S. 2001. Effects of Feed, Feed Composition and Feed Strategy on Fat Content and Fatty Acid Composition of Milk, Bulletin of IDF, 366/2001.
- Tessema Zewdu, Getenet Assefa and Yohanes Tereffe. 1995. Effect of under sowing of Annual Forage Legumes and fertilization on Wheat grain, straw and forage production at Adet. Proceeding of 3rd Conference of Ethiopian Society of Animal Production (ESAP), pp 245-249. Addis Ababa, Ethiopia.
- Van Soest, P.J. 1994. Nutritional Ecology of the ruminant. Cornell University Press, USA.
- Yihalem, Deneke. 2005. The effect of stage of harvesting on botanical composition, dry matter yield (DMY) and nutritive value of natural pasture at Andassa Livestock Research Center, Ethiopia. MSc. theses, Alemaya University, Ethiopia.
- Zinash Sileshi and Seyoum Bediye. 1989. Utilization of feed resources and feeding systems in the central zone of Ethiopia. In: IAR proceedings. Third national livestock improvement conference, 24-26 May 1989, Addis Abeba, Ethiopia.

Moringa (*Moringa oleifera*) as a Potential Feed for Livestock and Aquaculture Industry

Alemayehu Worku (MSc, Animal Production) Arba Minch University, College of Agricultural Sciences, Department of Animal and Range science. P.O.Box 21

Abstract

Moringa (Moringa oleifera) is the most useful trees as feed supplements to animals as their leaves are highly nutritious with excellent palatability, digestibility and balanced chemical composition of protein and minerals. Moringa leaves are readily eaten by cattle, sheep, goats, pigs and rabbits. Using moringa leaves in poultry, pigs and fish is feasible but only in limited amounts due to the presence of fibre and antinutritional factors. Moringa oleifera is a promising protein source for inclusion in fish diets at low levels. It is rich in protein and has been tested in various fish species as a potential replacement for fish meal. However, feeding trials show that only limited amounts of moringa leaf meal can be safely used in fish diets, which is probably due to the presence of phenolics, saponins, phytic acid and other metabolites with antinutritional effects in fish. Feeding chickens with Moringa leaves and seeds will improve egg production. The inclusion of Moringa oleifera leaves meal up to 30% in the diet of growing traditional chickens had no negative impact on live body weight, average daily weight gain, feed conversion ratio, carcass and organs characteristics, health and mortality rate in birds compared to their controls. Moringa leaves totally replacing cottonseed cake in growing lambs fed on low-quality hay increased hay intake, diet DM digestibility and daily weight gain. A study conducted in growing kids indicated that Moringa leaves used up to 50% as sole supplement into diets based on low quality forage increased daily weight gain and diet digestibility. Feeding moringa leaves had variable effects on DM intake and milk yield but did not change milk composition in dairy cattle. When it offered as sole forage (fresh or ensiled) plus molasses gave the same results as low nutritive forage supplemented with concentrate. In growing steers, moringa leaves used as sole concentrate and fed at 0.59% BW resulted in 380 g daily weight gain. Feeding tests in pigs with moringa leaf meal have been only mildly successful as high inclusion rates were found detrimental to performance. Moringa leaf meal could be included at 10% to partially replace commercial concentrate in growing pigs' diet in backyard conditions without hampering pig performance. As a conclusion, more attention need to be paid to the uses of Moringa oleifera in livestock and aquaculture industry as a large scale in countries like Ethiopia and other countries where the Moringa oleifera tree can be grown to produce more natural products and environmentally friendly materials.

Key words: Moringa, aquaculture, Livestock

Introduction

Moringa oleifera is the most useful trees as feed supplements to animals as their leaves are highly nutritious with excellent palatability, digestibility and balanced chemical composition of protein and minerals. Moringa leaves are a valuable source of protein for ruminants but they have a moderate palatability. They are used in smallholder rabbit farming in several African countries.

Using moringa leaves in poultry, pigs and fish is feasible but only in limited amounts due to the presence of fibre and ant nutritional factors. Moringa oil seed cake, the by-product of oil extraction, is poorly palatable to livestock and mainly used as green manure or flocculating agent in water treatments. Moringa seeds seem to be toxic to rabbits. The use of Moringa leaf meal can lower feed costs and hence increase the profitability of fish farming enterprises. In fish farming 40% of costs of production is contributed by feed. In order to avoid unnecessary cost of feed, the correct amount of feed and frequency of feeding must be determined before starting to feed.

Moringa oleifera Lam. or 'drumstick' tree (arising from the shape of the pods), or 'never-die-tree' is a multipurpose tree that thrives in both tropical and sub-tropical conditions. It is native to the sub-Himalayan regions of north-west India. This tree is now indigenous to many countries in Africa, Arabia, South East Asia, the Pacific and Caribbean Islands and South America, producing flowers and fruits continuously. Originally considered a tree of hot, semi-arid regions with annual rainfall 250 - 1500 mm, it has also been found to be well adapted to hot, humid, wet conditions with annual rainfall in excess of 3000 mm.

Moringa (***Moringa oleifera***) can grow in a variety of soil conditions, from well drained sandy or loamy soils (which the plants prefer) to heavier clay soils. The tree is reported to be tolerant of light frosts and can be established in slightly alkaline soils up to pH 9. Currently, the young leaves and pods are used as vegetables, the oil extracted from kernels for culinary and industrial purposes, the water extract of the kernels as a water purifying agent, the seed cake as fertilizer, and various parts of the tree in traditional medicine (Foidl *et al.*, 2001).

Objective

The objective of this study is to review the potential of Moringa (*Moringa oleifera*) as a potential feed for Livestock and Aquaculture Industry.

Forage yield, Nutrient composition and feed values of different parts of Moring Oleifera

Forage yield of Moringa Oleifera

Moringa (***Moringa oleifera***) has an outstanding growth and can be harvested for foliage in less than 2.5 months. Optimal cutting intervals range from 15 to 75 days, depending on local conditions ([Sultana et al., 2014](#); [Nouman et al., 2014](#); [Amaglo et al., 2007](#); [Reyes Sanchez et al., 2006](#), [Foidl et al., 2001](#)). Fodder yields are very variable and may range from 27 to 120 t/ha of fresh matter at first cutting ([Amaglo et al., 2007](#); [Reyes Sanchez et al., 2006](#); [Foidl et al., 2001](#)). Up to 9 cuttings/year could be done ([Radovich, 2009](#); [Bosch, 2004](#), [Foidl et al., 2001](#)). Highest growth and forage yield are obtained under warm, dry conditions, with some supplemental fertilizer and irrigation ([Radovich, 2009](#)). Plant management is important for leaf production. Pollarding and coppicing promote leafy regrowth and enhance leaf yield ([Orwa et al., 2009](#)).

The tree is fast growing and high yielding (an estimated 3.0 t seed / ha compared to average yields of sunflower and groundnut of 2.0 and 0.5 t / ha respectively). It can also be planted for forage production under intensive farming conditions. Initial trials in Nicaragua have shown a high biomass production of up to 120 tons dry matter / ha / yr, in eight cuttings after planting 1 million seeds / ha (Makkar and Becker, 1999a). The plant starts bearing pods 6 - 8 months after planting but regular bearing commences after the second year. The tree bears for 30 - 40 years. The drought tolerant

nature of the tree makes it particularly suited to those marginal areas where the costs associated with the cultivation and harvesting of other commercial crops are high.

Nutrient composition of different parts of Moringa Oleifera

Moringa (*Moringa oleifera*) leaves are valuable source of protein for ruminants. Its protein and organic matter are readily digestible in the rumen and/or in the intestine (Makkar et al., 1997; Makkar et al., 1996; Kakengi et al., 2005; Ndemanisho et al., 2007; Gutierrez et al., 2012). However, the available data are highly variable, and in vitro and in vivo OM digestibility reported in the literature range from 40 to 80%, possibly due to the large variability in fibre content. Moringa leaves and stems contain low amounts of tannins with no or low amounts of condensed tannins (Bakhashwain et al., 2010; Murro et al., 2003; Sarwatt et al., 2002; Aregheore, 2002; Makkar et al., 1997; Makkar et al., 1996). The levels of glucosinolates found in moringa leaves were not reported to impair ruminant nutrition (Bennett et al., 2003; Amaglo et al., 2010). However, moringa leaves contain saponins, which may impair palatability.

Moringa leaves seem to promote rumen microbial protein synthesis due to the substantial contents of readily fermentable nitrogen and energy (Soliva et al., 2005). Moringa ruminal in sacco DM degradability ranging from 82 to 95.6 % have been reported (Garcia et al., 2008d; Ndemanisho et al., 2007; Sarwatt et al., 2004). However, lower values (<70%) were observed in different animal species and different pore size of the nylon bags (Gutierrez et al., 2012; Garcia et al., 2008a). Including moringa leaf meal had depressive effect on metabolizable energy, OM digestibility and short chain fatty acids in ruminants in Nigeria (Tona et al., 2013).

Moringa (Moringa oleifera) leaves

Moringa (*Moringa oleifera*) leaves are usually considered as source of protein. However, the protein content range from 15% to more than 30% DM as it depends on the stage of maturity and on the fodder's respective proportions of leaflets, petioles and stems, the latter being much poorer in protein. Likewise, the fibre content of moringa leaves reported in the literature is extremely variable, with an ADF content ranging from 8% to more than 30% DM. Lignin content is also variable, from 2% to more than 10% DM. Moringa leaves contain high levels minerals (about 10% DM), particularly Ca and Fe. Moringa leaves contain high amounts of a wide range of vitamins (β-caroten, ascorbic acid, vitamin B1, B6 and niacin) (Price, 2007; Reyes Sanchez, 2004) as well as flavonoids (quercetin and kaempferol) which are known to be more potent antioxidants than ascorbic acid (Yang et al., 2006; Siddhuraju et al., 2003).

Moringa (Moringa oleifera) seed cake

Moringa (*Moringa oleifera*) seed cake defatted with a solvent is a high-protein ingredient containing about 60% DM of protein and limited amounts of fibre (NDF 9% DM) and fat (<1%). Its amino acid profile is rich in sulphur amino acids (methionine + cystine 6.1% of protein) but very poor in lysine (<1.5% of protein).

The seed kernel contains, on average, 40 **per cent** by weight of oil, the fatty acid composition of which is similar to that of olive oil and could be used for both culinary and industrial purposes. The seed oil contains 9.3 **per cent** palmitic, 7.4 **per cent** stearic, 8.6 **per cent** behenic, and 65.7 **per cent** oleic acids among the fatty acids. Myristic and lignoceric acids have also been reported.

In addition to high macronutrient content, moringa leaves and pods are also rich in vitamins and minerals. Leaves (100g) contain 440 mg Ca, 70 mg P, 7 mg Fe, 110 mg Cu, 5.1 mg I, 11,300 IU pro-vitamin A, 120 mg vitamin B, 0.8 mg nicotinic acid, 220 mg ascorbic acid, and 7.4 mg tocopherol per 100 g. Per 100 g, the pod is reported to contain 30 mg Ca, 110 mg P, 5.3 mg Fe, 184 IU pro-vitamin A, 0.2 mg niacin, and 120 mg ascorbic acid, 310 mg Cu, 1.8 mg I.

The high true protein content of leaves (23 **per cent** in DM, Makkar and Becker, 1997c), the high proportion of this protein potentially available in the intestine (Makkar and Becker, 1997c), the

presence of adequate levels of essential amino acids (higher than the levels present in the FAO reference protein), and low levels of antinutrients indicate their high nutritional quality. The high pepsin soluble nitrogen (82 - 91 **per cent**) and the low acid detergent insoluble protein (1 - 2 **per cent**) values for the meal suggest that most of the protein in the meal is available to most animals (Makkar and Becker, 1997c). The meal is deficient in lysine, leucine, phenylalanine + tyrosine and threonine when compared to the standard FAO protein but the contents of sulphur-containing amino acids are much higher.

Antinutrients

Moringa (***Moringa oleifera***) leaves are free from anti nutrients except for saponins and phenols. The concentration of phenol is much below the toxic threshold levels for animals (Makkar and Becker, 1997c) and saponins were inactive as far as haemolytic properties are concerned. Alkaloids are also present in kernel meals (root-bark have been found to have two alkaloids, moringine and moringinine; moringinine is known to stimulate cardiac activity, raise blood-pressure, act on sympathetic nerve-endings as well as smooth muscles all over the body, and depress the sympathetic motor fibres of vessels in large doses only.

Glucosinolates, lectins and alkaloids which form the major antinutrient substances in Moringa seed meal could be easily removed by water extraction (Makkar and Becker, 1999a). However, this method has the disadvantage of also removing some soluble nutrients. Solid state fermentation of the seed meal using ***Rhizopus oligosporus*** sp. could be considered as this mould has been found to degrade glucosinolates in defatted rapeseed meal (Bau *et al.*, 1994).

Moringa as a Potential Feed for Livestock and Aquaculture Industry

Moringa oleifera is native in Himalaya but is currently spread almost world-wide. However, there is scanty information worldwide on its potential as an animal feed.

Moringa in Aquaculture Industry

Sustainable aquaculture developments focus on increasing aquaculture production and productivity to alleviate poverty and hunger without compromising the environment. Aquaculture is the fastest-growing food production sector in the world and now supplies almost half of the global fish consumption. Trends in many of the drivers of demand indicate that aquaculture continue to expand. In particular, Asian and African aquaculture must grow significantly to meet domestic and regional demand for fish by increasing production by using underutilized water resources.

In the aquaculture, fish farmers always encounter predatory problem during the stocking of new fish species, and most often, they tend to use synthetic chemicals, which are non-biodegradable, as an effective solution. The bio-safety of products from aquaculture is paramount to consumers of aquatic foods from the aquaculture source. ***M. oleifera*** is biodegradable, environmentally friendly and cost-effective, and could use as supplemental protein source for fishmeal, and as aquaculture pond management tool to wipe predators in the fish pond prior to stocking with new fish species (Adesina and Omitoyin, 2011). Focus on plant research has increased all over the world and a large amount of data has collected which shows enormous potential of medicinal plants used in various traditional systems. Many herbs have developed into herbal supplements which are claimed to assist in healthy lifestyle (Sirimongkolvorakul *et al.*, 2011).

The production of aquaculture feeds was expected to rise from the current level of about 13 million metric tonnes (mmt) to about 30 mmt in 2010. It is estimated that a minimum of 3 mmt of fishmeal equivalent, alternative protein sources was required in the aquaculture industry yearly by the year 2010. The selection of plant-derived, protein sources for use as animal feeds should take human food security interests into account. It would be highly desirable if products from plants that can grow on degraded soil and require lower external energy subsidies could be used. Four examples of such plants, Moringa ***oleifera*** and ***Sesbania*** spp. are the most promising one. These plant species are

capable of growing on degraded lands, under stressful environmental conditions, and still sustain a reasonable production of nutrient -rich products havingwith potential as fish feed ingredients.

As the World's human population continues to expand beyond 6 billion, its reliance on farmed fish production as an important source of protein will also increase (Naylor *et al.*, 2000). Projections of world fishery production in 2010 range between 107 and 144 million tonnes (FAO, 2000). Most of the increase in fish production is expected to come from aquaculture, which is currently the fastest growing food production sector of the world. By the year 2030, aquaculture will dominate fish supplies and more than half of the fish consumed is likely to originate from this sector (FAO, 2000). The projected total production of feeds for aquaculture in the year 2010 range from 25 million metric tonnes (mmt; Tacon and Forster, 2001) to 32.6 mmt (IFOMA, 2000) against an approximate production estimate of about 13 mmt in the year 2000.

Aquaculture is capable of increasing the total production and fulfilling the high demand for fish protein sources (FAO, 2014). Of the total world production of fish, which amounted to 112.30 million tons in 1995, 18.97 % came from the aquaculture sector while the rest came from the captured fishery [1]. Most of the increase in fish production is expected to come from aquaculture, which is currently the fastest growing food production sector of the world [2]. In aquaculture systems the increasing price of feed is considered one of the most important factors that limit profitability, caused mainly by the cost of fishmeal used as a primary source of protein. As a result, there is a need to search for alternative protein sources for aquaculture diets. The high cost and fluctuating quality of imported fish meal have led to the need to identify alternative protein sources for use in fish feed formulations [5]. The identification and utilization of non-conventional and lesser-utilized plant protein sources to replace fishmeal, either partially or totally in practical fry diets has been an area of focus in aquaculture nutrition. Earlier studies have shown that, *Moringa oleifera* is a promising protein source for inclusion in fish diets at low levels.

Moringa leaf meal is rich in protein and has been tested in various fish species as a potential replacement for fish meal. However, feeding trials show that only limited amounts of moringa leaf meal can be safely used in fish diets, which is probably due to the presence of phenolics, saponins, phytic acid and other metabolites with antinutritional effects in fish (Richter *et al.*, 2003; Egwuoy *et al.*, 2013).

Nile tilapia (Oreochromis niloticus)

Moringa leaf meal can be introduced in Nile tilapia diets only in limited amounts, up to 8-10% dietary level (Abo-State *et al.*, 2014; Yuangsoi *et al.*, 2011; Richter *et al.*, 2003; Afuang *et al.*, 2003). In a diet where moringa leaves were included at 10% to provide supplementary protein, protein digestibility was reported to range from 68% to 75%, and daily weight gain was 30% higher (Yuangsoi *et al.*, 2011). Inclusion levels higher than 10% resulted in lower specific growth rate, lower nutrient utilization and poorer carcass composition (Abo-State *et al.*, 2014). Including moringa leaf meal at 12% (as fed, replacing 15% of soybean protein) significantly reduced DM digestibility, and a 24% inclusion rate reduced all nutrient digestibilities (Kasiga *et al.*, 2014).

Methanol-extracted leaf meal containing less saponins and phenolics could be included at up to 30% in tilapia fingerlings without hindering fish performance but resulted in lower protein accumulation in fish (Afuang *et al.*, 2003). Water-extracted leaf meal included at 15% dietary level had deleterious effect on fish feed intake, feed utilization and fish performance. The product was still highly unpalatable to fish, who spat out the feed pellets (Madalla *et al.*, 2008). Different moringa leaf extracts (tannin-reduced, saponin-reduced and saponin-enriched) were all shown to reduce fish performance (Dongmeza *et al.*, 2006).

In an experiment conducted in Tanzania on Nile tilapia fed diets containing Moringa leaf meal and sunflower seed cake indicated that Moringa leaf meal is better than sunflower seed cake as a protein source in Nile tilapia diets. Diet containing a mixture of Moringa leaf meal and sunflower leaf cake in equal proportions promotes higher growth rate of Nile tilapia than soybean meal. The fish on diet containing 50% SFSC and 50% MOLM had significantly higher average final body weight (28.08 g),

body weight gain (23.03 g), growth rate (0.27 g/d) and specific growth rate (2.27), total body length (11.02 cm) and width (3.45 cm) compared to the fish fed other diets.

On the other hand the study conducted in Nigeria on growth performance of fish fed varying levels of moringa olifera leaf meal diets indicated that the growth and nutrient utilization by fishes decreased as M. oleifera leaf meal increased in diets. This observation may be as a result of persistent increase in the substitution levels of fish meal with M. oleifera leaf meal in the diets which could retard growth as reported by Richter et al. and also supported by Afung et al. who reported that solvent extracted M. oleifera leaf meal could replace 30% of fish meal in the diets *Oreochromis niloticus*. The decrease in the growth rate could also be due to reduction in level of protein and essential amino acids in the diet having higher substitution levels of fish meal with M. oleifera leaf meal.

Redbreast tilapia (Coptodon rendalli)

Moringa leaf meal could replace up to 25% fish meal in the diets of redbreast tilapia (*Coptodon rendalli*) diet without compromising fish growth but resulted in hepatocyte degradation and enterocyte irritation and increased feed costs (Hlophe et al., 2014).

African catfish (Clarias gariepinus)

Moringa leaf meal could be included at 12.5% in the diets of African catfish fingerlings replacing groundnut cake without hampering fish performance (Olaniyi et al., 2013). Up to 20% moringa leaf meal inclusion did not affect fish performance, feed conversion ratio and protein efficiency compared but higher rates increased serum enzymes, which suggests some cellular damage (Ozovehe, 2013).

Basa fish (Pangasius bocourti)

Moringa seed cake could replace 50% soybean meal (8.5% dietary level) in basa fish diets based on fish meal and soybean meal. Higher rates resulted in poorer fish performance, degraded feed conversion ratio and protein efficiency. No signs of pathology were observed at any inclusion level (Yuangsoi et al., 2014).

Common carp (Cyprinus carpio)

In carps, moringa leaf meal could be included at 8.8% replacing 20% of soybean meal protein without compromising protein digestibility, fish growth and feed conversion ratio and with no deleterious effects on fish health (Yuangsoi et al., 2012).

Moringa in Livestock Industry

Moringa leaves are readily eaten by cattle, sheep, goats, pigs and rabbits. Branches are occasionally lopped for feeding cattle. The residents cut back the main stem to encourage side shoots which they use for livestock feeding. Leaves can also be used for fish.

Moringa Olifera as Poultry feed

Poultry production plays a major role in bridging the protein gap in developing countries where average daily consumption is far below recommended standards. However, the productivity of poultry in the tropics has been limited by scarcity and consequent high prices of the conventional chicken food. Hence, there is a need to search for locally available alternative sources of protein for use as feed supplement to poultry.

Feed costs amount to a considerable proportion of production cost in any intensive livestock production system. It has been reported that, feed cost represents up to 60-80% of the total cost of broiler production. Fishmeal, a conventional feed resource, has been used as the source of animal protein in diets of poultry in many countries due to unavailability of cheaper alternative protein

sources. With the present trend of rising prices of feedstuffs, considerable attention has been placed on the search for non-conventional feedstuffs.

Various leaf meals have been used in poultry diets, including those of *Leucaena*. In laying hens, the recommended inclusion rate for *leucaena* leaf meal is 10 %. Mulberry is another excellent feedstuff plant due to its good adaptability, long cultivation history, mature planting techniques, high leaf yield, abundant nutrition, and a great deal of active substances of health care.

Mulberry leaf powder supplementation at 10% would cut down the cost of poultry feed. In addition the protein from Moringa leaves may be fed to poultry in the form of leaf protein concentrate. Moringa leaf meals do not only serve as protein source but also provide some necessary vitamins, minerals and oxycarotenoids which cause yellow colour of broiler skin, shank and egg yolk. Feeding chickens with Moringa leaves and seeds will improve egg production. The inclusion of Moringa oleifera leaves meal up to 30% in the diet of growing traditional Senegal chickens had no negative impact on live body weight, average daily weight gain, feed conversion ratio, carcass and organs characteristics, health and mortality rate in birds compared to their controls. Considering these results and the high price of raw ordinary ingredients, particularly protein ingredient sources in poultry feeding; the recovering of these leguminous leaves in the diets of chickens is a real opportunity for traditional stockholders to improve at lower cost, not only the productivity and nutritional status of their birds but also their income with a 50% saving.

There has been a lot of research on the potential of moringa leaf meal (dried and ground moringa leaves) as an alternative feed ingredient for poultry, due to the rising interest in moringa and to the fact that the leaves have a high protein level. However, the digestibility of diets containing moringa leaf meal was found to be lower than that of control diets, especially for crude protein (and therefore amino acids), which was partly due to the fibre content, which also limits its energy value in poultry (Abou-Elezz et al., 2012b).

A study conducted in 2012 to determine the growth performance of Cobb broilers supplemented with varying concentrations of Moringa oleifera Aqueous Leaf Extract (MoALE) via the drinking water indicated that at 90 mL MoALE, the feed consumption of broilers was consistently lower than the control group. The live weight of broilers given 30 mL, 60 mL and 90 mL MoALEs were significantly higher than the control group. In terms of feed conversion ratio (FCR), all the MoALE treated broilers were more efficient converter of feeds into meat than the control group. Furthermore, the return of investment (ROI) of MoALE treated broilers (T1-T3) was significantly higher than the control group.

An experiment carried out in Tanzania to investigate the effect of substituting *Moringa oleifera* leaf meal (MOLM) for sunflower seed meal (SSM) as a protein source of egg strain commercial chickens on feed intake (FI), dry matter intake (DMI), egg weight (EWT), Laying percentage (LP), egg mass production (EMP), and feed conversion ratio (KG FEED/KG EGGS) were indicated that Good health status of experimental birds observed during the entire period of the study, suggested that use of MOLM have negligible amount of toxic materials already reported in other leaf meals. Feed and dry matter intakes demonstrate that MOLM is palatable and highly preferred by chickens. These findings were inconsistent with those reported in other leaf meals by (Vohra 1972; Ravindran et al 1986; Osei et. al 1990 and Bhatnagar et. al 1996) who observed a depression in intake when laying chickens were fed diets containing various levels of *Leucaena leucocephala* (LLM.). These variations probably suggest lower anti-nutritional factors and toxic materials in MOLM (Makker and Backer 1997) than in other leaf meals.

The study showed that substitution of sunflower seed meal with *Moringa oleifera* suggest the shrub to have a potential in poultry feeding. This is exhibited through its protein content, relatively low fibre and higher mineral contents. The study using layers showed that MOLM could be used as a source of plant protein since it was highly accepted even at high inclusion levels in the diet. However, for optimum utilization 10% inclusion is recommended. In areas where MOLM can be obtained for free and quality of eggs fetch higher premium complete substitution (20%) with MOLM is highly recommended.

Broilers

While some literature reviews have been rather optimistic (Moreki et al., 2014; Gadzirayi et al., 2014b), most studies show that the use of moringa leaf meal in broilers results in decreased performance. Inclusion rates as low as 5-7.5% sometimes reduced growth by 15% (Zanu et al., 2012; Olugbemi et al., 2010a; Oludoyi et al., 2012; Gakuya et al., 2014). Feed intake is generally not much impacted, which leads to a degradation of feed efficiency. Even if growth depression is sometimes linked to unbalanced diets, in other cases it appears to be a direct effect of moringa. However, this detrimental effect of moringa is not constant and some authors report performances similar to (but seldom higher than) those obtained with control diets, even with 7.5 to 10% moringa leaf meal (Onu et al., 2011; Foluke et al., 2013; El Tazi, 2014; Banjo, 2012). In any case, performance always deteriorates when moringa leaf meal is included at 20% or more in the diet (Tesfaye et al., 2013; Jiya et al., 2014, Gakuya et al., 2014). The general recommendation is to avoid the use of moringa leaf meal in intensive broiler production, as the risk of performance degradation is high. Very low levels (<2%) could be tested for potential probiotic effects.

Slow-growing or indigenous chickens

In slow-growing chickens, up to 10% moringa leaf meal could maintain growth performance in some studies while performance decreased at higher rates (Melesse et al., 2011; Gadzirayi et al., 2012; Chongwe, 2011). Other studies observed reduced growth with as low as 5% moringa in the diets (Gadzirayi et al., 2014a). A cost-benefit analysis is required on a per case basis, as including moringa leaf meal may spare the purchase of high price ingredients.

Layers

In layers, moringa leaf meal generally lowers laying performance and feed efficiency at high inclusion rates (15-20%) (Kakengi et al., 2007) but also sometimes at lower (5 to 7.5%) levels (Ebenebe et al., 2013; Olugbemi et al., 2010b). There are some reports of performance being maintained at 10% inclusion rate (Kakengi et al., 2007) and even improved at 2.5% (Ebenebe et al., 2013). In moderately productive layers, fresh moringa leaves added to *ad libitum* commercial feed improved laying performance but results were negative when the quantity of commercial feed was reduced (Abou-Elezz et al., 2012a). The recommendation is to use moringa leaf meal carefully in layer feeds, at no more than 5% of the diet.

Moringa as a feed additive

Moringa leaf meal and moringa leaf extracts have been tested in poultry as feed additives for the potential benefits on poultry health and meat or egg quality of their active compounds, though these compounds can also affect negatively digestion and metabolic processes. Some results showed a positive effect of moringa extracts or low levels (below 2%) of moringa leaf meal (Portugaliza et al., 2012; David et al., 2012; Teteh et al., 2013). No major toxicity problems have been reported (Ashong et al., 2011). The effect of moringa on serum and egg cholesterol levels is disputed, as some studies report a decrease in cholesterol (e.g. Ashong et al., 2011) and others an increase (e.g. Gakuya et al., 2014). As a consequence, moringa leaf meal cannot be used reliably to regulate cholesterol levels in poultry products.

Moringa as a feed for Sheep and Goats

Moringa leaves totally replacing cottonseed cake in growing lambs fed on low-quality hay increased hay intake (355 vs 324 g DM), diet DM digestibility (70 vs 60 %) and daily weight gain (62 vs 52 g/d) (Murro et al., 2003). Feeding growing goats with moringa leaves as sole forage or combined with other legume tree leaves in the diet of growing goats had no effect on total DM intake (278-289 g/d) and diet digestibility (76-77%) (Asaolu et al., 2011). Moringa leaves used up to 50% as sole supplement into diets based on low quality forage increased daily weight gain and diet digestibility (Aregheore, 2002). Moringa leaves offered to growing goats fed low-quality forage or cassava peels to replace

cottonseed cake, sunflower seed cake or commercial concentrate (250 g/d) had no effect on daily weight gain (Ndemanisho et al., 2007; Sarwatt et al., 2002, Asaolu et al., 2012). Moringa leaves could replace a commercial concentrate (250 g/d) in a diet based on cassava peels without modifying daily gain (21 g/d), which was higher than with other legume tree leaves (Asaolu et al., 2012). Supplementing growing goats fed on grass hay and wheat bran with moringa leaf meal instead of sunflower cake resulted in higher meat quality (physico-chemical characteristics and organoleptic quality parameters including higher first bite, aroma, flavour and juiciness scores) (Moyo et al., 2014).

Studies by Sarwatt et al (2002) on supplementation of *Moringa oleifera* to poor quality hay fed to growing Small East African Goats (SEAG) showed the existence of a negative nitrogen balance to goats supplemented with 25 and 50% *Moringa oleifera* leaf meal (MOLM). The preliminary results of effect of supplementing crop leftovers with equal amount of *Leucaena* leaf meal (LLM), *Grilicidia* leaf meal (GLM) and *Moringa oleifera* leaf meal (MOLM) showed that goats fed on MOLM were outperformed in terms of growth rate by those fed on the other multipurpose trees. This is perplexing because MOLM has relatively higher crude protein (Sutherland et al 1990, Makkar and Becker, 1997, Sarwatt et al 2002) and low antinutritional factors (Makkar and Becker, 1997) yields low animal performance? Kakengi et al (2003) evaluated and compared nutritive value of different morphological components of *Moringa oleifera* with *Leucaena leucocephala* leaf meal in Tanzania. They observed high pepsin and total soluble protein in *Moringa oleifera* leaf meal (MOLM) than other parts of the plant. The high pepsin and total soluble protein makes MOLM more suitable to monogastric animals.

Moringa as a feed for cattle

Moringa leaves have been assessed as a protein supplement for medium or low producing dairy cows fed low-quality forages. Feeding moringa leaves had variable effects on DM intake and milk yield but did not change milk composition. Moringa leaves offered as sole forage (fresh or ensiled) plus molasses gave the same results as low nutritive forage supplemented with concentrate. Fresh moringa leaves used as sole forage in dairy cows diet negatively modified the smell and taste of milk and cheese, which could be due to the presence of glucosinolates in the leaves. Milk from cows fed ensiled moringa leaves did not have off-flavour and aroma, possibly because the silage process destroyed most of the glucosinolates, as observed with other forages (Mendieta-Araica et al., 2011a). In growing steers, moringa leaves used as sole concentrate and fed at 0.59% BW resulted in 380 g daily weight gain (Reyes Sanchez et al., 2006). When moringa leaves replaced a commercial concentrate in growing steers (pure N'Dama or N'Dama x Jersey crossbred) fed on groundnut hay, they depressed DM intake, but increased the daily weight gain of both breeds: 625 vs 458 g/d (N'Dama) and 750 vs 625 g/d (crossbred) (Nouala et al., 2009).

BIOMASA conducted extensive trials using Moringa leaves as cattle feed (beef and milk cows), swine feed, and poultry feed. With moringa leaves constituting 50% of feed, milk yields for dairy cows and daily weight gains for beef cattle increased 30%. Birth weight, averaging 22 kg for local Jersey cattle, increased by 3-5 kg. The high protein content of Moringa leaves must be balanced with other energy food. Cattle feed consisting of 50% Moringa leaves should be mixed with molasses, sugar cane, sweet (young) sorghum plants, or whatever else is locally available.

Care must be taken to avoid excessive protein intake. Too much protein in pig feed will increase muscle development at the expense of fat production. In cattle feed, too much protein can be fatal (from alteration of the nitrogen cycle). Cattle were fed 15-17 kg of Moringa daily. Milking should be done at least three hours after feeding to avoid the grassy taste of Moringa in the milk.

With Moringa feed, milk production was 10 liters/day. Without Moringa feed, milk production was 7 liters/day. With moringa feed, daily weight gain of beef cattle was 1,200 grams/day. Without Moringa feed, daily weight gain of beef cattle was 900 grams/day. The higher birth weight (3-5 kg) can be problematic for small cattle. It may be advisable to induce birth 10 days prematurely to avoid problems. Incidence of twin births also increased dramatically with moringa feed: 3 per 20 births as opposed to the usual average of 1:1000.

In an experiment conducted on dairy cows to study effects of dried and ensiled *Moringa olifera*

on milk yield and milk flavor showed that Fresh Moringa had the highest intake as compared to Elephant grass diet which had the lowest intake. Compared with the control diet, ensiled Moringa had higher digestibility of both protein and fiber. With the exception of DM digestibility, no digestibility differences were found between fresh Moringa and Moringa silage treatments. Milk yield did not differ between any of the treatments and averaged 13.7 kg cow day⁻¹. Milk composition was similar among all treatments. Milk from the fresh Moringa treatment, however, had a grassy flavor and aroma, significantly different from the other two treatments, even though it was normal in color and appearance. No organoleptic differences were found between milk from the control treatment and the Moringa silage treatment. The conclusion is that Moringa silage can be fed to dairy cows in large quantities to produce the same quantity and quality of milk as traditional diets (Mendieta *et al.*, 2011).

Moringa as a feed for Pig

Fattening pigs on 50% Moringa stems and leaves, 10% Leucaena, 38% maize and 2% nutrient salts will lead to good growth rates and significant cost savings. Information about the nutritive value of moringa leaves and seed cake in pig feeding is scarce. *In vitro* estimations showed that moringa leaves could be valuable in pig feeding and may have a good energy value, though they do not completely meet the nutritional requirements of pigs (Kambashi *et al.*, 2014). Feeding tests with moringa leaf meal have been only mildly successful as high inclusion rates were found detrimental to performance. In Nicaragua, including up to 30% moringa leaf meal in growing pig diets as partial substitution for a commercial concentrate decreased pig performance and depressed feed conversion ratio but might still increase farmer income (Perez *et al.*, 2001). In the Philippines, moringa leaf meal could be included at 10% to partially replace commercial concentrate in growing pigs' diet in backyard conditions without hampering pig performance (Acda *et al.*, 2010).

Conclusion

As a conclusion, more attention need to be paid to the uses of *Moringa oleifera* in a large scale in countries like Ethiopia and other countries where the *Moringa oleifera* tree can be grown to produce more natural products and environmentally friendly materials. However the following conclusions are drawn as far as potential uses of Moringa in Aquaculture and livestock industry are concerned.

- *Moringa oleifera* is the most useful trees as feed supplements to animals as their leaves are highly nutritious with excellent palatability, digestibility and balanced chemical composition of protein and minerals.
- *Moringa oleifera* leaves are readily eaten by cattle, sheep, goats, pigs and rabbits. Even though currently *Moringa olifera* is spread almost world-wide, there is scanty information on its potential as an animal feed.
- *Moringa oleifera* is a promising protein source for inclusion in fish diets at low levels.
- *Moringa oleifera* leaf meal is rich in protein and has been tested in various fish species as a potential replacement for fish meal. However, feeding trials show that only limited amounts of *Moringa oleifera* leaf meal can be safely used in fish diets, which is probably due to the presence of phenolics, saponins, phytic acid and other metabolites with antinutritional effects in fish.
- Using *Moringa oleifera* leaves in poultry, pigs and fish is feasible but only in limited amounts due to the presence of fibre and ant nutritional factors.
- Feeding chickens with *Moringa oleifera* leaves and seeds will improve egg production.
 - *Moringa oleifera* leaves totally replacing cottonseed cake in growing lambs fed on low-quality hay increased hay intake, diet DM digestibility and daily weight gain.
 - *Moringa oleifera* leaves used up to 50% as sole supplement into diets based on low quality forage increased daily weight gain and diet digestibility of growing kids.
 - In dairy cattle feeding *Moringa oleifera* leaves had variable effects on DM intake and milk yield but did not change milk composition. *Moringa oleifera* leaves offered as sole forage (fresh or ensiled) plus molasses gave the same results as low nutritive forage supplemented with concentrate. In growing steers, *Moringa oleifera* leaves used as sole concentrate and fed at 0.59% BW resulted in 380 g daily weight gain.

- *Feeding tests in pigs with Moringa oleifera leaf meal have been only mildly successful as high inclusion rates were found detrimental to performance. Moringa oleifera leaf meal could be included at 10% to partially replace commercial concentrate in growing pigs diet in backyard conditions without hampering pig performance*

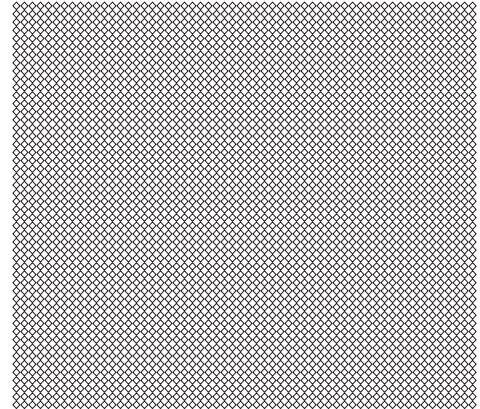
References

- Abo-State, H., Hammouda, Y., El-Nadi, A. ; AboZaid, H., 2014. Evaluation of feeding raw moringa (*Moringa oleifera* Lam.) leaves meal in Nile tilapia fingerlings (*Oreochromis niloticus*) diets. *Global Vet.*, 13 (1): 105-111
- Abou-Elezz, F. M. K.; Sarmiento-Franco, L.; Santos-Ricalde, R.; Solorio-Sanchez, J., 2012a. The nutritional effect of *Moringa oleifera* fresh leaves as feed supplement on Rhode Island Red hen egg production and quality. *Trop. Anim. Health Prod.*, 44 (5): 1035-1040
- Abou-Elezz, F. M. K.; Sarmiento-Franco, L.; Santos-Ricalde, R.; Solorio-Sanchez, J., 2012b. Apparent digestibility of Rhode Island Red hen diets containing *Leucaena leucocephala* and *Moringa oleifera* leaf meals. *Trop. Subtrop. Agroecosyst.* 15 (2): 199-206
- Acda, S. P., Masilungan, H. G. D., Moog, B. A., 2010. Partial substitution of commercial swine feeds with malunggay (*Moringa oleifera*) leaf meal under backyard conditions. *Philippine J. Vet. Anim. Sci.*, 36 (2): 137-146
- Adesina, B.T. and B.O. Omitoyin. 2011. Potential of *Moringa Oleifera* (Lam.) Fresh Root-Bark Extract as
- Afuang, W., Siddhuraju, P. and Becker, K. 2003. Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of moringa (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus* L.). *Aquaculture Research*. 34, 1147-1159.
- Amaglo, N. K., Timpo, G. M. ; Ellis, W.O. ; Bennett, R. N., 2007. Effect of spacing and harvest frequency on the growth and leaf yield of moringa (*Moringa oleifera* Lam.), a leafy vegetable crop. *Ghana J. Hort.*, 6: 33-40
- Amaglo, N., R. Bennett, R. Lo Curto, E. Rosa, V. Lo Turco, A. Giuffrid, A. Lo Curto, F. Crea, G. Timpo, 2010. Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. *Food Chem.*, 122: 1047-1054. An Organic Piscicide in Aquaculture Pond Management. *Egyptian Journal of Biology*, 1 (13): 8-13.
- Aregheore, E.M. (2002). Intake and digestibility of *Moringa oleifera* and batiki grass mixtures by growing goats. *Small Ruminant Research* 46: 23-28.
- Aregheore, E.M. 2002. Intake and digestibility of *Moringa oleiferabatiki* grass mixtures by growing goats. *Small Rumin. Res.* 46, 23-28.
- Asaolu, V. O., Binuomote, R. T. ; Akinlade, J. A. ; Oyelami, O. S. ; Kolapo, K. O., 2011. Utilization of *Moringa oleifera* fodder combinations with *Leucaena leucocephala* and *Gliricidia sepium* fodders by West African Dwarf goats. *Int. J. Agric. Res.*, 6 (8): 607-619
- Asaolu, V., Binuomote, R., Akinlade, J., Aderinola O. and Oyelami, O. 2012. Intake and Growth Performance of West African Dwarf goats fed *Moringa oleifera*, *Gliricidia sepium* and *Leucaena leucocephala* dried leaves as supplements to Cassava peels. *J. Bio. Agric. Healthcare*. 2, 76-88.
- Ashong, J. O., Brown, D. L., 2011. Safety and efficacy of *Moringa oleifera* powder for growing poultry. *J. Anim. Sci.*, 89 (Suppl.1): 84 (M220)
- Bakhshwain, A., Sallam, S. M. A., Allam, A. M., 2010. Nutritive value assessment of some Saudi Arabian foliages by gas production technique in vitro. *JKAU: Met., Env. & Arid Land Agric. Sci.* 21 (1): 65-80
- Bennet, R., F. Mellon, N. Foidel, J. Pratt, M. Dupont, L. Perkins, P. Kroon, 2003. Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees *Moringa oleifera* L. and *Moringa stenopetala* L. *Journal of Agriculture and Food Chemistry*, 51: 3546-53.
- Banjo, O. S., 2012. Growth and performance as affected by inclusion of *Moringa oleifera* leaf meal in broiler chicks diet. *J. Biol. Agric. Healthcare*, 2 (9): 35-38.
- Bhatnagar R, Kataria M and Verna S V S 1996 Effect of dietary *Leucaena* leaf meal on the performance and egg characteristics in white leghorn hens. *Indian Journal of Animal Science* 66 (12): 1291-1294.
- Bosch, C. H., 2004. *Moringa oleifera* Lam. In: Grubben, G. J. H.; Denton, O. A. (Eds). *PROTA (Plant Resources of*

Tropical Africa / Ressources végétales de l'Afrique tropicale, Wageningen, Netherlands

- Chongwe, A. M., 2011. The effect of Moringa supplementation on growth and health of indigenous Zambian chickens. M.Sc. dissertation, University of Zambia, Lusaka, Zambia. 47pp
- David, L. S., Vidanarachchi, J. K.; Samarasinghe, K.; Cyril, H. W.; Dematawewa, C. M. B. , 2012. Effects of Moringa based feed additives on the growth performance and carcass quality of broiler chicken. *Trop. Agric. Res.*, 24 (1): 12-20
- Dongmeza, E., Siddhuraju, P., Francis, G., Becker, K., 2006. Effects of dehydrated methanol extracts of Moringa (*Moringa oleifera* Lam.) leaves and three of its fractions on growth performance and feed nutrient assimilation in Nile tilapia (*Oreochromis niloticus* (L.)). *Aquaculture*, 261 (1): 407-422
- Ebenebe, C. I., Anigbogu, C. C., Anizoba, M. A., Ufele, A. N., 2013. Effect of various levels of Moringa leaf meal on the egg quality of Isa Brown Breed of Layers. *Adv. Life Sci. Technol.*, 14: 45-49
- Egwui, P. C., Mgbenka, B. O., Ezeonyejiaku, C. D., 2013. Moringa plant and its use as feed in aquaculture development: a review. *Anim. Res. Int.*, 10 (1): 1672-1680
- El Tazi, S. M. A., 2014. Effect of feeding different levels of Moringa Oleifera leaf meal on the performance and carcass quality of broiler chicks. *Int. J. Sci. Res.*, 3 (5): 147-151
- Foidl, N., Makkar, H. P. S., Becker, K., 2001. The potential of Moringa oleifera for agricultural and industrial uses. In: What development potential for Moringa products? October 20th - November 2nd 2001. Dar Es Salaam
- Foluke, A., Olufemi, A., 2013. Effects of graded levels of cassava peels fortified with moringa as a replacement to wheat bran on performance, digestibility and blood profile of broilers. *J. Agric. Sci. Technol. A*, 3 (3A): 210-215
- Gadzirayi, C. T., Mupangwa, J. F., 2014. The nutritive evaluation and utilisation of Moringa oleifera Lam. in indigenous and broiler chicken production: a review. *Greener J. Agric. Sci.*, 14 (1): 15-21
- Gadzirayi, C. T., Mupangwa, J. F., 2014. Feed intake and growth performance of indigenous chicks fed diets with Moringa oleifera leaf meal as a protein supplement during early brooding stage. *Int. J. Poult. Sci.*, 13 (3): 145-150
- Gakuya, D. W. ; Mbugua, P. N. ; Kavoi, B. ; Kiama, S. G., 2014. Effect of supplementation of Moringa oleifera leaf meal in broiler chicken feed. *Int. J. Poult. Sci.*, 13 (4): 208-213
- García, D. E.; Medina, M. G.; Cova, L. J.; Torres, A.; Soca, M.; Pizzani, P.; Baldizán, A.; Domínguez, C. E., 2008a. Preference of cattle for the foliage of twelve species with potential for agrosilvopastoral systems in the Trujillo State, Venezuela. *Pastos y forajes*, 31 (3) : 255-270
- Garcia, D. E., Medina, M. G.; Cova, L. J.; Soca, M.; Pizzani, P.; Baldizan, A.; Dominguez, C. E., 2008d. Accept-

Livestock Production



- ability of tropical tree fodder by cattle, sheep and goats in Trujillo state, Venezuela. *Zootecnia Trop.*, 26 (3): 191-196.
- Gadzirayi, C.T., Masamha, B., Mupangwa, J.F. and Washaya, S. 2012. Performance of broiler chickens fed on mature *Moringa oleifera* leaf meal as a protein supplement to Soybean meal. *Intern. J. Poult. Sci.* 11, 5-10.
 - Gutierrez, P., Rocha, L., Reyes Sanchez, N. ; Paredes, V. ; Mendieta Araica, B., 2012. Ruminal degradation rate of *Moringa oleifera* foliage in Reyna cattle using in sacco technique. *La Calera*, 12 (18): 37-44
 - Hlophe, S. N., Moyo, N. A. G., 2014. A comparative study on the use of *Pennisetum clandestinum* and *Moringa oleifera* as protein sources in the diet of the herbivorous *Tilapia rendalli*. *Aquacult. Int.*, 22 (4): 1245-1262
 - Jiya, E. Z., Ayanwale, B. A., Ibrahim, A. B. ; Ahmed, H., 2014. Growth response, meat yield and carcass characteristics of broilers fed beniseed (*Sesamum indicum*) and drumstick (*Moringa oleifera*) leaves as sources of lysine. *Am. J. Expe. Agric.*, 4 (10): 1178-1185
 - Kakengi A M V, Shem M N, Sarwatt S V and Fujihara T 2003 Can *Moringa oleifera* be used as a protein supplement to ruminants? *Asian-Australasian Journal of Animal Sciences* 18:1:42-47.
 - Kakengi, A. M. V., Shem, M. N.; Sarwatt, S. V., Fujihara, T., 2005. Can *Moringa oleifera* be used as a protein supplement for ruminants? *Asian Aust. J. Anim. Sci.*, 18 (1): 42-47
 - Kakengi, A.M.V., Kaijage, J.T., Sarwatt, S.V., Mutayoba S.K., Shem, M.N. and Fujihara, T. 2007. Effect of *Moringa oleifera* leaf meal as a substitute for sunflower seed meal on performance of laying hens in Tanzania. *Livest Res. Rural Dev.* 19, 8 Retrieved 15th April 2008 from <http://www.lrrd.org/lrrd19/8/kake19120.htm>.
 - Kambashi, B., Picron, P., Boudry, C., Thewis, A., Kiatoko, H., Bindelle, J., 2014. Nutritive value of tropical forage plants fed to pigs in the Western provinces of the Democratic Republic of the Congo. *J. Anim. Feed. Sci.*, 191: 47-56
 - Kasiga, T., Lochmann, R., 2014. Nutrient digestibility of reduced-soybean-meal diets containing *Moringa* or *Leucaena* leaf meals for Nile tilapia, *Oreochromis niloticus*. *J. World Aquac. Soc.*, 45 (2): 183-191
 - Makkar, H.P. and K. Becker (1996). Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. *Anim. Feed Sci. Tech.* 63: 211–228.
 - Makkar, H.P.S. and Becker, K., 1997. Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree. *J. Agric. Sci.* 128, 311-322.
 - Makkar, H. P. S., Becker, K., 1999a. Plant toxins and detoxification methods to improve feed quality of tropical seeds. *Asian-Aust. J. Anim. Sci.*, 12 (3): 467-480
 - Makkar, H. P. S., Becker, K., 1997c. Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree. *J. Agric. Sci.*, 128 (3): 311-322
 - Madalla, N., 2008. Novel feed ingredients for Nile tilapia (*Oreochromis niloticus* L.). In: PhD Thesis, Inst. Aquaculture, Univ. Stirling, Scotland, and UK
 - Melesse, A., Tiruneh, W., Negesse, T., 2011. Effects of feeding *Moringa stenopetala* leaf meal on nutrient intake and growth performance of Rhode Island Red chicks under tropical climate. *Trop. Subtrop. Agroecosyst.* 14 (2): 485-492
 - Mendieta-Araica, B. (2011). *Moringa oleifera* as an alternative fodder for dairy cows in Nicaragua. Ph.D thesis. Acta Universitatis Agriculturae Sueciae. ISBN 978-91-576-7569-9.
 - Mendieta-Araica, B., Spöndly, R., Reyes-Sánchez, N. and Spöndly, E. 2011. *Moringa* (*Moringa oleifera*) leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. *Livest. Sci.* 137, 10-17.
 - Moreki, J. C., Gabanagosi, K., 2014. Potential use of *Moringa oleifera* in poultry diets. *Global J. Anim. Scientif. Res.*, 2 (2): 109-115
 - Moyo, B., Masika, P.J. and Muchenje, V. 2014. Effect of feeding *Moringa* (*Moringa oleifera*) leaf meal on the physic-chemical characteristics and sensory properties of goat meat. *S. Afri. J. Anim. Sci.*, 44(1): 64-70.
 - Murro, J. K., Muhikambele, V. R. M., Sarwatt, S. V., 2003. *Moringa oleifera* leaf meal can replace cottonseed cake in the concentrate mix fed with Rhodes grass (*Chloris gayana*) hay for growing sheep. *Livest. Res. Rural Dev.*, 15 (11).

- Ndemanisho, E. E.; B. N. Kimoro; E. J. Mtengeti and V. R. Muhikambele (2007). In vivo digestibility and performance of growing goats fed maize stover supplemented with browse leaf meals and cotton seed cake based concentrates. LRRD 19 (8) www.lrrd.org/lrrd19/8/ndem19105.htm.
- Nouala, F. S., Muetzel, S., Hoffmann, E., Becker, K., 2009. Feed intake and digestion by two cattle breeds fed of baby corn stovers and groundnut hay supplemented with graded levels of concentrate and Moringa leaves. *Livest. Res. Rural Dev.*, 21 (10): 163
- Nouman, W., Basra, S. M. A., Siddiqui, M. T., Yasmee, A., Gull, T., Cervantes Alcayde, M. A., 2014. Potential of Moringa oleifera L. as livestock fodder crop: a review. *Turk. J. Agric. For.*, 38 (1): 1-14
- Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., Anthony, S., 2009. Agroforestry Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya
- Olugebemi, T.S., Mutayoba, S.K. and Lekule, F.P. 2010. Evaluation of Moringa oleifera meal inclusion in cassava chip based diets fed to Laying birds. *Livest. Res. Rural Dev.* 22, 6.
- Osei S A, Opuku and Atuahene C C 1990 Gliricidium leaf meal as an ingredient in layer diets. *Animal Feed Science and Technology* 29:303-308.
- Olaniyi, C. O., Ajani, N. O., Adetomi, M. N., 2013. Growth performance and nutrient utilization of Clarias gariepinus fed Moringa oleifera leaf meal. *J. Nat. Sci Res.*, 3 (8): 99-104
- Ozovehe, B. N., 2013. Growth performance, haematological indices and some biochemical enzymes of juveniles Clarias gariepinus (Burchell 1822) fed varying levels of Moringa oleifera leaf meal diet. *J. Aquacult. Res. Dev.*, 4 (2): 166
- Onu, P. N., Aniebo, A. O., 2011. Influence of Moringa oleifera leaf meal on the performance and blood chemistry of starter broilers. *Int. J. Food Agric. Vet. Sci.*, 1 (1): 38-44
- Oludoyi, I. A., Toye, A. A., 2012. The effects of early feeding of Moringa oleifera leaf meal on performance of broiler and pullet chicks. *Agrosearch*, 12 (2): 160-172
- Olugbemi, T. S., Mutayoba, S. K., Lekule F. P., 2010. Effect of moringa (Moringa oleifera) inclusion in cassava based diets fed to broiler chickens. *Int. J. Poult. Sci.*, 9 (4): 363-367
- Olugbemi, T. S., Mutayoba, S. K., Lekule, F. P., 2010. Evaluation of Moringa oleifera leaf meal inclusion in cassava chip based diets fed to laying birds. *Livest. Res. Rural Dev.*, 22 (6): 118
- Ndemanisho, E. E., Kimoro, B. N. ; Mtengeti, E. J. ; Muhikambele, V. R. M., 2007. In vivo digestibility and performance of growing goats fed maize stover supplemented with browse leaf meals and cotton seed cake based concentrates. *Livest. Res. Rural Dev.*, 19 (8): 105
- Portugaliza, H. P., Fernandez, T. J. Jr., 2012. Growth performance of Cobb broilers given varying concentrations of malunggay (Moringa oleifera Lam.) aqueous leaf extract. *Online J. Anim. Feed Res.*, 2 (6): 465-469
- Perez, H. J. R., Torres, P. F. J., 2001. Evaluación de marango (Moringa oleifera Lam.) como una alternativa en la alimentación de cerdos de engorde. *Red Marango de Nicaragua*
- Price, M. L., 2007. The Marango tree. *Nota Tecnica, ECHO*, 17391 Durrance road North fort Myers, FL 33917, USA
- Radovich, T., 2013. Farm and forestry production and marketing profile for Moringa. In: Elevitch, C.R. (Ed.) *Specialty Crops for Pacific Island Agroforestry*. Permanent Agriculture Resources (PAR), Holualoa, Hawai'i.
- Ravindran V, Kornegay E T, Rajaguru A S B, Potter L M and Cherry J A 1986 Cassava leaf meal as a replacement for coconut oil meal on broiler diets. *Poultry Science* 65(9): 1720- 1727.
- Reyes-Sánchez, N., Spörndly, E. and Ledin, I. 2006. Effects of feeding different levels of foliage from Moringa oleifera to creole dairy cows on intake, digestibility, milk production and composition. *Livest. Sci.* 101, 24-31.
- Richter, N., Siddhuraju, P. and Becker, K. 2003. Evaluation of nutrituional quality of Moringa (Moringa oleifera Lam.) leaves as an alternative source for Nile tilapia (Oreochromis niloticus L.). *Aquaculture*, 217, 599-611.
- Reyes Sanchez, N., 2004. Marango: Cultivation and utilization in animal feeding. *Guia tecnica nº5*, Universidad Nacional Agraria, Por un desarrollo agrario integral y sostenible, 24 p.
- Sarwatt, S.V., Kapange, S.S. and Kakengi, A.M.V. 2002. Substituting Sunflower seed-cake with Moringa oleifera leaves as a supplemental goat feed in Tanzania. *Agroforest. Syst.* 56, 241-247.

PROCEEDING

Animal Breeding and Reproduction

- Sarwatt, S.V., Milang'ha, M.S., Lekule, F.P. and Madalla, N., 2004. *Moringa oleifera* and cottonseed cake as supplements for smallholder dairy cows fed Napier grass. *Lives. Res. Rural Dev.* 16, 1.
- Siddhuraju, P. and K. Becker (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. *Journal of Agricultural and Food Chemistry*. 51: 2144–2155.
- Sirimongkolvorakul, S., W. Jiraungkoorsku, T. Tansatit, N. Preyavichyapugdee, P. Kosai and K. Uakulwarawat. 2011. Influence of *Moringa oleifera* on histopathological changes due to lead toxicity in red-tail tinfoil barb, *Puntius Altus*. *Proceedings of the 3rd International CEMEPE and SECOTOX Conference Skiathos*, 9-14.
- Soliva, C.R.; M. Kreuzera; N. Foidlb; G. Foidlb; A. Machmüller and H.D. Hessa (2005). Feeding value of whole and extracted *Moringa oleifera* leaves for ruminants and their effects on ruminal fermentation in vitro. *Anim. Feed Sci. and Tech.*, 118: 47-62.
- Sultana, N. ; Alimon, A. R. ; Haque, K. S. ; Sazili, A. Q. ; Yaakub, H ; Hossain, S. M. J., 2014. The effect of cutting interval on yield and nutrient composition of different plant fractions of *Moringa oleifera* tree. *J. Food, Agric. Env.*, 12 (2): 599-604
- Tesfaye, E., Animut, G., Urge, M., Dessie, T., 2013. *Moringa olifera* leaf meal as an alternative protein feed ingredient in broiler ration. *Int. J. Poult. Sci.*, 12 (5): 289-297
- Tete, A., Lawson, E., Tona, K., Decuyper, E., Gbeassor, M., 2013. *Moringa oleifera* leaves: hydro-alcoholic extract and effects on growth performance of broilers. *Int. J. Poult. Sci.*, 12 (7): 401-405
- Tona, G. O., Asaolu, V. O., Amao, O. A. ; Akingbade, A. A., 2013. Evaluation of chemical composition and in vitro fermentation parameters of *Moringa oleifera* leaf meal based diets as feed for ruminants in Nigeria. *Agric. J.*, 8 (4): 165-169
- Yang, R. Y., Tsou, S. C. S., Lee, T. C., Chang, L-C. ; Kuo, G., Lai, P-Y., 2006. *Moringa*, a novel plant rich in antioxidants, bioavailable iron, and nutrients. *Am. Chem. Soc. Symp. Series*, 925 (17): 224-239
- Yuangsoi, B., Charoenwattanasak, S., 2011. Utilization of *Moringa* (*Moringa oleifera* Lam.) leaf on growth performance and protein digestibility in *Tilapia* (*Oreochromis niloticus* L.). *Proc. 49th Kasetsart Univ. Ann. Conf., Kasetsart University, Thailand*, 1-4 February, 2011, 3 (Fisheries): 317-326
- Yuangsoi, B., Masumoto, T. Songklanakarin, 2012. Replacing *Moringa* leaf (*Moringa oleifera*) partially by protein replacement in soybean meal of fancy carp (*Cyprinus carpio*). *J. Sci. Technol.*, 34 (5): 479-485
- Yuangsoi, B., Klahan, R., Charoenwattanasak, S. Songklanakarin, 2014. Partial replacement of protein in soybean meal by *Moringa* seed cake (*Moringa oleifera*) in bocourti's catfish (*Pangasius bocourti*). *J. Sci. Technol.*, 36 (2): 125-135
- Vohra P 1972 Evaluation of metabolizable energy for poultry. *World's poultry Science Journal* 28: 204-214.
- Zanu, H. K., Asiedu, P., Tampuori, M., Abada, M., Asante, I., 2012. Possibilities of using *Moringa* (*Moringa oleifera*) leaf meal as partial substitute for fishmeal in broiler chicken diets. *Online J. Anim. Feed Res.*, 2 (1): 70-75

Floral calendar and seasonal availability of honeybee plants in Eastern Tigray, Northern Ethiopia

Haftom Gebremedhn¹, Guesh Godifay¹, Mearig Asefa¹, Gebreamlak Bezabh¹, Gebrecherkos Yeiebyo¹, Solomon Gebreyowhans¹

¹ Mekelle Agricultural Research Center, Email: haftush@yahoo.com, gueshgod@yahoo.com

Abstract

In any specific area, modern beekeeping cannot develop without an understanding of the floral calendar. However the floral calendar for the existed honeybee plants of the Eastern zone is not well documented and established. Hence, this study was designed to identify the existing honeybee plants and establish their floral calendar. The study was conducted in four districts of Eastern zone: Ganta afeshum, Erob, Atsby wonberta and Kilte awlalo districts. To identify existing honeybee plants and establish their floral calendars, data were collected from experienced beekeepers using semi-structured questionnaires. The study discovered variation on the seasonal availability of bee plans. High availability of bee plants was found from September to November while scarcity of honeybee plants was found from December to February. Most of the beekeepers in Erob (88%), Ganta afeshum (91.7%), Atsby wonberta (62.5%) and Kilte awlalo (62.9%) districts suppliment Beso and shiro as pollen or protein source and sugar as an energy source for their bees in January to February, February, March and March to April, respectively. In Atsby wonberta (67.6%) and Erob (45.8%) districts most of the beekeepers harvest honey two times/year but once in Ganta afeshum (70.7%) and Kilte awlalo (46.5%) districts. and . The existing beekeeping management practice like colony multiplication, super adding and reducing, inserting and removing of queen excluder and migratory beekeeping need to synchronize with the developed floral calendar. For proper honeybee manipulation and to introduce and multiplying bee forages, it is recommended to take into account the eastablished floral calendar.

Key words: Calendar, Flora, Honeybee, Tigray,

Introduction

Beekeeping is an important component of agriculture and rural development programmes of many countries. It helps to provide security in nutrition, economy and ecology (Atsbaha et al., 2015). Ethiopia is gifted with diverse and unique flowering plants of 6000 to 7000 species. Thus making it highly suitable for the presence of a large number of bee colonies (Fitchel and Admasu 1994; Gidey and Mekonen, 2010).

Tigray region is one of the potential beekeeping areas of Ethiopia and apiculture is a good source of income for smallholder beekeepers (Haftom and Tesfay, 2012). Due to diversified plant habitat, climatic condition, topography, and rainfall distribution, the region is also endowed with diversified plant types and quite a large number of honeybee colonies exist in the region (Alemtsehay et al, 2011). Eastern zone, one of the six zones of the Tigray Regional state, Northern Ethiopia, is one of the beekeeping potential areas in the region. This zone is well known for its white honey production which has a high market demand in the region and the nation in general (CIAFS, 2012). However, drought is considered to be the primary constraint in beekeeping in this zone. It affects the feed sources adversely and currently the scarcity of bee forage is becoming a serious problem in the area. Absconding of bee colonies is also the common problem faced by beekeepers in the area, mainly caused due to feed scarcity (Werkneh et al., 2008).

In any specific area, modern beekeeping can not develop without an understanding the floral calendar. For migratory beekeeping, special calendars for the different foraging zones along the migration route are also required (Robert et al., 2009). However, the floral calendar for the existing honeybee plants of the Eastern zone is not well documented and established. This makes difficult to minimize the shortage of bee forage of this zone through migratory beekeeping practice. This has also contributed to the prevailing traditional beekeeping practice in this Zone. Moreover, establishing floral calendar is one of the most useful tools of apicultural extension workers, which enables beekeepers to manage their colonies in the most rational manner based on the seasonal availability of flowering plants. Such information also has practical applicability to select and screen for further multiplication as a bee forage source for honey production. Hence, this study was designed to identify, document and establish floral calendar of Eastern Zone of the Tigray Regional State.

Materials and Methods

Study area

The study was conducted in four districts of the Eastern Zone of Tigray Region, Northern Ethiopia. These districts were Atsbi wonberta, Ganta afeshum, Erob and Kilte awlaelo. These districts were selected based their potential for honey production and their beekeeping practice.

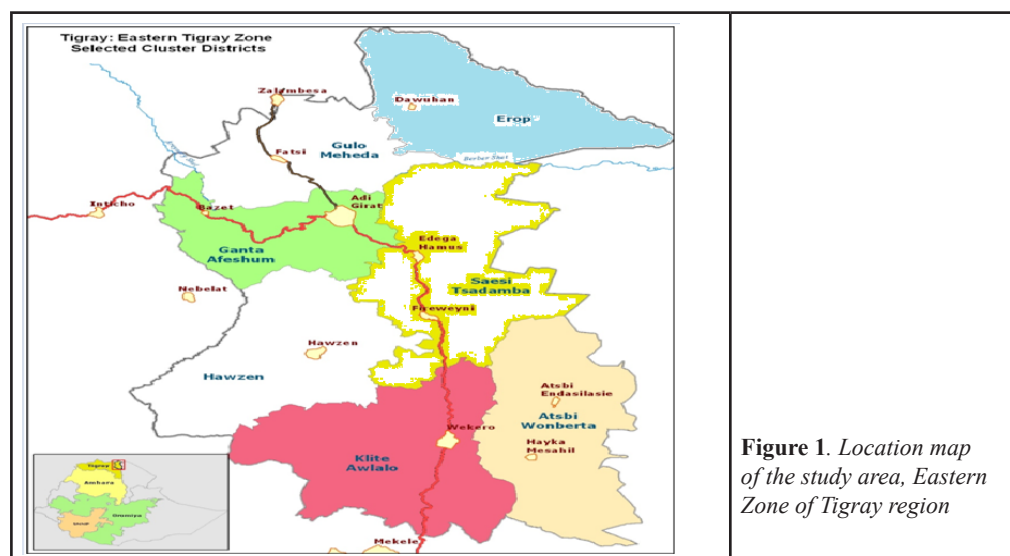


Figure 1. Location map of the study area, Eastern Zone of Tigray region

Respondent selection

The study was done by selecting experienced beekeepers from each district. For this purpose a total of 159 beekeepers were involved from the selected districts: 42 from Atsby wonberta, 29 from Erob, 44 from Ganta afeshum and 44 from Kilte awlaelo districts. Beekeepers were selected randomly based on their experience on beekeeping and their interest.

Honeybee plants identification

For identifying honeybee plants and prepare their flowering calendar combined methods were implemented. A semi-structured questioners were prepared to interview beekeepers. After identifying honeybee plants via questioner, field observation was also used to record habit and habitat of each bee plant with the assistance of local guides. In addition to survey work, unfamiliar specimens of flowering plant species were collected, pressed, dried and preserved according to the standard Herbarium techniques and identified at the National Herbarium of Addis Ababa University, Ethiopia.

Data analysis

The collected data were analyzed using descriptive statistic, using tables and graphs using SPSS version 20 statistical softwear.

Result and Discussion

General household characteristics

As demonstrated in Table 1, majority of the respondents were male (89.5%) while few were female (10.7%). This may indicates that beekeeping in the study area is mainly done by men than female. The low participation of women, might be due to the aggressive behaviour of the local bees and their traditional dressing style that is easy for getting bees' sting. Similarly, Yetimwork et al (2014) reported as the majority of the beekeeping activity were done by men (88.5%) in Kilte awlaelo district of Eastern Tigray.

The age of the beekeepers ranged from 20 to 78 years with a mean of 47.71 years. This showed that different age groups, involved in beekeeping activity. Among the respondents majority were married (87.4%).

Table 1. Sex and age of the respondents

Sex of the respondents		Age of the respondents		Marital status of the respondents	
Sex	%	Years		Marital status	%
Male	89.3	Minimum	20	Single	3.8
Female	10.7	Maximum	78	Married	87.4
Total	100.0	Mean	47.71	Divorced	7.5
		Total	100	Widowed	1.3
				Total	100.0

Honey harvesting frequency

In this zone the range of honey harvesting frequency/year ranges from one to four times (Table 2). In Atsby wonberta (67.6%) and Erob (45.8%) most of the respondents stated as they harvest honey two times but once in Ganta afeshum (70.7%) and Kilte awlaelo (46.5%) districts. Similarly, in Kilte awlaelo district Yetemwork et al (2014) stated as the majority of the beekeepers (61.5%) harvest honey one time/year. This variation might be due to the variation on seasonal availability of honeybee plants and bee management practices.

Table 2. Honey harvesting frequency/year in districts of Eastern zone

District	Number of respondents (%)			
	Once	Twice	Three times	Four times
Erob	12.5	45.8	37.5	4.20
Ganta afeshum	70.7	29.3	0.0	0.0
Atsby wonberta	0.0	67.6	32.4	0.0
Kilte awla'elo	46.5	39.5	14.0	0.0

Honey harvesting season

The first and second major honey harvesting season of the Eastern zone areas was indicated from October to November and May to June, respectively (Figure 2). In Ganta afeshum, Kilte awlaelo, Erob and Atsby wonberta districts most of the beekeepers stated as they harvested honey in September, October, September and September, respectively. In the second honey harvesting season most of the beekeepers from Ganta afeshum, Kilte awlaelo, Erob and Atsby wonberta stated as they harvest honey in May, June, May to June, and May, respectively. In Hawzen district, one of the Eastern zone of the Tigray region Haftom et.al. (2013) also reported the major honey harvesting season from September to November.. In AsgedeTsimbla district the major honey harvesting period was also indicated from October to November (Gidey et. al .2012). This indicates that as there is a variation on the honey harvesting season among the districts. This variation might be due to variation on the seasonal availability of honeybee plants and beekeepers manipulation. Honey harvesting period also matches with peak flowering period (Gidey et al 2012).

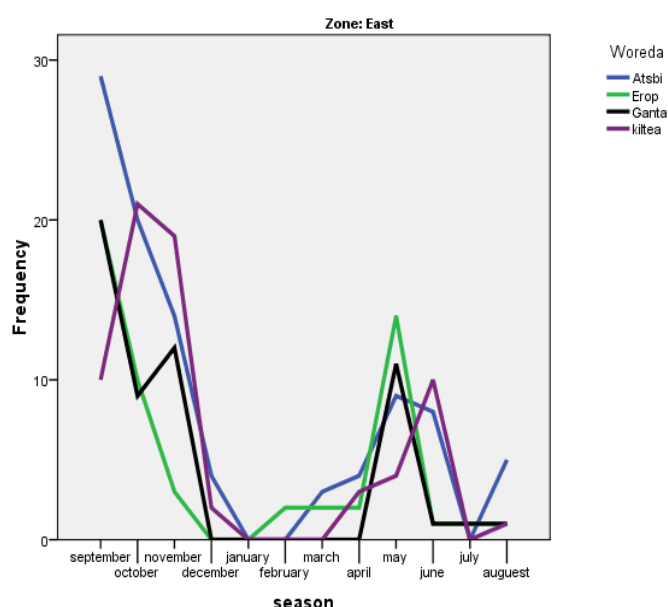


Figure 2, Honey harvesting season of districts in Eastern Zone

Seasonal availability of honeybee plants

In this study a total of 108, 68, 108 and 114 bee plants were identified from Atsby wonberta, Erob, Ganta afeshum and Kilte awlaelo districts, respectively (Table 3) . This may indicates how much these districts are diversified in honeybee plants which gives an opportunity for bees to collect pollen or/ and nectar year round.

Variation on seasonal availability of honeybee plants was demonstrated even though all the districts had similar trends related to the seasonal availability of bee plants (Figure 3). High availability of bee

plants was indicated starting from September to November while the shortage of honeybee plants was indicated in December, January, February, April, June and July. In the same zone, Gebru and Gebretsadik (2015) also stated variation on seasonal availability of bee plants and high availability of honeybee plants was reported from September to November. Variation in the seasonal availability of bee plants was also observed in Hawzen district, one of the beekeeping potential districts of Eastern Zone (Haftom et al 2013) and high and low availability of honeybee plants was stated from July to November and December to June, respectively. In the central highlands of Ethiopia, 58% of flowering species diversity also occurs from September to November (Amssalu, 2006).

The shortage of bee plants in the dry season might lead to high absconding problem of honeybees in these districts. Absconding also correlates with low flowering intensity and shortage of honeybee forage causes honeybee colonies to abscond (Amssalu 2006; Gidey and Mekonen 2010). Werknes et al (2008) also indicated absconding problem of bee due to feed scarcity in Atsby wonberta district.

Table 3. Honeybee plants diversity across different districts of Eastern zone

District	Number of honeybee plant species	Type of plants in %					
		Herb	Shrub	Tree	ST	C	Unknown
Atsbi wenberta	108	47	22	38	0	1	0
Erob	66	12	18	15	1	0	20
Ganta afeshum	108	17	16	22	3	0	50
kilteawla'elo	114	42	34	34	0	0	4

Where ST is shrub or tree and C is crawling

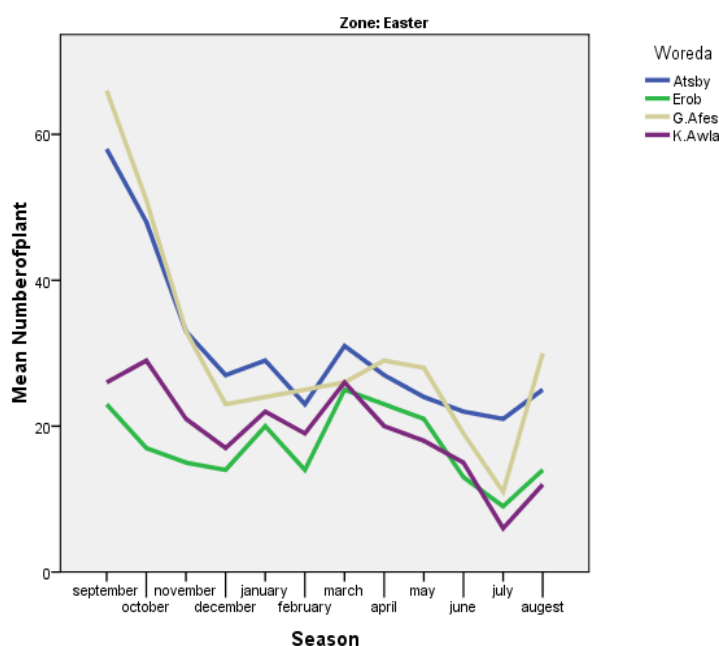


Figure 3. Seasonal availability of honeybee plants in Eastern zone

Major honeybee plants of Eastern Tigray

Based on their importance for honeybees in the area, ten major honeybee plants were also identified as the major honeybee plants in this zone (Table 4). Among the identified major honeybee plants, *Becium grandiflorum* was ranked first followed by *Hypoestes forskalii*. Similar to this *B.grandiflorum* and *H.gorskaolii* were ranked on the top (1st to 3rd) in all districts of the study area (Table 4, 5, 6, 7, and 8). In Hawzen district, *B.grandiflorum* and *H.forskaolii* were also ranked 2nd and 3rd, respectively, among the identified honeybee plants (Haftom et al 2013). Atsbaha et al (2015) also reported as *B.grandiflorum* and *H.forskaolii* are among the major honeybee plants in Tigray region.

Table 4. Major honeybee plants of Eastern Zone of Tigray Region

Local name	Scientific Name	Index	Rank	Plant Type
Tebeb	<i>Becium grandiflorum</i>	0.169	1 st	S
Girbia	<i>Hypoestes forskalii</i>	0.148	2 nd	H
Kalamitos	<i>Eucalyptus camaldulensis</i>	0.084	3 rd	T
Shewakerni	<i>Leucas abyssinica</i>	0.064	4 th	S/B
Awhi	<i>Cordia africana</i>	0.053	5 th	T
Belese	<i>Opuntia ficus-indica</i>	0.048	6 th	S/B
Kelwo	<i>Euclea Schimperii</i>	0.043	7 th	S/B
Kolkal	<i>Euphorbia abyssinica</i>	0.034	8 th	T
Dander	<i>Carduus nyassanus</i>	0.032	9 th	S/B
Awlie	<i>Olea europeae</i>	0.026	10 th	T

Where S is shrub; H is herb; T is tree; S/B is shrub or bush

Table 5. Major honeybee plants of Atsby wonberta districts

Local name	Scientific name	Index	Rank	Flowering period		Plant type or Habit
				Starting	Ending	
Tebeb	<i>Becium grandiflorum</i>	0.17	1 st	July	Sept	B
Girba	<i>Hypoestes forskalii</i>	0.16	2 nd	Sep	Nov	H
Kalamitos	<i>Eucalyptus camaldulensis</i>	0.08	3 rd	March	June	T
Shewakerni	<i>Leucas abyssinica</i>	0.07	4 th	Jan	Jan	B
Dander	<i>Carduus nyassanus</i>	0.04	5 th	Oct	March	B
Beles	<i>Opuntia ficus-indica</i>	0.03	6 th	March	May	B
Awlie	<i>Olea europeae</i>	0.03	7 th	Oct	Nov	T
Kliow	<i>Euclea schimperii</i>	0.03	8 th	Sep	March	B
Tahag	<i>Cynodon doctylon</i>	0.03	8 th			H
Hasti	<i>Erica arborea</i>	0.028	10 th	Sep	Feb	T

Where H is herb; T is tree; and B is or bush

Table 6. Major honeybee plants of Kilte awlaelo districts

Local name	Scientific name	index	rank	Flowering period		plant type
				Starting	Ending	
Girbia	<i>Hypoestes forskalii</i>	0.17	1 st	Sep	Oct	H
Tebeb	<i>Becium grandiflorum</i>	0.13	2 nd	Sep	Dec	S
Shewakerni	<i>Leucas abyssinica</i>	0.11	3 rd			S
Awhi	<i>Cordia africana</i>	0.10	4 th	Sep	Dec	T
Kalmitos	<i>Eucalyptus camaldulensis</i>	0.09	5 th	Jan	Mar	T
Kliow	<i>Euclea schimperii</i>	0.07	6 th	Jan	Apr	S
Dander	<i>Carduus nyassanus</i>	0.05	7 th	Jan	Feb	B
Suf	<i>Helianthus annuus L.</i>	0.04	8 th	Sep	Oct	H
Hamli Adri	<i>Brassica spp.</i>	0.03	9 th	Sep	Sep	H
Meshela bahri	<i>Zea mays</i>	0.02	10 th	Sep	Oct	H

Where S is shrub; H is herb; T is tree and B is bush

Table 7. Major honeybee plants of Ganta afeshum districts

Local name	Scientific name	index	rank	Flowering period		plant type	Remark
				Starting	Ending		

Tebib	<i>Becium grandiflorum</i>	0.182	1 st	Sep	Aug	S	Year round
Girbia	<i>Hypoestes forskalii</i>	0.127	2 nd	Sep	Oct	H	
Kelantos	<i>Eucalyptus</i>	0.097	3 rd	Sep	Aug	T	Year round
Beles	<i>Camaldulenes</i> <i>Opuntia ficus-indica</i>	0.087	4 th	Apr	Jun	S	
Awbi	<i>Cordia africana</i>	0.059	5 th	Sep	Oct	T	
Keliow	<i>Euclea schimperi</i>	0.056	6 th	Oct	Mar	B	
Awli	<i>Olea europeae</i>	0.04	7 th	May	Jul	T	
Shewakerni	<i>Leucas abyssinica</i>	0.039	8 th	Sep	Aug	B	
Eka	<i>Agave spp.</i>	0.033	9 th	Sep	Nov	S	Year round
Ere	<i>Oleo berhana</i>	0.032	10 th	Apr	May	S	

Where S is srub; H is herb; T is tree and B is bush

Table 8. Major honeybee plants of Erob districts

Plant Name	<i>Scientific name</i>	Index	Rank	Flowering Period		Plant Type
				Starting	Ending	
Tebib	<i>Becium grandiflorum</i>	0.239	1 st	Sep	Aug	S
Kolkal	<i>Euphorbia abyssinica</i>	0.187	2 nd	Jan	Mar	T
Girbia	<i>Hypoestes forskalii</i>	0.108	3 rd	Sep	Dec	H
Beles	<i>Opuntia ficus-Indica</i>	0.092	4 th	Mar	April	S
Awbi	<i>Cordia africana</i>	0.073	5 th	Dec	Jan	T
Mezba	<i>Euphorbia polyacantha</i>	0.059	6 th	Jan	Mar	T
Kelamitos	<i>Eucalyptus camaldulenes</i>	0.042	7 th	Jan	Jan	T
Ere	<i>Oleo berhana</i>	0.036	8 th	Mar	May	S
Eka	<i>Agave Spp.</i>	0.019	9 th	Dec	Jan	S
Hahut	<i>Rumex nervosus</i>	0.019	10 th	Oct	Jan	S

- Where S is srub; T is tree; and B is bush

Honeybee feeding practice and feed ingredients of honeybees

Due to the shortage of bee forage in the dry season (Figure 3) , beekeepers stated as they feed their bees. Most of the beekeepers of Erob (88%), Ganta afeshum (91.7%), Atsby wonberta (62.5%) and Kilte awlaelo (62.9%) districts feed their bees in January to February, February, March and March to April, respectively. Amonge the existing honeybee feeds, most of the beekeepers in Erob, Ganta afeshum, Kilte awlaelo and Atsby wonberta districts feed **Beso**, which is a roasted Barley powder, and shiro , which is a roasted bean powder , as pollen or protein source. As energy source most of the beekeepers feed honey followed by sugar (Figure 5).

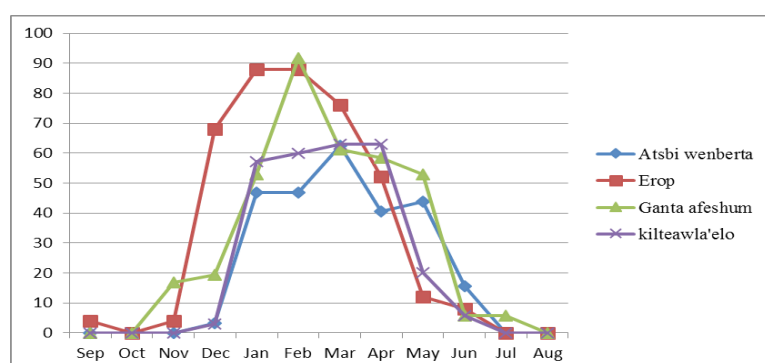


Figure 4. Feeding season of honeybee in the Eastern Zone of Tigray Region

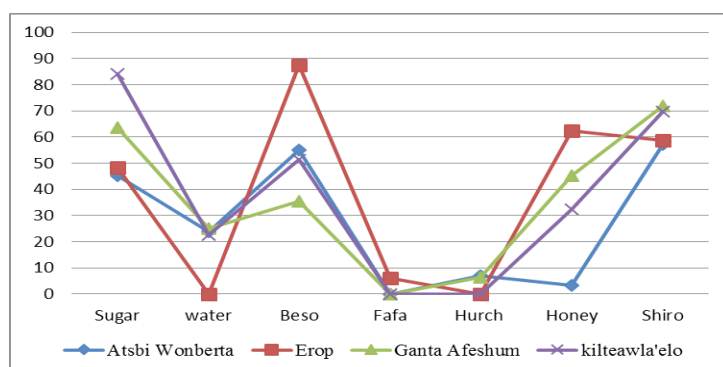


Figure 5. Honeybees feed ingredients in Eastern Tigray

Conclusions and Recommendations

The study discovered as there is a variation on seasonal availability of flowering honeybee plants. High availability of honeybee plant was found from September to November while scarcity of bee forage was found from December to February.

In Eastern zone there are two honey harvesting seasons. The major honey harvesting of Eastern Zone is from October to November. Most of the beekeepers of Atsby wonberta and Erob districts harvest honey two times/year but once in Ganta afeshum and Kiltawla'elo districts.

During the dry season or when there is a shortage of bee forage most of the beekeepers have a feeding practice of bees. Most of the beekeepers feed their bees **Beso(roasted barley powder)** and shiro(roasted bean powder) as pollen or protein source from January to April. The existing beekeeping management practice like colony multiplication, adding or/and removing box hive, inserting and/or removing queen excluder and migratory beekeeping need to synchronize with the developed floral calendar. For proper honeybee manipulation and to introduce and/or multiplying bee forages, it is recommended to take into account the established floral calendar.

Therefore, it is necessary to plant and multiply or introduce honeybee plants that fill the gap of the districts floral calendar. To improve hive production and productivity and to minimize colony absconding due to feed shortage, the beekeepers and extension workers need to supplement their bees based on the floral gap, especially from December to February. Moreover, extension workers, beekeepers and business groups should utilize the current floral calendar in their day to day hive and apiary management.

Reference

- Alemtsehay T, Yosef M and Gebremedhin W 2011 Seasonal availability of common bee flora in relation to land use and colony performance in Gergera watershed Atsbi Wembwrt district eastern zone of Tigray, Ethiopia, M.Sc. Thesis. Wondo genet college of forestry and natural resources, school of graduate studies, Hawassa university wondo genet, Ethiopia.
- Amssalu B 2006 Seasonal intensity of flowering and pollen-forage selectivity by honeybees, *Apis mellifera* in central highlands of Ethiopia. Proceedings of the 14th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, September 5-7, 2006. Part II: Technical Papers. , Addis Ababa, Ethiopia. pp 3-10.
- Atsbaha H, Taye T and Kebede D 2015. Assessment of honey production system, constraints and opportunities in three selected Districts of Tigray Region, Ethiopia. *Basic Research Journal of Agricultural Science and Review* ISSN 2315-6880 Vol. 4(10) pp. 304-315.
- Fitch R and Admasu A 1994 Honeybee flora of Ethiopia. The national herbarium, Addis Ababa University, Deutscher Entwicklungsdienst (DED). Margraf Verlag, Germany.
- CIAFS (The capacity to Improve Agriculture and Food security), 2012. The World Market For Honey. Market Survey #1.
- Gebru N and Gebretsadik H 2015. Assessment of Honey Bee Flora in Eastern Zone of Tigray, North Ethiopia.

Journal of Biology, Agriculture and Healthcare. Vol.5, No.1, 2015.

- Gidey Y, Bethelhem K, Dawit K and Alem M 2012 Assessment of beekeeping practices in AsgedeTsimbladistrict, Northern Ethiopia: Absconding, bee forage and bee pests. *African Journal of Agricultural Research* Vol. 7(1), pp. 1-5 .DOI: 10.5897/AJAR10.1071. ISSN 1991-637X.
- Gidey Y and Mekonen T 2010 Participatory Technology and Constraints Assessment to Improve the Livelihood of Beekeepers in Tigray Region, northern Ethiopia. CNCS Mekelle University. Volume 2 (1): 76-92.
- Haftom G, Tesfay Z, Murutse G and Estifanos A 2013: Seasonal honeybee forage availability, swarming, absconding and honey harvesting in Debrekidan and Begasheka Watersheds of Tigray, Northern Ethiopia. *Livestock Research for Rural Development*. Volume 25, Article #61. Retrieved February 19, 2014, from <http://www.lrrd.org/lrrd25/4/haft25061.htm>.
- Haftom G and Tesfay B 2012. Determining suitable size of stem cutting for propagating *Beciumgrandiflorum*. *Livestock Research for Rural Development*. Volume 24, Article #175. Retrieved, from <http://www.lrrd.org/lrrd24/10/haft24175.htm>.
- Robert K, Jacob G A, Donald R K, Victor A, Sarah A O, Twine R and Gay M 2009 National Beekeeping Calendar, Honeybee Pest and Disease Control Methods for Improved Production of honey and other hive products in Uganda, Final Project Report Submitted to National Agricultural Research Organisation (NARO), Entebbe Uganda. 59pp.
- Workneh A, Puskur R and Karippai RS. 2008. Adopting improved box hive in Atsbi Wemberta district of Eastern Zone, Tigray Region: Determinants and financial benefits. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 10. ILRI (International Livestock Research Institute), Nairobi, Kenya. 30 pp.
- Yetimwork G, Berhan T and Desalegn Be 2014. Characterization of bee-keeping systems and honey marketing in Eastern zone Tigray, Ethiopia. [Livestock Research for Rural Development 26 \(10\) 2014](#)

Enhancing Honey Quality, Honeybee Colony safety and Beekeepers Safety through Usage of modified Red Light battery for Night Time honey bee colony Inspection

Tessema Aynalem, Birhanu Kassa and Demelash Dagnew

¹Bahir Dar University

Introduction

Beekeeping is an environmentally friendly venture contributing much to the improvement of the livelihood of beekeepers. It is an important sub-agricultural economic activity that employs up to 2 million people. Despite the potential to produce huge volume of honey, current production is limited to only about 10% of the potential. Globally, there is large and growing demand for honey, due to its nutritional or medicinal qualities (Gizachew 2010). Due to the low quality of the honey produced the exported amount of honey is comparatively low (Beyene and David 2007). Africanized bees are characterized by greater defensiveness in established hives than European honeybees. They are more likely to attack a perceived threat and, when they do so, attack in larger numbers and tend to sting in greater numbers, resulting in greater worker bee's death number (loss).

Beekeepers allow the smoke to drift the bees from the opening, so as to notice the internal content of the hive. To calm the bees they use much smoke during internal hive inspection and honey harvesting. Smoking the bees of pushes the bees away from the comb and most commonly used fuel is cow dung. During this process a fresh look at the question of honey quality is useful. Honey is produced for sale in countries all over the world, and honeys from a wide range of climatic zones are candidates for sale on the world market. But different quality aspects such as purity, absence of fermentation, flavor and aroma are considered during marketing. Most of the honey quality defects are induced during harvesting. Many harvesting methods are available to separate bees from their honey. In order to know how the colonies are progressing is to open the hives and inspecting each comb. This will let the beekeeper know if the honey is being prepared and capped regularly, whether the colony is getting ready to swarm, whether the hive has been attacked by pests bees are removed by smoking brushing (Adjare, 1990). Excessive use of smoke during harvesting will flavor the honey quickly, makes the odor of honey smoky and contamination with microscopic soot no matter which smoker fuel has been selected.

In most parts of the World, bee hive opening for honey harvesting or for internal inspection is done at night. A high temperature during the day makes the bees active and difficult to handle (Aidoo, 2009). Worker bees become less active during the cooler times of the day and especially at night hours, (Yasuyuki, 2009). Most beekeepers therefore inspect their colonies late in the evening when temperatures is low and the bees are relatively calm, less defensive and easier to manipulate. At nights, ordinary white light torches (battery) are common to beekeepers for visibility during hive inspection; however, the aggressive African honey bees launch large attack towards the direction of ordinary white light torches (battery) and sting the keeper, which makes the work load heavier. At the time of hive opening, bees sting painfully, and the tropical bees can kill a beekeeper (reference). Every bee that stings dies afterwards. Thus as more bees strike in fact they die, and the field force worker bees reduction due to sting death results in less honey production (Adjare, 1990).

When ordinary white light torch (battery) light is used, worker bees are attracted in high numbers to sections of the hive where the light is shown. A beekeeper applies smoke to move bees away but the bees keep coming back to the illuminated area. In this case the honey and wax accepts more smoke than threshold. On the other hand, though our bees are mostly inspected at night, still there is high level of incidence of stinging on beekeeper, and more worker bees' death. In some cases large number of angry bees have stung the gloves of the person carrying the torch (battery) emitting ordinary white light.

A possible solution to this problem is basing on the fact that insects are less attracted to certain colored lights. Thus, the use of light with different colors during night time colony management could be an alternative for safe internal colony inspection and quality honey harvesting with fewer stings at the night to save the lives of the worker bees. This study was initiated to test the use of light with different colors during night time internal honeybee colony inspection as alternative to safe honeybee colony management and quality honey harvesting with fewer stings at night.

The Objectives of the study were

To evaluate different colored light source batteries for night internal colony inspection

To select less attractive colored lights sources to African honeybees for night time internal colony inspection

Materials and Methods

The study was conducted at Andassa livestock research Centre apiary site. Three identical batteries were used. The first battery was designed to produce ordinary white light and the others were modified to emit red light and blue light respectively by fitting round piece of red and blue polythene sheets on the glasses of each torch. Three sheets of white cloth measuring 100 cm² were obtained. The experimental design was RCBD. Inspected honeybee colonies were grouped as medium, strong and very strong based on worker bee population and bee coverage of the inside comb space. Two medium, two strong, and two very strong colonies were assigned for each treatment randomly. Each treatment was replicated six times and a total of 9 transitional and 9 frame hives during flowering season were used. At 8:00 pm when the day darkens, each honeybee colony was disturbed by tapping the side of the hive close to the entrance and one of the pieces of the cloth was hung about 20cm away from the hive and the white light was shown up on it being in the same direction as the bee's flight for foraging. The number of bees attracted to the spot light on the cloth were counted and recorded within five minutes. The experiments were repeated with other honey bee colonies. The other treatments, with modified red light sourced and blue light batteries were carried out with the same procedures and number of bees attracted to the spot light in the cloth within five minutes were counted and recorded

Materials that used to the experiment



Figure 1. *Ethiopian honeybee Colonies in frame and top bar hives*

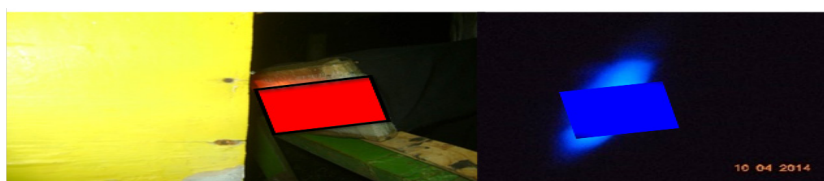


Figure 2. *Modified Red and blue light sourced batteries to treat frame hive*

Result and Discussion

Data was subjected to statistical analysis of variances (ANOVA) to test the degree of variance in the Ethiopian Apismellifera local races honey bee attraction to different color lights. The result revealed significant differences in the ability of different color lights to attract honeybees, (Table 1).

Apis mellifera local honeybee races were attracted to three different colored lights shown on white cloth mounted close to the beehive entrance at night. The numbers of Apismellifera local honeybee race worker bees were attracted to white, blue and red lights within a period of five minutes and counted after the honey bee colony was systematically disturbed at night. Results from the experiment showed differences in attraction rate for white light battery, blue light battery and red light as shown in table 2.

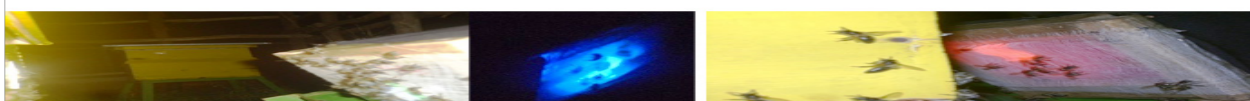


Figure 3. White Blue and red light sources respectively

Table 1. Analysis of Variance number of honey bees attracted to different colored battery lights

Source of variation	DF	Sum of squares	Mean squares	F Value	sig
Treatment	2	110455.4444	55227.7222	70.38***	0.0001
Error	15	11770.1667	784.6778		
Total	17	122225.6111			

CV=14.02553

It was observed that the color differences of the battery lights have resulted highly significance 0.0001, ($p \leq 0.05$). This indicates that the color effects in attracting honey bees when disturbed at night are not equal. LSD result of multiple comparisons in (Table 1) showed as there is a significant difference within various color lights. The attraction of honey bees to white and blue light was not significant comparatively, However the attraction of honey bees to red light was highly significant, (0.0001, $p \leq 0.05$).

Table 2. LSD multiple comparisons of bees attracted to different colored lights

Over all mean	Number of bees counted	
	LS mean	Sig
Treatment	199.72±13	***
White light	263±5.42 ^b	
blue light	246.83±5.42 ^b	
Red light	89.33±5.42 ^a	
Block		Ns
Medium colony	173.67±5.42	
Strong colony	196±5.42	
Very strong colony	229.50±5.42	
Cv	6.65	

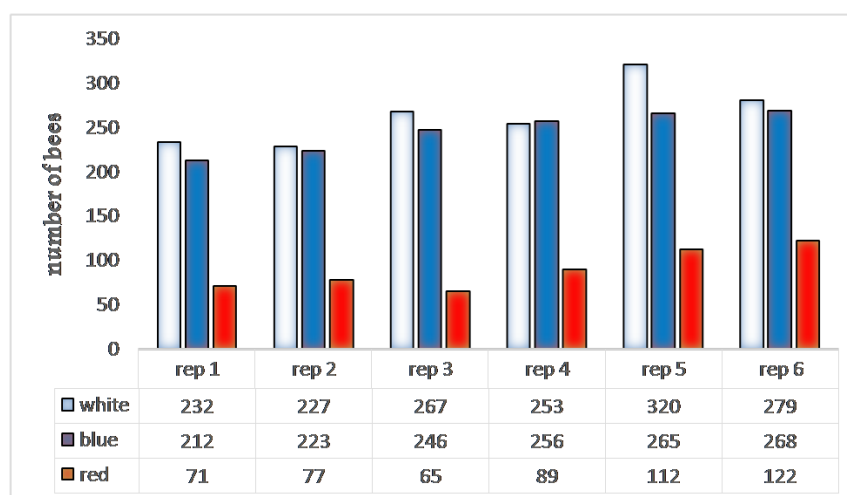


Figure 4. Number of bees attracted to different colored battery lights

Beekeeping plays a great role to contribute to poverty reduction and environmental protection including forest conservation through pollination activities of the bees (Gronenberg, 2001). Studies have shown that honey bees are extremely visual animals, with a large portion of their brain dedicated to visual processing (Gronenberg, 2001). Honey bees have well-developed color vision (Werner et al., 1988). Most researches used light traps has focused on monitoring of moths, and the literature reveals little about the attraction of beneficial insects such as honey bees to different lights, (Henda et al., 1999b). Traditionally internal honeybee colony inspection and honey harvesting are done at night when it gets cool and to avoid sting attacks of honeybees (Yasuyuki, 2009). The efficiency of three colored light source batteries in attracting honey bees with a view for improved night time hive inspection showed that red battery light attracted the least number of bees (89.33 ± 5.42) than blue (246.83 ± 5.42) and white lights (263 ± 5.42). This is on line with the work of Aidoo (2009) found that African honey bees are least attracted to red light than white light when disturbed in darkness. This finding also confirms the assertion of Henda et al., (1999c) that blue and cool white lights are about highly and equally attractive to moths than red light at night in Missouri, USA.

Analysis of variance of bee's attraction to light at night has given significant differences between different colored battery lights, (0.0001 , $p \leq 0.05$), indicating that honeybees can be managed less aggressive at night using red battery light. This reduces the fear and danger of sting. Fear of sting was identified as a major setback of bee keeping in Uganda, (Mujuni, 2012).

Conclusion and Recommendation

Results has shown that the fear and danger of African honeybee sting in apiculture can be reduced to the minimum if modified (ordinary) red colored battery light is used during night time internal inspection and management of honeybee colonies in different hives. Thus, the use of modified (ordinary) red battery light source during internal honeybee colony inspection at night reduced the bee sting and calmed aggressive bees. Due to less response of honeybees to ordinary (modified) red light, Excessive use of smoke will be avoided during honey harvesting which will result in reduction of the number of bees attracted to light and beekeeper, saves the beekeeper from unnecessary bee sting, reduces the mass death of worker honeybees after stinging the beekeeper and the beekeepers glove, reduces smoky odor of honey and contamination with microscopic soot, which intern improves the honey quality.

Unless for splitting queen rearing and other activities which needs clear observation of combs and comb contents, ordinary white light source batteries should not be used for internal Honeybee colony inspection.

When white light source batteries were used the death number of worker bees has increased which has great consequence on honey production.

In order to minimize or save the worker honeybees from death during internal colony inspection, to make the beekeeper safe from being stung by angry bees, to increase the quality of honey by avoiding over smoking, beekeepers have to use modified (ordinary) red battery light source. Further research is needed to show the actual productivity differences between different light source battery usage for honeybee's internal inspection and management.

References

- Aidoo, K. S. (2009). *Bees and Red light*, *Bees for Development Journal*, No 93
- Adjare, S. O. (1990). **Beekeeping in Africa**. Food and agriculture organization of the United Nations (FAO) **Agricultural Services Bulletin 68/6**, FAO, Rome, Italy.
- Gronenberg, W. (2001). Subdivisions of hymenopteran mushroom body calyces by their Afferent supply. *J. Comp. Neurol.* 435, 474-489.
- Henda N., Wayne C. B and Necibi, S. (1999b). Trapping of *Phyllophaga* sp. (Coleoptera: Scarabaeidae), *Epicauta* sp. (Coleoptera: Meloidae), and Green Stink Bugs (Hemiptera: Pentatomidae) with Different Sources of Light. *Journal of the Kansas Entomological Society*, Vol. 72(2), 222-225, Published by Kansas (Central States) Entomological Society, Retrieved Dec. 2012: <http://www.jstor.org/stable/25085899>
- HendaNabli, Wayne C. Bailey, and Necibi, S. (1999c). Beneficial Insect Attraction to Light Traps with Different Wavelengths. *Biological Control* 16, 185–188. Retrieved Dec. 2012: <http://www.idealibrary.com>
- Mujuni A, Natukunda K and Kugonza D.R. (2012). Factors affecting the adoption of beekeeping and associated technologies in Bushenyi District, Western Uganda. **Livestock Research for Rural Development. Volume 24, Article #133.**
- Werner, A., Menzel, R. and Wehrhahn, C. (1988). Color constancy in the honeybee. *J. Neurosci.* 8, 156-159.
- Yasuyuki M. (2009). Practices of Traditional Beekeeping – Cases observed in district of Kitui Kamba in Eastern Province of Kenya: (In) *Development of Beekeeping in Developing Countries and Practical Procedures – Case Study in Africa*. Japan Association for International Collaboration of Agriculture and Forestry (JAICAF).

Economic Value of Honeybee and Insect Pollination for *Guizotia abyssinica* Seed Producers of Ethiopia

Haftom Gebremedhn¹ and Alemayehu Tadesse*

¹Tigray Agricultural Research Institute, Mekelle Agricultural Research Center, Department of Apiculture and Sericulture, P.O.Box 492, Mekelle, Tigray, Ethiopia

Email: haftush@yahoo.com

Abstract

Almost half of the pesticide applications in Ethiopia are carried out in regions with high beekeeping potential. Due to lack of integration between beekeeping and pesticide application, it is also common to see pesticide application when honeybees are at high foraging activity. This is mainly due lack of awareness on the economic importance of honeybees' pollination. Thus, this study was designed to compute the economic value of honeybee pollination during *Guizotia abyssinica* seed production. The study was conducted in a Randomized Complete Block Design (RCBD) with three treatments and four replications in Mekelle Agricultural Research Center. The treatments were crops caged with honeybee, caged without honeybee and open pollinated. Crops caged with honeybees had the highest seed yield/ha (16.7quintal), whereas crops caged without insects had the lowest yield (9.6quintal). Crops caged with honeybees and open pollinated had 53.5% and 27.5% yield increment over crops caged without insects. The net benefit that added to the Ethiopian *G.abyssinica* growers due to insect pollination was 534,746,310.0Birr. By using honeybees for pollination in this plant, the Ethiopian farmers can earn also extra 1,046,160,927.0Birr. The present investigation indicated that honeybees and other insect pollinators had great economic value on *G.abyssinica* seed production. Therefore, it is recommended to keep sufficient number of honeybee colonies in the vicinity of *G.abyssinica* fields. Insect pollinators like honeybee should be protected from pesticide application damage, and crop production should be integrated with beekeeping.

Key words: Beekeeping, Honeybee, Pesticide, Pollinator, Profitability, Seed, yield

Introduction

Honeybees and flowering plants are dependent upon each other for their existence. Honeybee and other insect pollination is an essential input in the production of agricultural crops grown worldwide as water or fertilizer (Jacobs *et al.* 2006, Allsopp *et al.* 2008). Approximately one third of the global food production mostly pollinated by honeybees (Free 1993). However, the role of honeybees for pollination of the local farming systems is still poorly understood and up to now not sufficiently appreciated and need further investigation (Jacobs *et al.* 2006).

Despite local knowledge on the economic importance of honeybee pollination, it is also common to see pesticide application when honeybees are at high traffic (Haftom *et al.* 2014). Currently the use of insecticide and herbicides is a real challenge for the sustainable beekeeping development in Ethiopia as it kills the honeybee (Ejigu *et al.* 2009). In Ethiopia, about 541,467 liters of pesticides are aerially sprayed on 514,923 ha to control migratory pests every year (Amssalu 2012). Amssalu (2012) also reported that half of the pesticide applications in Ethiopia are carried out in regions with high beekeeping potential. Moreover there is lack of integration between beekeeping and pesticide application. In Burie district, of the Amhara Regional National State alone, 97.5% of the bee poisoning were due to the application of insecticides and herbicides (Tessega 2009). Death of one farmer also reported in North Wollo, due to conflict between beekeeper and crop grower (Amsalu 2012).

This is mainly due to lack of awareness on the economic importance of honeybees pollination. The role of honeybees for pollination of the local farming systems is still poorly understood and up to now not sufficiently appreciate (Jacobs *et al.* 2006). Moreover, the economic importance honeybees and other insects' pollination has not so far been exclusively studied locally and poorly known. Hence, this study was designed to compute the economic value of honeybee and insects pollination on *Guizotia abyssinica* seed production, which is the highly cross pollinated crop (Weiss 2000).

Materials and Methods

Area description

The study was conducted at Mekelle Agricultural Research Center farm, Illala site. The Research Center is found in the capital city of the Tigray regional state of Mekelle city. Illala is located North East of Mekelle at an elevation of 2012 meters and at N13°31'21. 2" latitude and E39°30'14. 7" longitude. The study was conducted during the 2013 cropping season.

Experimental management

To compute the economic value of honeybees and other insect pollinators, plants (*G.abysynica*) were grown with the recommended agronomic practices. The crops were planted with a seed rate of 10kg/ha, 40cm distance spacing between rows and 10cm distance between plants. The study was conducted in a complete randomized block design (RCBD) with three treatments, four replications and with a plot size of 9m² (3m×3m). The treatments were crops caged with honeybee, caged without honeybee and open pollinated (exposed to all insects including honeybees). Transferring of honeybee colony to cages was done at the beginning of the flowering period of the plant (5-10% flowering stage of the plant). The seed yield/plot was obtained by tacking the weighing of clean grains collected in the central area of each plot (1m by 1.2m) in all treatments. Seeds were measured after drying the plants.

Insect pollinators visiting G.abysynica flowers

To identify the type of insect pollinators and know the share of honeybees of the total insect pollinators' observation was done during the peak blooming period of *G.abysynica*. This was done starting from 8:30AM to 17:30PM at two hour intervals (8:30-3:30AM, 10:30-11:30AM, 12:30-13:30PM, 14:30-15:30PM and 16:30-17:30PM) five times/day. Recording of visitors was done for 15 consecutive days. This recording of insects was done in a quadrant holds five plants/five minutes

in each observation time. Each insect was categorized to each insect group. During recording of insects; the crop was kept free from any spray during flowering period.

Dependence of *G.abyssinica* on insect pollination

To compute the contribution of insect pollinators (honeybees and other insects) on seed yield of the plant compared with plants excluded from insects, i.e., how much such insect pollinators increased the crop yield over insect none pollinated *G.abyssinica*, it was investigated using equation 1 (Kasina *et al.* 2009). That is, the effect of insect pollination on seed yield of the plant was measured by comparing the yield of crops caged without insects and open pollinated.

$$D = \frac{(Y_{op} - Y_{wb})}{Y_{op}} \times 100 \quad \text{..... Equation 1}$$

Where D, represents the dependence of *G.abyssinica* on insect pollination, Y_{op} and Y_{wb} are yields of *G.abyssinica* obtained from crops that was freely accessed and not accessed by insects, respectively.

***G.abyssinica* yield attributed to insect pollination**

The national or regional *G.abyssinica* yield attributed to insect pollination was computed using equation 2 (Kasina *et al.* 2009).

$$\Delta y = Y(D) \quad \text{..... Equation 2}$$

Where Δy is the *G.abyssinica* production attributable with insect pollination, Y is the annual *G.abyssinica* production at national or regional level and D is the dependence of the *G.abyssinica* on insect pollination or the crop yield increment due to insect pollination.

Net benefit gained by the *G.abyssinica* producers due insect pollination

The net benefit gained by the *G.abyssinica* producers at national or regional level due to insect pollination was calculated using equation 3 (Nderitu *et al.* 2008).

$$W = \Delta Y(P - C) \quad \text{..... Equation 3}$$

Where W is the net benefit gained by the *G.abyssinica* producers due to insect pollination; ΔY is the increase in production as a consequence of insect pollination; P is the farm-gate price of *G.abyssinica* and C is variable costs related to *G.abyssinica* harvest. In this equation it was assumed insect pollination had no effect on the price, quality and demand of the commodity.

Economic value of honeybee pollination

To compute the share of honeybee pollination from the annual benefit or income earn by the *G.abyssinica* producers due to insect pollination, it was estimated using equation 4 (Jacobs *et al.* 2006).

$$E_b = Y \times P \times D \times B \quad \text{..... Equation 4}$$

Where E_b is the share of honeybee pollination from the annual benefit or income earn by the *G.abyssinica* producers due to insect pollination, Y is the annual *G.abyssinica* production in Kg, P is the farm gate price of *G.abyssinica*, D is the dependency of the crop on insects pollination and B is the share of honeybees of the total insect pollinators or the percentage of insect pollination that is accomplished by honeybees only.

Yield increment due honeybee pollination

The seed yield increment of *G.abbyssinica* due to honeybee pollination only in comparison with the crops caged without honeybees was calculated using equation 5 (Kasina *et al.* 2009).

$$Y_{HP} = \frac{(Y_{bp} - Y_{wb})}{Y_{op}} \times 100 \quad \text{..... Equation 5}$$

Where, Y_{HP} is percent seed yield increment due to honeybee pollination only, Y_{bp} is yields from crops pollinated by honeybee only, Y_{wb} is yield from caged plots without honeybees and Y_{op} is yield from open pollinated crops (pollinated by honeybees and other insects).

Results and Discussion

Insect visitors of G.abbyssinicas flowers

In this experiment a variety of insects visited *G.abbyssinica* flowers. The insect visitors including, Hymenoptera, Lepidoptera, Diptera, Coleoptera and Hemiptera were the most frequent visitors (Table 1). Among these pollinators Hymenoptera had the highest abundance (82%) followed by Diptera (12%) (Fig 1).

As shown in Table 1, more than ten insect species, including honeybees were identified as pollinators of *G.abbyssinica* flowers. *Apis mellifera* was the most dominant pollinators and comprised 79% (n=5067) of the observed pollinators of *G.abbyssinica*. This might be due to the presence of apiary sites near of the experimental site. This result was in agreement with the finding of Dhurve (2008) who reported that honeybees were the dominant pollinators in *G.abbyssinica* flowers.

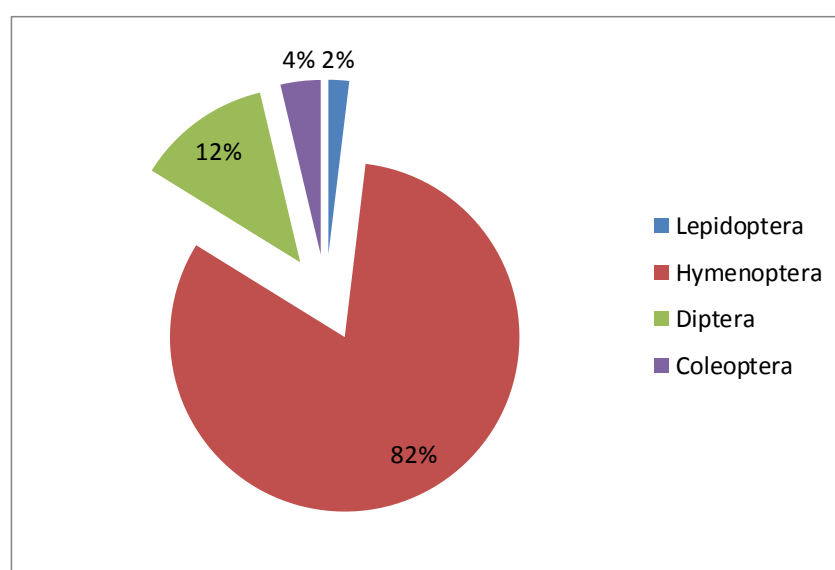


Figure 1. Abundance of insect pollinators at the order level during *G.abbyssinica* blooming

Seed yield of G.abbyssinica

There was a significant difference among the treatments regarding seed yield/ha (Table 2). Crops caged with honeybees had the highest seed yield/ha (16.7 quintal) followed by open pollinated crops (13.3 quintal), whereas crops caged without insects had the lowest yield (9.6 quintal). The higher yield of crops caged with honeybees might be due to the higher pollination efficiency of honeybees inside the cage. The honeybees in caged plot had only pollen and nectar sources from the *G.abbyssinica* plant and this might increase their pollination efficiency and resulted to provide higher yields than open pollinated crops. While honeybees pollinating the open plots had alternative pollen and/or nectar sources other than this plant. And this might reduce their pollination efficiency on this plant.

In this crop Sattigi *et al.* (2004) and Dhurve (2008) also reported the highest yield in crops caged with bees, while the low yield was reported in crops caged without insects. Similarly Rao and Suryanarayana (1990) revealed three times higher yield in plots caged with honeybees as compared with plots caged without honeybees. These results suggested that the pollination made by insects, in particular honeybee, was responsible in increasing the productivity of *G.abbyssinica*.

Economic value of insects and honeybee pollination

As it can be seen in Table 3 the yield increment in crops caged with honeybees was 53.5% higher than the plots excluded from insects, i.e. honeybees had 53.5% yield increment over crops excluded from insects. In *G.abbyssinica* Dhurve (2008) also reported crops caged with honeybees had 40.96% yield increments over crop caged without bees. In the opened plots, freely visited by all insects, the increase in the seed production compared to the crops caged without honeybees was 27.5% (Table 3). From this yield increment due to insects (27.5%), 79% was attributed to honeybees (Table 1). This is due to the reason that 79% of the visitors (100%) were honeybees (Table 1).

As stated in Table 4, extra 537,746,310 ETB (2.56million US\$) or 398,330.6 quintals of the total Ethiopia *G. abyssinica* production (1,448,474.8 quintals) potential are attributed to insect pollination, which is the *G.abbyssinica* production attributable to insect pollination. In relation to Tigray region, extra 2,318,827.5 ETB (110420.4 US\$) or 1717.7 quintals of the total regional *G.abbyssinica* seed production (62467quintals) attributable to insect pollination (Table 4).This is in comparison to plants excluded from insects. From this additional income generated due to insects at national level, 79% or 314,681.1 ETB (14984.8 US\$) was attributed to honeybees (Table 1 and Table 4). This result indicated that there will be 27.5% yield loss when there is a total loss of these beneficiary insect pollinators.

Using honeybees' only as pollinators had also a potential to produce extra 774,934.0 quintals or 1,046,160,927 ETB (4.98million US\$) and 33419.845 quintals or 45,116,790.8 ETB of the national and regional *G.abbyssinica* production, respectively, as compared with those crops excluded from insect pollinators (Table 5).

Even though the contribution of insect pollination was underestimated and not well appreciated in Ethiopia; the net benefit that added to *G.abbyssinica* seed producers of Ethiopia due to insect pollination was about 534,746,310ETB (25.5million US\$). This is the amount that the Ethiopian farmers' would have lost if there were no insects to pollinate this crop. By using honeybees for pollination of the plant the Ethiopian farmers can earn also 1,046,160,927 ETB (4.98million US\$) extra income. In Western Kenya the net benefit that acquired to the Kakamega farmers as a result of bee pollination on eight selected crops was about US\$3.2 million, which is around 40% of the annual market value of these crops (Kasina *et al.* 2009). In Eastern Kenya, the mode of pollination by honeybees for sunflower plants accounted 51% and this worth US\$ 1,697.21(Nderitu *et al.* 2008).

Table 1. Major insect visitors of *G.abbyssinicas* flowers

No	Species name	Order	Family	Abundance
1	<i>Euchromia amoena</i>	Lepidoptera	Ctenuchinate	122 (1.9%)
2	<i>Meliponula spp</i>	Hymenoptera	Apidae	154 (2.3%)
3	<i>Apis mellifera</i>	Hymenoptera	Apidae	5067 (79%)
4	<i>Philanthus triangulum</i>	Hymenoptera	Sphecidae	16 (0.25%)
5	<i>Chrysomya chloropyga</i>	Diptera	Calliphoridae	429 (6.7%)
6	<i>Microdon testaceus</i>	Diptera	Empididae	281 (4.4%)
7	<i>Eristalis tenax</i>	Diptera	Syrphidae	24 (0.37%)
8	<i>Eristalis crassipes</i>	Diptera	Syrphidae	63 (0.98%)
	<i>Cladophorus marshalli</i>	Coleoptera	Lycidae	13 (0.20%)
9	<i>Tumbling flowers beetles</i>	Coleoptera	Mordellidae	224 (3.5%)
10	<i>Others</i>			26 (0.41%)

Total	6419
-------	------

Table 2. Seed yield per net plot and hectare

Treatment	Seed yield / net plot (g)	Seed yield /hectare (quintal)
Open pollinated	159 ^{ba}	13.3 ^{ba}
Caged with honeybees	200 ^a	16.7 ^a
Caged without Insects	115 ^{cb}	9.6 ^{cb}
LSD	57.1	4.8
P value	0.035	0.03

Figures in the parentheses are seed yield/plant Log (base10) transformed values ; Column means with different superscript letters are significantly different ($P < 0.05$)

Table 3. Yield increment due insect and honeybee pollination in *G.abyssinica*

Yield increment due to insect pollination (D)	Yield increment due to honeybee pollination (Y_{HP})
27.5%	53.5%

Where D is percent seed yield increment due to insects' and Y_{HP} is Percent seed yield increment due to honeybee pollination

Table 4 . Amount and value of production of *G.abyssinica* attributable to insects pollination and share of honeybees pollination compare with plants caged without insects, in Ethiopia and Tigray region

Nation/ Region	A (ha)	Y (quintals)	D	B	P (ETB)	$\Delta y = y(D)$	$W = \Delta y * (p-c)$	$E_{b1} = W \times B$
Ethiopia	247,611.2*	1,448,474.8*	27.5%	79%	1350	39,8330.6	5,377,46310	424,819,584.9
Tigray	7,985	62,467**	27.5%	79%	1350	1,717.65	2,318,827.5	183,187.4

Where Δy , the *G.abyssinica* production attributable to insect pollination; Y, the annual *G.abyssinica* production in Ethiopia/Tigray; D, the dependence of the *G.abyssinica* on insect pollination; W, benefits for the farmer due to insects pollination; A, area coverage of *G.abyssinica*; P, farm-gate price of *G.abyssinica* per quintal in ETB; B, the share of honeybees of the total insect pollinators; C, variable costs related to *G.abyssinica* harvest and *, is the source of the data is Ministry of Agriculture, animal and plant health regulatory directorate ,2011, ** is the source of data is BOA ,2011 cropping season and E_{b1} is the share of honeybees' of the annual benefit earn by *G.abyssinica* producers due to insect pollination and 1US\$ =21Birr

Table 5 . Amount and value of production of *G.abyssinica* attributable to honeybees pollination over crops excluded from insect in Ethiopia and Tigray region

	A(ha)	Y (quintals)	Y_{HP}	P	$\Delta y = y(Y_{HP})$	$E_b = \Delta y * (p-c)$
Ethiopia	247,611.2*	1,448,474.8*	53.5%	1350	774934.0	1,046,160,927
Tigray region	7,985	62,467**			33419.8	45,116,790.8

Where Δy , the *G.abyssinica* production attributable to insect pollination; Y, the annual *G.abyssinica* production in Ethiopia; Y_{HP} the dependence of the *G.abyssinica* on honeybees pollination; A, area coverage of *G.abyssinica*; P, farm-gate price *G.abyssinica* per quintal in ETB; C, variable costs related to *G.abyssinica* harvest and *, is the source of the data is Ministry of Agriculture, animal and plant health regulatory directorate,2011, ** is the total *G.abyssinica* production of Tigray region and the source of data is BOA, 2011 cropping season and E_b the extra benefit or income earn by the *G.abyssinica* producers due to honeybee pollination over crops excluded from insects. 1US\$=21Birr

Conclusions and Recommendations

Insect pollination had a significant effect on seed yield of *G. abyssinica*. The highest seed yield/ha was

found in crops caged with honeybees (13.3 quintal) followed by open pollinated crops (16.7 quintal), while crops excluded from insects had the lowest yield (9.6 quintal). Plants caged with honeybees and open pollinated had 53.5% and 26% yield increment over crops caged without insects, respectively. So pollination made by insects, in particular honeybee, was responsible for enhancing the productivity of *G.abyssinica*.

The net benefit that added to *G.abyssinica* seed producers of Ethiopia due to insect pollination was 534,746,310Birr (25.5million US\$). This is the amount that the Ethiopian farmers' would have lost if there were no insects to pollinate this crop. By using honeybees for pollination of the plant they can earn also 1,046,160,927Birr (4.98million US\$) additional income compared with crops caged without insect.

Insect pollinators like honeybee should be protected from pesticide application damage, and crop production should be integrated with beekeeping. Thus, it is advisable to create awareness of the economic importance of honeybee pollination for the community and this honeybee pollination technology is highly recommended and should be considered as one of the inputs for *G.abyssinica* seed production.

Acknowledgements

We are grateful for the financial and material support provided by the Mekelle Agricultural Research Center of the Tigray Agricultural Research Institute. We are also very grateful to Kinfe Mezgebe of Mekelle agricultural research center coordinator for his very kind support throughout the study.

Reference

- Allsopp, M.H., W.J. de Lange and R.Veldtman.2008. Valuing insect pollination services with cost of replacement. PLoS one 3(9): e3128. Retrieved December 20, 2013, from <http://www.beesfordevelopment.org/uploads/valuing-insect-pollinatio.pdf>
- Amssalu, B. 2012. Toxicity effects of commonly used agro-chemicals to Ethiopian honeybees. Api-Trade Africa. Retrieved November 15, 2013, from http://www.apitradeafrica.org/publications/doc_details/112-toxicity-effects-of-commonly-used-agro-chemicals-to-ethiopian-honeybees.html
- BOA, 2011. Annual report of bureau of agriculture and rural development.
- Dhurve, S. S. 2008. Impact of honey bee pollination on seed production of *Guizotia abyssinica*. M.Sc. Thesis. Dharwad University of Agricultural Sciences, India.
- Ejigu, K., T. Gebey, and T. R. Preston.2009. Constraints and prospects for apiculture research and development in Amhara region, Ethiopia. **Livestock Research for Rural Development**. 21(172). Retrieved June, 2013, from <http://www.lrrd.org/lrrd21/10/ejig21172.htm>
- Ethiopian Ministry of Agriculture, 2011. **Animal and plant health regulatory directorate. Crop variety register**. Issue No.14.Addis Ababa, Ethiopia.
- Free, J. B. 1993. **Insect pollination of crops**. London: Academic Press. 768 p.
- Haftom, G., Z. Tesfay, G. Murutse and A.Estifanos. 2013. Seasonal honeybee forage availability, swarming, absconding and honey harvesting in Debrekidan and Begasheka Watersheds of Tigray, Northern Ethiopia. **Live-stock Research for Rural Development**. 25(61). Retrieved December, 2013from <http://www.lrrd.org/lrrd25/4/haft25061.htm>.
- Jacobs, F.J., C.Simoens, D. C. de Graaf and J. Deckers. 2006. Scope for non-wood forest products income generation from rehabilitation areas: focus on beekeeping. **Journal of the Drylands**, 1(2): 171-185.
- Kasina, J .M, J. Mburu, M. Kraemer and K. Holm-Mueller. 2009. Economic benefit of crop pollination by bees: A case of Kakamega small-holder farming in Western Kenya. **Journal of Economic Entomology**, 102(2): 467-473.
- Nderitu, J., G. Nyamasyo, M. Kasina and M. L. Oronje. 2008. Diversity of sunflower pollinators and their effect

on seed yield in Makueni District, Eastern Kenya. *Spanish Journal of Agricultural Research*, 6(2): 271-278.

- Oz, M., Karasu, A. Cakmak, A.T. I. Goksoy and Z .M.Turan. 2009a. Effects of honeybee (*Apis mellifera*) pollination on seed set in hybrid sunflower (*Helianthus annuus* L.). *African Journal of Biotechnology*, 8 (6): 1037-1043.
- Oz, M., A.Karasu, I.Cakmak, A.T. Goksoy and N. Ozmen 2009b. Effect of honeybees' pollination on seed setting, yield and quality characteristics of raped seed (*Brassica napus oleifera*).*Journal of Agricultural Science*, 78 (8):680-3.
- Rao, G.M. and M.C.Suryanarayana. 1990. Studies on the foraging behavior of honeybees and its effect on the seed yield in *Guizotia abyssinica*. [*Indian Bee Journal*](#), 52(1-4), 31-33.
- Sattigi, H. N., D. N. Kambreakar, K. P. Gundannavar and K. A. Kulkarni. 2004. Effect of bee pollination on the yield parameters of Niger *arnataka*. *Journal of Agricultural Science*, 17(4): 831-832.
- Tessega, B. 2009. Honeybee production and marketing systems, constraints and opportunities in Burie District of Amhara Region, Ethiopia. MSc. Thesis. Bahir Dar University.
- Weiss, E. A .2000. **Oil seed crops**. Second edition. Blackwell Science Ltd, pp 229-231.

Hygienic practices and bacteriological quality of raw cow milk along milk supply chain in Sidama high lands of southern Ethiopia

Mesfin Zewdu¹, Bedaso Mamo & Yoseph Mekasha

¹*Bensa District Office of Livestock and Fishery, Sidama zone, Southern Ethiopia*

Abstract

Milk is an important source of nutrients, and the only food for the offspring's of mammals. However, due to its high water activity and nutritional value, it serves as an excellent medium for growth of many kinds of microorganisms under suitable conditions. The present study assessed hygienic practices, and bacterial quality of raw cow milk at each critical control points along milk supply chain in Sidama highlands of southern Ethiopia. The study was conducted in 3 clustered districts (Arbegona, Bensa and Bona zuria) from November 2014 to May 2015. The study employed cross sectional survey & focus group discussion to assess hygienic practices, and determined bacterial quality of milk samples using standard procedures. A total of 120 respondents were interviewed, and 166 milk samples were collected. The data on microbial quality was log transformed before statistical analysis. The study showed that majority of the sampled dairy producer's (83.3%) had earthen barn floor which makes manure removal and cleaning of the barn difficult. Moreover, about 73.3% of the respondents do not use any bedding material and milking cows lie on muddy floor. In the study area, milking was done manually, and the frequency of milked was twice a day. Majority of dairy producers (82.5%) use plastic jars while only 17.5% use clay pot as milking utensil. Although majority of the respondents (85%) wash milk utensils daily, it was not efficient and the utensils were not properly dried. On the other hand, all the interviewed consumers (100%) in the district towns use only plastic containers for transporting milk from the site of production. About 64.2% of the respondents across the 3 districts did not wash their hands before milking, 65% did not wash udder before milking, and 54.8% did not dry the udder with towel. In general, the hygienic condition of milking utensils, milker and the milking environments were poor indicating the possibilities for microbial contaminations of raw cow milk. The mean AMBC of raw cow milk samples were 5.86 $\log_{10}$ cfu/ml, 8.25 $\log_{10}$ cfu/ml and 9.31 $\log_{10}$ cfu/ml for milk samples collected from the udder, bucket and marketed milk container after arrival. The mean CC were 3.61 $\log_{10}$ cfu/ml, 5.47 $\log_{10}$ cfu/ml and 7.47 $\log_{10}$ cfu/ml for milk samples collected from the udder, milking bucket and marketed milk container. There was significant difference ($p < 0.000$) in mean AMBC and CC among the critical control points. However, there was no difference ($P = 0.000$) in AMBC and CC among the districts. The mean AMBC and CC observed in the current study was higher than the minimum acceptable limit recommended by international standards. Thus, it could be recommended that awareness should be created among dairy cow producers, milk collectors, traders and consumers on the importance of hygienic milk production and handling, and the risk of raw cow milk consumption.

Key words: *microbial quality; milk supply chain; hygienic milk production; dairy producers*

Introduction

Milk is an important source of nutrients and the only food for the offspring of mammals (Pandey and Voskuil, 2011; Pal, 2012). However, consumption of contaminated food like milk may lead to food-borne diseases (FBDs). Specifically, human may be infected with milk-borne pathogens through consumption of infected raw or unpasteurized milk and milk products (Bertu *et al.*, 2010; Pal and Jadhav, 2013). Sometimes consumption of contaminated or spoiled milk and other dairy products may cause milk-borne diseases in humans (Pal, 2012). Indeed, food-borne diseases (FBDs) are a serious threat to people in Africa, responsible for 33-90% cases of deaths in children.

Ethiopia possesses the largest livestock population in Africa. Estimates for farmer holding in rural areas indicate that the country has about 53.99 million heads of cattle, 24.6 million goats, 25.5 million sheep and 0.92 million camels (CSA, 2013). In Ethiopia dairy production depends mainly on indigenous livestock genetic resources; more specifically on cattle, goats, camels and sheep. Cattle has the largest contribution (81.2%) of the total national annual milk output, followed by goats (7.9%), camels (6.3%) and sheep (4.6%) (CSA, 2013). While the industry is growing at a rapid rate, no milk quality standards currently exist. Therefore, it is important to establish milk quality standards that focus on food safety measures in order to improve public health.

The consumption of raw milk and milk products is common in Ethiopia, which is not safe from consumer health point of view as it is good media for the growth of microorganisms. Provision of milk and milk products of good hygienic quality is desirable for consumers. This is one reason why milk testing and quality control include hygiene as well as microbial qualities in addition to testing for fat content and heat stability (Giangiacomo, 2000). Prior to the discovery and widespread adoption of pasteurization for instance, raw milk and its products were responsible for serious bacterial infections such as diphtheria, scarlet fever and tuberculosis. Consumers all over the world are increasingly concerned about the safety of their food in general and milk and milk products in particular. Therefore, quality should not be ignored at all stages of the dairy value chain from stable to table.

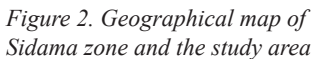
Raw milk is an important vehicle for the transmission of milk-borne pathogens to humans, as can be easily contaminated during milking and handling (Pal, 2012). Poor or improper handling of milk can exert both a public health and economic constraints thus requiring hygienic vigilance throughout the milk value chain (Swai and Schoonman, 2011). In some parts of the world including developing countries like Ethiopia, milk is still a significant source of these infections and other FBDs. However, there is limited information available on hygienic milk production practices and microbial quality of cow milk across the different production systems and supply chain in Ethiopia.

This study was aimed at assessing hygienic practices and bacteriological quality of raw cow's milk along milk supply chain in three clustered districts (**Arbegona, Bensa and Bona Zuria**) of **Sidama** highlands of southern Ethiopia.

Materials and Methods

Description of the Study Area

The study was carried out in **Arbegona, Bona zuria** and **Bensa** districts of **Sidama** highlands of southern Ethiopia. **Sidama** zone is located at 6° 40' 60" North and 38° 43' 0" East of the equator. The altitude of the study area ranges from 2,117 – 2,653 meters above sea level. The mean annual rainfall of the study area is 1,251-1,464 mm. The annual minimum and maximum temperature is 11°C and 15°C, respectively. According to Central Statistics Agency (CSA), **Sidama** zone has about 2million cattle, 236,416 Sheep and 68,388 Goats (CSA, 2013).



Study Design

A cross-sectional study was conducted from November 2014 to May 2015 to assess the hygienic practices and magnitude of bacterial contaminants of raw cow milk produced and supplied along the dairy value chain (producers to consumers) in the study area. Farmers involved in the study were small-holder dairy producers. The study unit was small-holder farmer with lactating cows where questionnaires were administered and raw cow milk was collected for microbial examination.

Sampling technique

The three districts (*Arbegona, Bona zuria and Bensa*) were selected purposely based on the potential of livestock resources by the Livestock and Irrigation Value Chains for Ethiopian Small-holders (LIVES) project. From each district, 5 PA's (lowest administration unit in Ethiopia) were purposely selected based on the livestock population & milk production potential, and accessibility. Representative households were selected from each PA purposely based on the availability of crossbred dairy cattle through the assistance from extension staff. A total of 120 households, 8 from each PA and 40 from each district, were selected for the study based on inclusion and exclusion criteria.

A total of 16 consumers, 6 (2 café, 1 restaurant and 3 consumers) from **Bensa**, 6 (3 café and 3 consumers) from **Arbegona** and 4 (1 café and 3 consumers) from **Bona zuria** who collect milk from producers were interviewed using the information from milk producers in order to assess the potential risk factors for milk contamination along the supply chain which comprises the duration from the final collection up to consumption.

Data Collection

Questionnaire survey

Structured questionnaire was used to collect information from small-dairy producers with lactating cows. The questionnaire was made with pre-coded response choices (closed-ended questions) with a few open-ended questions. Also, the questionnaire was used to collect information on possible risk factors for bacterial contaminations in milk. Risk factors considered in the current study were sanitary conditions of the barn/milking environment, hygiene of milking cows' udder and milk handlers, hygiene of milking equipment with special emphasis to hygiene of milking procedures and milk handling practices, utensils used for milking, milk storage and uses of milk.

Milk sample collection

Raw milk samples were collected from critical control points along the value chain across 15 PA's in three districts. Among 120 producers subjected for questionnaire interview, milk samples (cows'

udder and milking bucket) were taken from 84 households randomly. Moreover, 16 milk samples were taken from milk containers of consumers (café, restaurants and individuals) following snowball sampling technique. The number of milk samples collected from the udder of cow and milking bucket at the farm level, and milk container of consumers was 95, 55 and 16, respectively. Thus, a total of 166 samples of raw milk were used for the bacteriological analysis

Laboratory Analysis of Milk Samples

Microbial analyses of milk was carried out in the microbiology laboratory of Addis Ababa regional laboratory, where both aerobic mesophilic bacterial count (AMBC) and coliform count (CC) were conducted as described below.

Aerobic mesophilic bacterial count (AMBC)

Milk samples were serially diluted by adding 1mL of the test portion into 9 mL of 0.1% sterile peptone water. Dilutions were made so that plate counts ranged between 30 and 300 colonies. Appropriate dilutions were placed on petri dishes and pour plated with 10 to 15 mL molten plate count agar (about 45°C) (Oxoid, UK) and allowed to solidify for 15 minutes and incubated for 48 hours at 37°C. Finally, counts were made using a colony counter. The plate counts were calculated by multiplying the count on the dish by 10^n , in which n stands for the number of consecutive dilutions of the original sample.

Coliform count (CC)

Appropriate decimal dilutions were made by transferring 1 mL of the sample into 9 mL of 0.1% peptone water for initial dilution and by transferring 1 mL of the previous dilution into 9 mL of peptone water. After surface plating the appropriate dilution in duplicates on VRBA, Petri dishes were incubated at 32°C for 48 hours and counts made on typical dark red colonies normally measuring at least 0.5 mm in diameter on uncrowned plates.

Statistical data analysis

The data generated from the survey and laboratory were analyzed using Statistical Package for Social Science (SPSS) version 20. The survey data was described using descriptive and inferential statistics. Bacteriological counts were transformed into logarithmic scale ($\log_{10}$ cfu/ mL) and analyzed using the General Linear Model (GLM) procedure of SPSS. Means were compared and declared significant at $\alpha=0.05$.

Results

Dairy Cattle Housing and Cleaning Practices

In Sidama highlands majority of the sampled dairy producer's (83.3%) barn was earthen floor while the proportion of others with concrete floor was marginal (Table 1). Thus, manure removal from the former floor is difficult, which results in poor hygiene. Moreover, about 73.3% of the respondents do not use any bedding material and milking cows lie on muddy floor. Consequently, teats and udders of these cows inevitably become soiled while they are lying in such stalls. Similarly, majority of the respondents (56.7%) did not keep calves in a good hygiene, and most of them (94.2%) allow their calves to suckle dams.

Table 1. Types of housing, cleaning practice and calf management in three districts of Sidama zone

Variables		District		
		<i>Bensa</i> (n=40)	<i>Bona zuria</i> (n=40)	<i>Arbegona</i> (n=40)
Barn type	Concrete floor	27.5%	15%	7.5%
	Earthen	72.5%	85%	92.5%
Bedding materials	Grass bedding	12.5%	22.5%	45%
	Earthen bedding	87.5%	77.5%	55%
Barn Cleaning frequency	Daily	87.5%	75%	72.5%
	3 times a week	12.5%	25%	27.5%
Calf management	Clean body	15%	55%	60%
	Soiled body	85%	45%	40%

Feeding and Watering Practices

The dominant form of feeding regime across all the study districts was free grazing on natural pasture. However, about 25% of the interviewed producers supplement their cows with locally available feed resources such as enset leaf. There were different source of water used for cattle in the study area. The majority of the respondents (94.2%) had access to river water followed by dug well water (5.8%) while none of them used pipe water.

Table 2. Feeding and watering practices of dairy cattle in the study area

Variables	Districts		
	<i>Bensa</i> (n=40)	<i>Bona</i> (n=40)	<i>Arbegona</i> (n=40)
Feeding regime			
Grazing natural pasture	100%	100%	100%
Supplemented with local feed	12.5%	22.5%	40%
Source of water for farm activities			
Pipe	0%	0%	0%
River	82.5%	95%	95%
Well	17.5%	5%	5%
Both river and well	52.5%	42.5%	47.5%

Milking and Hygienic Practices

In Sidama highlands, milking dairy cows is done manually (stripping), and this was, mostly by women's. Cows were usually milked twice a day except with few farmers (about 8.3%) who milk three times a day. Plastic containers (buckets) and clay pots are used during milking. Among the interviewed households, 82.5% use plastic jars while 17.5% use clay pot as milking utensil. The majority of the respondents (85%) wash milk utensils daily, while 15% clean three times a week before milking. However, the cleaning is not efficient and utensils are not properly dried. It was observed that milkers dip their fingers in the milking vessel to moisten teats of the cows with the intention of facilitating milking. On the other hand, all the interviewed consumers (100%) in urban centers (district towns) use only plastic containers for transporting milk from producers.

In the present study, majority (64.2%) of the respondents across the 3 districts did not wash their hands before milking, while the remaining 35.8% did wash their hands with water. However, none of the interviewees wash their hands between milkings of different cows. Among interviewed households, about 65% did not wash udder before milking while the remaining 35% did. Similarly, about 54.8% of all the interviewees households did not use towel to dry udder after washing rather they massage the udder with bare hands while about 45.2% reported that they use local material such as *kacha (Agave sisalena)* for teat and hand drying purposes. Generally, it was observed that the hygienic condition of milking utensils, milker and the milking environments were poor indicating the possibilities for microbial contaminations of raw cow milk.

Table 3. Hygienic practices followed by dairy producers in three selected districts of Sidama zone, southern Ethiopia

Major Hygienic Practices	Districts		
	Bensa (n=40)	Bona zuria (n=40)	Arbegona (n=40)
Milking frequency			
Twice a day	85%	95%	95%
Three times a day	15%	5%	5%
Milking utensils used for milking			
Plastic	97.5%	77.5%	72.5%
Clay pot	2.5%	22.5%	27.5%
Cleaning frequency of milking utensils			
Daily	97.5%	77.5%	80%
Three times a week	2.5%	22.5%	20%
Milking utensils used for transport			
Plastic	100%	100%	100%
Wash hands before milking?			
Yes	42.5%	32.5%	32.5%
No	57.5%	67.5%	67.5%
Wash udder and teats before milking?			
Yes	40%	30%	35%
No	60%	70%	65%
Milking after drying teats?			
Yes	37.5%	31.3%	57%
No	62.5%	68.7%	43%

Bacterial Count

Aerobic mesophilic bacterial count (AMBC)

The mean aerobic mesophilic bacterial count (expressed in $\log_{10}$ cfu/ml) of raw cow milk sampled at three critical points are shown in Figure 1. The overall mean AMBC was 5.86, 8.23 and 9.31 $\log_{10}$ cfu/ml for milk samples collected directly from the udder, milking bucket and milk containers of consumers upon arrival, respectively, and the difference was significant ($p < 0.000$). There was no difference ($p > 0.05$) in AMBC among the different districts. There was an increasing trend of aerobic mesophilic bacterial count as the milk passed through udder, milking bucket and consumer's container. Accordingly, AMBC increased by 40% (2.37 $\log_{10}$ cfu/ ml) from point of production (milk sampled directly from the udder) to milk samples taken from milking bucket at the farm. Likewise, AMBC increased by 13 % (1.08 $\log_{10}$ cfu/ ml) from milking bucket at the farm level to marketed milk

with consumers container up on arrival. The increase from point of production to marketed milk of consumers upon arrival was $3.45 \log_{10}$ cfu/ ml.

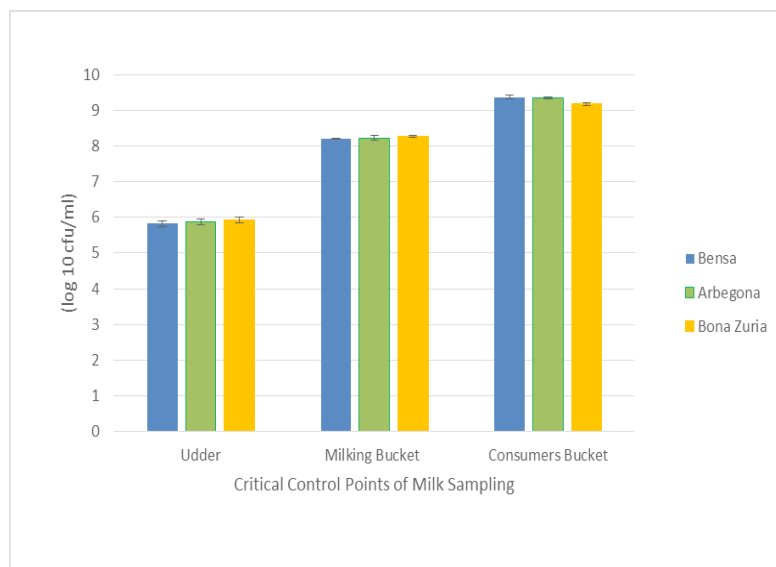


Figure 1. Mean ($\pm$ s.e.) aerobic mesophilic bacterial count of pooled milk sample in the study area

Coliform count (CC)

The mean coliform counts (expressed in $\log_{10}$ cfu/ml) of raw milk sampled at three critical points are shown in Figure 2. The overall mean CC was 3.61, 5.48 and $7.47 \log_{10}$ cfu/ml for milk samples collected directly from the udder, milking bucket and marketed milk containers of consumers upon arrival, respectively. There was significant difference ($p < 0.000$) in mean CC among milk sampling critical points. There was an increasing trend of coliform counts as the milk passed through udder, milking bucket and marketed milk containers upon arrival. Accordingly, the count increased by $1.87 \log_{10}$ cfu/ ml from point of production (milk sampled directly from the udder) to milking bucket at the farm level. In a similar manner, it increased by $1.99 \log_{10}$ cfu/ ml between sampling from milking bucket at the farm level to marketed milk containers at market. The overall increment from point of production to arrival at market was $3.86 \log_{10}$ cfu/ ml.

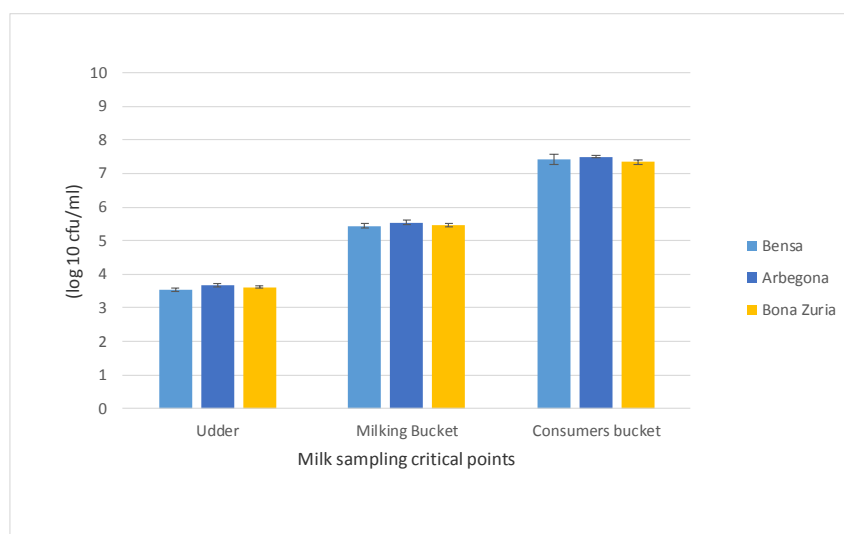


Figure 2. Mean ($\pm$ s.e.) coliform counts of pooled milk samples ($\log_{10}$ cfu/ml) across milk sampling critical points

Discussion

In Ethiopia milk is mostly marketed through the informal channel, which is not regulated by any institution/agency, and thus, it may pose a health hazard to consumers due to contamination with pathogens. This study, therefore, evaluated hygienic milk production and handling practices and microbial quality of cow milk across milk supply chain in Sidama highlands of southern Ethiopia.

Hygienic milk production practices

The present study showed that milk was generally produced by dairy producers under unhygienic environmental condition. Most smallholder dairy farmers manage their cattle in poor cattle houses that were not cleaned regularly and may have implications on sources of pathogens for mastitis and other diseases to animals. Meanwhile, such unclean environment are likely to be sources of milk contaminations. Similar observations have been reported previously (Shija, 2013). Moreover, failure to wash udder and/or teats before milking, reckless milking personnel, failure to wash hands before milking, use of poor quality water for cleanliness (hands and milk equipments), failure to cover milk after milking and prolonged milk storage under room temperature were among the major factors which predispose milk to microbial contaminations at household level.

As observed during the field visit, the barns were not constructed to facilitate drainage of the farm wastes, which leads to soiling of dairy cows and contamination of milk. Most of the respondents clean the barn on daily basis only by removing the feces, which is in agreement with Zelalem (2010). Teats and udders of cows inevitably become soiled while milking cows lay in stalls or when they are allowed to stay in muddy barnyard. Used bedding has been shown to harbor large numbers of microorganisms (Murphy and Boor, 2000). Milking was also performed in the same place after cleaning. Although, the high proportion of dairy cow owners earthen their barn floors, clean, dry and comfortable bedding condition is important to minimize the growth of pathogenic microorganisms. Practices that expose the teat end to these organic bedding sources, wet and muddy pens increase the risk of occurrence of mastitis and milk contamination.

In general, providing proper shelter for animals has not been given the required attention. This may have a negative impact on the quality of milk and milk products produced and processed. Proper and clean housing environment is a prerequisite to produce milk and milk products of acceptable quality (Asaminew, 2007). The general hygiene at milking time is known to affect the numbers of microorganisms in the milk. The dominant milking practice in the study area was hand milking. Indeed, the hand milking practiced by animal attendants could result in microbial contamination of the milk. These practices could have contributed to the observed high bacterial load in the milk. Previous studies had similar observations (Swai and Schoonman, 2011; Shija, 2013).

Most dairy farm owners in the present study do not clean their cow's udder and teat with water. Cleaning the udder of cows before milking is important since it could have direct contact with the ground, urine, dung and feed refusals while resting. Lack of washing udder before milking can impart possible contaminants into the milk. The current study is in agreement with other reports (Derese, 2008). Contrary to this study, Haile *et al.* (2012) reported that 82.5% of the small size farms owning households in Hawassa city are practicing pre milking udder washing. Cleaning of the udder before milking is important to remove both visible dirt and bacteria from the outer surface of the udder. Unless properly handled, milk can be contaminated by microorganisms at any point from production to consumption. Producers should, therefore, make udder washing a regular practice in order to minimize contamination and produce good quality milk.

Production of milk of good hygienic quality for consumers requires good hygienic practices (clean milking utensils, washing milker's hands, washing the udder and use of individual towels) during milking and handling, before delivery to consumers or processors (Getachew, 2003). In the study area, the majority of the respondents practiced washing of their milk utensils. However, the cleaning is not efficient and utensils are not properly dried. Surfaces such as milking equipments and hands coming in contact with milk if not clean enough may cause milk contaminations. During the current study, pots and plastic containers were the major utensils for collection and storage of milk. Narrow necked plastic containers which were commonly used are not easily washed especially in the bottom and inner corners thus may lead to sticking of milk residues. In such a situation, microorganisms can rapidly

build up in potentially nutritious milk residues of storage containers consequently contaminating the milk on subsequent uses. Similarly, Shija (2013) observed high microbial load in milk which was handled in narrow necked plastic containers.

The source of water used for cleaning milking equipment and hands is restricted to river and dug well water. However, the quality of these water sources may not be of the required standard and, thus, can contribute to poor quality of milk. It is, therefore, important to boil or treat water originated from river and well before using it for cleaning purpose.

Bacteriological quality of cow raw milk

The increment of bacterial load through milk supply chain observed in the study could be attributed to contamination of the milk at different stages starting from production to consumption. This could happen while pooling milk from different sources together with unhygienic handling, storing the milk without cooling and others. Consistent with this findings, Farah *et al.* (2007) reported that there was an increase in bacterial counts through milk supply chain where the highest count was observed from bulk milk of cow stored for 24 hrs without cooling in Somalia.

The lack of difference in AMBC among the districts might be due to similar milking and milk handling practices across the three districts. However, the mean AMB count from udder milk samples ($5.86 \log_{10}$ cfu/ml) observed in the current study was higher compared to $5.11 \log_{10}$ cfu/ml reported for smallholder dairy farms in Debre Zeit, Ethiopia (Alehegne, 2004), and 3 to $4 \log_{10}$ cfu/ml reported for dairy farms at Awassa College of Agriculture, Ethiopia (Mogessie and Fekadu, 1993). Similarly, the mean AMB counts for milk samples taken from the milking bucket at farm level in the present study ($8.25 \log_{10}$ cfu/ml) was higher than $6.0 \log_{10}$ cfu/ml reported for milk samples taken from selected dairy farms in Addis Ababa (Bekele and Bayleyegn, 2000) and $7.6 \log_{10}$ cfu/ml reported for milk samples collected from smallholder livestock producers of East Wollega, Ethiopia (Alganesh *et al.*, 2007). The present AMB count of milk samples collected from the marketed milk container ($9.31 \log_{10}$ cfu/ml) was higher than the value ($8.38 \log_{10}$ cfu/ml) reported for milk samples collected from similar containers in central highlands of Ethiopia (Yilma and Faye, 2006). The AMB count for milk samples collected from containers upon arrival in the present study was also higher than $6.63 \log_{10}$ cfu/ml reported for raw milk samples used for consumption in Sudan (Abd Elrahman *et al.*, 2009).

The differences in AMBC count might be attributed to the differences in the hygienic conditions such as the quality of cleaning water, milk containers, personal hygiene followed by the various producers. The overall mean AMBC observed in the current study was higher than the maximum

recommended level of 2.0×10^6 cfu/ml (EAS, 2007). As observed during sampling, higher AMBC obtained in the current study might be related to the overall sanitary conditions followed. Most of the farms in the present study housed and milked their animals under substandard hygiene, and there was lack of experience and facilities for milk cooling. Murphy and Boor (2000), noted that ineffective use of cleaning water without heat treatment and the absence of sanitizers tend to fasten growth of less heat resistant organisms. A higher count also suggests that the milk has been contaminated by bacteria from different possible sources. This may be due the contribution of insufficient pre-milking udder preparation, the use of poor quality water for cleaning without heat treatment and the storage container and time. As reported by Van Kessel *et al.* (2004), the use of insufficient and poor quality water for cleaning of milk handling equipments can result in milk residues on equipment surfaces that provide nutrients for the growth and multiplication of bacteria that can then contaminate the milk.

The overall mean coliform count observed from cows udder in the current study ($5.52 \log_{10}$ cfu/ml) was higher than $4.03 \log_{10}$ cfu/ml reported for milk samples collected from cows kept under traditional condition in the Wolayta zone (Rahel, 2008), $4.84 \log_{10}$ cfu/ml for milk samples collected from cows in the Bahir Dar milkshed (Derese, 2008) and $4.49 \log_{10}$ cfu/ml in milk samples collected from cows in West Shewa zone of Oromia region (Asaminew, 2007). Similarly, the present CC for samples collected from milking bucket ($5.47 \log_{10}$ cfu/ml) was higher than 4.11 to $4.85 \log_{10}$ cfu/ml reported for milk samples collected from storage containers in Addis Ababa (Bekele and Bayleyegn, 2000) and $4.46 \log_{10}$ cfu/ml reported for milk samples collected from storage in East Wallega, Ethiopia (Alganesh *et al.*, 2007). However, the present findings was comparable with $5.4 \log_{10}$ cfu/ml reported for milk samples obtained from milk collecting utensils (Mogessie and Fekadu, 1993). On the other hand, the present mean CC of raw milk samples collected from marketed milk containers upon arrival ($7.47 \log_{10}$ cfu/ml) in this study was higher than $5.61 \log_{10}$ cfu/ml reported for raw cow milk samples used for processing in Sudan (Abd Elrahman *et al.*, 2009).

The overall coliform counts observed in the current study were much higher when compared with the recommended values given by the American Public Health Service: < 100 cfu/ml for Grade A milk and 101- 200 cfu/ml for Grade B milk (WHO, 1997). The presence of high numbers of coliforms in milk indicates that the milk has been contaminated with fecal materials. Unclean udder and teats can contribute to the presence of coliforms from a variety of sources such as poor farm hygiene, use of improperly washed milking equipment, unsanitary milking practices, contaminated water and cows with subclinical coliform mastitis can all lead to elevated coliform count in raw milk (Jayarao *et al.*, 2004).

The high aerobic mesophilic bacterial and coliform counts observed in the present study showed that the milk produced by dairy producers in the study area was of poor bacteriological quality. Moreover, the higher bacterial loads (AMBC and CC) observed in the milk samples from the present study compared to the recommended acceptability level for consumption implies that milk is produced and handled under poor hygienic conditions in the study area. This leads to the possibility of contracting infection or intoxication from milk-borne pathogens during consumption of the milk. The risk of infection and contaminations gets worse when milk is consumed in its raw state which was a common habit in the study area. This may be true with report by WHO (2003), in that zoonosis selectively affect families which live in rural areas.

From the results of this study, it was found that the majority of the milk samples had higher bacterial count than the maximum recommended level, suggesting that it is unfit for human consumption. The presence of high total bacterial load in raw milk indicates contamination possibly from lactating cows, milking equipment's, storage containers, unsatisfactory hygiene/sanitation practiced at farm level, unsuitable storage condition, unclean udder and/or teats, poor quality of water used for cleanliness and unhygienic milk handling by milkers. Further it indicates the degree of hygienic practices along the milk supply chain, and the time elapsed since milking at ambient temperature (Shija, 2013). Thus, based on the present findings, awareness should be created and capacity developed on hygienic milk production and milk handling practices, and food safety to dairy producers, milk collectors, traders and consumers in the study area.

Conclusion

The present study evaluated hygienic milking practices and microbial quality of raw cow milk along milk supply chain in selected districts of Sidama highlands. The study identified various factors which could predispose raw cow milk to microbial contamination. This included poor condition of cattle house and floor, lack of experience to wash hands and udder/teats before milking, poor quality of water used for cleanliness (hands and milk equipment's), type of milk storage containers and milk storage duration under room temperature. Moreover, the study showed that raw cow milk and milk products were widely consumed in the study area. However, the raw cow milk available to consumers has a high level of bacterial contamination, which is beyond the threshold indicating that the milk produced and marketed in the study area was of poor quality. Thus, it could be recommended that awareness should be created among dairy cow producers, milk collectors, traders and consumers on the importance of hygienic milk production and handling, and risk of raw cow milk consumption.

Acknowledgement

This study was carried out with the financial support of the Government of Canada (Foreign Affairs, Trade and Development; DFATD) through the Livestock and Irrigation Value chains for Ethiopian Smallholders (LIVES) project.

References

- Abd Elrahman, A.M., Ahmed, M.S., El Zubeir, M., Owni, O. and Ahmed, A. (2009): Microbiological and Physiochemical Properties of Raw Milk Used for Processing Pasteurized Milk in Blue Nile Dairy Company (Sudan). *Australian J. Basic Appl. Sci.*, **3**: 3433-3437.
- Alehegne, W. (2004): Bacteriological quality of Bovine milk in small holder dairy farms in Debre Zeit, Ethiopia, Faculty of veterinary Medicine, Addis Ababa University, M.Sc thesis, Addis Ababa, Ethiopia, Pp 34.
- Alganesh, T., Ofodile, L.N. and Fekadu, B. (2007): Microbial quality and chemical composition of whole milk from Horro cattle in East Wallega Ethiopia. *Chemical Society of Nigeria*, **33** (1): 31-36.
- Asaminew, T. (2007): Production, handling, traditional processing practices and quality of milk in Bahir Dar milk shed, M.Sc.Thesis. Haramaya University, Ethiopia.
- Bekele, G. and Bayileegn, M. (2000): Bacteriological quality of raw cow's milk from four dairy farms and a milk collection center in and Around Addis Ababa. *Berliner and Mucnchener Tieraerztliche Wochenschrift*, **113**: 276-278.
- Bertu, W.J., Dapar, M., Gusi, A.M., Ngulukun, S.S., Leo, S. and Jwander, L.D. (2010): Prevalence of Brucella antibodies in marketed milk in Jos and environs. *Afr. F. Sc.J.*, **4**: 062 - 064.
- Clare, D.A., Bang, W.S., Cartwright, G., Drake, M.A., Coronel, P. and Simunovic, J. (2005): Comparison of sensory, microbiological, and biochemical parameters of microwave versus indirect UHT fluid skim milk during storage. *D. Sci.J.*, **88**: 4172-4182.
- CSA. (2013): Agricultural Sample Survey. Livestock, Poultry and Beehives population (private peasant holdings). Federal Democratic Republic of Ethiopia Central Statistical Authority (CSA), Addis Ababa, Ethiopia.
- Derese, T. (2008): Present situation of urban and peri-urban milk production and quality of raw milk produced in **West Shewa** Zone, Oromia Region. M.Sc.Thesis. Haramaya University, Ethiopia.
- EAS (2007): **Raw Cow Milk – Specification**. East African Community (EAC 67:2007) standard. Pp 1 - 19.
- Faraha, M. and Salik, S. (2007): Evaluation of bacteriological contamination in raw (unprocessed) milk sold in different regions of Lahore, Pakistan. *J. Agric. Soc. Sci.*, **3**(3): 104-106.
- Getachew, F. (2003): A Review of the small scale dairy sector in Ethiopia. FAO prevention of food losses programme. Milk and milk products, post-harvest losses and food safety in sub-saharan Africa and Near East.
- Giangiacomo, R. (2000): Milk testing, quality control, hygiene and safely. FAO e-mail conference on "Small-scale milk collection and processing in developing countries". June 6– August 3, 2000, Pp. 108.
- Haile, W., Zelalem, Y. and Yosef, T.G. (2012): Hygienic practices and microbiological quality of raw milk pro-

- duced under different farm size in Hawassa, Southern Ethiopia. **Agric. Res. and Rev.**, **1**: 132- 142.
- Jayarao, B.M., Pillai, S.R., Sawant, A.A., Wolfgang, D.R. and Hegde, N.V. (2004): Guidelines for monitoring bulk tank milk somatic cell and bacterial counts. **J. Dairy Sci.**, **87**: 3561-73.
 - Mogessie, A. and Fekadu, B. (1993): Effect of container smoking and udder cleaning on microflora and keeping quality of raw milk from a dairy farm in Awassa. **Tropical Sci.**, **33**: 368-378.
 - Nanu, E., Latha, C., Sunil, B.P., Magna, T. and Vrinda, K.M. (2007): Quality assurance and public health safety of raw milk at the production point. **Am. J. Food Technol.**, **2**: 145-152.
 - O'reilly, C. E., O'connor, P. M., Kelly, A. L., Beresford, T. P. and Murphy, P. M. (2006): Use of hydrostatic pressure for inactivation of microbial contaminants in cheese. **Appl. Environ. Microbiol.**, **66**: 4890-4896.
 - Pal, M. (2007): Zoonoses. 2nd Ed, **Satayam Publishers**, Jaipur, India.
 - Pal, M. (2012): Public health hazards due to consumption of raw milk. **The Ethiopian Herald** March 14, 2012.P 10.
 - Pal, M. and Jahdav, V.J.(2013): Microbial contamination of various Indian milk products. **Bev. Food World**, **40**: 43-44.
 - Pandey, G.S. and Voskuil, G.C. (2011): Manual on milk safety, quality and hygiene. Golden Valley Agricultural Research Trust, Zambia, P 52.
 - Rahel, N. (2008): Traditional and improved milk and milk products handling practices and compositional and microbial quality of milk and buttermilk in **delbo** watershed of **Wolayta** Zone, M.Sc.Thesis. Department of Animal and Range Sciences, Hawassa College of Agriculture, School of Graduate Studies, Hawassa University, Ethiopia.
 - Rai, A.C. and Dawvedi, F. (1990): Bacteriological quality of market milk. **Indian Dairyman**, **101**: 487-491.
 - Shija, F. (2013): Assessment of milk handling practices and bacterial contaminations along the dairy value chain in Lushoto and Handeni districts in Tanga region. Unpublished dissertation for award of MSc. degree at Sokoine University of Agriculture, Morogoro, Tanzania, Pp 1 - 88.
 - Swai, E.S. and Schoonman, L. (2011): Microbial quality and associated health risks of raw milk marketed in the Tanga region of Tanzania. **Asian Pacific Trop. Biomed.J.**, **1**: 217 - 222.
 - Van den Berg, J.C. (1988): Dairy technology in tropics and subtropics. Pudoc, Wageningen, the Netherlands, P 290.
 - Van Kessel, S.J., Karns, S.J. and Gorski, L. (2004): Prevalence of **Salmonellae**, **Listeria monocytogeneus**, and fecal coliforms in bulk tank milk on US dairies. **J. Dairy Sci.**, **87**: 2822- 2830.
 - Van Schaik, G., Green, L.E., Guzman, D., Esparza, H. and Tadich, N. (2005): Risk factors for bulk milk somatic cell counts and total bacterial counts in smallholder dairy farms in the 10th region of Chile. **Preventive Vet. Med.**, **67**: 1-17.
 - WHO. (1997): Global estimation of food- borne disease. World Health Statistics in Raw Milk, International Dairy Federation Brussels, Pp 8-11.
 - WHO. (2003): Diet, nutrition and prevention of chronic disease. Report of a joint FAO and WHO Expert Consultation, Geneva, 2002. WHO Technical Report Series 916. Geneva, World Health Organization.
 - Yilma, Z. and Faye, B. (2006): Handling and microbial load of cow's milk and Irgo fermented milk collected from different shops and produced in central highlands of Ethiopia. **Eth. J. Anim. Prod.**, **6**: 67-82.
 - Zelalem, Y. (2010): Microbial properties of Ethiopian marketed milk and milk products and associated critical points of contamination: an epidemiological perspective, Addis Ababa, Ethiopia.

An overview of Dairy Products Quality and Safety

Based on Review of researches conducted in different parts of Ethiopia

Desalegn Gebremedhin

Livestock Officer, Tigray Field Office, FAO Ethiopia

Abstract

The purpose of this paper is to bring the issue of milk and milk products' quality and safety to the attention of responsible institutions, professionals, and the community at large in order to do more on improving the quality statuses of dairy products. It is prepared based on a review of researches conducted in different parts of Ethiopia by the Milk and Milk Products Quality and Safety Directorate of the Ethiopian Meat and Dairy Industry Development Institute/EMDIDI and other professionals from different universities. The results of the different studies conducted signified that both whole/raw milks and pasteurized milks significantly varied from the standards. Added water as high as 30% and fat percent from whole milk as low as 2.4% were detected while again the microbial loads have been found to be extremely higher than the standards. It was observed that milk production, handling, transportation, and processing in the dairy sector have serious shortcomings and hence are highly exposed to contamination. The current condition of quality of milk and milk products both in terms of compositional and microbiological aspect is not in good condition. All pasteurized milks checked were highly adulterated while actually the compositional quality of pasteurized milk should have only little deviation from a good quality whole milk. So, it is understood that the current quality status of raw and pasteurized milk is much below standards and calls for an urgent action by all pertinent and responsible bodies to reverse the situation. All food manufacturers have the responsibility to ensure that quality assurance systems are in place to provide consumers with a product that is wholesome and safe to eat and at the same time all relevant public institutions have the responsibility to ensure that rules and regulations are properly implemented and the public at large safeguarded from food-borne diseases.

Introduction

Milk is the only food of the young mammal during the first period of its life. It is known as nature's most perfect food, one of the essential food components for human beings. Although milk is produced by many other mammals, the most widespread milking animal for human consumption in the world is the cow. Production of milk for the purpose of human consumption is believed to have begun more than 6,000 years ago.

Milk is virtually sterile when it is synthesized in a healthy cow's udder (mammary gland). It is particularly susceptible to contaminations for several reasons. Cattle while grazing can ingest contaminants, which are naturally present such as lead in soil or are deposited on grass from industrial emissions or are present in soil as a result of the use of persistent pesticides. Another major route of intake of contaminants is through compounded animal feeds, which are particularly important for aflatoxin and other mycotoxins. Residues of a range of veterinary drugs including antibiotics and sulfa drugs in milk could also be important public health concerns if they are not used according to label directions or the proper withholding times. Residues of veterinary drugs exceeding Maximum Residue Limits (MRLs) may have influence on technological properties of the milk for manufacturing fermented milk products and also may be of toxicological significance for the consumer. Mastitis, which is an inflammation of the mammary gland resulting from a variety of types of injury including infectious agents and which is considered the most costly disease complex in the dairy industry also contributes to the reduction of milk quality to a great extent.

Therefore, milk testing and quality control is an essential component of any milk processing industry whether small, medium or large scale. Milk being made up of 87% water is prone to adulteration by unscrupulous middle men and unfaithful farm workers. Moreover, its high nutritive value makes it an ideal medium for the rapid multiplication of bacteria, particularly under unhygienic production and storage at ambient temperatures. It is well known that good quality raw materials are essential in order for any processor to make good dairy products. A milk processor or handler will only be assured of the quality of raw milk if certain basic quality tests are carried out at various stages of production and transportation of milk from the producer to the processor and finally to the consumer.

Food-borne diseases have enormous impacts on the health and livelihoods of people around the globe and are of great concern to consumers, producers, and policy makers. Food contamination sickens and kills millions of people every year; young children and poor people in developing countries often suffer the most. Moreover, poor quality milk causes huge economic losses to the producer, to the processor, and to the nation at large. Food safety is, therefore, more than a matter of preventing illness!

The current milk collection and utilization systems in Ethiopia are categorized mainly into two. The first one is the informal milk collection systems where direct delivery of fresh milk is made by producers to consumers or through one or more market agents. It is characterized by sales to itinerant traders or individuals with no licensing requirement, low cost of operations and no regulation to operate. More than 90% of the national milk is marketed through the informal channels and is consumed unpasteurized.



Figure 1. Photos illustrating informal milk collection and sales practices

The other category is the formal milk collection system which is limited mainly to peri-urban and urban areas particularly in Addis Ababa and other big towns. Fresh milk is collected from individual smallholder dairy producers, individual collectors, cooperatives, and commercial dairy farms, and transported to the different processing plants. Much less than 10% of the total milk produced in the country goes through this marketing channel.

This paper considered raw and pasteurized milks and not other milk products for the assessment of the status of milk quality. It is believed that these two products could fully represent the other products because good quality dairy products could be obtained only from good quality raw milk.

Milk Quality and Public Health

Basically, milk quality can be broadly assessed based on compositional/nutritional value, characteristics and flavor, hygienic quality, and freedom from any dirt. Accordingly, there are generally accepted standards for milk to be safe, sound, wholesome product, which is fit for human consumption with little variations amongst countries depending on how stringent they are in controlling and ensuring the production of good quality dairy products.

There are no clear statistical information on the number of people who contract illnesses and ultimately die all over the world due to the consumption of poor quality/unsafe foods including milk and milk products, but it is believed to be one of the major causes of death which again brings about huge concerns by consumers about the quality and safety of foods of milk origin or other sources.

The public health concerns related to the consumption of poor quality milk and milk products, amongst others, include the development of drug resistance, milk borne illnesses/zoonosis, and deaths. For instance, studies have revealed the presence of pathogenic bacteria, *Staphylococcus aureus*, and its toxins in more than 30% of raw milk. *S. aureus* causes serious intestinal disorders and its toxins are not destroyed by pasteurization.

Recent Results of Researches Conducted on Milk Quality in Ethiopia

Summaries of some recent research findings conducted in different parts of Ethiopia by different researchers on milk samples taken from dairy companies and dairy farms to check both the compositional and microbial qualities are presented in the following two tables.

Table 1. Summary of research findings on physicochemical analyses of raw and pasteurized milk for selected parameters

Research conducted by	Year	Purpose of research	Research areas ^b	Source of Milk samples	Sample size(N)	Results		
						Mean Fat (%)	Mean Total Solids (%)	Mean Added Water (%)
EMDIDI ^a	2015	To evaluate National Milk Quality status	Different regions	Processing companies ^c	Raw milk =25	3.81	10.49	7.23
					Pasteurized milk = 12			
						3.01	9.67	15.20

^aEMDIDI = Ethiopian Meat and Dairy Industry Development Institute

^bResearch areas include Oromia, SNNPR, Amhara, and Tigray

^cMilk samples taken from these companies represent thousands of liters and hundreds of farmers who delivered the milk

Table 2. Summary of research findings on microbiological analyses of raw and pasteurized milk for selected parameters

SNo	Researcher	Year	Purpose of research	Research areas ^b	Source of Milk samples	Sample size(N)	Coliform bacteria ^d (cfu/ml)	Total bacterial count (cfu/ml)
1	EMDIDI ^a	2015	To evaluate National Milk Quality status	Different regions	Processing companies ^c	Raw milk=13 Pasteurized milk = 11	>6.2*10 ⁴ >1.2*10 ⁴	>4.8*10 ⁷ >1.9*10 ⁷
2	Asaminew Tassew and Eyassu Seifu	2010	To evaluate microbial quality of raw cow's milk	Bahir Dar Zuria and Mecha district	Farmers and dairy cooperatives	84	1.0*10 ⁵	1.0*10 ⁸
3	Amakelew S, et al.	2015	To determine the microbial quality of cow milk	Dawa Cheefa District, Oromia Zone of the Amhara Regional State	Hotels, cooperative, and household producers	50	1.0*10 ⁵	1.0*10 ⁷

^aEMDIDI = Ethiopian Meat and Dairy Industry Development Institute

^bResearch areas include Oromia, SNNPR, Amhara, and Tigray

^cMilk samples taken from these companies represent thousands of liters and hundreds of farmers who delivered the milk

^d Samples with uncountable bacterial count detected(N= 4 samples taken from bulk tanks) by EMDIDI are not included here

According to the Ethiopian Standards Agency (ESA), the specifications for whole/raw cow milk standard, among other parameters are minimum milk fat percentage of 3.5; minimum protein percentage of 3.2; and minimum total solids of 12.8%. Again according to the same source, the bacteriological quality of whole/raw cow milk is set to be less than 200,000; 200,000 - 1,000,000; 1,000,000 - 2,000,000 and above 2,000,000 CFU/ml for very good, good, bad, and very bad, respectively. Similarly, the grades of milk quality according to the total number of coliform plate count/ml is set to be less than 1000; 1000 - 50,000; 50,000 - 500,000 and above 500,000 cfu/ml for very good, good, bad, and very bad, respectively. According to the existing milk quality standards of Ethiopia set by the Ethiopian Standards Agency, no fecal coliform and not more than 10cfu/ml of non fecal coliform should be present in pasteurized milk. These standards are more or less similar to other international standards according to different literatures. However, the research findings presented above and other published and unpublished research findings indicate that the qualities of raw/whole milks are not in accordance with the set standards. The levels of the major milk constituents in different companies are below standards while the amount of added water is frighteningly high in most milk processing companies. Moreover, the results found in different studies indicate that the bacteriological quality of pasteurized milk is alarmingly below the set standards calling for an urgent action to revert the situation.

Consumer protection requires mandatory application of existing standards. This includes, but is not limited to, payment of milk according to quality; disease investigation in dairy animals; culling of animals carrying diseases that can be transmitted by milk to humans, and animal insurance.

Where Does the Quality of Milk Deteriorate?

- *At the farm: poor cow's health, poor quality feeds and feeding, poor farm hygiene;*
- *Milking procedures: improper milker's hygiene and health, unclean milking equipments, inappropriate milking procedures, and unsuitable storage facilities;*
- *Transporting and handling: improper equipment, unsuitable temperature, longer time than appropriate;*
- *Reception at the industries and subsequent processing procedures;*
- *Whole salers/distributors, retailers;*
- *At the consumers' level due to poor handling*
- *Reasons for Deterioration of Milk and Milk Products Quality*
- *Shortage of knowledge and knowhow on hazards related to milk hygiene by actors particularly at the production and marketing chains;*
- *Intentional adulteration of milk not only by water but also by other substances at the different production and processing levels intended to accumulate wealth unethically;*
- *Lack of commitment and determination by the pertinent institutions and/or responsible personnel at all levels;*
- *Lack of stringent mandatory quality standards and quality related laws and/or failure to implement the available ones lack of law enforcement mechanism*
- *Lack of applicable accountability and/ or lack of materialization of accountabilities*
- *Whose Responsibility is Ensuring Good Milk Quality?*
- *In Ethiopia, there are public and other institutions and civic societies who have direct or indirect roles and responsibilities to ensure the quality and safety of milk and milk products or support in any way possible to those who are directly involved in the process of ensuing good quality dairy products. These institutions include, amongst others, the following:*

PROCEEDING

Animal Breeding and Reproduction

- *Ethiopian Milk Producers Association?*
 - *Ethiopian Milk Processors Industry Association*
 - *Ethiopian Milk Collectors' and marketers' Association*
 - *Ministry of Industry: EMDIDI, EFBFIDI*
 - *Ministry of Livestock and Fisheries Development*
 - *Ministry of Health: EFMHACA,*
 - *Ministry of Trade: Ethiopian Trade Competition and Consumers' Protection Authority,*
 - *Higher learning institutions*
 - *Ministry of Justice*
 - *Ethiopian Standards Agency*
 - *Veterinary Drug and Feed Administration and Control Authority*
 - *National and Regional Research Institutions*
 - *Ethiopian Conformity Assessment*
 - *Regional Bureaus of Agriculture and Rural Development and Livestock Agencies*
 - *Professional Associations: ESAP, EVA*
 - *NGOs who have involvement in the dairy sector of the country*
 - *Therefore, if these institutions which have huge technical, material, and financial resources could join efforts and work hand in hand to improve the quality and safety of dairy foods, undoubtedly they can make significant progress in improving the status of milk quality.*

Challenges

- *Shortage of knowledge and skills among actors in the dairy value chain on the hazards associated with unhygienic and poor quality dairy products*
- *Limited sense of ownership among the relevant actors in the dairy value chain to ensure the production, processing and marketing of good quality dairy products*
- *Limitations in working together collaboratively by the relevant institutions and absence of guidelines clearly specifying the roles and responsibilities of institutions working on milk quality and standards*
- *Challenges related to the implementation of mandatory quality standards (lack of commitment, absence of law enforcement governing the set standards etc)*
- *Increasing ambitions to accumulate wealth unethically*

Opportunities

- *Overall attention given by the government to the livestock subsector and the availability of standards for dairy products*
- *The existence of appropriate public institutions mandated to support, monitor, and regulate the quality and safety of dairy products*
- *Increasing demand for dairy products and for investments in the dairy sector*
- *Increasing involvement of non-governmental organizations and UN agencies in dairy production*

Conclusion

Maintaining the quality of milk and milk products to the standards is ethical and legal obligations of the producers while the responsibility of regulating and controlling quality standards lies mainly upon the pertinent public institutions and civil societies; but the issue of milk/food quality is essentially the big concern of the consumers. Milk quality control requires the use of approved tests to ensure the

application of approved practices, standards and regulations concerning milk and milk products. The tests are designed to ensure that milk products meet accepted standards for chemical composition and purity as well as levels of different microorganisms and hence should be strictly exercised.

Nevertheless, milk production, handling, transportation, and processing in the dairy sector in Ethiopia have serious shortcomings and hence are increasing the risk of contamination of dairy products and compromising quality and safety. This situation is posing a serious danger on the health and safety of consumers. So, it is concluded that the current quality status of raw and pasteurized milk is below standards and calls for an urgent action to reverse the situation.

Therefore, all food manufacturers have obligations to ensure that quality assurance systems are in place to provide consumers with a product that is wholesome and safe to eat and at the same time all relevant public institutions have the responsibility to ensure that rules and regulations are properly implemented and the public at large safeguarded from food-born diseases.

Recommendations

- *Rules and regulations on food hygiene should be materialized by involving conditions and measures necessary for the production, processing, storage, and marketing of foods, which are safe, sound, wholesome and fit for human consumption*
- *The issue of implementing quality standards and quality-based payments for dairy products should not be left open-ended*
- *Educate the community at large and create awareness using all possible means about the hazards of consuming raw milk/ unpasteurized milk which can pose a serious health risk*
- *All those who have responsibilities and stakes directly or indirectly should join efforts, resources, and technical expertise and prepare a road map to work together to ensure the production and marketing of quality dairy products*
- *Upgrade the technical knowhow and skills of the pertinent institutions and their respective personnel*
- *Institutions with mandates and responsibilities to support, control, and enforce law to ensure that milk production, processing, and marketing are according to standards, must dispose their responsibilities accordingly*
- *Improve the animal health situation in general and that of the dairy cattle in particular as poor animal health is one of the most important causes for the deterioration milk quality*
- *Marketing of milk and milk products should be in accordance with the Ethiopian milk quality standards and must be supported by implementing law enforcing mechanisms*
- *Milk quality control should be implemented along the milk value chain_ at farm and at milk collection centers and during transportation and processing*
- *Exercise accountability!!*

Acknowledgement

I am very grateful to Dr. Kelay Belihu for generously taking his precious time to review and provide constructive inputs to this manuscript.

References

- Amakelew S, et al. (2015): Microbial Quality of Cow Milk in Dawa Chefa District, Amhara Region, Ethiopia; *J Adv Dairy Res* 2015, 3:2
- Asaminew Tassew and Eyassu Seifu(2010): Microbial quality of raw cow's milk collected from farmers and dairy cooperatives in Bahir Dar Zuria and Mecha district, Ethiopia; *AGRICULTURE AND BIOLOGY JOURNAL OF NORTH AMERICA* ISSN Print: 2151-7517, ISSN Online: 2151-7525, doi:10.5251/abjna.2011.2.1.29.33
- Barrie Axtell, Peter Fellows, Linus Gedi, Henry Lubin, Rose Musoke, Peggy Oti-Boateng, and Rodah Zulu(2008): *Setting up and running a small-scale dairy processing business*. FAB S.A., Belgium.
- Ethiopian Meat and Dairy Industry Development Institute (2015): *Proceedings of the Workshop on Milk Qual-*

PROCEEDING
Animal Breeding and Reproduction

ity for Consumers' Safety, June 25-26, 2015. Addis Ababa, Ethiopia

- *Ethiopian Standards Ref No ES 3460:2009 (2009): Unprocessed whole/raw cow milk specification. 2nd edition*
- *Ethiopian Standards Ref No ES 3462:2009(2009): pasteurized liquid milk specification. 2nd edition*
- *FAO/TCP/KEN/6611(): Milk testing and Quality Control. Training Programme for Small Scale Dairy Sector and Dairy Training Institute – Naivasha*
- *F.Harding (1999): Milk Quaity. Aspen Publishers, Inc. Gaithersbug, Maryland.*
- *Gosta Bylund (1995): Dairy Processing Handbook. Tetra Pak Processing Systems AB, S-221 86 Lund, Sweden*
- *International Dairy Federation–Special Issue 9701(1997): Monograph on Residues and Contaminants in Milk and milk products. IDF General Secretariat: 41, SquareVorgote, B-1030 Brussels*
- *P. Walstra, T.J. Geurts, A.Noomen, A.Jellema, and M.A.J.S.Van Boekel (1999): Dairy Technology, Princiles of Milk Properties and Processes. MARCEL DEKKER, INC. New York.Basel*

Variation in Strength and Keeping Quality of Pepsin Rennet from Bovine and Ovine adult ruminant species

Sara Endale, Mitiku Eshetu, Zelalem Yilma, Binyam Kassa

¹Department of Animal and Range Sciences, Dilla University, Dilla, Ethiopia

Abstract

A study was conducted to find replacement options of liquid calf rennet making from adult ruminants abomasa for smallholder cheese makers. The extracted rennet was analyzed for clotting activity, shelf life, rennet pH and curd pH. Commercial rennet was also used for comparison. Bovine rennet showed higher clotting activity (0.1795 ± 0.02), shorter clotting time (9.5 minutes) and higher soxhlet strength (39.97 ± 2.42) compared with ovine rennet with no marked difference with that of commercial rennet. All rennet samples were active up to six weeks of storage while ovine and bovine rennet start losing their quality stability after six and nine weeks of storage, respectively. A highly significant difference was observed between locally and commercially produced rennet in terms of rennet and curd pH. Further investigations are recommended to further concentrate these milk coagulant options.

Key words: bovine rennet, ovine rennet, clotting activity, rennet pH, curd pH, shelf life

Introduction

Milk-clotting enzyme is the first active agent in cheese-making and essential ingredients for the production of various cheese varieties. Clotting of milk is usually an enzyme-driven step during which rennet enzymes bring about cleavage of Met105– Phe106 of κ -casein. Today, nearly all types of cheese are manufactured by clotting the milk with a milk clotting enzyme and then processing the curd in various ways.

For centuries, calf rennet has been used as a milk coagulant in the production of all varieties of cheese. According to the report of FAO (2010), since 1961, the world cheese production increased by a factor of approximately 3.5 with a decrease in the use of rennet due to limited availability of calf stomachs. This led to the need to search for substitutes (Jacob *et al.*, 2011). Demand for coagulating enzymes started exceeding the supply already about 40 years ago (de Koning, 1978) and today, only 20-30% of the demand for coagulants can be covered by calf rennet (Jacob *et al.*, 2011).

Although many proteinases can induce the coagulation of milk, most are too proteolytic or have the incorrect specificity and hence can lead to reduced cheese yield or defective cheeses. The clotting activity of such proteinases can also affect curd properties, such as firmness or softness, during processing (Fox and Stepaniak, 1993). Thus, for both economic and processing reasons, it is essential to know the milk clotting activity of certain rennet type, which allows the cheese maker to select the adequate enzyme for each type of cheese and adjust enzyme proportion to control milk coagulation and thus optimize cheese yield and quality.

Considering the nutritional, economic and value addition importance of cheeses as well as the unaffordable price of commercially available rennet to most resource poor producers, it is essential to search for locally available and affordable rennet. Moreover, a significant number of livestock are slaughtered for domestic meat consumption as well as export (CSA 2013). This means that, a substantial volume of liquid rennet can be prepared from adult livestock. However, there is very limited information available on production and efficiency of rennet making from locally available

sources. Therefore, the objective of this research was to compare the strength and shelf life of bovine and ovine rennet types with commercial ones.

Materials and Methods

Description of the Study Area

The experiment was conducted in the Milk Laboratory of Holetta Agricultural Research Center (HARC) of the Ethiopian Institute of Agricultural Research (EIAR). It is located 34 km to the West of Addis Ababa in the central highlands of Ethiopia (2400 m above sea level, 38.5°E longitude and 9.8° N latitude). The average maximum and minimum daily temperatures are 21 °C and 6 °C, (<http://www.eiar.gov.et/index.php/holeta-agricultural-research-center>).

Experimental materials and preparation of liquid rennet

Fresh abomasums of adult cattle and sheep were collected from one abattoir and one slaughter house in the vicinity of Holetta. Commercial pepsin powder was used as a control treatment was purchased from Addis Ababa market. Rennet was prepared according to the method described by O'Connor (1993) as shown in Figure 1. After removing the internal contents, abomasal tissues was cleaned with tape water internally while their veins and fat contents were removed externally. Then they were inflated with air and dried in wooden- wire mesh cabinet placed in an open air. After drying, each abomasum was cut into very thin strips separately, weighed and soaked in 1000 ml solution of the 150g NaCl and 40g calcium chloride and 10ml acetic acid solution individually. The solution was stored at 24-25 °C. The extract was filtered with muslin cloth. After filtration a yellowish clarified solution (approximately 950 ml) was obtained.

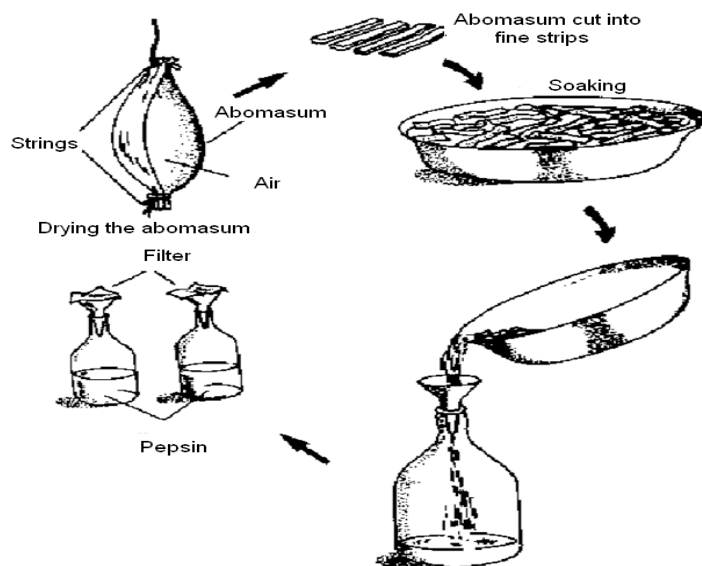


Figure 1. Schematic diagram of rennet making

Source: O'Connor, 1993

Preliminary observation

In the current study, the rennet produced was crude extract and the amount of pepsin present in the solution was unknown. It was therefore necessary to establish at least indicative strength of the rennet before applying it to milk and calculate the appropriate dosage that was needed for optimal curdling.

To determine the correct amount of rennet added into the cheese milk, preliminary observation was conducted based on the standard used by O'Connor (1993). Different rennet concentrations were set to identify the minimum curd forming concentration (Table 1).

Table 1. Rennet concentrations set to determine the minimum curd forming concentration

Rennet concentrations tested in ml/liter of milk		
Cattle rennet	Sheep rennet	
0.3	0.3	10
0.5	0.5	15
1	1	20
2	2	25
3	3	30
4	4	35
5	5	40

Based on the minimum curd forming potential, bovine crude rennet at a concentration of 2ml/lit of milk and ovine crude rennet at a concentration of 30ml/lit of milk were selected and tested.

Observations

Rennet strength

Rennet strength is conventionally measured by determining the time required to coagulate milk under standardized condition. The clotting activity (strength) of rennet types was measured and reported in clotting strength according to (Berridge, 1952). In addition, the time length in day's rennet maintains its strength was also determined by testing the extracted rennet samples every week. Rennet pH and curd pH was measured in each evaluation analysis.

Measurement of Rennet clotting time

The method of Berridge (1952) was used to measure clotting time. The main steps were as follows. The standard substrate was prepared from cow milk heated at 32 °c at 10% (w/v) solution of CaCl_2 (0.01M) solution. The prepared animal rennet 1ml/10ml of standard substrate was added and mixed manually and incubated in a water bath at 32°C. After thoroughly mixing three times, the zero clotting time started. The milk clotting activity of each extract was measured, with the assumption that all the soluble proteins from the extract were enzymes which coagulate milk at 32°C. The clotting activity equation as reported by Berridge (1952) in rennet units (RU) was used.

$$\text{RU} = 10 \times V / T_c \times Q$$

RU: rennet unit

V: volume of standard substrate (ml)

Q: volume of animal rennet (ml)

T_c: time of clotting (sec)

Clotting strength

The clotting activity of rennet types was also reported in clotting strength of Soxhlet (F) based on the equation of (Bourdier and Luquet, 1981).

$$F = \text{RU} / 0.0045$$

Statistical Analysis

All experiments were performed with four replicates each. A repeated measure analysis was applied to assess differences among the “rennet extract from bovine and ovine” and the commercial enzymes by using SAS Software version 9.1. Failure data analysis was run to fit the expiry date data to Weibull survival distribution to model the shelf-life data (rennet) as used by Schmidt and Bouma (1992). For each experiment mean comparisons were done separately using least significant difference (LSD) test for variables whose F-values showed significant difference at 5 % significance level.

Weibull model:

$$f(x; k, \lambda) = \frac{k}{\lambda} \left(\frac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k} \text{ Weibull distribution with the general function;}$$

; $x > 0$. (x = failure day)

$k > 0$ is the **shape parameter** and $\lambda > 0$ is the scale parameter of the distribution. $k < 1$ indicates that the failure rate decreases over time. If the failure rate is constant over time, then $k = 1$. $k > 1$ indicates the failure rate increases over time

Results and Discussion

Clotting activity

At individual observation level, the clotting activity of the milk coagulants used ranged from the lowest 0.0074RU for ovine pepsin to the highest 0.196RU for commercial pepsin with the overall average value being 0.13RU. On average, the highest clotting activity (0.189 RU) was observed for the commercial pepsin, while the lowest value (0.023 RU) was recorded for ovine pepsin (Table 2). No apparent ($P > 0.05$) difference was observed between commercial and bovine pepsins in their clotting activity, while ovine pepsin showed significantly ($P < 0.05$) lower clotting activity compared with the other two. It can be observed that average clotting activity increased with increasing Soxhelt strength and decreasing clotting time. Accordingly, the highest clotting activity recorded for the commercial pepsin corresponded with the highest Soxhelt strength and shortest clotting time.

Variation in milk clotting activity (MCA) and strength might be related to differences in the nature of the clotting ability of raw materials, the proteolytic efficiency and/or the concentration of the rennet types on the milk substrate used. For instance, as indicated by Guinee and Wilkinson (1992), the MCA of rennet relies on its ability to degrade casein micelles, the action being dependent on the chymosin and pepsin content of the rennet complex. As a critical parameter in the progress of curd formation, clotting time can be usefully related to curd firmness and curd yield. The weak clotting ability of ovine rennet observed in the present study might be attributed to the weak such property of pepsin present in the rennet solution. This observation is in agreement with that of Vairo Cavalli et al (2005), who indicated that the breakdown of cow milk by ovine caseinate took place much slower than that by bovine counterpart. The weak clotting power of ovine pepsin on cow milk might be related to species specificity. Calvo and Fontecha (2004) also indicated that the clotting ability of each rennet proteolyses is stronger for their species specific casein compared with that of other species.

Table 2. Mean ($\pm$ SD) clotting time, change in clotting activity (rennet unit: RU) and strength of Soxhelt (F) for the three milk coagulants tested

Milk Coagulants	No. of observation	Clotting time (min)	Clotting activity (RU)	Strength of Soxhelt (F)
Overall Mean	12	13.43	0.13 $\pm$ 0.14	33.3 $\pm$ 1.57
Bovine pepsin	4	9.50 ^a	0.179 ^a $\pm$ 0.02	39.9 ^a $\pm$ 2.42

Ovine pepsin	4	22 ^b	0.023 ^b ± 0.02	16.9 ^b ± 2.42
Commercial pepsin (C)	4	8.80 ^a	0.189 ^a ± 0.02	42.2 ^a ± 2.42

Means within the column followed by different superscripts are significantly different ($P \leq 0.05$)

Stability of rennet from bovine, ovine and commercial source

Result illustrated in figure 3 showed the cumulative failure days (risk condition) of different rennet source. The stability of all rennet sources were not affected during the 6 weeks of storage i.e. the failure probability (hazard) of losing stability was zero. Due to the short period of the experiment, the highest shelf life (stability) was observed for commercial rennet which shows no failure date (hazard) during the ten weeks of storage while ovine rennet started to lose its stability after six weeks of storage. On the other hand, bovine rennet was active up to 9th weeks of storage. The changes that have taken place during storage may depend on manufacturing process, temperature of storage and extent of exposure of the rennet to light. Arvanitoyannis (2009) indicated that rennet can resist to even very high temperatures when it is dry. However liquid rennet solutions are less stable and the substance decomposes in various speeds (Pometto et al 2006). In the current study rennet was stored in dark closed container that may help the enzyme to retain its stability. However, temperature of storage (room temperature) may affect their stability by creating heat variation. The efficiency of liquid rennet reduces at room temperature, the intensity of which related to the strength of the solution and the rennet strength decreases when the substance is handled and stored improperly, with light, heat and shaking exerting clear detrimental effects on the rennet (Arvanitoyannis 2009).

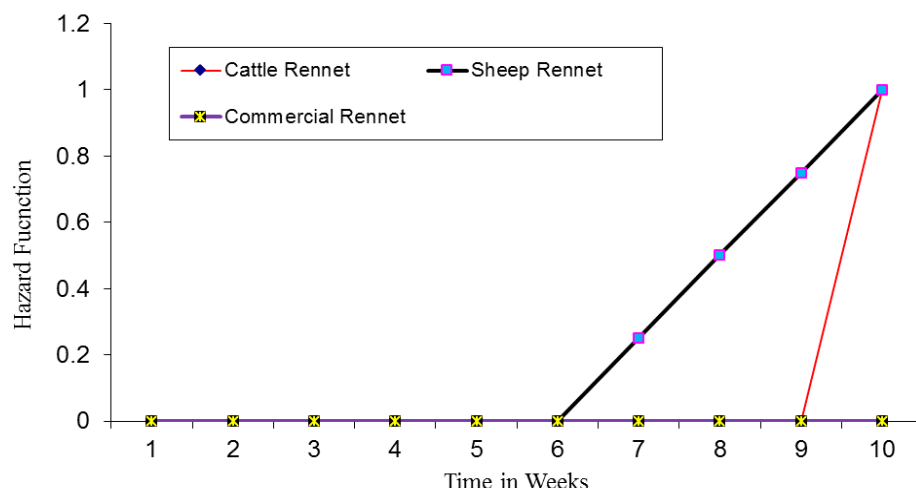


Figure 2. Cumulative failure plots of rennet extracted from bovine and ovine abomasums and commercial rennet

The pH value of stored rennet ranged from 4.21 to 3.45. The repeated measure analysis revealed that highly significant difference ($P < 0.05$) was observed between pH values of locally produced and commercial rennet. Commercial rennet showed no variation in terms of rennet pH.

During the storage period, pH value of locally produced liquid rennet was declined (Figure 3). pH plays a significant role in the stability of coagulant enzyme. The pH decline of bovine and ovine rennet might be because of lack of purification methods and storage temperature used in the processing. As reported by De Caro et al (1995) high recorded loss of rennet may be related to primitive way of manufacture and lack in purification processes. In the current study, bovine and ovine the rennet were crude extract and stored at room temperature. Hooydonk and Van Den Berg (1988) further supported that the strength of natural rennet could not be maintained at constant level. When rennet is kept at high temperatures, pepsin activity increases in whey proteins (Hooydonk and Van Den Berg 1988). In addition, lactic acid bacteria may contribute to development of acidity for reducing stability.

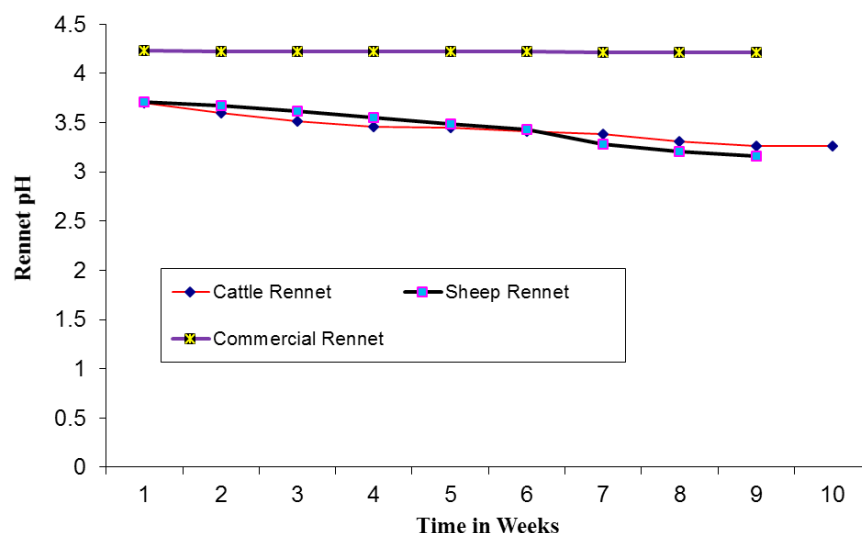


Figure 3. pH of stored rennet from cattle, sheep and commercial rennet source.

Curd pH value of stored rennet was ranged from 5.34 to 6.12. Mean curd pH value of repeated measure analysis revealed that highly significant difference ($P < 0.05$) were observed between bovine, ovine and commercial rennet. During the storage period, curd was formed even though the pH was declined (Figure 3). The result showed a consistent decline in curd pH with storage period indicating its diminishing shelf life. Milci et al (2005) revealed that average pH values of Halloumi cheeses made from bovine milk ranged from 5.37- 6.45 which is in agreement with the current findings.

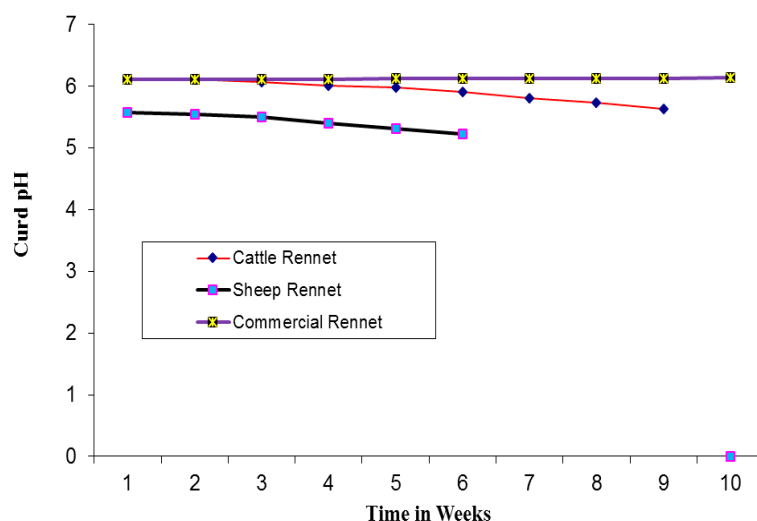


Figure 4. pH of curd obtained from Bovine, Ovine and commercial rennet source

Conclusion

The locally produced bovine rennet demonstrated higher clotting activity, shorter clotting time and higher soxhelt strength, with no marked difference with that of the commercial rennet with all the three parameters considered. It was confirmed that the highest clotting activity (0.189 RU) was observed for the commercial pepsin, while the lowest value (0.023 RU) was recorded for ovine pepsin. The obtained results contribute to a better knowledge of the locally produced rennet properties and shelf life.

In general in areas where commercial rennet is unavailable and expensive, cattle rennet could be an alternative rennet source for better clotting strength and easily availability. Production of bovine rennet in the country also creates employment opportunity and minimizes foreign currency. The proposed extracting methods may be adapted for small scale farmers and cooperatives that produce milk and process cheese, as an alternative rennet source. .

References

- Arvanitoyannis, I.S., 2009; *Haccp and Iso 22000. Application to foods of animal origin*, Blackwell Publishing Ltd, United Kingdom, 560 P. Isbn 9781444320923.
- Berridge, N. J., 1952. An improved method of observing the clotting of milk containing rennin. **Journal of Dairy Research**, 9, 328–329.
- Bourdier, J.F. and F.M. Luquet, 1981. *Dictionnaire laitier*. Tec. Doc. Lavoisier, Paris.
- Calvo, M.V. and J. Fontecha, 2004. Purification and characterization of a pregastric esterase from a hygienized kid rennet paste. **Journal of Dairy Science**. 87: 1132-1142.
- CSA (Central Statistics Agency), 2013. *Agricultural sample survey volume II. Report on livestock and livestock characteristics (private peasant holdings)*. Addis Ababa, Ethiopia.
- De Caro, J.; F. Ferrato; R. Verger, and A. De Caro, 1995. Purification and molecular characterization of lamb pregastric lipase. *Biochem. Biophys. Acta*, 1252:321–329.
- de Koning, P. J., 1978. Coagulating enzymes in cheese making. **Dairy Industries International** 43 7–12.
- Ethiopian Institute of Agricultural Research (EIAR), 2013. <http://www.eiar.gov.et/research-center/3-fedral-research-center/26-Holetta-Agricultural-research-center>, Accessed on 23 sept. 2013.
- Fox, P.F. and L. Stepaniak, 1993. Enzymes in cheese technology, **International Dairy Journal**, Vol. 3, P. 509–530.
- Guinee, T.P. and M.G. Wilkinson, 1992. Rennet coagulation and coagulants in cheese manufacture. **Journal of the Society of Dairy Technology**, 45, 94–104.

PROCEEDING

Animal Breeding and Reproduction

- Hooydonk, A.C. M. and G. Van den berg, 1988. Control and determination of the curd-setting during cheese making. *Bull. IDF* 225: 2-10.
- Jacob, M., D. Jaros and H. Rohm, 2011. Recent advances in milk clotting enzymes, *International Journal of Dairy Technology*, 63, pp. 14-33.
- Milci, S., A.Z. Goncu, H. Alpkent and A. Yaygın, 2005. Chemical, microbiological and sensory characterization of Halloumi cheese produced from ovine, caprine and bovine milk. *International Dairy Journal* 15 (6-9), 625-630.
- O'Connor, C.B., 1993. *Traditional cheese making manual*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.
- Pometto, A., K. Shetty, G. Paliyath and R. E. Levin, 2006. *Food biotechnology*, 2nd Ed, Taylor & Francis Group, Llc, 2008 P. Isbn 978-1-4200- 2797-6.
- Schmidt, K., and J. Bouma, 1992: Estimating shelf-life of cottage cheese using hazard analysis. *Journal of Dairy Science*, **75**: 2922-2927.
- Vairo Cavalli, S., S. Claver, N. Priolo, and C. Natalucci, 2005. Extraction and partial characterization of a coagulant preparation from *Silybum marianum* flowers. Its action on bovine caseinate. *Journal of Dairy Research*, 72: 271-275.

On-farm evaluation of the effect of lactoperoxidase system on microbial quality of raw cow milk

**Tewodros Bimerow, Mekonnen Tilhaun, Demelash Kassahun, Adebabay Kebede
Andassa Livestock Research Center, P.O.box, Bahir Dar, Ethiopia**

Abstract

The effect of the lactoperoxidase (LP) system on the microbial quality of crossbred dairy milk was assessed during storage at ambient temperature. The titratable acidity, coliform count (CC), and total bacteria count (TBC) in LP activated crossbred cow milk samples (T3 and T4) was significantly ($P < 0.05$) lower than TBC in the control (T1) and in milk samples treated with T2 both in 12 and 24 hours. The result of this study revealed that initial pH of the control and other treatments milk samples were the same. In control and smoked jar milk even if there is significance difference in samples after 12 and 24 hours, a considerable decrease in pH was noted, whereas in LP, LP plus smoked jar and refrigerator samples, the changes were slight and within the acceptable range of pH value of fresh raw milk. Based on the result of clot on boiling, alcohol and Methyl blue tests of the control (T1) and smoked jar samples (T2) were positive at 12 and 24h. Whereas, the LP plus smoked (T4), LP (T3) and refrigerator (T5) samples were negative at 12 and 24 h. It can be concluded that on-farm activation of the LP system can significantly improve the keeping quality of cow's milk during storage and transportation at an ambient temperature.

Key Words: Crossbred dairy cows, Lactoperoxidase, Microbial quality

Introduction

Milk is an easily perishable raw material. Contaminating bacteria may multiply rapidly and render it unsuitable for processing and/or unfit for human consumption. There are several ways in which the spoilage of milk may be controlled, including refrigeration, heat treatment (pasteurization in bulk or in pouch), microfiltration (with or without pasteurization), bacteriostatic, high-pressure treatment and use of chemical preservatives (including salting at levels of 3–12%). Some of these procedures require expensive equipment and are not widely applicable, particularly in small-scale dairy production and processing systems in developing countries where up to 80% of the milk produced may enter the informal market (FAO/WHO, 2005). In addition Smoking of milk vessels is the major method that is traditionally used to preserve raw milk in the study area.

The natural antimicrobial system present in milk, the lactoperoxidase system, has been used to preserve raw milk quality in areas where it is not possible to use refrigeration for economic reasons (Seifu et al 2005). Lactoperoxidase system is based on the activation of the lactoperoxidase, thiocyanate and hydrogen peroxide system (naturally present in milk in varying concentrations) to inactivate several vital metabolic bacterial enzymes, consequently blocking their metabolism and ability to multiply (Gaya et al., 1991, Tenovuo 2002, FAO/WHO 2005). However based on the available scientific information the meeting concluded that none of the components of the lactoperoxidase system(LP-s) presents a significant toxicological risk to public health at the levels proposed and the LP-s is a safe method of raw milk preservation when implemented according to established guidelines. In addition evidence of undesirable effects were not observed in the populations consuming milk activated with the LP-s for more than 10 years (Fernandez, Marrero and Capdevila, 2005). The activation of the lactoperoxidase has a bacteriostatic effect on the raw milk and effectively extends the shelf life of raw milk for 7–8 hours under ambient temperatures of around 30°C or longer at lower temperatures. This allows adequate time for the milk to be transported from the collection point to a processing centre without refrigeration (FAO/WHO, 2005). As reviewed by Abdallah (2005), the time delay

from milk to delivery at the processing plant often exceeds five hours very negatively affecting the quality of mainly non refrigerated milk, which is often rejected by dairy processing plants and is also not acceptable to consumers (Barabas, 1995). This situation forces producers to find methods for raw milk preservation, the addition of products that represent a potential public health hazard, for example, formaldehyde, antibiotics and others (Korhonen, 1980). Evidence from extensive studies in Cuba and Latin American countries (Ponce, 2004) suggests that use of LP-s activation has reduced the utilisation of some of the non-approved practices mentioned above. Therefore adoption of the LP-s has the potential to reduce the use of these non-approved methods, and hence reduce potential risk to consumer health.

Difficulties in applying refrigeration are specially a problem for most areas in our country setting up or expanding their milk production. In this regard, in Amhara region particularly evening milk is not transported to milk cooperatives for further processing particularly, in rural smallholder and peri urban dairy producers. Due to this fact evening milk is destined solely for home consumption or processed into other milk by products. In these situations, it would be beneficial to have access to alternative method, other than refrigeration, for retarding bacterial growth in raw milk during collection and transportation to the milk collection centre and lactoperoxidase system is a better recommended chemical preservative for milk and to be evaluated in our conditions of smallholder dairy producers so as to help them reach their evening milk safely to the milk collection centre or market. Therefore this study was conducted to evaluate the effect of lactoperoxidases and smoking system on microbial quality of cow's milk.

Materials and Methods

Description of Study area

This experiment was executed in Bahirdar Zuria district of West Gojjam zone of Amhara region Ethiopia. The city of Bahir Dar Zuria district is Bahir Dar (the regional capital city) which is found 560 km northwest direction from Addis Ababa. The district has a total population of 362,562 and an estimated total area of 116,762 ha. The altitude of the district ranges from 1,750 to 2,300 masl. The district is categorized into midland or 'woinadega' agro- ecology and its annual rainfall varies from 820 to 1,250 mm. The average minimum and maximum temperature of the district is 10 °C and 32 °C respectively (Bahir Dar Zuria District Office of Agriculture and Rural Development, 2007). The livestock population of the Bahir Dar Zuria district is estimated to be 206,865 cattle, 14,329 sheep, 26,049 goats, 18,728 donkeys, 716 mules and 346,546 poultry. Furthermore, there are about 19,706 honeybee colonies in the district (CACC, 2003).

Farmer selection and milk sampling

Ten farmers were selected from the already established, smallholder dairy producer Farmer Research and Extension Group (FREG) members of Andassa and Sebatamit peasant associations who had crossbreeds at middle stage of lactation and no record of mastitis. From each crossbred cow about 1 litre of milk sample was collected from each 10 dairy producers at morning time after milking and directly from the owners' milk vessels. These samples were pooled together and thoroughly mixed. The pooled milk samples were delivered to Bahir Dar University Food and Biochemical Engineering Laboratory for analysis of milk composition. Then the pooled sample was divided into five portions (treatments) of 1 litre each labelled as T1, T2, T3, T4 and T5 and kept in plastic jar for standard plate count, coli form count, titratable acidity, alcohol test, methyl blue, PH and clot on boiling test.

Treatment

The first portion of milk (T1) control was milk without any added preservative for 24 hours. The second portion of milk (T2) was milk kept in smoked plastic jar in order to determine the effect of container smoking on microbial quality for 24 hours. Container smoking was done using wood splinters of *Terminalia brownie* (Abalo). The third portion of milk sample (T3) was subjected to activation of the LP system for 24 hours. The fourth portion of milk sample (T4) was milk subjected to activation of

the LP system and kept in smoked plastic jar to determine the combined effect of the LP system and container smoking on microbial quality of the milk for 24 hours. The fifth portion of milk sample (T5) was milk kept in refrigerator without any added preservative for 24 hours with a temperature of 4°C.

The pooled milk samples were delivered to Bahir Dar University Food and Biochemical Engineering Laboratory in ice box within 2 hours after milking to determine the initial microbial load of the milk samples used and effect of different treatments on milk preservation potential within 24 hours. Then the pooled sample was divided for six portions each containing one litre milk. The control milk sample and milk samples subjected to the different treatments were stored at an ambient temperature for a period of 24 h. Samples were taken from these milk samples at 12 and 24 h of storage for determination of standard plate count, coli form count, titratable acidity, methyl blue, PH and clot on boiling test. All tests were done in duplicate.

Method of laboratory analysis

Activation of Lactoperoxidase system

Activation of the lactoperoxidase (LP) system was done after 2 - 3 h of milking by addition of 14 g of freshly prepared solution of 1 mg/ml sodium thiocyanate (General Chemical Division, New York) per liter of milk as a source of thiocyanate (SCN⁻) ion. After 1 min of thorough mixing, 10 ml of freshly prepared solution of 1 mg/ml hydrogen peroxide (BDH Chemicals Ltd., Poole, England) was added into the milk and the mixture was thoroughly mixed for 1 min (IDF, 198).

Standard plate count (SPC)

The total bacterial count was made by adding 25 ml of milk sample into sterile stomacher bag having 225 ml peptone water (1%). After thoroughly mixing, the sample was serially diluted up to 10⁻⁵ in sterile test tubes having 9 ml peptone water (1%) and duplicate samples (1 ml) were pour plated using 15-20 ml standard plate count agar solution and mixed thoroughly. The plated sample was allowed to solidify and then incubated at 37°C for 48 hours. Colony counts were made using colony counter.

Coliform count (CC)

The coliform count was made by mixing 25 ml of milk sample into sterile stomacher bag having 225 ml peptone water (1%). After mixing, the sample was serially diluted up to 10⁻⁴ in sterile test tubes having 9 ml of peptone water and duplicate samples (1 ml) were pour plated using 15-20 ml Violet Red Bile Agar solution (VRBA) in sterile Petri dish. After thoroughly mixing, the plated sample was allowed to solidify and then incubated at 30°C for 24 hours. Finally, colony counts were made using colony counter. Typical dark red colonies were considered as coli form colonies.

Titratable acidity of milk

Milk acidity was measured by adding 14 mg of Sodium thiocyanate (NaSCN) per liter of milk. The milk was mixed to ensure an even distribution of the SCN. Secondly, 30 mg of sodium per-carbonate is added per liter of milk. The milk is then stirred for another 2-3 minutes to ensure that the sodium per-carbonate is completely dissolved and the hydrogen peroxide is evenly distributed in the milk.

The titratable acidity of the milk was expressed as percent lactic acid and calculated as reported by Richardson (1985). In fresh raw milk the titratable acidity percentage ranges from 0.12%-0.16% with an average of 0.14%. If the titratable acid of the milk exceeds 0.17% the milk is considered as negative result for raw milk quality.

PH value of the milk

PH is the concentration of hydrogen ion. Measured using PH meter. PH of fresh raw milk normally ranges from 6.4-6.8 with an average 6.6. Higher figures equal or greater than 7.7 indicate problem of

mastitis case. Lower figures than the normal indicate lower keeping quality.

Clot on boiling test

Milk that is subjected to increase in its acidity will be unstable in its ionic balance. As a result its proteins become unstable against temperature for this it will clump when the milk is boiled.

When 5ml of milk is boiled in to water bath for 5 minutes using a clean dry test tube appearance of clump inside the test tubes indicates positive result.

Methyl blue

The length of time milk takes to decolorize methylene blue is a good measure of its bacterial content and hence of its hygienic quality. This time period is governed primarily by the activity of the reducing bacteria present in the milk plus the oxygen content. When the oxygen has been utilized the methylene blue is reduced, changing in color from blue to white considered as a positive result.

Methylene blue test was performed according to the method described by the C.B. O'Connor (1995).

Alcohol Test

The alcohol test, together with the acidity test, is used on fresh milk to indicate whether it will coagulate on processing. Milk that contains more than 0.21% acid, or calcium and magnesium compounds in greater than normal amounts, will coagulate when alcohol is added which is considered as a positive result. Alcohol test was performed according to the method described by the C.B. O'Connor (1995)

Stastical Analysis

Data for total bacterial count and coliform count were transformed tolog10 before subjected to statistical analysis. Mean comparison was done using least significant difference (LSD) for variables whose F values were found to be significant. Significant differences were calculated at 5% significance level. The whole data analysis was done using SAS (2002).

Result

Physicochemical properties of raw milk

According to De, (2008) the composition of milk depends upon the species, breed, season, feed & water, stage of lactation, age, time of milking, weather etc. The raw milk samples used in this experiment were collected from 10 small holder farmers. The physicochemical properties of the milk samples was 5% fat, 3.065% protein, 13.57% total solids, 8.59% solids-not-fat, 4.75% lactose and 0.74% ash.

Effect of the lactoperoxidase system and container smoking on acid development in crossbred cow

The effect of the lactoperoxidase system on titratable acidity of crossbred cow' milk is shown in table1. T4 (activation of the LP plus smoking system), T5(refrigerator system) and T3(activation of the LP system)significantly ($P < 0.05$) retarded lactic acid production as compared to the control (T1) and the milk samples kept in smoked containers (T3) at 12 h of storage (Table 1). Milk samples treated with T4 had the same level of acidity at 12 h of storage from the initial time (Table 1). While the titratable acidity increased by 0.117% and 0.054% in the control (T1) and container smoking (T2) milk at 12h from the initial time (Table 1).

No significant difference in acid production was observed between the control (T1) and smoked container (T2) at 24 h of storage (Table1). However, T3, T4 and T5 resulted in significant reduction

in acid production as compared to the control at 24 h of storage (Table 1). The level of lactic acid in milk samples stored in smoked containers was significantly higher ($P < 0.05$) than in milk samples treated with the LP system (T3), LP combined with smoking (T4) and refrigerator both at 12 and 24 h of storage (Table 1).

In fresh raw milk the titratable acidity percentage ranges from 0.12%-0.16% with an average of 0.14%. Based on this; T3 (LP system), T4 (LP combined with smoking) and T5 (refrigerator) maintain the titratable acidity in normal range for 24h by reducing acid production. However, T1 and T2 do not maintain the normal range for 12h.

Table 1. Effect of different treatments on acidity (% lactic acid), (mean $\pm$ SD) in crossbred cow milk stored at an ambient temperature (22 - 23°C) over a period of 24 h (n = 2).

Treatments	Storage time		
	Initial	12h	24h
T1	0.117 $\pm$ 0.0127	0.234 ^a $\pm$ 0.00	0.495 ^a $\pm$ 0.00
T2	0.117 $\pm$ 0.0127	0.171 ^a $\pm$ 0.00	0.489 ^a $\pm$ 0.00
T3	0.117 $\pm$ 0.0127	0.13 ^b $\pm$ 0.006	0.121 ^b $\pm$ 0.006
T4	0.117 $\pm$ 0.0127	0.117 ^b $\pm$ 0.00	0.135 ^b $\pm$ 0.00
T5	0.117 $\pm$ 0.0127	0.126 ^b $\pm$ 0.127	0.135 ^b $\pm$ 0.00

T1= control (without preservative), T2= Container smoking, T3= Lactoperoxidase (LP), T4= LP plus smoking and T5= refrigerator. Mean bearing different superscript letters with in the same column differ significantly ($P < 0.05$), SD=standard deviation.

Effect of the lactoperoxidase system and container smoking on microbial quality of crossbred cow milk

The effect of the LP system on total bacteria count (TBC) in crossbred cow milk stored at an ambient temperature is shown in table 2. The TBC in LP activated crossbred cow milk samples (T3 and T4) was significantly ($P < 0.05$) lower than TBC in the control (T1) and in milk samples treated with T2 both in 12 and 24 hours (Table 2).

Table 2. Effect of different treatments on Total bacteria count (log₁₀ cfu/ml) (mean $\pm$ SD) in crossbred cow milk stored at an ambient temperature (22 - 23°C) over a period of 24 h (n = 2).

Treatments	Storage time		
	Initial	12h	24h
T1	6.86 $\pm$ 0.014	7.36 ^a $\pm$ 0.00	7.46 ^a $\pm$ 0.007
T2	6.86 $\pm$ 0.014	6.97 ^a $\pm$ 0.014	7.24 ^a $\pm$ 0.007
T3	6.86 $\pm$ 0.014	6.24 ^b $\pm$ 0.003	6.73 ^b $\pm$ 0.021
T4	6.86 $\pm$ 0.014	6.25 ^b $\pm$ 0.005	6.75 ^b $\pm$ 0.031
T5	6.86 $\pm$ 0.014	6.26 ^b $\pm$ 0.007	6.74 ^b $\pm$ 0.036

The effect of the LP system (T2) on coliform count (CC) in crossbred cow milk kept at an ambient temperature is shown in table 3. The CC in LP activated crossbred cow milk samples (T3 and T4) was significantly ($P < 0.05$) lower (1.94 and 1.92 log units at 12h and 0.86 and 0.84 log unit at 24 h respectively) than CC in the control (T1) at 12 and 24 h of storage (Table 3). However, no significant difference in CC was observed between T3 and T4 at the same storage period. While the CC increased by 0.17 and 0.48 log units in the control at 12 and 24 h respectively, it decreased by 1.77 and 0.38 log units in the LP-activated crossbred cow milk (T3) at 12 and 24 h of storage respectively as compared to the initial count (Table 2).

Table 3. Effect of different treatments on coliform count (log10 cfu/ml) (mean $\pm$ SD) in crossbred cow milk stored at an ambient temperature (22 - 23°C) over a period of 24 h (n = 2).

Treatments	Storage time		
	Initial	12h	24h
T1	5.92 $\pm$ 0.007	6.09 ^a $\pm$ 0.007	6.4 ^a $\pm$ 0.007
T2	5.92 $\pm$ 0.007	5.31 ^a $\pm$ 0.007	6.38 ^a $\pm$ 0.007
T3	5.92 $\pm$ 0.007	4.15 ^b $\pm$ 0.031	5.54 ^b $\pm$ 0.007
T4	5.92 $\pm$ 0.007	4.17 ^b $\pm$ 0.032	5.57 ^b $\pm$ 0.006
T5	5.92 $\pm$ 0.007	4.18 ^b $\pm$ 0.007	5.58 ^b $\pm$ 0.036

Effect of the lactoperoxidase system and container smoking for PH, clot on boiling, Alcohol and methyl blue test

In this study the result clot on boiling, alcohol and Methyl blue tests present in table 4. Based on the result clot on boiling, alcohol and Methyl blue tests of the control (T1) and smoked jar samples (T2) were positive at 12 and 24h. Whereas, the LP plus smoked (T4), LP (T3) and refrigerator (T5) samples were negative at 12 and 24 h. **Table 4.** Effect of different treatments for clot on boiling, alcohol and methyl blue test at ambient temperature (22 - 23°C) over a period of 24 h (n = 2).

Treatments	Storage time								
	Initial	12h			24h				
	Clot on boiling test	Alcohol test	Methyl blue test	Clot on boiling test	Alcohol test	Methyl blue test	Clot on boiling test	Alcohol test	Methyl blue test
T1	Not Coagulate	Fresh	Good	Coagulate	Not fresh	Very bad	Coagulate	Not fresh	Very bad
T2	Not Coagulate	Fresh	Good	Coagulate	Not fresh	Very bad	Coagulate	Not fresh	Very bad
T3	Not Coagulate	Fresh	Good	Not Coagulate	Fresh	Good	Not Coagulate	Fresh	Good
T4	Not Coagulate	Fresh	Good	Not Coagulate	Fresh	Good	Not Coagulate	Fresh	Good
T5	Not Coagulate	Fresh	Good	Not Coagulate	Fresh	Good	Not Coagulate	Fresh	Good

T1= control (without preservative), T2= Container smoking, T3= Lactoperoxidase (LP), T4= LP plus smoking and T5= refrigerator.

The PH value of the result is presented in table 5. The result of this study revealed that initial pH of the control and other treatments milk samples were the same. In control and smoked jar milk even if there is significance difference in samples after 12 and 24 hours, a considerable decrease in pH was noted, whereas in LP, LP plus smoked jar and refrigerator samples, the changes were slight and within the acceptable range of PH value of fresh raw milk.

Table 5. Effect of different treatments on PH value at ambient temperature (22 - 23°C) over a period of 24 h (n = 2).

Treatments	Storage time		
	Initial	12h	24h
T1	6.74 $\pm$ 0.00	6.16 ^a $\pm$ 0.007	5.56 ^a $\pm$ 0.07

T2	6.74±0.00	6.3 ^b ±0.007	5.97 ^b ±0.14
T3	6.74±0.00	6.8 ^c ±0.07	6.83 ^c ±0.07
T4	6.74±0.00	6.8 ^c ±0.05	6.84 ^c ±0.007
T5	6.7±0.00	6.8 ^c ±0.21	6.77 ^c ±0.16

T1= control (without preservative), T2= Container smoking, T3= Lactoperoxidase (LP), T4= LP plus smoking and T5= refrigerator. Mean bearing different superscript letters with in the same column differ significantly ($P<0.05$), SD=standard deviation.

Discussion

Differences between shelf lives of treated (LP, LP plus smoked jar and refrigerator) and control and smoked jar milks at all storage conditions were highly significant ($P<0.05$) showing that the LPS is effective in preserving raw milk. The increase in milk shelf life of 24 hours under ambient conditions can permit transportation of milk from far-off zones to the /market places without fear of spoilage.

The average extension in shelf life of 24 hours under ambient temperatures is greater than values obtained by FAO (11 – 12 hours at 25 °C). Greater results are probably due to high hygienic conditions during milking, which gave the milk a lower initial microbial load. This implies that better hygienic condition during milking have a positive impact on the shelf life of milk.

Smoking is the most common method that is traditionally used for the taste and smell of yoghurt and milk in the study area and that it is difficult to find farmers who deliver milk to the market in unsmoked containers. In the present study, smoking alone did not show improvement on the microbial quality of crossbred cow milk. However, when combined with the LP system it significantly improved the shelf life of crossbred cow milk as determined by level of acid production and microbial count as the same as the milk that are subjected LP system only. This suggests that container smoking and the LP system do not antagonize each other and could be used LP system by it self or combined together to inhibit acid production and prolong the shelf life of crossbred cow milk under field conditions. However Smoking by it self could not be used for milk preservation method. This finding is similar with the finding of Nigussie and Seifu (2008) who reported that smoking alone did not show improvement on the microbial quality of goats' milk.

The results of the acidity test, Merhyl blue test, PH test, clot on boiling test, alcohol test and microbial counts support each other and indicate that activation of the LP system in addition to container smoking can maintain the quality of crossbred cow milk for at least 24 h during storage at an ambient temperature.

The decrease in coliform count (0.38 log units) observed in LP-activated crossbred cow (T3) at 24 h of storage as compared to the initial count suggests that activation of the LP system can extend the shelf life of crossbred cow milk during storage at an ambient temperature up to 24 h by inhibiting the proliferation of coliforms.

The decrease (0.13 log units) in total bacterial count observed in LP-activated crossbred cow (T3) at 24 h of storage as compared to the initial count suggests that activation of the LP system can significantly decrease the total bacterial flora in crossbred cow milk even during storage of milk at an ambient temperature for 24 h.

Conclusion

On-farm activation of the LP system can significantly improve the keeping quality of cow's milk during storage and transportation at an ambient temperature. It should be noted that since the LP system involves use of some chemicals, activation of the system should be done by experienced individuals. So that, in smallholder dairy farmers it is better that the evening milk transported to the milk cooperatives and then the activation of LP carried out by them.

Acknowledgement

We want to thank East Africa Agricultural Productivity Project (EAAPP) for funding this study and Andassa Livestock Research Center for providing vehicle for field work. Lastly, also thanks to Wondimagegne Mengesha and Mulat Lakewe for their contribution during milk collection.

Reference

- Abdalah, M.I.M. n.d (2005). A new trial for preservation of raw cow's milk at 30 °C and 5 °C by activation of the natural lactoperoxidase system. Giza, Egypt.
- Barabas, J., 1995. An alternative method of milk treatment. *World Animal Review* 83, 71-73.
- Central agricultural census commission (CACC) (2003), "Ethiopian agricultural sample enumeration, 2001/02", pp. 45-46, Results for Amhara Region, Statistical Reports on Livestock and Farm Implants (Part IV), Addis Ababa, Ethiopia.
- Fernández O, Marrero E, Capdevila JZ. Safety considerations on lactoperoxidase system use for milk preservation. *Rev Salud Anim.* 2005;27:205-209.
- FAO [Food and Agricultural Organization of the United Nations].2005. The lactoperoxidase system of raw milk preservation.
- Gaya, P., Medina, M. & Nuñez, M. 1991. Effect of the lactoperoxidase system on *Listeria monocytogenes* behaviour in raw milk at refrigeration temperatures. *Applied and Environmental Microbiology*, 57: 3355–3360.
- Helen Nigussie and Eyassu Seifu, Effect of the lactoperoxidase system and container
- smoking on the microbial quality of goats' milk during storage at an ambient temperature *Journal of Cell and Animal Biology* Vol. 2 (9), pp. 166-170, September, 2008
- IDF (1988). Code of practices for preservation of raw milk by the lactoperoxidase system. *Bull. Int. Dairy Fed.* 234: 1-15.
- Korhonen, H. 1980. A new method for preserving milk - the lactoperoxidase antibacterial system. *World Animal Review*, 35: 23–29.
- O'Connor C B 1994 Rural Dairy Technology. ILRI training manual No. 1. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia. 133p.
- Ponce P, Capdevila JZ, Armenteros M. Aspectos prácticos y consideraciones sobre peligros microbiológicos y químicos en el uso sistema lactoperoxidasa en el trópico americano. *Rev Salud Anim.* 2004;25:163-72.
- SAS (2002). *Users' Guide: Statistics (Version 8)*. SAS Institute Inc., Cary, NC.
- Tenovuo J 2002 Clinical applications of antimicrobial host proteins lactoperoxidase, lysozyme and lactoferrin in xerostomia efficacy and safety. *Oral Diseases*, Volume 8, pp 23-29.

Small Ruminant Production Systems in Ada Barga and Ejere Districts of West Shoa Zone, Oromia, Ethiopia

Yadeta Neme^{1§}, Manzoor Ahmed Kirmani¹ and Gemedu Duguma²

¹**Department of Animal Science, College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box 378, Jimma, Ethiopia.**

²

Abstract

The small ruminants' production systems were studied in the three agro-ecologies (AEZs) of Ada Barga and Ejere districts, West Shoa Zone, Oromia, Ethiopia. The three agro-ecologies were highland (HL), midland (ML) and lowland (LL). A total of 180 households 69 from HL, 74 from ML and 37 from LL were purposively selected for this study. Detailed structured questionnaires, respondent interviews and FGD were employed to collect data. The overall objective of both sheep and goat rearing across all AEZs were source of income as it ranked first. The major availability of feed was natural pasture that ranked first with total index 0.96 and 0.49 in wet and dry season, respectively. The overall proportions of respondents keep sheep (grazing sheep) with other livestock species (32.8%). Only 20.6% and 30.6 of the respondents practiced separation of new born kids and lambs, respectively from their dams or other flocks.

Key words: Small ruminants, production system, Ethiopia, agro-ecologies

Introduction

More than 85% of the Ethiopian population depends on agriculture for their livelihoods. The subsector contributes about 16.5% of the national Gross Domestic Product (GDP) and 35.6% of the agricultural GDP (Metaferia *et al.*, 2011). It also contributes 15% of export earnings and 30% of agricultural employment (Behnke 2010). The small ruminants (sheep and goat), contribute substantial amounts to income, food (meat and milk), and non-food products like manure, skins and wool in Ethiopia. These small ruminants also serve as means of risk mitigation during crop failures, property security, monetary saving and investment in addition to many other socio-economic and cultural functions (Solomon *et al.*, 2010). Earlier studies have indicated that small ruminant production in Ethiopia needs to be addressed systematically by describing the genetic resource bases, production and marketing systems (Tesfaye *et al.*, 2010; 2011; Zewudu *et al.*, 2012).

The Ada Barga and Ejere districts (Woredas), West Shoa Zone, Oromia Regional State, Ethiopia, have huge potential for small ruminant production, but there is paucity of scientific information on their production systems in both districts. Thus the present study was carried to assess the small ruminant production systems in these two districts.

Material and Methods

The study area

The study involved two districts, viz: Ada Barga and Ejere. The Ada Barga district (Woreda) is located at a distance of 60 km, West of Addis Ababa, capital city of Ethiopia. It receives an average annual rainfall ranging from about 887 to 1,194 mm. The minimum, medium and maximum daily temperatures of the area are 10, 15 and 25°C respectively. The district has relatively high vegetation cover that serves as a source of livestock feed, natural habitat for different wild life and potential area for small ruminant, dairy, apiculture and irrigated agriculture. Acacia species are major forest tree species in the area. Major vegetable crops produced in the district are onion, potato, cabbage, and garlic to a smaller extent. Garlic is produced only in small plots although it is a high priced vegetable. The major soils of the Ada Barga district are: platy 44%, red 39% and brown (mixture) 17%. The district is situated at an altitude ranging from 1400 to 3,270 m.a.s.l (meters above sea level) and comprises of 29% highland (>2300 m.a.s.l), 34% midland (1500 to 2300 m.a.s.l) and 37% lowland (< 1500 m.a.s.l) areas as per Zonal Basic Data, 2000. The livestock species reared in the district include cattle, sheep, goat, poultry and equines in their order of preference. The district has high potential for both sheep and goat production. The small ruminants' population of the district is about 101,085 of which sheep is 57,511 and goats 43,574 (Fanos, 2012).

The Ejere district (Woreda) is located at a distance of 40 km, West of Addis Ababa, capital city of Ethiopia. The district receives an average annual rainfall ranging from about 900 mm to 1,200 mm. The minimum and maximum daily temperatures of the area are 22 and 28°C, respectively. The district has relatively high vegetation cover that serves as a source of livestock feed, natural habitat for different wild life and also a potential area for small ruminant, dairy, apiculture and irrigated agriculture. Major vegetable crops produced in the district were onion, potato, cabbage, and garlic to a smaller extent. The major soils of Ejere district are: red soil 58%, black soil 32% and loam soil 10%. The district is situated at an altitude ranging from 2060 to 3,185 m.a.s.l (meters above sea level) and thus comprises of only two agro-ecological zones, viz: highland (>2300 m.a.s.l) and midland (1500 to 2300 m.a.s.l) according to Zonal Basic Data, 2000. The livestock species inhabiting the district include cattle, sheep, goats, poultry and equines. The small ruminant population of the district is about 51,565 of which sheep are 41,368 and goats are about 10,197 heads (Fanos, 2012).

Data sampling procedure and sample size

The secondary data relating to livestock population, farming practices, demography, etc, collected from the respective District Agricultural Department Offices and Livestock Development Agencies, were used for the present study. The kebeles (peasant associations) in the two districts were stratified

into three agro-ecological zones (AEZs), viz: low lands (<1500 masl), midlands (1500-2300 masl) and high lands (>2300 masl) according to Ministry of Agriculture (2000) and Dereje (2011). The discussions with District Livestock Head and experts showed that in Ejere district 12 and 18 kebeles fall in highland and midland agro-ecological zone, respectively. Out of these one kebele (Damotu) and two kebeles (Chiri and Kimoye) falling in highlands and midlands, respectively, were purposively selected on the basis of sheep and goat production potential. Similarly Ada Barga district has been stratified in three agro ecological zone, viz: highland (11 kebeles), midland (13 kebeles) and lowland (15 kebeles). One kebele from each of the three agro-ecological zones, viz: Ulagora (highland), Laku Karsa (midland) and Wogidi (lowland) were selected based on potential for small ruminant production. Thus a total of six kebeles were selected from the two districts for present study.

A total of 180 households were purposively selected owning four or more sheep / goat from the total number of house-holds (1833 rearing small ruminant) in the six kebeles for the present study (Table1). The numbers of household (69, 74 and 37 in HL, ML and LL, respectively) from each selected kebeles were determined according to proportionate sampling technique as under:

$W = [A/B] \times N_0$; Where: W= Number of household to be calculated from singe selected ke-beles; A=Total number of households per kebeles; B= Total number of households all six kebeles; and N_0 = the calculated sample size.

The sample size 180 house hold was determined according to the Arsham (2002) as indicated below:

$N = 0.25/SE^2$; Where: N= Sample size; and

SE= Standard error (0.0373) with 95% confidence level

However during this study farmers having an average flock size of ≥ 4 sheep or goats were interviewed for this study. The sheep and goat rearing farmers were interviewed separately. However, during this some of the farmers rearing both sheep and goats were interviewed two times and this resulted in the total sum of interviews exceeding the sample size of 180 household and total percentages above 100%.

Table 1. Number of households selected per six kebeles.

Agro ecological zone (AEZs)	Selected kebeles	Total number of household possessing small ruminants	Proportionate number of households selected/ kebele
Highland	Damotu	413	41
	Ulagora	290	28
Midland	Kimoye	178	17
	Chiri	249	24
	Laku Karsa	331	33
Lowland	Wogidi	372	37
Total	6 Kebeles	1833	180

Data collection

The data on small ruminant production system, viz: flock structure (age, sex, number of male and female), purpose of keeping small ruminant, marketing of small ruminants (reason of buying/selling, age and sex of animals to be sold) were collected from selected sheep / goat producers in the study area using a structured questionnaire. Focused group discussions were also undertaken using checklists to collect information on sheep and goat production system. Group composed of 6-9 members of key informants was formed for gathering information. Key informants such as elders, community leaders, women representative, animal health technician and development agents were targeted for the FGD.

Data analysis

The data collected was organized, summarized and analyzed by the statistical package for Social Sciences (SPSS ver.20, 2013). Comparison of means by one way ANOVA was done using the SPSS. The General Linear Model (GLM) of SPSS ver. 20 was also used to compare production system parameters across the agro-ecologies and their significance difference was tested. The following one way model on various performances parameters of sheep and goat was used.

$$Y_{ij} = \mu + AEZ_i + e_{ij} ; \text{ where}$$

Y_{ij} = Y^{th} observation in i^{th} class

μ = Overall mean

AEZ_i = effect of agro ecologies, where $i = 1, 2, 3$,

e_{ij} = Random error

Indices were calculated to provide ranking of breeding objective of sheep and goat, major available feed in both wet and dry seasons, trait preferences (for both male and female sheep and goats), adaptive feature for sheep and goats, major small ruminant production constraints, way of entry and exit of small ruminants.

The indices were calculated as stated here under:

Index = sum of [(3 x number of household rank first) + (2 x number of household rank second) + (1 x number of household rank third)] for a particular cause divided by sum of [(3 x number of household rank first) + (2 x number of household rank second) + (1 x number of household rank third)] for all causes in an agro ecology.

Results and Discussion

Farming activities

The perusal of results on farming activities (Table 2) showed that all respondents across AEZs of the study area (Ada Barga and Ejere districts of west Shoa Zone) were following mixed crop-livestock farming system. The current results were in conformity with respect to highland and lowland AEZs with earlier report of Solomon (2014), who found that mixed crop-livestock farming system was followed in the altitude between 1500 to 3000 masl in Metema and Abergelle districts of the Amhara National Regional State of Ethiopia.

Table 2. Farming activities in the study area

Particulars	HL (N=69)	ML (N=74)	LL (N=37)	Total
Farming activities (%):				
Livestock production alone	0	0	0	0
Crop production alone	0	0	0	0
Mixed livestock crop production	69(38.3)	74(41.1)	37(20.6)	180(100.0)
Most crops cultivated /produced (%):				
Wheat	41(22.8)	25(13.9)	3(1.7)	69(38.3)
Barley	16(8.9)	23(12.8)	-	39(21.7)
Maize	-	3 (1.7)	15(8.3)	18(10.0)
Sorghum	-	8 (4.4)	10(5.6)	18(10.0)
Teff	8(4.4)	8(4.4)	5(2.8)	21(11.7)
pea	4(2.2)	7(3.9)	4(2.2)	15(8.3)

HL=highland, ML=midland, LL=lowland, N=number of respondents

Flock structure and production objectives

The flock structure by age and sex of both goat and sheep in the three AEZs (Table 3) showed that all age groups in the two sexes of both species were significantly affected by AEZs except male and female 6 months to 1 year in goat and male 6 months to 1 year, castrate groups in sheep. The pair-wise comparison of means in goats showed significant differences among HL-ML, HL-LL AEZs in male / female kids aged < 6 months; HL-LL, ML-LL AEZs in male goat groups > 1 year and HL-ML, HL-LL AEZs in females goat aged > 1 year. Similarly the pair-wise comparison of means in sheep revealed significant differences among all three pairs of AEZs in male lambs aged < 6 months; HL-ML, HL-LL in female lambs aged < 6 months, female lambs aged 6 months to 1 year and female sheep aged > 1 year and between HL-LL in male sheep aged > 1 year. The results were in agreement with the finding of Yaekob (2014) with respect to goat in the three AEZs.

Table 3. Flock structure over sexes and ages.

Particulars	HL Mean (SD)	ML Mean (SD)	LL Mean (SD)	Overall mean	p-value
Goat flock structure by age and sexes					
Male kids < 6months	0.04(0.03) ^a	1.04(0.18) ^b	1.05(0.22) ^b	0.66(0.09)	0.000
Female kids <6 months	0.04(0.03) ^a	0.96(0.18) ^b	1.08(0.23) ^b	0.63(0.09)	0.000
Male 6 months to 1 year	0.03(0.02)	0.18(0.05)	0.32(0.17)	0.15(0.04)	0.053
Female 6 months to 1 year	0.01(0.01)	0.1(0.04)	0.14(0.07)	0.08(0.02)	0.162
Male > 1 year	0.03(0.02) ^a	0.35(0.08) ^a	1.00(0.24) ^b	0.36(0.06)	0.000
Female > 1 year	0.39(0.15) ^a	2.62(0.29) ^b	3.65(0.48) ^b	1.98(0.19)	0.000
Castrate	-	0.23(0.07)	0.27(0.16)	0.15(0.04)	0.042
Sheep flock structure by age and sexes					
Male lambs < 6months	1.75(0.20) ^a	0.70(0.12) ^b	0.08(0.04) ^c	0.98(0.10)	0.000
Female lambs <6 months	1.72(0.25) ^a	0.55(0.12) ^b	0.14(0.06) ^b	0.92(0.12)	0.000
Male 6 months to 1 year	0.32(0.09)	0.20(0.08)	-	0.21(0.04)	0.058
Female 6 months to 1 year	0.45(0.11) ^a	0.12(0.05) ^b	0.05(0.03) ^b	0.23(0.05)	0.004
Male > 1 year	0.42(0.10) ^a	0.26(0.05) ^{ab}	0.08(0.04) ^b	0.28(0.04)	0.028
Female > 1 year	5.41(0.50) ^a	2.39(0.27) ^b	1.00(0.32) ^b	3.12(0.26)	0.000
Castrate	0.12(0.04)	0.12(0.05)	-	0.09(0.02)	0.204

SD= standard deviation, Same superscript indicate non-significant differences, Different superscript indicate significant differences at P<0.05 level

The overall mean of goat per household were lower in female aged 6 months to 1 year (0.08), male aged 6 months to 1 year (0.15) and male > 1 year (0.36) compared to other groups. Similarly overall mean number of sheep / household were lower in male aged 6 months to 1 year (0.21), female aged 6 months to 1 year (0.23) and male > 1 year (0.28) compared to other groups. The possible reason for lower mean numbers of these groups may be sale of these animals. The overall means number of goat and sheep per household were highest in adult females aged > 1 year. The present results were lower than the reports of Solomon (2014) who reported 4.2 (2.32), 3.1 (2.58), 0.6 (0.92) and 25.9 (36.29), 9.5(14.29), 2.8(2.94) for breeding does, kids and breeding buck in lowland Metema district and highland Abergelle goat of the Amhara National Regional State of Ethiopia respectively.

The rankings of sheep and goat production objectives in all the three AEZs were presented in table 4. The first reason for sheep and goat rearing in all three agro ecologies was reported to be as a source of income generations through sale of live animals with an index value of 0.41, 0.47 and 0.48 (for sheep) and 0.6, 0.42 and 0.47 (for goat) in high, mid and low lowland AEZs, respectively. The FGD revealed that sale of live animal generates cash income to the farmer which may be used to buy clothing and food items, pay taxes, purchase fertilizers and other household goods. These

findings were in agreement with reports of earlier workers (Solomon *et al.*, 2010; Mekuriaw *et al.*, 2012; Arse *et al.*, 2013 and Hundie and Geleta, 2015). The second main reason (Table 4) for sheep and goat rearing in all the three agro ecologies was reported to be as a source of meat (personal consumption) except for sheep in midland and lowland areas where the second reason was found to be as saving (insurance) against any unforeseen calamity. The index value were 0.18 in high and 0.17 in (midland and lowland), respectively, for sheep whereas these were 0.21, 0.24 and 0.20 in high, mid and lowland, respectively, for goat. The present finding (ranking of meat as second objective) was in agreement with earlier reports (Belete, 2009; Mengistie *et al.*, 2010 and Alubel, 2015). The third reason of sheep rearing was manure (0.15) in highland, meat (0.12) in mid land and saving/social function (0.11) in lowland. Similarly third reason of goat rearing was saving (0.14 and 0.15 in high and midland, respectively) and manure (0.11) in lowland areas. The overall objectives (Table 4) for sheep rearing (across all AEZs) ranked in the order of income (0.45), saving (0.17) and meat (0.14). However the overall objectives for goat rearing (across all AEZs) ranked as income (0.50), followed by meat (0.21) and saving (0.12).

Table 4. Ranking of sheep and goat production objectives by agro ecologies

Particulars	High land				Midland				Lowland				Over-all
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I	
Production objective of sheep:													
Income generation	37	26	3	0.41	33	9	1	0.47	8	1	0	0.48	0.45
Meat	13	14	12	0.18	0	13	3	0.12	1	1	1	0.11	0.14
Manure (fertilizer)	7	5	30	0.15	1	2	23	0.11	0	0	3	0.06	0.11
Social (cultural function)	1	1	0	0.01	0	3	0	0.02	0	3	0	0.11	0.05
Saving (insurance)	6	14	11	0.14	3	13	8	0.17	0	2	5	0.17	0.17
Risk/benefit distribution with other animals	3	7	11	0.08	5	1	6	0.07	0	2	0	0.07	0.08
Production objective of goat:													
Income generation	7	0	0	0.6	35	7	1	0.42	21	8	0	0.47	0.50
Meat	0	3	0	0.21	7	22	2	0.24	6	7	2	0.20	0.21
Manure (fertilizer)	0	0	2	0.07	1	4	10	0.07	1	2	10	0.11	0.08
Social (cultural function)	0	1	0	0.06	1	3	3	0.04	0	3	1	0.04	0.05
Saving (insurance)	0	1	2	0.14	2	5	24	0.15	0	6	3	0.08	0.12
Risk/benefit distribution with other animals	0	0	0	0	3	6	3	0.08	2	2	6	0.09	0.05
Milk	0	0	0	0	0	0	0	0	0	0	1	0.01	0.003

R1= first rank, R2=second rank, R3= third rank, I= index

Feed and feeding system

Grazing of small ruminants was common feeding practice in the study area. The grazing is carried on three types of grass land, viz: Land owned by the sheep/ goat rearer themselves (private grazing land), land taken on rent and community grazing land. The interviews with respondent (Table 5) showed that 10.6, 14.4 and 15.6% of households possessed their own grazing land; 26.7, 24.4 and 1.7 % utilized rented grazing land; and 1.1, 2.2 and 3.3%, respectively, made use of community grazing land in HL, ML and LL AEZs. The present findings indicated that private grazing land and community grazing land were utilized by higher % of respondents in LL AEZ compared to HL and ML AEZs. The proportion of respondents using community grazing land in the present study with respect to HL and ML were very low than the earlier report of Fсахatsion *et al.* (2013) who reported 41.3 and 46.7% of respondents utilizing community grazing land in high and midland respectively at Gamo gofa zone, Southern Ethiopia. However the trend of higher proportion of respondents in ML followed by HL was similar to the trend found by current investigator. In the same study (Fсахatsion *et al.*, 2013) found that the proportion of respondents using own/private grazing land was 25.0% in high and 22.8% in midland. The present result was lower than these reports.

Table 5. Most common grazing land of sheep and goat.

Most common grazing land	HL	LL	ML	Overall mean
On the own land	10.6	14.4	15.6	13.53
On the rented land	26.7	24.4	1.7	17.6
On the communal land	1.1	2.2	3.3	2.2

The Index values of major sheep and goat feed sources in three agro ecologies during dry and wet season is presented in table 6. Natural pasture was the major source of small ruminant feed both in dry and wet seasons in all the three agro-ecologies. The current finding was in agreement with Grum (2010) in Metema district, around Amhara region; Amelmal (2011) in Dawuro Zone, Konta Special Woreda of SNNPR; Biruh (2013) in Low Land areas of South Omo Zone and Alubel (2015) around Amhara and Tigray National Regional States. The natural pasture was ranked as first feed source for small ruminants in both wet (with index value of 0.98, 0.96 and 0.95) and dry season (with index value of 0.49, 0.48 and 0.49) in three AEZs (HL, ML, LL, respectively) in the current study. Table 6 revealed that natural pasture was the only feed source of small ruminants during wet season. However, during dry season apart from natural pasture, the other major feed sources were crop residues (ranked second), crop aftermath (ranked third) and hay (grass only, ranked fourth) in that order in all the three AEZs with an overall index values of 0.30, 0.15 and 0.04, respectively.

Table 6. Ranking of major sheep and goat feed sources in agro-ecologies of districts in wet and dry seasons.

Most available feed sources for sheep and goat	High land				Midland				Lowland				Total	
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I		I
Wet season														
Natural pasture	69	59	0	0.98	74	60	0	0.96	37	35	0	0.95	0.96	
Non conventional	0	2	5	0.02	0	5	3	0.04	0	2	7	0.05	0.04	
Total	69	61	5	1.00	74	65	3	1.00	37	37	7	1.00	1.00	
Dry season														
Natural pasture	58	3	3	0.49	57	7	5	0.48	30	3	2	0.49	0.49	
Hay (Grass only)	1	6	2	0.05	2	4	4	0.04	0	3	1	0.04	0.04	
Crop aftermath	3	17	11	0.15	5	14	15	0.15	2	10	4	0.15	0.15	
Non conventional	0	2	8	0.03	0	0	4	0.01	0	0	6	0.03	0.02	

Crop residues	7	41	0	0.28	10	49	1	0.32	5	21	1	0.29	0.30
Total	69	69	24	1.00	74	74	29	1.00	37	37	14	1.00	1.00

The grazing management (Table 7) revealed that small ruminants were grazed in six different ways in the three AEZs. These six ways were (i) sheep alone, (ii) goat alone (iii) mixed sheep and goat, (iv) sheep with other livestock but not goat, (v) goat with other livestock but not sheep and (vi) sheep and goat mixed with all other livestock species found in the area. The overall proportion of respondents following these 6 grazing ways were 32.8, 20.6, 18.9, 13.9, 8.9 and 5.0 % for sheep with other livestock but not goat, sheep alone, goat with other livestock but not sheep, goat alone, sheep and goat mixed with all other livestock and mixed sheep & goat, respectively. However, FGD showed that farmers prefer feeding goats alone instead of gazing/browsing them with sheep. This may be due to the fact that goats have the ability to browsing many plant species within short period and less time is required to fill their gut than sheep.

The grazing / browsing practices in dry season (Table7) showed that majority of respondents (23.4 and 27.8 in HL and ML, respectively) followed free grazing of sheep and goat. However free grazing was practiced by a very small proportion (1.7 %) of respondents in LL area in which 12.2 % of respondents (majority) followed herded grazing practice. The possible reason for this may be high population of predators in LL AEZ due to presence of high forest cover. During wet season the small ruminants were herded during grazing by majority of respondents in all the three AEZs (21.7, 27.8 and 13.9 % in HL, ML and LL, respectively). The possible reason may be that the farmers protect standing crops from any damage due to free grazing of small ruminants and also availability of good grass cover during wet season. These results, for both dry and wet season, were not in agreement with the earlier report of Belete (2009) for sheep dominant, goat dominant, and mixed livestock systems in western Ethiopia.

Table 7. Grazing management of sheep and goat (percentage)

Particulars	Highland (N = 69)	Midland (N =74)	Lowland (N = 37)	Total
Grazing ways				
Sheep alone	11.7	8.3	0.6	20.6
Goat alone	-	5.0	8.9	13.9
Mixed Sheep and goat	0.6	4.4	-	5.0
Sheep with other livestock but not goat	22.8	6.1	3.9	32.8
Goat with other livestock but not sheep	1.1	11.7	6.1	18.9
Sheep and goats with other livestock	2.2	5.6	1.1	8.9
Grazing / browsing Practices in dry season				
Free grazing	23.4	27.8	1.7	53.9
Tethered grazing	0.6	0.6	1.7	2.8
Herded	3.3	2.8	12.2	17.2
Roaming and tethered grazing	9.4	8.9	2.2	20.6
Herded and tethered	0.6	1.1	3.9	5.6
Grazing / browsing practices in wet season				
Tethered grazing	8.9	8.3	1.1	16.1
Herded	21.7	27.8	13.9	63.3
Herded and tethered	7.8	5.0	5.6	20.6

Perusal of results in table 8 showed that rain water followed by river water was the main source of water for sheep and goat during rainy season in all AEZs. However during dry season river water followed by spring water were the main sources for watering small ruminants in the three AEZs.

These were in agreement with the report of Alubel (2015) who reported that rivers were an important source of water during dry and wet seasons in crop livestock system households. The frequency of watering during rainy season (Table 8) showed that small ruminants had free access to the water. This may be due to abundant availability of water during rainy season. During dry season small ruminants were either watered once in a day (32.2, 36.7 and 14.4 % of respondents) or once in two days (2.2, 2.2, and 6.1 % of respondents) in HL, ML and LL areas, respectively. The possible reason is shortage of surface water during dry season. This was corroborated by FGD which revealed that during dry season springs and some rivers get dried and as a result not only sheep and goat but also human beings spent their time to search water.

Table 8. Source and frequency of watering sheep and goats in dry and wet seasons.

Description	HL		ML		LL		Overall	
	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season
Source of water for sheep and goat								
River	8.9	31.7	10.6	33.3	2.2	14.4	21.7	79.4
Spring	1.7	6.1	5.6	7.8	1.1	6.1	8.3	20.0
Ground water	-	0.6	0.6	-	-	-	0.6	0.6
Rain water	27.8	-	24.4	-	17.2	-	69.4	-
Frequency of watering sheep and goat								
Freely available	33.9	3.9	35.0	2.2	16.1	-	85.0	6.1
Once a day	4.4	32.2	6.1	36.7	4.4	14.4	15.0	83.3
Once in 2 days	-	2.2	-	2.2	-	6.1	-	10.6

Housing

The findings in the present study are presented in table 9. Majority of household in midland (16.1%) and lowland (13.9%) of districts were confining their sheep and goats in family house. However in HL the majority (18.9 %) of respondents housed sheep in separate house. Verandah was also used for housing both sheep / goat in next order by 10.0, 15.6 and 5.6 % of respondents in HL, ML and LL areas, respectively. The current study was in agreement with earlier reports (Tsedeke, 2007 and Tesfaye, 2008). However it is in disagreement with reports of Alubel (2015) who found that majority (83.82%) of goat producers in Ziquala districts confine their goats without roof and small proportion (18.18%) of farmer confine their goats in family house. The majority of respondents in highland and midland (28.9%, 14.4% in HL & ML, respectively) reported that sheep and goat were confined separately in the house. However in lowland area both these species (sheep / goat) were confined with other livestock (10.0 %). The present finding in LL area was in agreement with Alubel (2015). In the study areas different housing materials were used in roofs (Table 9). The wood was used by 21.1 and 15.6 % of respondents in HL and LL areas whereas corrugated iron sheets were used by 21.7 % of respondents in ML area. The wood was the main construction material of sheep and goat houses in all AEZs (35.6, 38.3 and 13.9 % in HL, ML and LL, respectively). The possible reason may be availability of wood as the area is endowed with good number of Eucalyptus trees. Earth / soil are used by majority of respondents for flooring. This may be favoured as it is more economical.

Table 9. Types of sheep and goat houses and housing materials in three AEZs

Types of house and housing materials	HL N (%)	ML N (%)	LL N (%)	Pooled N (%)
Housing sheep and goat:				
In family house	17 (9.4)	29 (16.1)	25 (13.9)	71 (39.4)
Separate house	34 (18.9)	17 (9.4)	2 (1.1)	53 (29.4)

Veranda (Front extension of building)	18 (10.0)	28 (15.6)	10 (5.6)	56 (31.2)
System of confining:				
Sheep alone	52 (28.9)	26 (14.4)	5 (2.8)	83 (46.1)
Goat alone	2 (1.1)	24 (13.3)	13 (7.2)	39 (21.7)
Sheep and goats alone	6 (3.3)	14 (7.8)	1 (0.6)	21 (11.7)
With all other animals	9 (5.0)	10 (5.6)	18 (10.0)	37 (20.6)
Housing materials in roofs of sheep and goat houses				
Iron sheet	31 (17.2)	39 (21.7)	9 (5.0)	79 (43.9)
Wood	38 (21.1)	35 (19.4)	28 (15.6)	101 (56.1)
Materials used for construction of walls of sheep and goat houses				
Iron sheet	3 (1.7)	2 (1.1)	-	5 (2.8)
Wood	64 (35.6)	69 (38.3)	25 (13.9)	158 (87.8)
Stone	2 (1.1)	3 (1.7)	12 (6.7)	17 (9.4)
Materials used for flooring				
Wood	2 (1.1)	3 (1.7)	5 (2.8)	10 (5.6)
Stone	6 (3.3)	13 (7.2)	12 (6.7)	31 (17.2)
Earth/soil	61 (33.9)	58 (32.2)	20 (11.1)	139 (77.2)

Culling of small ruminants

The farmers cull their animals for a number of reasons (Table 10). The feed scarcity (14.4%, 13.9 %), sickness (10.6%, 12.8 %), productivity problems (6.1%, 6.1 %) were first, second and third reasons for culling sheep and goats in HL and ML areas in the present study. However in LL the first, second and third reason for culling was sickness (5.6 %), productivity problem and/or predators (3.9, 3.9 %) and feed scarcity (3.3 %). The overall figures for reasons for culling of sheep /goat were feed scarcity (31.7 %), sickness (28.9 %) and productivity problem (16.1 %). A small proportion of respondents (1.7, 2.2 and 2.2%) in HL, ML and low land areas cull their sheep / goat for undesirable phenotypic characteristics (black coat color, abnormal legs and hoofs). Similar findings were reported by Tsedeke (2007) in Alaba. The FGDs stated that sickness, feed scarcity and productivity problem were the first three reason for culling sheep and goat in the three AEZs.

Table 10. Reason of culling sheep and goats in agro ecologies of study area (%)

Reason of culling sheep and goat (%)	HL(N=69)	ML(N=74)	LL(N=37	Overall (N=180)
Old age	5	5.0	1.7	11.7
Sickness	10.6	12.8	5.6	28.9
Productivity problem	6.1	6.1	3.9	16.1
Physical defect	1.7	2.2	2.2	6.1
Predator	0.6	1.1	3.9	5.6
Feed scarcity	14.4	13.9	3.3	31.7

Castration of rams and bucks

The present study showed that a small proportion of respondents (farmers) castrate male of both species and the overall figures were 7.2 and 8.3% of respondents for sheep and goat, respectively. The majority of respondents carried castration at the age of 12 months in both species (5.0 and 8.3 % for sheep and goat, respectively). The castration method followed was traditional (by crushing either with

stone or iron hammer) by majority of respondents (7.2 %) in all AEZs. Similar findings were reported by Tsedeke (2007) in Alaba. The reasons for castration enumerated by the respondents (overall) were (a) to fetch more prices (9.4 %), (b) to avoid mating (5.0 %) and (c) to reduce aggressiveness (1.1 %). The majority of respondents in highland (2.2%), midland (6.6%) and lowland (2.2%) castrate their animals from February-December.

Acquisition methods and exit of household flock of small ruminants

The ranking, according to the indices estimated (**Table 11**), of acquisition of sheep in HL was home-born with an index of (0.55), purchase (0.33), and gift (0.08). This finding was in agreement with Yisehak *et al.* (2013) who reported similar order of ranking in south western Ethiopia. However, the rankings of acquisition of sheep in ML were home-born followed by purchase followed by share-arrangement and differed from HL in respect of third rank only. The corresponding indices estimated were 0.65, 0.33, and 0.02, respectively. In LL areas the ranking was home-born followed by share arrangement followed by purchase with the value of indices as 0.75, 0.19 and 0.06, respectively.

The rankings of goat acquisition were similar in the three AEZs in the present study. The rankings were home-born, purchase and share arrangement with indices of 0.62, 0.29, 0.09 in HL; 0.76, 0.19, 0.03 in ML and 0.53, 0.33, 0.06 in LL. The first two ways of reducing numbers (Table11) in sheep were same in all AEZs and these were sale followed by death. The indices estimated were 0.65, 0.19 for HL, 0.58, 0.23 for ML and 0.64, 0.24 for LL areas. However there was difference in the ranking of third and fourth reason of reducing numbers in the three AEZs.

In goat there was no similarity in the ranking of reasons for reducing numbers (Table 11). In HL the ranking was sale followed by slaughter and death / predators with index values of 0.34, 0.30 and 0.18, respectively. In ML the rankings was death followed by sale and share out with index values of 0.44, 0.42 and 0.07, respectively. In LL the rankings estimated were sale followed by death and by predators with index values of 0.53, 0.22 and 0.18, respectively.

Table 11. Flock acquisition and exit way of sheep and goat in three AEZs

	Highland				Midland				Lowland				Overall	
	R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I	I	
Sheep: Acquisition method														
Home born	42	10	0	0.55	32	0	0	0.65	8	0	0	0.75	0.65	
Purchase	17	19	0	0.33	10	9	0	0.33	0	1	0	0.06	0.24	
Receive share arrangement	1	0	5	0.03	0	1	0	0.02	1	1	1	0.19	0.08	
Gift	7	1	1	0.08	0	0	1	0.01	0	0	0	0.00	0.03	
Sheep: Exit way														
Sale	57	0	0	0.65	31	4	0	0.58	7	0	0	0.64	0.62	
Death	8	13	0	0.19	7	9	1	0.23	2	1	0	0.24	0.22	
Slaughter	1	6	1	0.06	1	2	6	0.07	0	0	0	0.00	0.04	
Predators	1	6	2	0.07	0	1	0	0.02	0	1	2	0.18	0.09	
Theft	0	0	2	0.01	1	0	0	0.02	0	0	0	0.00	0.01	
Share out	0	1	2	0.02	2	5	0	0.09	0	0	0	0.00	0.03	
Goats: Acquisition method														
Home born	7	0	0	0.62	44	0	0	0.76	20	0	0	0.53	0.64	
purchase	0	5	0	0.29	4	11	0	0.19	10	4	0	0.33	0.27	
Receive share arrangement	0	0	3	0.09	1	1	0	0.03	0	2	3	0.06	0.06	

Gift	0	0	0	0.00	0	1	0	0.01	0	1	0	0.02	0.02
Goats: Exit way													
Sale	5	0	0	0.34	29	1	0	0.42	22	1	1	0.53	0.43
Death	1	2	1	0.18	16	22	0	0.44	2	12	0	0.22	0.28
slaughter	0	4	5	0.30	1	2	0	0.03	1	1	1	0.05	0.13
Theft	0	0	0	0.00	1	0	0	0.01	0	0	0	0.00	0.00
Share out	0	0	0	0.00	0	7	0	0.07	0	1	0	0.02	0.03
predators	1	0	5	0.18	2	0	0	0.03	5	0	9	0.18	0.13

Weaning practices

The results (Table 12) showed that almost half of the respondent of the study areas do not separate new born lambs and kids. The overall proportion of farmers practicing weaning of lambs / kids, was 30.6 and 20.6%. The weaning was carried either during day or night or both. However among these three times, the majority of respondents weaned their lambs / kids during day in all AEZs (Table12). Similar finding has been reported by Girma *et al.* (2013) in Adami Tulu Jido Kombolcha district of east Shoa Zone, Ethiopia. The FGD revealed that almost all farmers weaned new born lambs / kids at day time. Some farmers stated that if weaning was done at night, the weaners bleat / make bleating noise and disturb all other flock and even owners as reasonable number of animals were confined in family houses.

Table 12. Weaning practices in the three AEZs (%)

Particulars	HL	ML	LL	Total
New born lambs – weaning practiced:				
Yes	16.1	11.1	3.3	30.6
No	21.1	12.2	1.7	35.0
New born lambs – weaning time:				
Day	8.9	5.6	2.8	17.2
Night	0.6	1.7	0.0	2.3
Both	6.7	3.9	0.6	11.1
New born kids – weaning practiced:				
Yes	0.6	14.4	5.6	20.6
No	3.3	12.8	11.1	27.2
New born kids – weaning time:				
Day	0.6	6.7	2.2	9.4
Night	0.0	2.8	1.1	3.9
Both	0.0	5.0	2.2	7.2

Health management practices

Treating sick sheep / goat (Table 13), using modern drugs, is common in all the three AEZs. The proportion of respondents using modern treatment ranged from 11.1% (LL) to 35.6% (HL) with an overall proportion of 80.0 %. In lowland percentage of respondents treating their sick sheep and goats were lower than the two AEZs due to clinics being far apart from their homestead. The results showed that government veterinary clinics were the main sources of modern treatment of sick sheep and goat in all AEZs. The present results were in agreement with Dereje *et al.* (2013) and Yenesew (2010). The traditional forms of treatment, wherever followed, comprised of three methods, viz: bleeding under the tongue, firing /branding under the neck by hot iron metal and drenching of chopped white oil mixed with cooked pepper.

Table 13. Health management practice of sheep and goat (percentage) in three AEZs

Particulars	HL	ML	LL	Overall
Treatment of sick animal				
Traditional treatment	2.8	7.8	9.4	20.0
Modern	35.6	33.3	11.1	80.0
Source of Veterinary service				
Government	32.2	23.9	13.9	70.0
Private institutions	6.1	17.2	6.7	30.0
Traditional treatment practices through				
Bleeding under the tongue	1.7	3.3	2.8	7.8
Firing /branding under the neck by hot iron metal	0.6	2.8	4.4	7.8
Drenching of chopped white oil mixed with cooked pepper	0.6	1.7	2.2	4.4

Summary and recommendations

This study was conducted in Ada Barga and Ejere districts of west Shoa Zone of Oromia Regional State of Ethiopia to characterize central highland sheep and goat production system in their production environment based on agro ecology (high, mid and lowland) of the areas. The overall objectives for sheep rearing (across all AEZs) ranked in the order of income (0.45), saving (0.17) and meat (0.14). However the overall objectives for goat rearing (across all AEZs) ranked as income (0.50), followed by meat (0.21) and saving (0.12). The results showed that 10.6, 14.4 and 15.6% of households possessed their own grazing land; 26.7, 24.4 and 1.7 % utilized rented grazing land; and 1.1, 2.2 and 3.3%, respectively, made use of community grazing land in HL, ML and LL AEZs. During dry season apart from natural pasture, the other major feed sources were crop residues (ranked second), crop aftermath (ranked third) and hay (grass only, ranked fourth) in that order in all the three AEZs. Majority of house hold in midland (16.1%) and lowland (13.9%) of districts were confining their sheep and goats in family house. However in HL the majority (18.9 %) of respondents housed sheep in separate house. Verandah was used for housing both sheep / goat in next order by 10.0, 15.6 and 5.6 % of respondents in HL, ML and LL areas, respectively. Based on this study it is recommended that (i) comprehensive farmers awareness program needs to be under taken on scientific small ruminant management system emphasizing lamb/kid management, advantages of pasture management by community, advantages of separate housing and disadvantages of increasing inbreeding; and (ii) a location / area specific dosing / vaccination schedule be developed to reduce mortality due to diseases and parasitic infestation.

Acknowledgement

The authors are thankful to Jimma University, Ethiopia and the Livestock and Irrigation Value-chain for Ethiopian Smallholders (LIVES) project of the International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia, for supporting this study.

References

- Alubel Alemu, 2015. *On-farm Phenotypic Characterization and Performance Evaluation of Abergelle and Central highland goat breeds as an input for designing community-based breeding program*. Accept for award of M.Sc (Animal Genetic and breeding), Haramaya University, Haramaya, Ethiopia, 2014 pp 147
- Amelmal Alemayehu, 2011. *Phenotypic characterization of indigenous sheep types of Dawuro Zone and Konta special woreda*. Award for M.Sc Thesis Presented to School of Graduate Studies, Haramaya University, Ethiopia. 118pp
- Arse Gebeyehu, Feyisa Hundessa, Gurmessa Umata, Merga Muleta and Girma Debele, 2013. *Assessment on challenges and opportunities of goat farming system in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State, Ethiopia*. *Afr. J. Agric. Res.* 8(1):26-31
- Arsham, H., 2002. *Descriptive Sampling Data Analysis. Statistical Thinking for Managerial Decision Making*. <http://ubmail.ubalt.edu/harsham/Business-stat/opre504.htm#rwhyssm>

PROCEEDING

Animal Breeding and Reproduction

- Behnke, R., 2010. *The Contribution of Livestock to the Economies of IGAD Member States: Study Findings, Application of the Methodology in Ethiopia and Recommendations for Further Work*, IGAD LPI Working Paper 02-10. Odessa Centre, IGAD Livestock Policy Initiative, Great Wolford, UK
- Belete Shenkute., 2009. *Production and marketing systems of small ruminants in Gomma district of Jimma zone, western Ethiopia*. M.Sc. Thesis. Hawasa University, April, 2009, Awassa, Ethiopia. Pp 38-54.
- Biruh Tesfahun, 2013. *Phenotypic and production system characterization of Woyto Guji Goats in Lowland areas of South Omo Zone*. An MSc thesis submitted to School of Animal and Range Science, School of Graduate Studies Haramaya University. 89pp.
- Dereje T., 2011. *Community based characterization of Hararghe high land goats in Daro-Labu district West-ern Hararghe*, An MSc Thesis presented to the school of Graduate studies of Jimma University. Jimma, Ethiopia.
- Dereje Tsegaye, Berhanu Belay and Aynalem Haile, 2013. *Prevalence of Major Goat Diseases and Mortality of Goat in Daro-Labu District of West Hararghe*, **Ethiop. J. Sc.** 2 (3): 665-672
- **Fanos Mekonnen, 2012. Zonal diagnosis and intervention plan West Shoa, Oromia. Livestock and irrigation value chains for Ethiopians small holders' pp 47.**
- Fсахatsion Hailemariam, Abera Melesse and Sandip Banerjee, 2013. *Traditional sheep production and breeding practice in Gamo gofa Zone, Southern Ethiopia* International Journal of Livestock Production Research Vol. 1, No. 3, Pp43.
- Girma Debele, Mieso guru, Feyisa Hundessa and Misgana Duguma, 2013. *Assessment of farmers' management practices and factors affecting goats' production system in Adami Tulu Jido kombolcha district of east Shoa zone, Ethiopia*. **Agri. and bio. J. of N. Americ.** 4 (5):20.526
- Grum Gebreyesus, 2010. *Community-Based Participatory Characterization of the short Eared Somali Goat Population around Dire Dawa*. An MSc thesis submitted to School of Animal and Range Science, School of Graduate Studies Haramaya University. 129pp.
- Hundie Demissu and Geleta Gobena, 2015. *Assessment on production situation and breeding practices of 'Horro sheep' under traditional management in Horro Guduru and East Wollega Zones, West Ethiopia*. *Global Journal of Animal Breeding and Genetics*, SSN: 2408-5502 **Vol. 3(3), pp. 146-152.**
- Mekuriaw S, Mekuriaw Z, Taye M, Yitayew A, Assefa H, Haile A., 2012. *Traditional management system and farmers' perception on local sheep breeds (Washera and Farta) and their crosses in Amhara Region, Ethiopia*. *Livestock Res. Rural Develop.* p.24, Article #4. Retrieved November 9, 2012, from <http://www.lrrd.org/lrrd24/1/meku24004.htm>
- Mengistie Taye, Girma Abebe, Solomon Gizaw, Sisay Lemma, Abebe Mekoya and Tibbo Markos, 2010. *Traditional management systems and linear body measurements of Washera sheep in the western highlands of the Amhara National Regional State, Ethiopia*. *Livestock Research for Rural Development* Volume, 22, 169
- Metaferia F, Cherenet T, Gelan A, Abnet F, Tesfaye A, Ali JA, Gulilat W, 2011. *A Review to Improve Estimation of Livestock Contribution to the National GDP*. Ministry of Finance and Economic Development and Ministry of Agriculture, Addis Ababa, Ethiopia
- MOA (Ministry of Agriculture), 2000. *Agro ecological Zonation of Ethiopia*. Addis Ababa, Ethiopia.
- Solomon Abegaz, 2014. *Design of community based breeding programs for two indigenous goat breeds of Ethiopia*. Doctoral Thesis, January 2014 Vienna, Austria.
- Solomon G, Aynalem H, Taddelle D., 2010. *Breeding objectives and breeding plans for Washera sheep under subsistence and market oriented production systems*. *Ethiopian. Journal of Animal production* **EJAP.** 10 (1): 1 – 16.
- SPSS Version, 20.0 (2013). *Software Package for Social Sciences for Window*.
- Tesfaye Getachew, Haile A, Tibbo M, Sharma A K, Sölkner J and Wurzinger M, 2010 *Herd management and breeding practices of sheep owners in a mixed crop-livestock and a pastoral system of Ethiopia*. **Afri. J. Agri.** 5(8): 685–691
- Tesfaye Getachew, Solomon Gizaw, Sisay Lemma and Mengistie Taye, 2011 *Breeding practices, growth, and carcass potential of fat-tailed Washera sheep breed in Ethiopia*. *Tropical Animal Health Production* 43:1443–1448.

- Tesfaye Getachew, 2008. Characterization of Menz and afar indigenous sheep breeds of smallholders and pastoralists for designing community-based breeding strategies in Ethiopia msc.thesis October 2008 Haramaya University. Haramaya.
- Tsedeke K. 2007. Production and marketing of sheep and goats in Alaba, SNNPR. Msc thesis. Hawasa University. Hawasa, Ethiopia
- Yaekob Lorato., 2014 Community Based Characterization of Woyto Guji goat in Loma district, SNNP. Accept regional State of Ethiopia Accept for award of M.sc (Animal Breeding and Genetics), Jimma university, Jimma, Ethiopia. 2014 Pp 142
- Yenesew Abebe, 2010. Assessment of small ruminant production systems and on-farm evaluation of urea treated wheat straw and concentrate feeding on sheep body weight change in Burie woreda, west Gojjam. MSc. thesis. 2010 Haramaya University. Haramaya.
- Yisehak Kechero, Taye Tolamariam and Aynalem Haile, 2013. Characteristics and Determinants of Livestock Production in Jimma Zone/Southwestern Ethiopia. *Afri. J. Bas. & Ap.Sci.* 5 (2): 69-81
- Zewudu Edea, A Haile, M Tibbo, A K Sharma, J Sölkner and M Wurzinger, 2012. Sheep production systems and breeding practices of smallholders in western and south-western Ethiopia: Implications for designing community-based breeding strategies. *Livestock Research for Rural Development* 24 (7)

Socio-economic Characteristics of Households and Small Ruminant Marketing Systems in Ada Barga and Ejere Districts of West Shoa Zone, Oromia, Ethiopia

Yadeta Neme¹, Manzoor Ahmed Kirmani and Gemedu Duguma

¹Department of Animal Science, College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box 378, Jimma, Ethiopia.

Abstract

The marketing systems, opportunities and constraints of small ruminant rearing were studied in the three agro-ecologies (AEZs) of Ada Barga and Ejere districts, West Shoa Zone, Oromia, Ethiopia. The three agro-ecologies were highland (HL), midland (ML) and lowland (LL). A total of 180 households 69 from HL, 74 from ML and 37 from LL were purposively selected for this study. Detailed structured questionnaires, respondent interviews and FGD were employed to collect data. Majority of respondents sell small ruminants aged 06 months – 01 year and adult (> 01 year) in both sexes (male and female) across all three AEZs. Diseases, feed shortage and water shortage were major constraints ranked first, second and third with an overall index of 0.40, 0.20 and 0.16 for sheep and 0.35, 0.31 and 0.13 for goat, respectively. The constraint should be addressed to increase productive and reproductive performance of small ruminants.

Key words: Small ruminants, Marketing system, Ethiopia, Agro-ecologies, Opportunities, Constraints.

Introduction

More than 85% of the Ethiopian population depends on agriculture for their livelihoods. The subsector contributes about 16.5% of the national Gross Domestic Product (GDP) and 35.6% of the agricultural GDP (Metaferia *et al.*, 2011). It also contributes 15% of export earnings and 30% of agricultural employment (Behnke 2010). The small ruminants (sheep and goat), contribute substantial amounts to income, food (meat and milk), and non-food products like manure, skins and wool in Ethiopia. Small ruminants also serve as means of risk mitigation during crop failures, property security, monetary saving and investment in addition to many other socio-economic and cultural functions (Solomon *et al.*, 2010). Moreover, they have many advantages over large ruminants for most smallholder farmers, including among others: lower feed costs, quicker turnover, easy management and appropriate size at slaughter (Wilson and Morrical, 1991; Abegaz, 2002; Donkin, 2005). They also suffer far less mortality during periods of drought than large ruminants (Galal, 1983; Wilson and Morrical, 1991). In addition, subsistence farmers prefer small ruminants as the risk of large ruminants dying and leaving them with nothing is too great (Sölkner *et al.*, 1998).

Most of the Ethiopian small ruminants are owned and managed by resource poor smallholder producers under traditional and extensive production systems. Market oriented or commercial production is almost non-existent. On the other hand, there is huge demand for live sheep and sheep meat in the Gulf countries. The demand and prices for sheep are also increasing locally due to increased urbanization and increased income (Duguma *et al.*, 2012). The demand for small ruminants is even pressing given that the current population of the country is expected to rise to about 129 million by the year 2030. Nevertheless, the present production is unable to satisfy the increasing demand of the export abattoirs with the required export quality slaughter animals (Negasa and Jabar, 2008). Since production is not market oriented, supply is also inconsistent. Currently, it is reported that the export abattoirs are operating at 56% of their operational capacities. Though Ada Barga and Ejere districts (Woredas), West Shoa Zone, Oromia Regional State, Ethiopia, have huge potential for small ruminant production, there is no documented information on their marketing systems in both districts. Thus the present study was carried to assess the small ruminant marketing systems in both districts.

Material and Methods

The study area

Detailed descriptions of the characteristics of Ada Barga and Ejere districts have been described in a companion paper Yadeta *et al.* (2016a) and the same holds good for present investigation.

Data sampling procedure and sample size

The secondary data relating to socio-economic characteristics, demography and small ruminant marketing system were collected from the respective District Agricultural Department Offices, Livestock Development Agencies and Trade & Market Development Office (OTMD). The kebeles (peasant associations) in the two districts were stratified into three agro-ecological zones (AEZs), viz: low lands (<1500 masl), midlands (1500-2300 masl) and high lands (>2300 masl) according to Ministry of Agriculture (2000) and Dereje (2011). The discussions with District Livestock Head and experts showed that in Ejere district 12 and 18 kebeles fall in highland and midland agro-ecological zone, respectively. Out of these one kebele (Damotu) and two kebeles (Chiri and Kimoye) falling in highlands and midlands, respectively, were purposively selected on the basis of sheep and goat production potential. Similarly Ada Barga district has been stratified in three agro ecological zone, viz: highland (11 kebeles), midland (13 kebeles) and lowland (15 kebeles). One kebele from each of the three agro-ecological zones, viz: Ulagora (highland), Laku Karsa (midland) and Wogidi (lowland) were selected based on potential for small ruminant production. Thus a total of six kebeles were selected from the two districts for the present study.

A total of 180 households were purposively selected owning four or more sheep / goat from the total number of house-holds (1833 rearing small ruminant) in the six kebeles for the present study (Table1).

The numbers of household (69, 74 and 37 in HL, ML and LL, respectively) from each selected kebeles were determined according to proportionate sampling technique as under:

$W = [A/B] \times N_o$; Where: W= Number of household to be calculated from single selected kebele; A=Total number of households per kebele; B= Total number of households all six kebeles; and N_o = the calculated sample size.

The sample size 180 house hold was determined according to the Arsham (2002) as indicated below:

$N = 0.25/SE^2$; Where: N= Sample size; and
SE= Standard error (0.0373) with 95% confidence level

However during this study farmers having an average flock size of ≥ 4 sheep or goats were interviewed for this study. The sheep and goat rearing farmers were interviewed separately. However, during this some of the farmers rearing both sheep and goats were interviewed two times and this resulted in the total sum of interviews exceeding the sample size of 180 household and total percentages above 100%.

Data collection

The data on marketing of small ruminants (reason of buying/selling, age and sex of animals to be sold) were collected from selected sheep / goat producers in the study area using a structured questionnaire. Focused group discussions were also undertaken using checklists to collect information on sheep and goat marketing system. Group composed of 6-9 members of key informants was formed for gathering information. Key informants such as elders, community leaders, women representative, animal health technician and development agents were targeted for the FGD.

Agro ecological zone (AEZs)	Selected kebeles	Total number of household possessing small ruminants	Proportionate number of households selected/kebele
Highland	Damotu	413	41
Midland	Ulagora	290	28
	Kimoye	178	17
	Chiri	249	24
	Laku Karsa	331	33
Lowland	Wogidi	372	37
Total	6 Kebeles	1833	180

Table 1. Number of households selected per six kebeles.

Data analysis

The data collected was organized, summarized and analyzed by the statistical package for Social Sciences (SPSS ver.20, 2011). Comparison of means was done by one way ANOVA. The General Linear Model (GLM) of SPSS ver. 20 was also used to compare some of the socio-economic parameters (Family size and land holding) across the agro-ecologies and their significance difference was tested. The following one way model was used:

$Y_{ij} = \mu + AEZ_i + e_{ij}$; where

Y_{ij} = Y^{th} observation in i^{th} class

μ = Overall mean

AEZ_i = effect of agro ecologies, where $i = 1, 2, 3$,

e_{ij} = Random error

Results and Discussion

Socio economic characteristics

The results of socio economic characteristics, across three AEZs, have been presented in Table 2. Perusal of table showed that majority of households covered in the current study were male headed in the three agro-ecologies. The male and female headed households were 80.6% and 19.4% (pooled), respectively. Study of age of house hold heads in both sexes showed that all HH heads fell in the age group of 21-50 years except male headed HH in HL area. This was in agreement with the findings of Alubel (2015), who reported similar trends in Ziquala district and Lay Armachiho districts of Amhara Regional State. The study of the educational level of house hold heads showed that majority of the HH heads were illiterate (20.60, 21.70 and 12.10 % in HL, ML and LL, respectively) followed by the group who could “read and write” (13.30, 12.80 and 7.8 % in HL, ML, and LL, respectively). The marital status of household head revealed that 93.3 % (Pooled) were married in the study area. The pooled results showed that majority of the households heads professed orthodox (90.5%), followed by protestant (7.2%), waqefata (1.7 %) and seventh day Adventist (0.6 %).

Table 2. Gender, educational level, marital status and religious belief of house-hold heads

Descriptor	Agro-ecology							
	Highlands		Midlands		Lowlands		Pooled	
	N	%	N	%	N	%	N	%
No. of households	69	38.3	74	41.1	37	20.5	180	100.0
Gender of HH heads								
Male headed	53	29.4	63	35.0	29	16.1	145	80.6
Female headed	16	8.9	11	6.1	8	4.4	35	19.4
Age of Male headed HH:								
21-50 years	16	8.9	46	25.6	24	13.0	86	47.8
51 and above	37	20.6	17	9.4	5	2.3	59	32.8
Female headed age								
21-50 years	10	5.6	8	4.4	6	3.3	24	13.3
51 and above	6	3.3	3	1.7	2	1.1	11	6.1
Education level of HH heads								
Illiterate	24	13.3	23	12.8	14	7.8	61	40.0
Read and write	37	20.6	39	21.7	22	12.1	98	54.4
Primary	6	3.3	8	4.4	1	0.6	15	8.3
Secondary	2	1.1	4	2.2	-	-	6	3.3
Marital status of HH heads								
Single	0	0	1	0.6	0	0	1	0.6
Married	66	36.7	67	37.2	35	19.4	168	93.3
Divorced	0	0	4	2.2	1	0.6	5	2.8
Widow	3	1.7	2	1.1	1	0.6	6	3.3
Religion								
Orthodox	61	33.9	71	39.4	31	17.2	163	90.5
Adventist	1	0.6	0	0	0	0	1	0.6
Protestant	5	2.8	2	1.1	6	3.3	13	7.2
Waqefata	2	1.1	1	0.6	0	0	3	1.7

N= Number of respondents, HH=household

Family size and land holding per house hold

The differences among male / female members of the families and total family size across the three AEZs were non-significant (Table 3). The total family size in highland, midland and lowland were 7.6, 6.8 and 7.1, respectively in the present study. These values were higher than the average family size of 5.5 reported from Oromia Regional State in 2013 (CSA, 2013).

The total cultivated land showed significant ($p < 0.05$) difference among the three AEZs (Table 3). The highest (2.9 hect.) and lowest (1.9 hect.) cultivated land was found in ML and LL AEZs, respectively. The pair-wise comparison showed that difference in the mean cultivated land between HL and LL was significant ($p < 0.05$) whereas differences in remaining mean pairs were not significant. Similarly total grazing land also showed significant ($p < 0.05$) difference among three AEZs. The highest (0.9 hect.) and lowest (0.5 hect.) average grazing land was found in LL and HL AEZs, respectively. Pair-wise comparison revealed significant differences among all pairs. The highland areas encountered scarcity of grazing land whereas lowland areas were faced with shortage of cultivated land in the study areas. The current results were comparable with earlier reports of Fсахatsion (2013) for Gamo Gofa Zone (SNNP regional state). The possible reasons could be human population growth, land degradation and soil erosion resulting in declining of landholding per household across the three agro-ecologies of the districts.

Table 3. Family size, Land holding per household in three AEZs

Descriptors	High land (N=69)	Midland (N=74)	Lowland (N=37)	Overall (N = 180)	P-value
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Family size (numbers)					
Male	3.9 (1.7)	3.5 (1.6)	3.8 (2.6)	3.7 (1.6)	0.296
Female	3.6 (1.6)	3.3 (1.4)	3.3 (2.2)	3.4 (1.5)	0.527
Total	7.6 (2.6)	6.8 (2.2)	7.1 (2.4)	7.1 (2.4)	0.224
Land (hectars)					
Total cultivated land	2.1 (1.5) ^a	2.9 (2.0) ^{ab}	1.9 (1.3) ^b	2.4 (1.7)	0.004
Total grass land	0.5 (0.4) ^a	0.6 (0.5) ^b	0.9 (0.8) ^c	0.7(0.6)	0.038

N= number of respondent, SD= standard deviation, Same superscript indicate non-significant differences, Different superscript indicate significant differences

Small Ruminant Marketing Systems

Reason of selling, buying and marketing place in sheep and goats

The reasons for sale of small ruminants (Table 4) were need of cash, difficulty in management, sale for old age / defects and crop failure, in descending order, in HL and ML areas. However, in LL first reason for sale was crop failure followed by need for cash followed by difficulty in management and / or sale due to old age or defect. These results indicated that both species have an important role in meeting the income needs of the farmers and thus serve as a buffer from hardship. The current results were in agreement with Belete (2009) who reported that farmers in western Ethiopia sold their animals for cash need.

The farmers in the study areas reported three reasons, viz: replacement, house-hold consumption

and trading for buying both sheep and goat or replacement stock (Table 4). The replacement was the main reason, ranked number one, for purchase in all AEZs. The house-hold consumption and trading were ranked number two (both reasons) for purchase in HL and LL whereas these were ranked as second and third reasons of purchase in ML. The trend of current results was in agreement with Berhanu *et al.* (2015) who reported that in highland of Ethiopia 62% of farmers buy small ruminants for replacement purpose, 14.4% for house-hold consumption and 13.8% for trading. Most of the small ruminants that are bought for replacement purposes ewe lambs and young does.

Table 4. Reason of selling, buying and marketing place of sheep and goat in three AEZs

Particulars	HL (%)	Rank	ML (%)	Rank	LL (%)	Rank	Total (%)	Rank
Reason of selling sheep and goat								
Need of cash income	(15.6)	1	(14.4)	1	(6.7)	2	(36.7)	1
Difficulty in management	(11.7)	2	(9.4)	2	(3.3)	3	(24.4)	2
Sale due to old age / defect	(6.1)	3	(8.9)	3	(3.3)	3	(18.3)	4
Crop failure	(5.0)	4	(8.3)	4	(7.2)	1	(20.6)	3
Reason of buying sheep and goat								
Replacement	(33.9)	1	(33.9)	1	(16.2)	1	(83.9)	1
Household consumption	(2.2)	2	(3.9)	2	(2.2)	2	(8.3)	2
Trading	(2.2)	2	(3.3)	3	(2.2)	2	(7.8)	3
Marketing place of sheep and goats								
Farm gate	(11.1)	2	(7.8)	3	(3.3)	3	(22.2)	3
District market	(18.9)	1	(17.2)	1	(11.7)	1	(47.8)	1
Both	(8.3)	3	(16.1)	2	(5.6)	2	(30.0)	2

The results of marketing place (Table 4) showed that district markets were the main marketing place for these two species in all AEZs. The farm gate was ranked second place by HL respondents whereas it was ranked third by ML and LL respondents. The current study was in agreement with Terfa *et al.* (2012) reported that most of sheep producers (66%) sold their sheep in the nearest market whereas, 7% sold within the village and 7% in distant market. Also Berhanu *et al.* (2015) who reported that most of small ruminant sold at district market (38.2%).

Sale of small ruminants by sex and age groups

The results (Table 5) showed that majority of respondents sold small ruminants falling in two age groups, viz: 06 months – 01 year and adult (> 01 year), in both sexes (male and female) across all three AEZs. The respondents ranked these two age groups as first (06 months –01 year) and second (adult, greater than 01year) in all AEZs in both sexes. The FGD also showed similar trends in the sale of these two age groups. Similar finding (06 months – 01 year and adult > 01 year of male sheep) was reported by Yenesew *et al.* (2013) in Burie district, north western Ethiopia.

The preference of sale of “06 months - 01 year” age group as number one (Table 5) in both sexes indicated that a good number of male and female hoggets, with good genetic potential, were regularly but unintentionally eliminated from the population through sale. Alubel (2015) has also arrived at this possibility. Gameda (2010) who conducted research on Bonga and Horro sheep breeds, in mixed crop-livestock systems reported that male lambs are sold as early as three to four months of age resulting in acute shortage of breeding rams in the flocks. According to the author such early disposal of young animals culminates into unintentional negative selection because the fast growing animals with good genetic potential for growth are continuously eliminated before they pass their good genes to the subsequent generations whereas the genetically inferior ones remain in the flocks and thus contribute relatively less desirable genes to the next generation. This trend greatly affected future improvement and thus narrowed the genetic base of flocks resulting in high coefficient of inbreeding

as Ne is getting decreased in both sexes.

Table 5. Preference of households for sale of small ruminants by sex and age groups

Sex	Age group	HL (N 69)		ML (N 74)		LL (N 37)		Overall (N 180)	
		%	Rank	%	Rank	%	Rank	%	Rank
Male	< 06 months	5.6	3	4.4	4	3.3	3	13.3	4
	06 months – 01 year	20.0	1	18.3	1	8.3	1	46.7	1
	Adult (> 01 year)	10.0	2	12.2	2	7.2	2	29.4	2
	Castrated	2.8	4	6.1	3	1.7	4	10.6	3
Female	< 06 months	5.0	3	3.3	3	3.3	3	11.7	3
	06 months – 01 year	14.4	1	19.4	1	10.6	1	44.4	1
	Adult (> 01 year)	18.9	2	18.3	2	6.7	2	43.9	2

Season of marketing sheep and goats

The study (Table 6) showed that sale of small ruminants was related to the seasonal holiday markets in all study areas. The majority of respondents sold their small ruminants at the time of Easter, Christmas, Ethiopian New Year, Epiphany and Meskel festivals in descending order in HL areas. However in ML small ruminants were sold during Christmas, Easter, Ethiopian New Year, Epiphany and Meskel festivals in decreasing order. In LL areas farmers sold small ruminants during Easter, Ethiopian New Year, Christmas, Epiphany and Meskel festivals in decreasing order. These results indicated that during major cultural and religious holidays, especially after long fasting by orthodox Christian believers (during this fasting period consumption of animal products is strictly banned), there is a sharp increase in demand for meat. The present results were in agreement with earlier findings by Ehui (2000), Tsedeke (2007) and Gemedā *et al.* (2012). Only few farmers can take advantage of this opportunity as they get better returns. Despite the high market demand and the corresponding sheep and goats prices during the different social and religious festivals, smallholder producers usually cannot wait for such periods due to pressing cash needs in different times of the year (Gemedā *et al.*, 2013).

Table 6. Season of marketing sheep and goats (%)

Time of selling	HL	ML	LL	Overall
Epiphany	5.0	5.6	2.2	12.8
Easter	13.9	10.6	8.9	33.3
Ethiopian new year	7.2	8.9	4.4	20.6
Christmas	10.0	12.8	3.3	26.1
Meskel	2.2	3.3	1.7	7.2

Market channels

The major marketing channels linking producers with end users were six (Figure 1). These different channels represent the full range of available outlets through which sheep and goats move from the different collection points in major production areas to terminal markets to meet end-users needs.

Marketing participants and mode of price setting

It was reported that small ruminant producers sell their animals anywhere they find it appropriate. They sell at farm gate, in the nearest or distant markets where the price seems higher. The results (Table 7) showed that the respondents sold their small ruminants to farmers (42.80 %), small traders

(22.2 %), large traders (13.90 %), hotels (11.1 %) and general consumer (10.0). The results indicated that hotels and general consumers fell at the last steps of the marketing participants. This conversely showed that small traders, who in fact were middleman, were important marketing participants. This finding was in agreement with Tsedeke (2007) in southern Ethiopia and Yenesew (2010) in Burie woreda of Amhara National Regional State, Ethiopia, who reported that general consumers (12.2%) and hotels (16.7%) showed less marketing participating for sheep and goat buying.

The results of mode of price setting (Table 7) showed that majority (97.2%) of the respondents market their animals based on “eye-ball” estimation (visual appraisal) whereas only few (2.8%) farmers preferred to sell their animals based on live weight. This finding was in agreement with Tsedeke (2007) in southern Ethiopia who reported that most of producers market their animals based on eye-ball estimation and few of them (2.0%) sell on live weigh basis. Animals were reported to be marketed on individual basis and agreement to prices reached after a long one-to-one bargaining between buyers and sellers and sometimes brokers. They visually inspected the animals, and negotiated and haggled over the prices until consensus was arrived at. Gameda *et al.* (2013) reported that market information available to small ruminant producers is very limited in the study areas, and most of the market information is generated either through visits to the markets before engaging in any transaction or from other producers.

The average number of sheep and goat sold / household / year (Table 7) was 4.4 (3.7) and 2.2 (2.4), respectively, in the present study. The result of the current study was higher than Yenesew (2010) in Burie woreda, west Gojjam, who reported that one household sold on average 1.1 heads of sheep per year.

Table 7. Marketing participants and mode of price setting in sheep and goat buying

Particular	N	%
Participants		
Farmers	77	42.80
Small traders	40	22.20
Hotels	20	11.10
General consumer	18	10.00
Large traders	25	13.90
(II) Mode of price setting		
Eye ball estimation	175	97.2
Weight base	5	2.8
(III) Average number of animals sold		
	Mean	SD
Average number of sheep sold/household per year	4.4	3.7
Average number of goats sold/household per year	2.2	2.4

Channel 1	Producer	small trader	hotels	
Channel 2	Producer	small trader	general consumer	
Channel 3	Producer	general consumer		
Channel 4	Producer	large trader	general consumer	
Channel 5	Producer	small trader	large trader	
Channel 6	Producer	small trader	large trader	general consumer

Figure 1: Marketing channels of small ruminants

Constraints and Opportunities of Small Ruminant Production

Constraints in small ruminant production

The identification of major constraints for a given farm animal production system in a given area is a prerequisite to plan appropriate intervention strategies for improving productivity. Accordingly major constraints faced by small ruminant production system, based on interview of respondents, in the study areas were identified and are presented in table 8. The results showed that disease was ranked as first constraint for both species in all the three agro ecologies with index values of 0.42, 0.48 and 0.31 in HL, ML and LL, respectively for sheep and 0.40, 0.42, 0.23 in HL, ML and LL, respectively for goat. Solomon *et al.* (2013) also identified diseases as first constraint in sheep production under perennial crop-livestock and cereal livestock production systems. Lack of improved breeds as a constraint was identified by respondents as number two in case of goats in HL area. Feed shortage, water shortage, long dry season were ranked either second, third or vice versa for both species in the three AEZs. The present findings were in agreement with Yenesew *et al.* (2013) who reported that in Bure district of North western Ethiopia feed shortage was very severe especially in the highland kebeles and Mesay *et al.* (2013) in Lemu-Bilibilo district in Arsi zone also reported that, shortage of feed at the end of dry season when all crop residues have been consumed and pasture growth is poor, was the major constraint for livestock production in the area.

Table 8. Rank of major constraints by sheep and goats rears.

Major constraints		High land (N=69)				Midland (N=74)				Lowland (N=37)				Over- all
		R1	R2	R3	I	R1	R2	R3	I	R1	R2	R3	I	
Sheep														
	Shortage of feed	12	26	17	0.27	1	25	10	0.25	0	0	3	0.06	0.20
	Shortage of water	6	22	15	0.20	1	1	21	0.10	2	2	0	0.19	0.16
	Diseases	44	15	3	0.42	37	5	0	0.48	4	2	1	0.31	0.40
	Predators	0	0	0	0.00	1	0	1	0.02	1	2	0	0.13	0.05
	Lack of improved breed	3	1	1	0.03	0	0	1	0.00	0	0	2	0.04	0.02
	Long dry season	0	1	16	0.05	2	10	1	0.11	1	3	2	0.20	0.12
	Shortage of capital	2	2	6	0.04	0	1	8	0.04	1	0	1	0.07	0.05
Goats														
	Shortage of feed	3	4	0	0.40	15	18	8	0.30	8	8	0	0.23	0.31
	Shortage of water	0	1	1	0.06	7	1	31	0.18	5	0	10	0.14	0.13
	Diseases	4	1	1	0.40	23	27	0	0.42	9	1	12	0.23	0.35
	Predators	0	0	0	0.00	2	0	2	0.02	4	1	0	0.08	0.03
	Lack of improved breed	0	0	5	0.11	0	0	0	0.00	2	0	0	0.03	0.05
	Long dry season	0	0	0	0.00	0	3	7	0.04	0	17	0	0.19	0.08
	Shortage of capital	0	1	0	0.04	2	0	0	0.01	2	3	5	0.10	0.05

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular constraints divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all constraints.

The age-wise and season-wise mortality pattern in small ruminants during the period of the last 12

months (2014) is presented in Table 9. The results showed that respondents reported that mortality among young stock (0-6 months of age) was higher in all AEZs for both species. The overall percent of respondent reporting this were 10.4 (less than 03 months), 5.6 (3-6 months) for sheep and 9.4 (less than 03 months) and 7.2 (3-6 months) for goat in the present study. This was in agreement with Sharif *et al.* (2005) and Girma *et al.* (2013) who reported that kids were at higher risk of dying. The present results showed that young stock was exposed to high mortality and possible reasons may be paucity of energy in neonates (this deficient energy together with their weak immunological status exposes them to infections). Thus management intervention in terms of protection from cold / windy climate, incessant rains and feeding needed to be developed for both species. Gameda *et al.* (2002) indicated that prepartum supplementation of breeding ewes, preferential treatment of maiden ewes and providing preferential treatment of ewes lambing may partially solve lamb mortality problem. Perusal of table 9 further showed that respondents reported that higher mortality occurred during winter (Dec. – Feb.) in sheep for all AEZs and goat in HL area only. However, summer (June - August) season was reported to be period of higher mortality in goats in ML and LL AEZs. The later finding was in disagreement with Sharif *et al.* (2005) and Girma *et al.* (2013) who reported pre weaning kids frequently died in winter season. However, FGD responded that there were massive attacks of fox on young stock and hyena / other wild animals on adult flock. This finding was in agreement with Tsedeke (2007) in Alaba southern Ethiopia; Assen and Aklilu (2012) in different agro-ecological zones in Tigray and Solomon *et al.* (2014) in Amhara National Regional State of Ethiopia.

Table 9. Age-wise and season-wise mortality pattern in small ruminants during the period of the last 12 months (2014) (in %)

	HL	ML	LL	Overall
Sheep:				
Age groups:				
Lambs (less than 3 months)	3.9	5.4	1.1	10.4
Lambs (3 to 6 months)	3.3	1.7	0.6	5.6
Adult Ewes (> 1 year)	1.7	1.1	0.0	2.8
Adult Rams (> 1 year)	1.7	0.6	0.0	2.2
Castrates	1.1	0.6	0.0	1.7
(b) Season:				
Winter (Dec. – Feb.)	4.4	3.3	1.1	8.9
Summer (June - August)	3.3	1.7	0.0	5.0
Autumn (September – Nov.)	2.2	2.2	0.0	4.4
Spring (March - May)	1.7	2.2	0.6	4.3
Goat:				
Age groups:				
Kids (less than 3 months)	0.0	6.1	3.3	9.4
Kids (3 to 6 months)	1.1	3.9	2.2	7.2
Adult Does (> 1 year)	0.0	5.0	0.6	5.6
Adult Bucks (> 1 year)	0.6	3.3	1.1	5.0
Castrates	0.6	1.7	0.6	2.8
Season:				
Winter (Dec. – Feb.)	1.1	3.8	2.8	7.7
Summer (June - August)	1.1	11.7	3.3	16.1
Autumn (September – Nov.)	0.0	1.7	1.1	2.8
Spring (March - May)	0.0	2.8	0.6	3.4

The results in Table 8 showed that shortage of water was ranked as third constraint followed by long dry season as a fourth constraint for sheep and goat production. Accordingly distance covered during dry season in search of water, as reported by respondents, is presented in table 10. The results showed that good proportion (8.9, 9.4 and 10.0 % in HL, ML and LL, respectively) of respondents reported that a distance of 3-5 km was covered in search of water during dry season. The other distances covered in search of water were either < 1 km (14.4, 13.3 and 2.2 % in HL, ML and LL, respectively) or 1-2 km (13.3, 15.0 and 4.4 % in HL, ML and LL, respectively). The current study agreed with earlier workers (Tsedeke, 2007 and Mesay *et al.*, 2013). The FGD revealed that during dry season water in some of the rivers dries up and thus not only animals but even human beings spent their time to search water, especially in LL areas.

Table 10. Distance covered during search of water in dry season in three AEZs

Distance	HL (%)	ML (%)	LL (%)
Watered at home	1.7	3.3	3.9
<1km	14.4	13.3	2.2
1-2km	13.3	15.0	4.4
3-5km	8.9	9.4	10.0
Total	38.3	41.1	20.6

Opportunities in small ruminant rearing

The respondents listed four main reasons for small ruminant rearing (Table 11) and these were, viz: low start-up cost, multispecies grazing, increase in mutton / chevon demand and minimal labour requirements. The order of their importance in HL and LL was low start-up cost, multispecies grazing, increase in mutton / chevon demand and minimal labour requirements whereas it was multispecies grazing, low start up cost, increase in mutton / chevon demand and minimal labour requirements in ML AEZ. The earlier study of Okpebholo (2007) also showed that low start-up cost as an important factor in providing opportunity for the development of a small ruminant production system by a small-scale farmer with limited resources. The multispecies grazing, as found in present study, agreed with the reports of Arse *et al.* (2013) in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State, Ethiopia. Similarly, increase mutton /chevon demand, as found in present study, was in agreement with finding reported by Solomon *et al.* (2010) indicating that sheep and goat breeds in the lowlands of the country were in good demand in the middle east markets.

Table 11. Opportunities of sheep and goat breeding (in %) in three AEZs.

Particulars	HL (N=69)	ML (N= 74)	LL (N=37)	Overall (%)
Low start up cost	13.9	15.0	9.0	38.3
Multispecies grazing	12.2	16.1	5.0	33.3
Meat demand increase	7.2	6.1	3.3	16.7
Minimal labour requirements	5.0	3.9	2.8	11.7

Gender-wise labour allocation (percentage) in small ruminant rearing

The gender-wise labour allocation in small ruminant rearing (Table 12), as reported by respondents, showed that hired labour was engaged by small proportion (< 12 %) of respondents and thus labour

provided by family members was mainly responsible for small ruminant rearing. Among family members, as per respondent interviews, all members including men, women, boys and girls, participated in various management activities in varying proportions. The men were involved in buying (68.9 %), selling (66.6 %) and attending sick animals (58.3 %). The women were involved in cleaning flock barn (35.6 %), attending sick animal (23.9 %) and buying / selling (20.6 %). Similarly boys and girls participated in flock herding (65.6, 19.4 % for boys and girls, respectively), cleaning flock barn (9.4 and 51.7 %, for boys and girls, respectively) and feeding / watering (60.0 & 19.4 % for boys and girls, respectively). The present results were in agreement with Tsedeke (2007) and Zawudu *et al.* (2012) in western and south-western Ethiopia.

Table 12. Gender-wise labour allocation in small ruminant rearing (%)

Tasks	Home labour				Hired labour	Total
	Men	Women	Boys	Girls		
Flock herding	3.3	0.6	65.6	19.4	11.11	100.0
Buying	68.9	20.6	6.7	3.3	0.6	100.0
Selling	66.6	20.6	7.2	3.9	0.0	100.0
Attending sick animals	58.3	23.9	11.1	4.4	2.2	100.0
Cleaning flock barn	2.2	35.6	9.4	51.7	1.1	100.0
Feeding and watering	3.3	6.2	60.0	19.4	11.1	100.0

Summary and recommendations

This study was conducted in Ada Barga and Ejere districts of west Shoa Zone of Oromia Regional State of Ethiopia to investigate central highland sheep and goat marketing system, Opportunities and constraints of small ruminant rearing in these areas. The results showed that majority of respondents sell small ruminants aged 06 months – 01 year and adult (> 01 year) in both sexes (Male and female) across all the three AEZs. The respondents sold their small ruminants to farmers (42.80 %), small traders (22.2 %), large traders (13.90 %), hotels (11.1 %) and general consumer (10.0). The study showed that disease was ranked as first constraint for both species in all three agro ecologies. Feed shortage, water shortage, long dry season were ranked either second, third or vice versa for both species in the three AEZs. However lack of improved breeds as a constraint was identified by respondents as number two in case of goats in HL area. The opportunities were listed as low start up cost, multispecies grazing, increase in mutton / chevon demand and minimal labor requirements in decreasing order of their importance in HL and LL whereas it was multispecies grazing, low start up cost, increase in mutton / chevon demand and minimal labor requirements in ML AEZ.

Acknowledgement

The authors are thankful to Jimma University, Ethiopia and the Livestock and Irrigation Value-chain for Ethiopian Smallholders (LIVES) project of the International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia, for supporting this study.

References

- Abegaz, S., 2002. Genetic evaluation of production, reproduction and survival in a flock of Ethiopian Horro sheep. PhD thesis, University of the Free State, South Africa.

PROCEEDING

Animal Breeding and Reproduction

- Alubel Alemu, 2015. On-farm Phenotypic Characterization and Performance Evaluation of Abergelle and Central highland goat breeds as an input for designing community-based breeding program. Accept for award of M.Sc (Animal Genetic and breeding), Haramaya University, Haramaya, Ethiopia, 2014 pp 147
- Arse Gebeyehu, Feyisa Hundessa, Gurmessa Umata, Merga Muleta and Girma Debele, 2013. Assessment on challenges and opportunities of goat farming system in Adami Tulu, Arsi Negelle and Fantale districts of Oromia Regional State, Ethiopia. *Afr. J. Agric. Res.* 8(1):26-31
- Arsham, H., 2002. Descriptive Sampling Data Analysis. Statistical Thinking for Managerial Decision Making. <http://ubmail.ubalt.edu/harsham/Business-stat/opre504.htm#rwhyrssm>
- Assen Ebrahim and Aklilu Hailemichael, 2012 sheep and goat production and utilization in different agro-ecological zones in Tigray, Ethiopia. *Livestock Research For Rural Development* 24 (1) 2012.
- Behnke, R., 2010. The Contribution of Livestock to the Economies of IGAD Member States: Study Findings, Application of the Methodology in Ethiopia and Recommendations for Further Work, IGAD LPI Working Paper 02-10. Odessa Centre, IGAD Livestock Policy Initiative, Great Wolford, UK
- Belete Shenkute., 2009. Production and marketing systems of small ruminants in Gomma district of Jimma zone, western Ethiopia. M.Sc. Thesis. Hawasa University, April, 2009, Awassa, Ethiopia. Pp 38-54.
- Berhanu Gebremedhin, Dirk Hoekstra, Azage Tegegne, Kaleb Shiferaw and Aklilu Bogale, 2015. Factors determining household market participation in small ruminant production in the highlands of Ethiopia. *Lives working paper* 31 (2)
- CSA, 2013. Ethiopian agricultural sample enumeration 2012/2013. Central Statistic Authority, Federal Democratic Republic of Ethiopia. Volume II. Report on livestock and livestock characteristics (private peasant holdings).
- Dereje T., 2011. Community based characterization of Hararghe high land goats in Daro-Labu district Western Hararghe, An MSc Thesis presented to the school of Graduate studies of Jimma University. Jimma, Ethiopia.
- Ehui S.K., Benin S. and Nega Gebreselassie, 2000. Factors affecting urban demand for live sheep: The case of Addis Ababa, Ethiopia. Socio-economic and Policy Research Working Paper 31. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp 32
- Fсахатсион Hailemariam, AberraMelesse and Sandip Banerjee, 2013. Traditional sheep production and breeding practice in Gamo gofa Zone, Southern Ethiopia *International Journal of Livestock Production Research* Vol. 1, No. 3, Pp43.
- G. Duguma, K. Degefa, T. Jembere, W. Temesgen, A. Haile and G. Legese, 2012. Value chain analysis of sheep in Horro district of Oromia Region, Ethiopia. www.africarising.net
- Galal, E.S.E., 1983. Sheep germplasm in Ethiopia. *Animal Genetic Resources Information Bulletin*, 1/83:4 – 12.
- Gemeda D. (2010). Participatory definition of breeding objectives and implementation of community based sheepbreeding programs in Ethiopia, PhD Thesis, University of Natural Resources and Life Sciences, Vienna, Austria.
- Gemeda D., Degefa K., Jembere T., Temesgen W., Haile A., Duncan, A.J. and Legese G., 2013. Value chain analysis of sheep in Horro district of Oromia Region, Ethiopia, Addis Ababa: ICARDA. <http://hdl.handle.net/10568/35373>
- Gemeda, D., Kifle, D., Temesgen, J., Worku, T., Aynalem, H. and Getachew, L., 2012. Value chain analysis of sheep in Horro district of Oromia region, Ethiopia. www.africasing.net.
- Gemeda, D., Schoeman, S.J., Cloete, S.W.P. and Jordan, G.F., 2002. The effect of non-genetic factors on pre weaning survival rate in the Tygerhock Merino lambs. *Eth. J. Anim. Prod* (2):115-125.
- Girma Debele, Mieso guru, Feyisa Hundessa and Misgana Duguma, 2013. Assessment of farmers' management practices and factors affecting goats' production system in Adami Tulu Jido kombolcha district of east Shoa zone, Ethiopia. *Agri. and bio. J. of N. Americ.* 4 (5):20.526
- Mesay Yami, Bedada Begna and Teklemedihin Teklewold, 2013. Enhancing the productivity of livestock production in highland of Ethiopia: Implication for improved on-farm feeding strategies and utilization, Ethiopian Institute of Agricultural Research (EIAR), Assela, Ethiopia.
- Metaferia F, Cherenet T, Gelan A, Abnet F, Tesfaye A, Ali JA, Gulilat W, 2011. A Review to Improve Estimation

of Livestock Contribution to the National GDP. Ministry of Finance and Economic Development and Ministry of Agriculture, Addis Ababa, Ethiopia

- MOA (Ministry of Agriculture), 2000. *Agro ecological Zonation of Ethiopia*. Addis Ababa, Ethiopia.
- Negassa, A. and Jabar, M., 2008. *Livestock ownership, commercial off-take rates and their determinants in Ethiopia*. Research Report N° 9. ILRI (International Livestock Research Institute), Nairobi, Kenya. 52pp.
- Okpebholo Fidelis and Tyrell Kahan, 2007. *Opportunities and Challenges for Developing Small Ruminant Systems*. Cooperative Extension Program, College of Engineering Sciences, Technology and Agriculture, Florida A&M University, Tallahassee, Florida the *Caprine Chronicle*, Volume 22, Issue 4.
- Sharif L, and Obiedat J., 2005. Risk factors for lamb and kid mortality in sheep and goat farms in Jordan. *Bulgarian journal of veterinary medicine*.
- Sölkner, J., Nakimbugwe, H., Zarate, A.V., 1998. Analysis of determinants for success and failure of village breeding programs. 6th WCGALP, 11–16 January 1998, Armidale, NSW, Australia. 25:273 - 280.
- Solomon Abegaz, 2014. *Design of community based breeding programs for two indigenous goat breeds of Ethiopia*. Doctoral Thesis, January 2014 Vienna, Austria.
- Solomon Gizaw, Azage Tegegne, Berhanu Gebremedhin and Dirk Hoekstra, 2010. *Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement*. Working Paper No. 23
- Solomon Gizaw, Tesfaye Getachew, Zewdu Edea, Tadele Mirkena, Gemedo Duguma, Markos Tibbo, Barbara Rischkowsky, Okeyo Mwai, Tadelle Dessie, Maria Wurzinger, Johann Sölkner, and Aynalem Haile, 2013. *Characterization of indigenous breeding strategies of the sheep farming communities of Ethiopia*
- SPSS Version, 20.0 (2013). *Software Package for Social Sciences for Window*.
- Terfa, Aynalem, H., Baker, D., and Girma D, T., 2012 *sheep market participation of rural household in western Ethiopia*. *African J.agri.res.* 7(10):1504-1511
- Tsedeke K. 2007. *Production and marketing of sheep and goats in Alaba, SNNPR*. Msc thesis. Hawasa University. Hawasa, Ethiopia.
- Wilson, D.E. and Morrical, D.G., 1991. The national sheep improvement program: A review. *J. Anim. Sci.* 69:3872 – 3881.
- Yadeta Neme, Manzoor Ahmed Kirmani and Gemedo Duguma. 2016a. *Small Ruminant Production Systems in Ada Barga and Ejere Districts of West Shoa Zone, Oromia, Ethiopia*. 24th ESAP (accepted)
- Yenesew Abebe, 2010. *Assessment of small ruminant production systems and on-farm evaluation of urea treated wheat straw and concentrate feeding on sheep body weight change in Burie woreda, west Gojjam*. MSc. thesis. 2010 Haramaya University. Haramaya.
- Yenesew Abebe, Solomon Melaku and Azage Tegegne, 2013. *Assessment of sheep marketing system in Burie district, North Western Ethiopia*. *Wudpecker Journal of Agricultural Research* 2(3): 97 – 102.
- Zewudu Edea, A Haile, M Tibbo, A K Sharma, J Sölkner and M Wurzinger, 2012. *Sheep production systems and breeding practices of smallholders in western and south-western Ethiopia: Implications for designing community-based breeding strategies*. *Livestock Research for Rural Development* 24 (7).

Zika Virus Disease, Its Implication on Animals (Pets and other farm Animals)

Alemayehu Worku

Arba Minch University, College of Agricultural Sciences, Department of Animal and Range Science. P. O.Box21

Abstract

This review was conducted with the objective of assessing the status of zika virus disease and its association with Animals. Rapid survey results and conference papers were reviewed to address the core issues (Background, objectives, findings and conclusion) of this study. Zika Virus infection was first discovered in 1947 and is named after the Zika forest in Uganda. In 1952, the first human cases of Zika were detected and since then, outbreaks of Zika have been reported in tropical Africa, Southeast Asia, and the Pacific Islands. Zika virus disease (Zika) is a disease caused by Zika virus that is spread to people primarily through the bite of an infected *Aedes* species mosquito. The most common symptoms of Zika are fever, rash, joint pain, and conjunctivitis (red eyes). The illness is usually mild with symptoms lasting for several days to a week after being bitten by an infected mosquito. The incubation period ranges between approximately three to 12 days after the bite of an infected mosquito. Most of the infections remain asymptomatic (approximately 80%). Disease symptoms are usually mild and the disease is usually characterized by a short-lasting self-limiting febrile illness of 4–7 days duration without severe complications, with no associated fatalities and a low hospitalization rate. Even though the most common form of Zika transmission is through mosquito bites, but the virus has been isolated in semen, and cases of sexual transmission have been observed. On the other hand there is growing evidence on the possibilities that the virus transmission from mother to child even though research is currently under way on possible mother-to-child transmission of the virus and its effects on babies. But very recently, a link (still unproven) between infection of pregnant women and birth defects (babies born with small heads and brains (microcephaly)) has been reported, predominantly in Brazil. So far a lot of questions have been raised about Zika virus and animals, however until today except animals anyone not previously exposed to the virus and who lives in an area where the mosquito is present may be infected with the virus. To answer the question can animals get infected with Zika virus? It depends on what you include in “animals.” we could be technical and say that humans are animals. Beyond that, non-human primates are susceptible. Again, we need to think about the question. Infected means they get exposed to the virus and it replicates in the body. That may occur, but there is no any evidence of it at this point. The more relevant question is whether animals can get sick from Zika virus exposure, and there’s also no evidence of that to date. A third aspect is whether infected (but potentially healthy) animals could be a reservoir for the virus, being able to pass it on to mosquitoes. There’s no evidence of that, either. So, the clearest answer is probably “maybe”.

Key words: *aedes* mosquito, animals, primates, zika

Introduction

Zika virus disease (Zika) is a disease caused by Zika virus that is spread to people primarily through the bite of an infected *Aedes* species mosquito. The most common symptoms of Zika are fever, rash, joint pain, and conjunctivitis (red eyes). The illness is usually mild with symptoms lasting for several days to a week after being bitten by an infected mosquito. People usually don't get sick enough to go to the hospital, and they very rarely die of Zika. For this reason, many people might not realize they have been infected. Once a person has been infected, he or she is likely to be protected from future infections (CDC, 2016).



Figure 1. *Aedes*
Mosquito

Zika virus was first discovered in 1947 and is named after the Zika forest in Uganda. In 1952, the first human cases of Zika were detected and since then, outbreaks of Zika have been reported in tropical Africa, Southeast Asia, and the Pacific Islands. Zika outbreaks have probably occurred in many locations. Before 2007, at least 14 cases of Zika had been documented, although other cases were likely to have occurred and were not reported. Because the symptoms of Zika are similar to those of many other diseases, many cases may not have been recognized (CDC, 2016).

In May 2015, the Pan American Health Organization (PAHO) issued an alert regarding the first confirmed Zika virus infection in Brazil and on Feb 1, 2016, the World Health Organization (WHO) declared Zika virus a public health emergency of international concern (PHEIC). Local transmission has been reported in many other countries and territories. Zika virus likely will continue to spread to new areas (CDC, 2016).

From February 2014 to 17 January 2016, there are 18 countries and territories in the Americas that have confirmed autochthonous circulation of Zika virus (ZIKV) in 2015 and 2016: Brazil, Barbados, Colombia, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Haiti, Honduras, Martinique, Mexico, Panama, Paraguay, Puerto Rico, Saint Martin, Suriname, and Venezuela. Between November 2015 and January 2016, local transmission of the virus was detected in 14 new countries and territories (WHO, 2015).

Zika, a flavivirus transmitted mainly by mosquitos in the genus *Aedes*, was discovered in 1947 in Uganda. From the 1960s to 1980s, human infections were found across Africa and Asia, typically accompanied by mild illness. The first large outbreak of disease caused by Zika infection was reported from the Island of Yap (Federated States of Micronesia) in 2007, as the virus moved from south-east Asia across the Pacific. During a 2013-14 outbreak in French Polynesia, the neurological disorder Guillain-Barre syndrome was linked to Zika infection. In South America, the first reports of locally transmitted infection came from Brazil in May 2015. In July 2015 Brazil reported an association between Zika virus infection and GBS. In October 2015 Brazil reported an association between Zika virus infection and microcephaly. For neither event was a causal link proven (WHO, 2015).

In February 2016, as infection moved rapidly through the range occupied by *Aedes* mosquitos in the Americas, WHO declared that Zika infection associated with microcephaly and other neurological disorders constitutes a Public Health Emergency of International Concern (PHEIC). By the start of February 2016, local transmission of Zika infection had been reported from more than 20 countries

and territories in the Americas, and an outbreak numbering thousands of cases was under way in Cabo Verde, western Africa. Beyond the range of mosquito vectors, Zika virus infections are expected to be carried worldwide by international travel (WHO, 2015).

Zika is spread by the *Aedes* genus of mosquito, which transmits the disease when it bites a person, infected with Zika, then bites another host. The two most common mosquitoes to transmit the disease are the *Aedes aegypti* and *Aedes albopictus* species. Both are invasive species with worldwide distributions, including in the American south and south-west. It is believed that *Aedes albopictus*, also called the Asian tiger mosquito, was imported to the United States in the mid-1980s in used tires from Asia.

Usually, Zika's symptoms include fever, red and bumpy rash, joint pain and pink eye. Hospitalization rates are low and the [World Health Organization](#) said no deaths have been reported from Zika. However, a "high rate" of patients with Zika have no symptoms at all, according to the WHO. This is concerning to virologists, who believe that Zika could easily establish a foothold in the southern United States and other areas with tropical climates because people may not know they are infected.

Objective

To assess on status Zika virus infection, and its association with animals

Methodology

Different research outputs, rapid survey results and conference papers were reviewed to address the core issues (Background, objectives, findings and conclusion) of this study.

Findings/Literature Review

What is Zika virus infection?

Zika virus infection is caused by the bite of an infected *Aedes* mosquito, usually causing rash, mild fever, conjunctivitis, and muscle pain. The virus was isolated for the first time in 1947 in the Zika forest in Uganda. Since then, it has remained mainly in Africa, with small and sporadic outbreaks in Asia. In 2007, a major epidemic was reported on the island of Yap (Micronesia), where nearly 75% of the population was infected. On 3 March 2014, Chile notified PAHO/WHO of autochthonous transmission of Zika virus on Easter Island, where the virus continued to be detected until June 2014. In May 2015, the public health authorities of Brazil confirmed the transmission of Zika virus in the country's northeast. Since October 2015, other countries and territories of the Americas have reported the presence of the virus (WHO, 2016).

What are the symptoms?

The most common symptoms of Zika virus infection are exanthema (skin rash) and mild fever, usually accompanied by conjunctivitis, muscle or joint pain, and general malaise that begins 2-7 days after the bite of an infected mosquito. One out of four infected people develops symptoms of the disease.



Figure 2. Skin rash and red eyes

Among those who do, the disease is usually mild and can last 2-7 days. Symptoms are similar to those

of dengue or chikungunya, which are transmitted by the same type of mosquito.

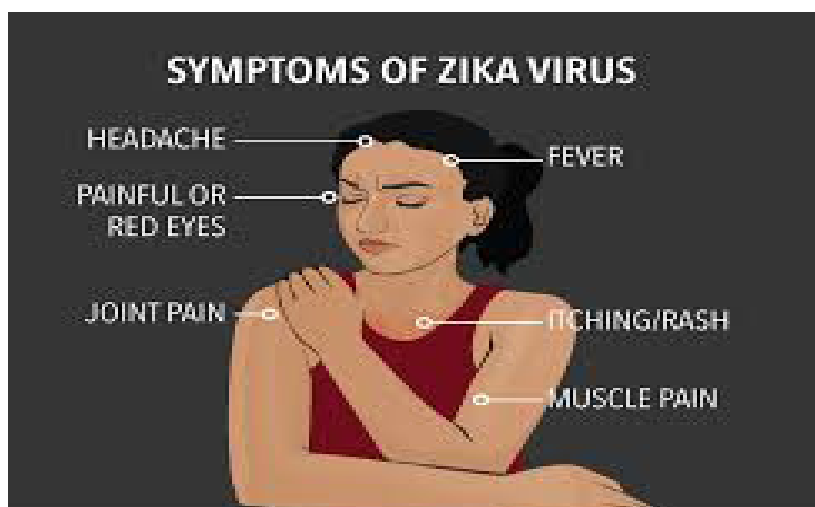


Figure 3. *Symptoms of zika virus*

Neurological and autoimmune complications are infrequent, but have been described in the outbreaks in Polynesia and, more recently, in Brazil. As the virus spreads in the Americas, giving us more experience with its symptoms and complications, it will be possible to characterize the disease better (WHO, 2016).

How is Zika virus transmitted?

Zika virus is transmitted to people through the bite of an infected *Aedes* mosquito. This is the same mosquito that transmits dengue and chikungunya. Recently other, though less common, modes of transmission have been observed. Zika virus disease is a mosquito-borne disease caused by Zika virus which causes in general a mild febrile illness with maculo-papular rash. *Aedes* mosquitoes are considered as main vectors. Before 2007, viral circulation and a few outbreaks were documented in tropical Africa and in some areas in Southeast Asia. Since 2007, several islands of the Pacific region have experienced outbreaks (WHO, 2016).

In 2015, Zika virus disease outbreaks were reported in South America for the first time. Zika virus disease is now considered as an emerging infectious disease. A significant increase of patients with Guillain–Barré syndrome (GBS) was reported during the 2014 outbreak in French Polynesia and the Americas since 2015. A similar increase along with an unusual increase of congenital microcephaly was observed in some regions in north eastern Brazil in 2015. Causal relationships are currently under investigation. There is no prophylaxis, treatment or vaccine to protect against Zika virus infection. Therefore, preventive personal measures are recommended to avoid mosquito bites during the daytime (WHO, 2016).

The pathogen

Zika virus disease is caused by a virus from the *Flavivirus* genus, *Flaviviridae* family, from the Spondweni group. It was first isolated in 1947 from a monkey in the Zika forest, Uganda, then in mosquitoes (*Aedes africanus*) in the same forest in 1948, and in a human in Nigeria in 1952. There are two Zika virus lineages: the African lineage and the Asian lineage which has recently emerged in the Pacific and the Americas (Hayes, 2009 and Fayó *et al*; 2014).

Clinical features and Sequel

The incubation period ranges between approximately three to 12 days after the bite of an infected mosquito. Most of the infections remain asymptomatic (approximately 80%). Disease symptoms are usually mild and the disease is usually characterised by a short-lasting self-limiting febrile illness of 4–7

days duration without severe complications, with no associated fatalities and a low hospitalization rate. The main symptoms are maculopapular rash, fever, arthralgia, fatigue, non-purulent conjunctivitis/conjunctival hyperaemia, myalgia and headache. The maculopapular rash often starts on the face and then spreads throughout the body. Less frequently, retro-orbital pain and gastro-intestinal signs are present (ECDC, 2016).

Congenital central nervous system malformations such as microcephaly in fetuses and newborns from mothers possibly exposed to Zika virus during pregnancy were notified during recent Zika disease outbreaks (French Polynesia and Brazil). Unusual increases of Guillain–Barré syndrome were reported in several countries in the Americas and French Polynesia coinciding with the Zika virus outbreak. Further evidence is needed to establish a causal link between Zika virus infection and these neurological/neurodevelopmental impairments or auto-immune conditions (ECDC, 2016).

Epidemiology

Serological surveys in Africa and Asia indicate a most likely silent Zika virus circulation with detection of specific antibodies in various animal species (large mammals such as orangutans, zebra, elephants, water buffaloes) and rodents. The knowledge of geographical distribution of Zika virus is based on results of serosurveys and viral isolation in mosquitoes and humans, and with reports of travel-associated cases. Before 2007, the areas with reported Zika virus circulation included tropical Africa and Southeast Asia. Very few outbreaks were documented prior to 2007. An outbreak was reported on Yap Island, Federated States of Micronesia from April to July 2007 (Duffy *et al*; 2009). This was the first outbreak of Zika virus identified outside of Africa and Asia. Between 2013 and 2015, several significant outbreaks were notified on islands and archipelagos from the Pacific region including a large outbreak in French Polynesia. In 2015, Zika virus emerged in South America with further spread across the Americas (Hayes *et al*; 2009, Cristiane *et al*; 2015 and Musso *et al*; 2014).

Transmission

Zika virus is transmitted by mosquitoes. It has been isolated from *Aedes aegypti* mosquitoes and experimental infections show that this species is capable of transmitting Zika virus. Other *Aedes* mosquito species (notably *Ae. africanus*, *Ae. albopictus*, *Ae. polynesiensis*, *Ae. unilineatus*, *Ae. vittatus* and *Ae. hensilli*) are considered as potential vectors of Zika virus. These species bite during the day. Additional modes of transmission have been identified. Perinatal transmission can occur most probably by trans-placental transmission or during delivery when the mother is infected. Sexual transmission was reported in a few instances. There is a potential risk of Zika virus transmission from a blood transfusion. More information on mosquitoes can be found here: *Aedes albopictus* and *Aedes aegypti* (Diallo *et al*; 2014, Li *et al*; 2012 and Wong *et al*; 2013)

Diagnostics

Zika virus disease diagnostics is primarily based on detection of viral RNA from clinical specimens in acutely ill patients. The viraemic period appears to be short, allowing for direct virus detection during the first 3–5 days after the onset of symptoms. Zika virus RNA has been detected in urine up to 10 days after onset of the disease. From day five post onset of disease, serological investigations can be conducted by detection of Zika-specific IgM antibodies and confirmation by neutralisation, seroconversion or four-fold antibody titer increase of Zika specific antibodies in paired serum samples. Serological results should be interpreted according to the vaccination status and previous exposure to other flaviviral infections (ECDC, 2016)

Case management and treatment

There is no vaccine or specific prophylactic treatment. Differential clinical diagnostic should be considered as well as co-infection with other mosquito-borne diseases such as dengue fever, chikungunya and malaria. The treatment is symptomatic and mainly based on pain relief, fever

reduction and anti-histamines for pruritic rash. Treatment with acetylsalicylic acid and no-steroidal anti-inflammatory drugs was discouraged because of a potential increased risk of haemorrhagic syndrome reported with other flaviviruses as well as the risk of Reye's syndrome after viral infection in children and teenagers (ECDC, 2016)

Public Health Control Measures

No vaccine or prophylactic treatment is available. Integrated vector management aiming to reduce mosquito vector density in a sustainable manner is of primary importance. Intersectoral collaboration and efficient public communication strategies to ensure community participation are required for sustainable vector control program. Activities supporting the reduction of mosquito breeding sites in outdoor/indoor areas by draining or discarding sources of standing water at the community level include removal of all open containers with stagnant water in and surrounding houses on a regular basis (flower plates and pots, used tyres, tree-holes and rock pools), or, if that is not possible, treatment with larvicides), tight coverage of water containers, barrels, wells and water storage tanks, wide use of window/door screens by the population. During an outbreak elimination of adult mosquitoes through aerial spraying with insecticides can be considered. More information on mosquitoes can be found here: *Aedes albopictus* and *Aedes aegypti* (ECDC, 2016).

Infection Control, Personal protection and prevention

Prevention is also based on protection against mosquito bites. *Aedes* mosquitoes bite during the daytime both indoors and outdoors. Therefore personal protection measures should be applied during the day. Personal protection measures to avoid mosquito bites should be applied when in risk areas by using appropriate mosquito repellents and wearing long-sleeved shirts and long trousers especially during the hours of highest mosquito activity, sleeping or resting in screened or air-conditioned rooms, otherwise use insecticidal treated mosquito nets, even during the day, removing mosquito breeding sites in close outdoor/indoor premises (ECDC, 2016)

Use mosquito repellent in accordance with the instructions indicated on the product label. Travellers with immune disorders or severe chronic illnesses should consult their doctor or seek advice from a travel clinic before travelling, particularly on effective prevention measures. Similar protective measures apply to a symptomatic patient in order to prevent transmitting the disease to non-infected mosquitoes. More information on mosquitoes can be found here: *Aedes albopictus* and *Aedes aegypti* (ECDC, 2016)

Some cross cutting Questions associated with Zika Virus Infection

Can Zika virus be transmitted through donated blood?

Currently there is limited knowledge of Zika virus and the ways it can be transmitted. However, the following suggest it may present a risk to blood safety: The virus has been detected in blood donors in areas where Zika is circulating. Transmission of related viruses (dengue, chikungunya and West Nile virus) by blood transfusion has been documented, and thus transmission of Zika virus is possible (WHO, 2016).

Brazilian health authorities have reported 2 cases of possible transmission of the virus by blood transfusion. Studies are needed to assess the prevalence of the virus and of transmission through blood transfusion and blood products to better understand the risk Zika presents. What precautions should be taken to ensure that the blood supply is safe in countries where Zika infection is occurring?

Specific measures recommended preventing Zika infection should be part of an overall blood strategy based on the guidelines in PAHO's Plan of Action for Universal Access to Safe Blood 2014-2019 for strengthening national blood programs. These guidelines recommend:

Organizing blood services well and concentrating processes

Implementing quality management programs throughout the transfusion chain and ensuring Good Manufacturing Practices; Ensuring that blood donation is voluntary, repeated, and from low-risk populations, and eliminating mandatory replacement donation; Ensuring the appropriate use of blood and blood products; Providing continuous training for blood services staff and blood products users, Providing health surveillance, hemovigilance, and risk management (WHO, 2016).

Ideally the blood supply during a regional outbreak of Zika should be maintained by increasing blood collections in non-affected areas. In non-affected areas, consideration may be given to deferring potential donors who have recently visited areas with ongoing transmission of Zika virus infection for 28 days after their departure from these areas (WHO, 2016)..

Can it be transmitted through sexual contact?

The most common form of Zika transmission is through mosquito bites, but the virus has been isolated in semen, and cases of sexual transmission have been observed. Currently the available evidence is being analyzed to better understand the public health impact of sexual transmission of Zika. The IHR Emergency Committee on Zika virus, at its meeting March 8, 2016, said, that pregnant women should be advised not travel to areas of ongoing Zika virus outbreaks; pregnant women whose sexual partners live in or travel to areas with Zika virus outbreaks should ensure safe sexual practices or abstain from sex for the duration of their pregnancy (WHO,2016).

What can be done to prevent sexual transmission?

All patients (male and female) with Zika virus infection and their sexual partners' (particularly pregnant women) should receive information about the potential risks of sexual transmission of Zika virus, contraceptive measures and safer sexual practices, and should be provided with condoms when feasible. Women who have had unprotected sex and do not wish to become pregnant because of concern with infection with Zika virus should also have ready access to emergency contraceptive services. Sexual partners of pregnant women, living in or returning from areas where local transmission of Zika virus is known to occur, should use safer sexual practices or abstinence from sexual activity for the duration of the pregnancy (WHO, 2016).

Can it be transmitted from mother to child?

There is growing evidence that this type of transmission is possible. Research is currently under way on possible mother-to-child transmission of the virus and its effects on babies. Pregnant women in general, and particularly those who develop symptoms of Zika virus infection, should be closely monitored by health providers (WHO, 2016).

What treatment is there?

Treatment consists of relieving pain, fever, and any other symptom that inconveniences the patient. To prevent dehydration, it is recommended to control the fever, rest, and drink plenty of water. There is no vaccine or specific drug for this virus (WHO, 2016).

Can it cause death?

Zika is a new virus for the Region of the Americas. In the past, it had very limited geographical and demographic distribution, and there was no evidence that it caused death. However, in the current outbreak, sporadic cases have been reported of more serious manifestations and complications that have sometimes resulted in death (WHO, 2016).

Who is at risk of Zika infection?

Anyone not previously exposed to the virus and who lives in an area where the mosquito is present, and where imported or local cases have been reported, may be infected. Since the Aedes mosquito is

found throughout the Region (except in continental Chile and Canada), it is likely that outbreaks will occur in other countries that have not yet reported any cases (WHO, 2016).

How is Zika diagnosed?

Diagnosis is based on clinical symptoms and epidemiological circumstances (such as Zika outbreak in the patient's area or trips to areas where the virus is circulating). Blood tests can help to confirm the diagnosis. Some (virological PCR tests) are useful in the first 3-5 days after the onset of symptoms, while others (serological tests) detect the presence of antibodies but are useful only after five days. Once it has been demonstrated that the virus is present in a given area or territory, confirmation of all cases is not necessary, and laboratory testing will be adjusted to routine virological surveillance of the disease (WHO, 2016).

Can people with Zika pass the illness to others?

Zika needs a vector (a means of transportation) to infect people; generally, that vector is the mosquito. However, Zika virus has been found in semen and person-to-person sexual transmission has been documented. Travelers to an area with Zika should continue to take steps to prevent mosquito bites for 3 weeks after they leave the Zika-affected area to avoid spreading the virus, even if they do not feel sick. Only one in five infected people develop symptoms. Zika virus can be found in the blood of an infected traveler and passed to another mosquito through mosquito bites. An infected mosquito can then spread the virus to other people (WHO, 2016).

Zika virus and Animals

A lot of questions have been raised about Zika virus and animals. It's great to see that people are thinking more broadly about infectious diseases (but it isn't doing much for my productivity this week). To recap, Zika virus is a mosquito-borne virus related to West Nile virus and dengue virus. Most people that are infected don't get sick at all, and when they do, they usually get only mild signs of illness that resolve on their own. In the past few years, Zika virus has emerged in the Americas, particularly Brazil. Very recently, a link (still unproven) between infection of pregnant women and birth defects (babies born with small heads and brains (microcephaly)) has been reported, predominantly in Brazil (Worms and Germs, 2016).

Can animals get infected with Zika virus?

It depends on what you include in "animals." We could be technical and say that humans are animals. Beyond that, non-human primates are susceptible. Zika was first identified in 1947 when yellow fever researchers working in the Zika forest in Uganda stumbled onto it. They had a macaque in a cage and it developed a febrile illness from something that was transmissible. The virus was described as Zika virus in 1952 and then found in people a couple of years later (Worms and Germs, 2016).

Can domestic animals get infected with Zika virus?

Again, we need to think about the question. Infected means they get exposed to the virus and it replicates in the body. That may occur, but we don't have any evidence of it at this point. The more relevant question is whether animals can get sick from Zika virus exposure, and there's also no evidence of that to date. A third aspect is whether infected (but potentially healthy) animals could be a reservoir for the virus, being able to pass it on to mosquitoes. There's no evidence of that, either (Worms or Germs, 2016).

So, the clearest answer is probably "maybe." When it was a flu-like illness confined to some regions in Africa, Zika wasn't a high priority so research hasn't been extensive. The risk to pets in areas where the virus is circulating (areas where there are *Aedes egypyi* and *Aedes albopictus* mosquitoes) is probably very low. It would be good to look into the risks associated with domestic animals, including their susceptibility to disease and potential roles as reservoirs, but the likelihood that there is a relevant

issue with either of these is probably remote.

Are Horses at Risk?

There's currently no evidence that Zika virus can infect horses. Zika which is a mosquito-borne virus related to [West Nile virus](#) and dengue fever has only been found in nature in humans and nonhuman primates. It's possible that horses could be exposed if they live in areas where infected *Aedes aegypti* or *Aedes albopictus* mosquitoes are present; however, exposure doesn't necessarily mean disease. For example, a horse could be exposed to a person with chickenpox but wouldn't get sick because the chickenpox virus is unable to infect horses. As far as we know, Zika virus is the same, but this hasn't received any research of which I'm aware.

While we can't yet say there's no risk, it's reasonable to assume that the likelihood of Zika virus infecting horses and causing serious disease is low. Now that Zika virus has emerged in areas where horses are common, there researchers will hopefully study whether this virus can infect horses. In the unlikely event that Zika virus does cause disease in horses it would probably mainly cause mild disease, with fever and other general signs that go away on their own. The main concern in people is a link to birth defects (specifically microcephaly, or the abnormal smallness of the head with incomplete brain development), something that still needs to be proven. There's no indication that Zika-associated birth defects occur in species other than humans.

Can the Zika virus affect pets?

The once-obscure [Zika virus](#) is now making daily headlines as it surfaces in more countries and health officials rush to make recommendations to keep it from spreading. We know the virus is primarily spread by mosquitoes. Only about one in five people infected with Zika virus will get sick, according to the Centers for Disease Control and Prevention, and even then the symptoms are usually mild. However, the disease has been linked to serious birth defects and other major health problems. We know it is of most concern to pregnant women and there is at least one case of it being [spread by sexual contact](#) (MNN, 2016).

"I think unless you're talking about pet monkeys, which should be extremely rare cases, as far as dogs and cats, I don't know of any information or scientific studies on that topic," says [Chris Barker](#), a researcher in the School of Veterinary Medicine's Department of Pathology, Microbiology, and Immunology at the University of California, Davis. Barker studies the epidemiology of mosquito-transmitted diseases. Of two common mosquito species that spread Zika *Aedes aegypti* and *Aedes albopictus* the former prefers biting humans and the latter has a broader palate. [CDC researcher Roberto Barrera](#) found that up to 20 percent of bites from the *Aedes aegypti* mosquito in several rural communities in Puerto Rico were on dogs (MNN, 2016).

"Certainly there's the potential for a pet to become infected," says Barker. "What we don't know is what that means for the health of the animal." If a dog or cat were to become infected, we also don't know if they could spread the virus to humans. "What would ultimately matter in terms of whether a pet would play a role in transmission is how much virus would be in the animals' blood," Barker says. Although there have been no cases of Zika being transmitted via mosquito in the United States, the mosquitoes that are capable of transmitting the virus do live in the U.S. So one of the best ways to protect people (and pets) from possible infection is to practice good mosquito control on your property (MNN, 2016).

"Encourage people to limit mosquito production from their own backyards, and they should encourage their neighbors to do the same. That's one of the best measures we can take," says Barker. "Where we do have the mosquitoes, we want to do everything we can to minimize the mosquitoes and limit the transmission risk." (MNN, 2016).

The way forward

Is there a way to vaccinate against it?

The short answer? No. “There are no licensed vaccines against the Zika virus anywhere in the world,” said Lucey. The Brazilian government has recently [announced](#) that it will fund efforts to develop a vaccine in “record time,” according to the Health Minister Marcelo Castro which is expected to take three to five years. According to Lucey, an effort led by the National Institutes of Health to develop a Zika vaccine has also only recently begun (GLP, 2016).

There is some good news. Nikos Vasilakis of the University of Texas Medical Branch [said](#), “Given the existence of highly successful and efficacious vaccines against yellow fever and Japanese encephalitis viruses, which are closely related to Zika virus, development of a live attenuated or chimeric vaccine would be straightforward.” However, Lucey cautioned that expecting that a solution is around the corner might be too optimistic. “Assuming that the scientific and pharmaceutical industry challenges can be met as quickly as possible, based on past new vaccine development timelines, we are several years away from having an FDA-licensed Zika vaccine,” he said to [GENeS](#) (GLP, 2016).

Genetically engineered solution?

PROCEEDING

Animal Breeding and Reproduction

The first line of action in almost all cases is to get rid of the mosquitoes and prevent them from breeding further. This involves fumigation and removing sources of stagnant water where mosquitoes can breed. Brazilian authorities have even [deployed](#) army troops to hasten this process (GLP, 2016).

A more biotech based vector control solution is the use of genetically engineered mosquitoes developed by the British firm Oxitec. The modified male *Aedes aegypti* mosquitoes mate with females in the wild population and produce offspring that do not survive to adulthood, essentially making the males sterile. Such a mosquito was approved for use in the city of Piracicaba, Brazil last year in the middle of the dengue outbreak and trials showed that they reduced vector populations by as much as 82 percent. Yesterday, Oxitec announced that it was expanding its production facilities in Piracicaba in view of a potentially increased demand to combat dengue and Zika (GLP, 2016).

Though a similar trial was [proposed](#) in Florida which also has a high *Aedes* mosquito population, it's adoption has been controversial in the United States. The FDA is currently [reviewing](#) the application for a trial and it is not known whether the rapid spread of Zika and its potential to quickly move to the US will hasten the process in any way. The biological basis of this control strategy is well understood and similar strategies have been used for decades for insects mainly of agricultural significance (GLP, 2016).

When GENeS [asked](#) experts about the expansion plans of Oxitec, the reactions were mostly positive."In my opinion [it] is generally an encouraging sign that this and related genetics-based technologies for the control or local elimination of mosquitoes is moving towards the mainstream," said David O'Brochta, a professor of Entomology at the University of Maryland.

Is Zika virus our next global health crisis?

Having survived the human drama of SARS, Avian Flu, Swine Flu, and Ebola - are we now headed for another infectious disease disaster? The Zika virus, rapidly spreading around the world and now detected in Australians returning from South America, may very well turn out to be our next health crisis. The Department of Foreign Affairs and Trade has now issued a new advice warning to Australians, particularly pregnant women, to reconsider plans to travel to 22 countries affected by the virus (Drum, 2016)

Zika is a mosquito-borne flavivirus, closely related to dengue to which its symptoms are very similar.

Like both the dengue and Chikungunya viruses, the disease is transmitted by aedes mosquitoes and results in rashes, fever, headaches and severe joint pain. In the case of Zika only one in five of those infected will go on to develop symptoms but there is a possibility that the infection can produce microcephaly (abnormal smallness of the head) in newly born infants. While the evidence is still not conclusive there is little doubt that the number of young children born with microcephaly has substantially increased in countries such as Brazil where over the last year Zika has spread widely (Drum, 2016)

Zika is named after a forest in Uganda where the disease was first isolated in a rhesus monkey in 1947. It was first found in humans in Nigeria in 1954. Looking back on the last 15 years, have we learnt anything about the identification and control of infectious disease outbreaks? I very much doubt it. Before 2013 only a handful of Zika cases had been recorded but during 2015 the disease spread rapidly, producing a number of significant outbreaks in the Pacific Islands, South America and South East Asia. Recently the infection has also been recorded in Puerto Rico, and cases are now beginning to appear in the USA and UK among travellers returning from Latin America (Drum, 2016)

The large-scale outbreak in Brazil, that seems to have commenced in 2015, has virologists linking the infection to the birth defect microcephaly for the first time. In parts of Latin America women are now being advised to postpone becoming pregnant for at least six months. Like many infections, the disease accompanies international travellers around our world, particularly those who had spent time in Latin America or the Pacific Islands. This, allied to the fact that the aedes mosquitoes responsible for spreading dengue throughout the world are also widespread in parts of Australia, places us at risk. Also, like dengue, there is no cure for Zika and treatment simply focuses on relieving the symptoms (Drum, 2016)

It is still unclear as to why Zika, which until recently was relatively rare, seems to be spreading so quickly. Many believe that human mobility and intrusion into infected areas plays a critical role but some argue that increasing temperatures, changing the breeding pattern and distribution of mosquito populations, may also be to blame. There is little doubt that we are living in a highly mobile world where millions of people move every day across international borders in pursuit of holidays, education and business - or fleeing from natural disasters or civil unrest.

In addition, more people are seeking to visit remote rural locations in Latin America and the Pacific, possibly exposing them to encounters with infected mosquitoes. It would also seem true that both increasing temperatures and a higher frequency of tropical downpours may well influence the number and distribution of aedes mosquitoes.

But are we witnessing the early stages of a 'pandemic in progress'? If an epidemic of Zika was to break out in Australia, would it produce the same reaction and fear that we saw with SARS and Avian and Swine Flu? Possibly not given that we have been living with dengue for well over 100 years. But on the other hand, the possible implications for mothers giving birth would most certainly engender considerable fear and apprehension. There is little doubt that infectious disease is one of the major challenges facing our world today (Drum, 2016)

Given our experience with dengue and other mosquito-borne infections we tend to be governed by the rubric: 'If it kills us, then we do something about it. Whereas, if it just debilitates and incapacitates, we tend to live with it'. If this was untrue we would have had a cure or vaccine for dengue decades ago. Presumably the same might apply to Zika. The ebola outbreak in West Africa also indicated how poorly we react and respond to epidemic crises. The 'standby, wait, and watch' attitude of the developed world seems to be based on a belief that epidemics in underdeveloped countries will eventually burn themselves out and that unless they directly threaten North America or Europe we do not need to react and respond.

We still do not have an international response and reaction agency charged with quickly identifying and responding to epidemics wherever they might occur in the world. With respect to infectious disease there is still much we have to do to ensure a safe and secure world (Drum, 2016)

What can we expect in the near future?

There appears to be little chance of Zika slowing down. The US aside, Brazil is expecting to host thousands, if not millions of travelers from around the world first for Carnival in February and then in the 2016 Summer Olympics. It could lead to the rapid spread of Zika to other parts of the world, said some experts, though local officials in Brazil suggest that by then the rainy season would be over, allowing the outbreak to subside. Summer is also when things might ramp up in the US, especially in the southern parts where conditions are more ideal for mosquitoes to breed. Better quality of resources and healthcare may prevent the virus from spreading as fast though. "I anticipate Zika becoming much worse in the near future," said professor Lucey of Georgetown University (GLP, 2016).

Conclusions

- Zika virus disease (Zika) is a disease caused by Zika virus that is spread to people primarily through the bite of an infected **Aedes** species mosquito.
- Zika virus was first discovered in 1947 and is named after the Zika forest in Uganda. In 1952, the first human cases of Zika were detected and since then, outbreaks of Zika have been reported in tropical Africa, Southeast Asia, and the Pacific Islands.
- Zika is spread by the *Aedes* genus of mosquito, which transmits the disease when it bites a person, infected with Zika, then bites another host. The two most common mosquitoes to transmit the disease are the **Aedes aegypti** and **Aedes albopictus** species.
- Usually, Zika's symptoms include fever, red and bumpy rash, joint pain and pink eye. Hospitalization rates are low and the [World Health Organization](#) said no deaths have been reported from Zika.
- So far a lot of questions have been raised about Zika virus and animals, however until today except animals anyone not previously exposed to the virus and who lives in an area where the mosquito is present may be infected with the virus.
- To answer the question can animals get infected with Zika virus? It depends on what you include in "animals." we could be technical and say that humans are animals. Beyond that, non-human primates are susceptible.
- Again, we need to think about the question. Infected means they get exposed to the virus and it replicates in the body. That may occur, but there is no any evidence of it at this point.
- The more relevant question is whether animals can get sick from Zika virus exposure, and there's also no evidence of that to date. A third aspect is whether infected (but potentially healthy) animals could be a reservoir for the virus, being able to pass it on to mosquitoes. There's no evidence of that, either. So, the clearest answer is probably "maybe".

References

- Bulletin of the World Health Organization, 2015; Type: Research in Emergencies Article ID: BLT.16.171082.
- Centers for disease control and preventions (CDC), 2016. CDC 24/07: saving lives, protecting people. [www. zika virus/About Zika Virus Disease Zika virus CDC.htm](http://www.zikavirus/about-zika-virus-disease-zika-virus-cdc.htm).com
- Cristiane WC, Igor ADP, Mariana K, Moreno SR, Monaise MOS, Gubio SC, et al. Outbreak of Exanthematous Illness Associated with Zika, Chikungunya, and Dengue Viruses, Salvador, Brazil. *Emerging Infectious Disease journal*. 2015; 21 (12):2274.
- Diallo D, Sall AA, Diagne CT, Faye O, Faye O, Ba Y, et al. Zika virus emergence in mosquitoes in southeastern Senegal, 2011. *PLoS One*. 2014;9 (10):e109442.
- Drum TV, AEDT ABC News 24. [www. zika virus/Is Zika virus our next global health crisis - The Drum](http://www.zika-virus/Is-Zika-virus-our-next-global-health-crisis-The-Drum) (Australian Broadcasting Corporation).htm. com
- Duffy MR, Chen TH, Hancock WT, Powers AM, Kool JL, Lanciotti RS, et al. Zika virus outbreak on Yap Island, Federated States of Micronesia. *N Engl J Med*. 2009 Jun 11;360(24):2536-43.
- European Centers for Disease Control (ECDC), 2016. Factsheet of health professionals. [www. zika virus/Factsheet for health professionals.htm](http://www.zika-virus/Factsheet-for-health-professionals.htm).com
- Faye O, Freire CC, Iamarino A, Faye O, de Oliveira JV, Diallo M, et al. Molecular Evolution of Zika Virus during Its Emergence in the 20(th) Century. *PLoS Negl Trop Dis*. 2014;8(1):e2636.

- Genetic Literacy Project (GLP). Science Trumps Ideology, 2016. www.zika-virus/Everything-you-need-to-know-about-Zika-virus-that's-spreading-like-wildfire-Genetic-Literacy-Project.htm.com
-
- Hayes EB. Zika virus outside Africa. *Emerg Infect Dis*. 2009 Sep;15(9):1347-50.
- Li MI, Wong PS, Ng LC, Tan CH. Oral susceptibility of Singapore *Aedes (Stegomyia) aegypti* (Linnaeus) to Zika virus. *PLoS Negl Trop Dis*. 2012;6(8):e1792.
- Mother Nature Network (MNN), March 22, 2016. [www.zika-virus/Can the Zika virus affect pets MNN - Mother Nature Network.htm.com](http://www.zika-virus/Can-the-Zika-virus-affect-pets-MNN-Mother-Nature-Network.htm.com)
- Musso D, Nilles EJ, Cao-Lormeau VM. Rapid spread of emerging Zika virus in the Pacific area. *Clin Microbiol Infect*. 2014 Oct;20 (10):O595-6.
- WHO, 2016. Zika virus infection and fever: frequently asking question.
- Wong PS, Li MZ, Chong CS, Ng LC, Tan CH. *Aedes (Stegomyia) albopictus* (Skuse): a potential vector of Zika virus in Singapore. *PLoS Negl Trop Dis*. 2013 Aug;7 (8):e2348.
- Worms and Germs blog 2016. Promotion safe pet ownership. University of Guelph, changing lives improving life.

Urban and Peri-urban dairy value chain analysis in Welmera Woreda, Oromia special Zone surrounding Addis Ababa, Oromia Regional State, Ethiopia

Tadele Mamo¹ and Tewodros Tefera

¹ Ethiopian Institute of Agricultural Research (EIAR), Holetta Agricultural Research Center, Holetta, Ethiopia

Abstract

The aim of this paper was to analyze dairy value chain in Welmera Woreda using data collected from different value chain actors. The primary data were collected from 120 dairy producers, cooperatives, processors, traders and hotels while the secondary data were collected from published and unpublished sources. Descriptive analysis was used to analyze the data. The result shows that different value chain actors ranging from input provision to consumers are involved in the chain. Producers and processing industries were found to add the largest value in the informal and formal market chain, respectively. Increase in demand for dairy products, availability of large profit margin and attention given to dairy cooperatives were mentioned as opportunity while feed shortage and lack of quality input, lack of improved milk processing machines and less access to crossbred heifers at fair price were mentioned as the major constraints in the dairy production sector. Lack of modern transportation services, adulteration, interruption in electric supply were mentioned as the major constraints in different levels. To solve these constraints and enable the value chain actors to capture opportunities available, different governmental and nongovernmental organizations must join their hands to bring an improvement in the dairy sector.

Key words: *Urban, Peri-urban, dairy, value chain, Welmera, Ethiopia.*

Introduction

The term value chain is well defined in different literatures in different ways with similar meaning.

Kaplinsky and Morris (2001) defined it in both simpler and broader senses. In a simpler sense, it is defined as the entire activities needed in the process of conception, production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use of a product or services. In the broader sense, it is defined as the complex range of activities implemented by various actors (primary producers, processors, traders, service providers, etc) to bring a raw material to the retail of the final product rather than only looking at the activities implemented by a single enterprise. The German Technical Cooperation (GTZ 2007) defined value chain based on the functional view as a series of functions (activities) from the provision of specific inputs for a particular product to primary production, transformation, marketing, and up to the final sale of the particular product to consumers. And, based on the value chain actors, it defines as a set of enterprises (operators) performing these functions such as producers, processors, traders and distributors of a particular product.

Nowadays, Value chain analysis is becoming an important approach to easily understand and respond to different constraints encounter along the value chain. It encompasses four broad consecutive tasks. These are: 1) value chain mapping; 2) quantifying and describing value chains in detail; 3) economic analysis of value chains and benchmarking and 4) analyzing the constraints and formulating upgrading strategy GTZ (2007).

There have been several attempts to analyze dairy value chain in Ethiopia. For instance, Getnet (2009) tried to assess dairy value chain at the national level while YONAD Business Promotion Consultancy Group (2009) assessed the dairy value chain in the pastoralists of Borena area. Similarly, Girma and Verschuur (2014a) analyzed the milk value chain of dairy cooperatives of Ada'a district, East Shewa zone of Oromia regional State. They also assessed factors affecting milk value chain in smallholder dairy farmers of the same area (Girma and Verschuur 2014b).

While these past research findings contributed a lot to the sector in analyzing the value chain, none of them have given a special focus to urban and peri-urban dairy production system despite it is one of the four dairy production systems (pastoral system; highlands smallholder crop-livestock system; urban and peri-urban system and intensive commercial system (Azage and Alemu 1998; Staal *et al.* 2008; Belete *et al.* 2010) in the country.

Urban and peri-urban agriculture in general and dairy production in particular, has a great economic importance especially in developing nations. It creates employment opportunity which in turn has a positive impact on income and food security of the urban poor. It also balances the supply and demand of food in the city on more global basis (Smith and Olaloku 1998). The urban and peri-urban agriculture has some advantages like: availability of relatively better infrastructure, better market access for perishable dairy products such as milk. There is also relatively better access to inputs like concentrates and services that makes it an important venture.

Analyzing the dairy value chain to understand the whole process in such areas is very important to have first hand information used for policy makers in developing countries like Ethiopia. Hence, this paper was aimed to analyze the dairy value chain in urban and peri-urban dairy production system in Welmera woreda of Oromia special zones surrounding Addis Ababa of Oromia regional state, Ethiopia.

Methodology

Description of the Study Area

The study was carried out in Welmera woreda (district), one of the Oromia special zones surrounding Addis Ababa in Ethiopia. Holetta is the capital town of the woreda which is situated at 40Km distance to the west of Addis Ababa. According to the Welmera Woreda Agriculture and Rural Development Office (WWARDO 2010), the total area coverage of the district is 775km² with most of the area having a highland and mid highland agro ecology with an altitude above sea level ranges from 2060m to 3380m. The livelihood of peri-urban part of this area depends on crop-livestock farming system while the urban dwellers have an additional employment opportunity. Figure 1. shows the map of the area.

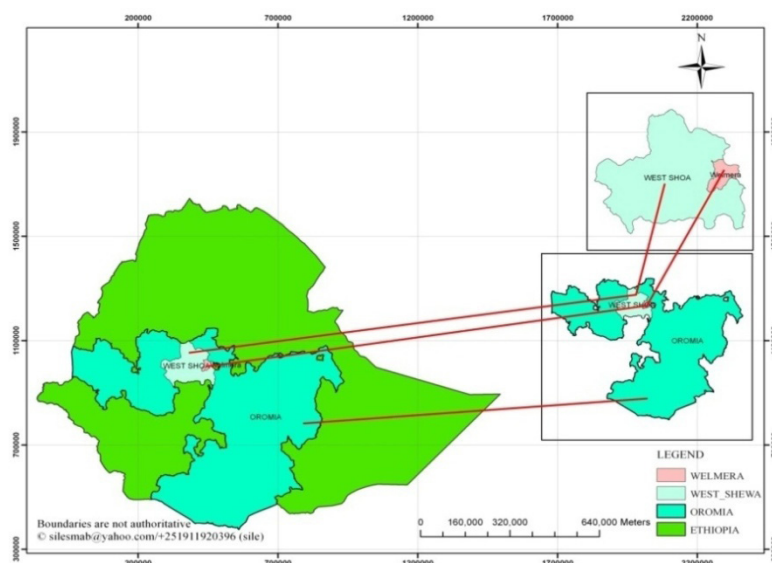


Figure 1. Map of the Welmera Woreda

Sampling Procedure, Types and Sources of Data and Methods of Data Collection

Sample Size and Sampling Techniques

Determining sample size and sampling procedure was applied only to dairy producers among all value chain actors. Other value chain actors are few in number in the study area and no need of sampling. Dairy producers sampling procedures is described as follows.

Dairy Producers Sampling

A multistage sampling technique was used to determine the sample households. First, the Welmera woreda was purposively selected based on its huge potential for urban and peri-urban dairy production system. Then, four peri-urban and two urban kebeles (villages) were randomly selected. After the kebele selection, households who own dairy cows were identified from the households list available at each *kebele* office. Finally, 92 peri-urban and 28 urban dairy producers were selected to have 120 total sample dairy farmers.

Method of Data Collection

The primary data collection was done through a structured questionnaire prepared for different value chain actors using experienced and trained enumerators who are fluent in local language. Day to day supervision and check up was done by a supervisor (a researcher) to increase the quality of the data.

Data analysis

The data collected from different value chain actors were analyzed using descriptive analysis and presented using tables, figures and maps.

Results and Discussion

Dairy Value Chain Actors

Several dairy value chain actors that perform the value chain functions are identified in the study area. They can be categorized as 1) input providers, 2) Service providers, 3) Enablers and 4) core (direct) value chain actors. Previous studies conducted on the dairy value chain analysis also identified these

actors (Getnet 2009; YONAD Business Promotion Consultancy Group 2009; Girma and Verschuur 2014a, b).

Input Providers

Input providers identified in the area include feed providers, artificial insemination, medicine (health), milk containers and improved heifer providers.

Feed: Most of feed inputs for the dairy producers is derived from own source in peri-urban producers. Private grazing is the main feed regime for peri-urban producers whereas zero grazing is the dominant feed regime in urban producers. Urban dairy producers mainly use purchased inputs such as concentrates and molasses. Hay, crop residues and concentrates are the dominant type and sources of feed in the study area. Most of the purchased feeds such as concentrates and molasses are supplied by cooperatives and private traders found at Holetta town. The high inflation of the purchased feed is reported as the main constraint in the feed input.

Artificial Insemination (AI) and Health Services: Both artificial insemination (AI) and health service provision is done by the government through the office of agriculture and rural development in the study area. Although there are some emerging private agencies that provide these services, farmers are reluctant to pay for high price and depend on services provided by the government. However, there is a problem of AI service provision for peri-urban producers found at far distance from the Holetta town. The AI service provided by the government is inefficient and needs several services per conception due to low quality of AI coupled with low level of producers' knowledge in heat detection which made the use of AI less effective in the study area. Hence, there is a need to improve the efficiency of AI service and arranging training to raise the knowledge of dairy producers.

Milk containers suppliers: Most of the dairy producers use plastic can (jerry can) as a milk container that are easily available at a local market. They found that aluminium can which is better in keeping milk quality due to easy in cleaning is very expensive to use at farmer level. However, large milk traders and cooperative union use aluminium can that are purchased from Addis Ababa.

Heifer providers: Crossbred dairy heifers are provided by Holetta Agricultural Research Centre (HARC) though there is a wide gap between demand and supply. Local heifers are purchased from the local market. However, the price of crossbred heifer is very expensive and there is no private or government agency that officially provide heifers. This result therefore suggests that encouraging private investors to fill this gap or capacitating the dairy cooperatives towards filling this gap would have a positive effect.

Services providers: Service providers include financial and technical services providers.

Financial services: Financial services provided to the dairy sector in the study area is almost absent as farmers and traders do not borrow money either from formal or informal sector. However, microfinance institutions like African Village, **Gashaw** microfinance and Oromia saving and credit share company (OSCSO) provide limited financial services for dairy producers. In addition, Oromia international bank and commercial banks of Ethiopia provide financial services to Biftu Berga dairy cooperative union to purchase fixed assets like vehicles and milk processing machines.

Technical services: research institution like Holetta agricultural research centre (HARC), Holetta agricultural technical and vocational education and training college (ATVET), Holetta cattle genetics improvement farm, and bureau of agriculture and rural development provide different technical services for dairy producers in the study area. In addition, different NGOs like Land O' Lake, Self help Africa and SNV technically support the dairy sector in the area.

Table 1. Lactation period, milk yield per lactation and daily milk production of dairy cows.

Breed type	Items	Urban			Peri-urban		
		Max.	Min.	Ave.	Max.	Min.	Ave.

Local	Lactation Period(months)	10	6	7.8	12	5	7.9
	Milk yield (Litres/lactation)	600	180	468	750	120	362
	Milk yield (Litres /day)	3	1	2.03	3.3	0.6	1.6
	Milk to produce 1Kg of butter (L)	14	14	14	18	14	14.9
	Milk to produce 1Kg of cheese (L)	7	5	6	7	5	6.3
Crossbred	Lactation Period(months)	11	7	9.03	11	7	8.6
	Milk yield (Litres /lactation)	3780	720	1837	2850	540	1535
	Milk yield (Litres /day)	14	2.7	6.74	10	2	6
	Milk to produce 1Kg of butter (L)	24	20	22	24	20	21.4
	Milk to produce 1Kg of cheese (L)	12	10	11	12	10	10.7

Source: Own survey result, 2011.

Enablers

Enablers are those enable the actors through capacity building and enhancing their skill. These include Welmera woreda agricultural and rural development office, NGOs like SNV, Land O'lake, Self help Affrica, Holetta Agricultural Research Centre (HARC), Holetta Cattle genetics improvement farm and Holetta ATVET College.

Core (Direct) Value Chain Actors

These are producers, cooperatives, traders, processors, hotels/restaurants/cafeterias and final consumers.

Dairy Producers

Dairy Production and Management System

Urban and peri-urban dairy production system is the most dominant type in the study area. Most of the urban dairy farmers keep crossbred and few local breeds while the opposite is true for peri-urban dairy producers who use mainly local cows. There are differences in milk yield per lactation and daily milk production in urban and peri-urban dairy producers. Table 1 shows that the average lactation period, milk yield per lactation and daily milk yield of local dairy cows are 7.8 months, 468 litres and 2.03 litres for urban dairy producers whereas the figures are 7.9 months, 362 litres and 1.6 litres for peri-urban dairy producers. The results show that local cows are more productive in urban compared to peri-urban and this might be due to improved management system in urban areas suggesting that improving management system can increase daily milk yield and total milk yield per lactation period. Similarly, the productivity of crossbred cows is higher in urban. The average lactation period, milk yield per lactation and daily milk yield of crossbred dairy cows are 9.03 months, 1837 litres and 6.74 litres for urban dairy producers while the figures are 8.6 months, 1535 litres and 6 litres for peri-urban dairy producers (Table 1). Hence, training the dairy producers on improved dairy management would have a positive result.

Most of the milk produced from local dairy cows in peri-urban dairy producers is processed into butter and local cheese (*ayib*) by traditional means while only urban producers sell almost all raw milk of both breeds. This result is supported by the findings of Berhanu *et al* (2011) and Mamo *et al* (2014) that found the inverse relationship between milk value addition and distance to raw milk market.

On average, 14 litres and 14.9 litres of milk produced from local cows are used to produce a kilo gram of butter in urban and peri-urban producers, respectively. On the other hands, the average quantity of milk of crossbred cows to produce a kilo gram of butter in urban and peri-urban producers is 22 litres and 21.4 litres, respectively. This result suggests that availing relatively modern milk processing materials to help dairy producers who own local cows may be considered as an option.

Grazing regime and types of feed: The main feed regimes in the study area consist of private, communal and zero grazing (Table 2). However, most of the urban producers use zero grazing (78.6 %) while the peri-urban producers use only private grazing (39.1%) followed by private grazing with a combination of communal grazing (31.5%). Supplementary to grazing regime, dairy producers use different sources of feed in the study area. Hay, crop residue and concentrates are used as the main feed source by urban producers while hay and crop residue are mainly used in peri-urban farmers. In addition, concentrates are used by urban dairy producers in larger quantity compared to peri-urban producers (Table 3). However, all of the dairy producers reported that the cost of concentrate feed is becoming very expensive nowadays and they feel it as a main constraint.

Table 2. Main grazing regime of the sample households.

Households responded 'yes' to	Urban		Peri-urban		Total	
	N	%	N	%	N	%
main grazing regime						
Communal grazing only	0	0	2	2.2	2	1.7
private grazing only	0	0	36	39.1	36	30
zero grazing only	22	78.6	7	7.6	29	24.2
communal and private grazing	1	3.6	29	31.5	30	25.0
communal and zero grazing	1	3.6	1	1.1	2	1.7
private and zero grazing	3	10.7	5	5.4	8	6.7
communal, private and zero grazing	1	3.6	12	13.0	13	10.8
Total	28	100	92	100.0	120	100

Source: Own Survey data, 2011.

Table 3. Main feed type of the sample households.

Households responded 'yes' to	Urban		Peri-urban		Total	
Feed types	N	%	N	%	N	%
Hay and Crop residue	2	7.1	46	50	48	40
Hay, crop residue, molasses, concentrate, <i>atela</i> *	3	10.7	11	12.0	14	11.7
hay, crop residue and concentrates	19	67.9	33	35.9	52	43.3
hay and concentrate	4	14.3	0	0.0	4	3.3
crop residue and concentrates	0	0.0	1	1.1	1	0.8
Hay, crop residues and molasses	0	0.0	1	1.1	1	0.8
Total	28	100.0	92	100.0	120	100

Source: Own Survey data, 2011. *is a by-product produced when local alcohol (arekie) is prepared at home.

Table 4. Breeding means, sources, costs, efficiency and accessibility of AI or bulls services.

Means of breeding used	Natural for both local and cross breeds		AI for both local and cross breeds		AI for cross and natural for locals	
(Number and %)	83	69.2%	21	17.5%	16	13.3%
Sources of:	Own		Private		Government	
Bull (Number and %)	73	88%	10	12%	0.0	0.0%
AI (Number and %)	0.0	0.0%	0.0	0.0%	37	100%

Cost, efficiency, accessibility Artificial Insemination Own bull (natural) Private bull (natural)

Cost (ETB per service)	9.31	-	47.69
Service per conception*	1.71	1.2	1.1
Accessibility (distance in Km)	2.52	-	1.35

Source: Own survey data, 2011

Breeding Strategy: Most of the dairy producers use natural bulls for breeding. From a total of 120 sample households, 83 households (69.2%) use natural breeding strategy for both local and cross breed cows. Most of them use their own bulls while some 12% use private bulls. Out of 120 sample households, 21 and 16 households use artificial insemination for both local and cross breed cows and only for cross breed cows, respectively (Table 4).

Costs, Efficiencies and Accessibility of AI and Bull Services: The AI cost per service ranges from ETB 2 to ETB 4 at a normal condition at government office.

Table 5. Dairy Producers and marketing cooperatives in Welmera Woreda.

Name	Establishment date	Initial capital (ETB)	Initial members		Current members	
	year		Male	Female	Male	Female
Loan Weya	2007	4050	17	10	48	11
Nano Gelgel	2005	2300	20	3	27	5
Lalisa	2008	3900	31	8	19	7
Biftu Bekeka	2008	3400	28	6	23	8
Jitu	2008	4200	37	5	49	9
Biftu Berga DPMU*	2009	302747	435	210	488	210

Source: Own Survey data, 2011 *dairy production and marketing union.

However, if the service taker wants to get service out of working days, AI technicians receive additional money as service costs and the total cost per service reaches up to ETB 50 that makes the average AI cost per service to be ETB 9.31. On the other hands, the cost of natural bulls per service ranges from ETB 25 to 60 with a mean charge of 47.69 ETB. The average service per conception (number of frequency for a cow to conceive) of AI, own bulls and private agency bulls is found to be 1.71, 1.2 and 1.1 times, respectively. Dairy producers travel on average 2.52kms and 1.35kms to receive AI and private agency bulls' service, respectively (Table 4).

Dairy Cooperatives

There are five primary cooperatives and one cooperative union of dairy production and marketing cooperatives operating in the area (Table 5). The cooperative union encompasses thirteen primary cooperatives (five from Welmera district, five from Ejere district and three from Ada Berga district). The Biftu Berga dairy production and marketing cooperative union was established in 2009 and acting as inputs provider (feed and fertilizer) for members until May 2011. Nowadays, it is acting as milk collecting union after purchasing a vehicle for milk transporting since June 2011. It collects milk from members and non members and sells most of the collected raw milk to Beral Milk processing and very few to retailers and consumers. Even though the union is near to the capital city (Addis Ababa) where the milk price is very high compared to Holetta town, it could not sell its products due to lack of appropriate place for establishing shop.

Different NGOs like Land O'lake and Self help Africa support the Biftu Berga cooperative union as sources of finance and technical support. In addition, Oromia International Bank (OIB) provides credit services to the union for purchasing vehicles and processing machines. The union is planning to establish milk processing machines in the near future to increase the profit margin of its members.

Milk Processors and Traders

Two large scale and one medium scale dairy processors are operating in the study area. Sebeta agro-industry (Mama) and Lame dairy (**Shola**) are the two large dairy processing industries that have milk collection centres at Holetta town. They collect milk from urban and peri-urban producers using their own vehicles. The collected raw milk is transported to Addis Ababa for processing. Another medium scale milk processing industry that collects and processes milk in the study area is Beral milk. It is a medium sized milk processing industry that own 200 own dairy cows at Holetta and collect additional milk from Biftu Berga dairy cooperative union and from farmers.

In addition, six traders operate the milk collection activity in the area. However, most of the traders do not own milk quality testing. Due to this reason, they usually buy milk from cooperatives rather than collecting from farmers since they think that cooperatives are relatively genuine in providing quality milk. These traders can buy 6900 litres of milk on average per month. All of the milk traders owned mobile phone and fridge. Two of them owned their own vehicle to transport their milk and to give services to other traders by charging 50 cents per litre to transport milk from Holetta to Addis Ababa.

Hotels, Restaurants and Cafeterias

Hotels, restaurants and cafeterias are one of the direct value chain actors operated in Welmera woreda. A total of ten (four hotels, one restaurant, three cafeterias and two small coffee and tea rooms) found in Holetta town were surveyed to assess their linkage to dairy value chain in 2011. The average daily and annual milk purchase capacity of hotels/restaurants/cafeterias is 7.7 and 2810.5 liters, respectively. Ayib (local cheese) and butter are purchased twice a week during market days from peri-urban dairy producers. The average ayib and butter purchase per week is 6.8Kg and 6.5Kg, respectively. The main source of milk is urban dairy Producers, while the main source for ayib and butter is peri-urban dairy producers. The milk purchased by hotels, restaurants and cafeterias are sold in the form of boiled milk (safi), sprees and milk with coffee (wetet bebuna) and yogurt (irgo). The majority of the milk is sold in the form of sprees (2.5L/day) followed by milk with coffee.

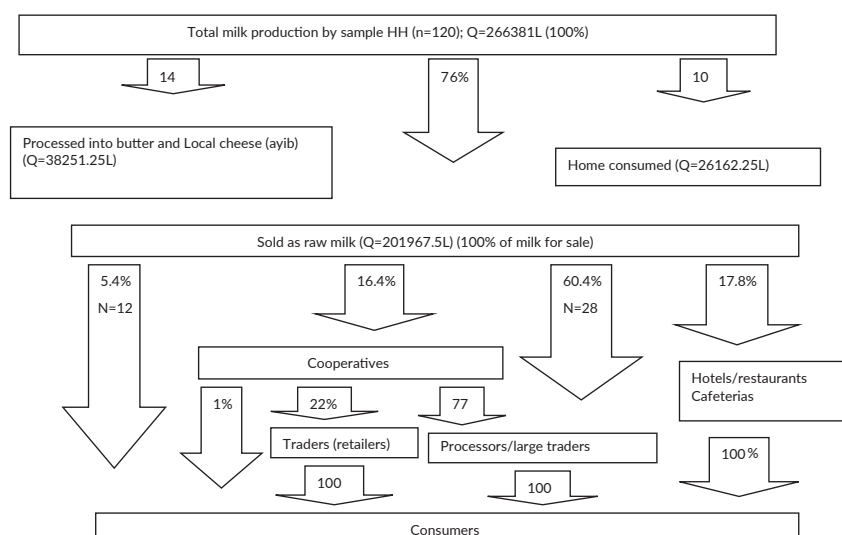


Figure 2. Milk production, consumption, processing and marketing of households

Source: Own diagram from survey data 2011.

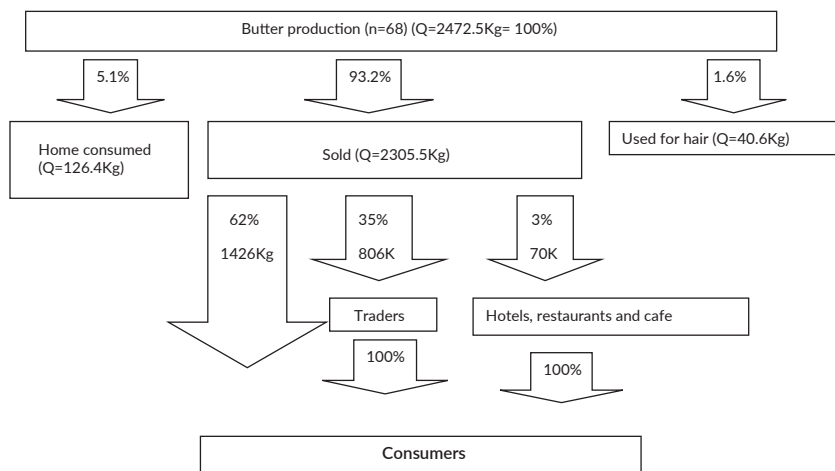


Figure 3. Butter production, consumption and marketing of sample households

Source: Own diagram from survey data 2011.

Consumer Households

Dairy product consumers are rural consumers and urban consumers. Most of the rural consumers are the dairy producers themselves who consume 10% of their produce. There are also some development agents and elementary teachers who consume milk by purchasing from dairy farmers. Urban consumers are the dwellers of Holetta town and Addis Ababa city. Most of the consumers are the children of less than 6 years of age. Other adult consumers usually consume the milk and milk products like butter and cheese during the holidays and at hotels, cafeterias and restaurants in the form of boiled milk (safi), sprees and milk with coffee (wetet bebuna) and yogurt (irgo).

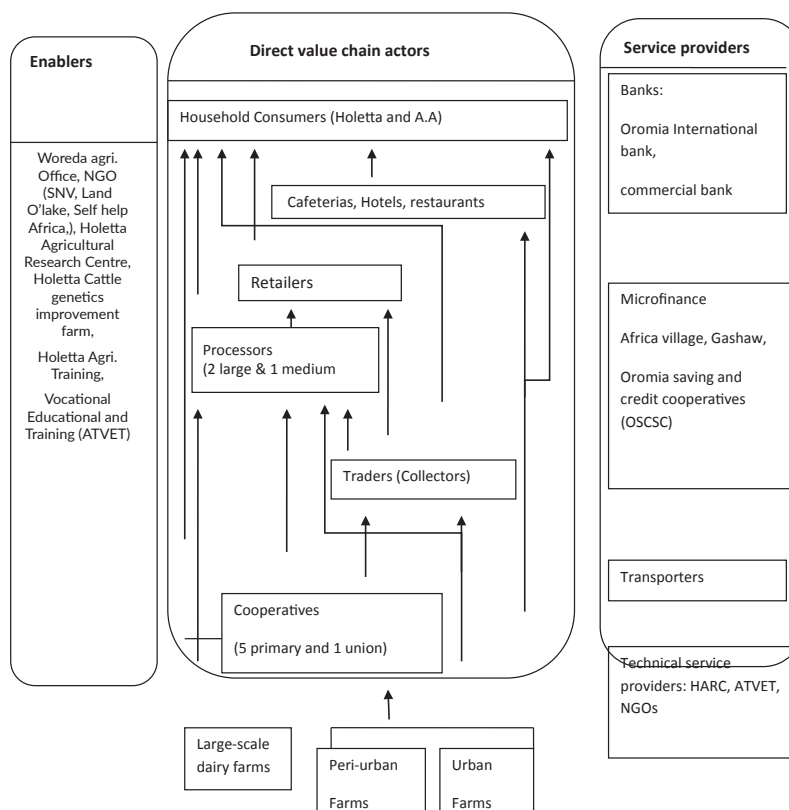


Figure 4. Milk value chain map of Welmera Woreda, based on the sample households

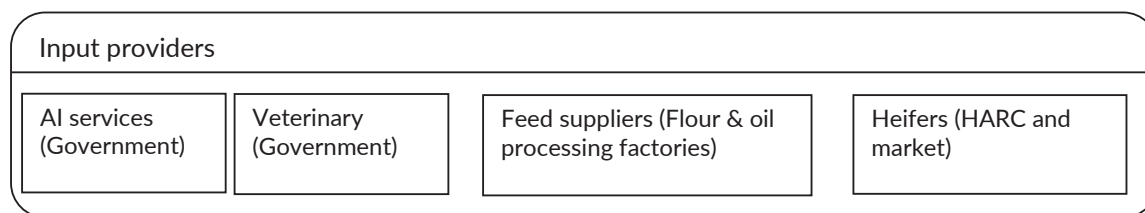


Figure 4. Milk value chain map of Welmera Woreda, based on the sample households

Source: Own diagram from survey data 2011.

Dairy Products Flows and Value Chain Mapping

Milk and Butter Production, Consumption and Marketing Flows

Dairy product flow starts from cow and ends with consumption. In this study, milk and butter are the main dairy products focused on. As shown in Figure 2, 14%, 76% and 10% of the net milk production (excluding the milk fed by calves) is processed into butter and cheese, sold as raw milk and consumed as raw milk, respectively. The raw milk reaches the final consumer in different ways.

The majority of the milk (some 60%) is channelled through traders/processors (Sebeta Agro industry and Lame dairy (Sholla) milk processing and other small scale milk processing plants) operating in the study area. Some 5.4%, 16.4% and 17.8% of the milk are sold through direct sales to consumers, cooperatives and hotels/restaurants/cafeterias, respectively. The cooperatives sell 1%, 22% and 77% of their total milk to consumers, traders (retailers) and processors, respectively. The final milk consumers in the study area are Holetta town consumers and Addis Ababa consumers.

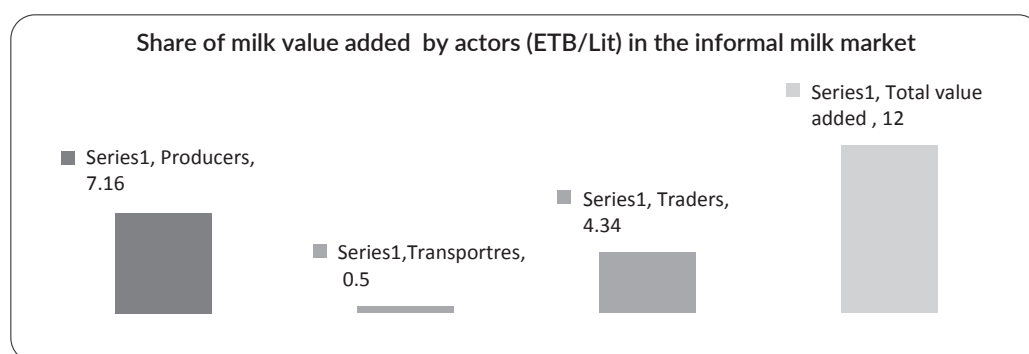


Figure 6. Share of milk value added by different actors in the formal channel

Source: survey result of 2011 data collected from different actors

Figure 3 shows the butter flows in the study area. It indicates that 5.1%, 93.2% and 1.6% of the total butter produced was used for home consumption as food, sold and used for hair treatment, respectively. Out of the total butter supplied to the market, 62%, 35% and 3% reaches directly to consumers, traders and hotels/restaurants/cafeterias, respectively.

Dairy Value Chain Mapping In Welmera Woreda

The dairy value chain map shows that there are different value chain actors in Welmera woreda can be summarized and mapped (Figure 4).

Analysis of Share of Value Added in the Milk Value Chain

The result shows that, in the informal milk channel, dairy producers add the highest value by using different inputs to produce milk. They play an important role in adding form value addition (produce milk from inputs like feed and other important inputs to new product). On the other hands, the transporters add the least value (place value addition) while the traders of raw milk value addition is medium. As a result, a litre of raw milk has a value of Ethiopian Birr (ETB) 12 (about USD 0.75 when it reaches the final consumer of Addis Ababa market (Figure 5).

As shown in Figure 6, large processors of dairy products add the highest value followed by dairy producers in the processed milk channel. These large dairy processors convert the raw milk to less perishable, high value pro cessed products using modern milk processing machines. They also have their own transport vehicles to collect the raw milk from farmers at different milk collecting centres out of Addis Ababa including Holetta.

Analysis of Opportunities and Constraints at Different Chain Actors

Table 6 summarizes different opportunities and constraints identified at different levels of the dairy value chain actors in the study area.

Table 6. Opportunities and constraints identified at different levels of the dairy value chain.

chain actors	Opportunities	Constraints
Producers	High demand to dairy products Easy access to product market	High cost of feed Lack of accessing crossbred heifers High cost of crossbred cows Lack of milk processing machines

PROCEEDING

Animal Breeding and Reproduction

Dairy cooperatives	Increase in demand Help from NGOs Improved awareness towards cooperatives services	Adulteration Abnormal competition from large agro industries Lack of shops to sell product in Addis Ababa
Traders	High demand to dairy product High profit margin	Problem of modern transportation services Adulteration Lack of shops to sell milk Limitation of capital
Processors	High demand to dairy products High profit margin	Adulteration Interruption in electric supply
Retailers	High demand	Adulteration
Hotels/cafeterias and restaurants	High demand Increased urbanization	Adulteration Fluctuation in demand

Source: Own analysis based on interview result.

Conclusion and Recommendations

Different value chain actors participate in the value chain in the Welmera Woreda. The majority of the milk produced is sold as raw milk while the least proportion is consumed at home. Of the raw milk produced, very small portion is directly sold to the final consumers. However, the largest portion of butter produced at the farm level is directly sold to the final consumer. Increase in demand for dairy products, availability of large profit margin in the dairy sector and attention given to dairy cooperatives were identified as opportunities in the dairy value chain while feed problem and lack of other quality input supply, lack of improved milk processing machines and less access to crossbred heifers at fair price were mentioned as the major constraints in the production sector. Lack of modern transportation services, adulteration, interruption in electric supply were listed as the major constraints in different value chain levels. The dairy cooperative union (Biftu Berga dairy production and marketing union) is not comfortable with abnormal competition basis of large dairy industries (mentioned as constraint to their business) as they tried to kick out the cooperatives from the dairy business. The result of this study suggests that improving the efficiency of AI service and arranging training to raise the level of dairy producers knowledge on improved dairy management including heat detection and feed management, encouraging private investors to fill the gap of improved heifer supply or capacitating the dairy cooperatives towards filling this gap, introducing relatively modern milk churning machines to process local dairy milk would have a positive effect in the dairy sector. Therefore, It can be recommended that different governmental and nongovernmental organizations have to join their hands together to solve the constraints mentioned at different levels and capture the opportunities available at the dairy sector.

Acknowledgements

We would like to acknowledge different value chain actors who spent their invaluable time with us to answer our questions by sacrificing their busy time. We also acknowledge Rural Capacity Building Project (RCBP) for financing the data collection activity during the survey time.

References

- Azage T, Alemu G.1998. Prospects for peri-urban dairy development in Ethiopia. In: Proceedings of 5th national conference of Ethiopian Society of Animal Production (ESAP), 15–17 May 1997, Addis Ababa, Ethiopia. p. 248.
- Belete A, Azage T, Fekadu B, Berhanu G. 2010. Cattle milk and meat production and marketing systems and opportunities for market-orientation in Fogera woreda, Amhara region, Ethiopia. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 19. ILRI (International Livestock Research

Institute), Nairobi, Kenya. p. 65.

- Berhanu K, Kindie G, Derek B, Belay K. 2011. Determinants of participation decisions and level of participation in farm level milk value addition: The case of small holder dairy farmers in Ethiopia. *Ethiop. J. Appl. Sci. Technol.* 2(2): 19-30.
- Getnet H. 2009. The impact of global economic and financial crises on the Ethiopian dairy industry. A case study. In: Least developed countries ministerial conference, 3-4 December 2009, p. 68, Vienna international center, Austria. United Nations Industrial Development organization.
- Girma D, Verschuur M. 2014a. Analysis of milk value chain: the case of Ada'a dairy cooperative in Ada'a district, East Shawa zone of Oromia regional state, Ethiopia. *Wudpecker J. of Agric. Res.* ISSN 2315-7259. Vol. 3(1):16 – 25.
- Girma D, Verschuur M. 2014b. Assessment of factors and factors affecting milk value chain in smallholder dairy farmers: A case study of Ada'a District, East Shawa Zone of Oromia regional State, Ethiopia. *African Journal of Agricultural Research*. 9(3): 345-352, DOI: ISSN 1991-637X © 2014 Academic Journals 10.5897/AJAR2013.6967. <http://www.academicjournals.org/AJAR>
- GTZ. 2007. *Value Links Manual – The Methodology of Value Chain Promotion*. German Technical Cooperation (GTZ). 1st ed. Eschborn, Germany. p. 221.
- Kaplinsky R, Morris M. 2001. *A Handbook for Value Chain Research*. A report prepared for the International Development Research Center (IDRC). <http://www.ids.ac.uk/ids/global/pdfs/vchnov01.pdf> (Accessed on June 2011). p. 113.
- Mamo T, Tefera T, Byrne N. 2014. Factors influencing urban and peri-urban dairy producers' participation in milk value addition and volume of milk value added in Welmera Int. J. of Livestock Produc. Woreda, West Shewa Zone of Oromia Regional State, Ethiopia. 5(9): 165-172.
- Smith OB, Olaloku. 1998. Peri-Urban Livestock Production Systems. *Cities Feeding People Series Report 24*. International Development Research Centre, Dakar, Senegal and International Livestock Research Institute, Addis Ababa, Ethiopia. <http://idl-bnc.idrc.ca/dspace/10625/22320/1/108521.pdf> (Accessed on July 2011).
- Staal SJ, Pratt AN, Jabbar M. 2008. Dairy development for the resource poor. Part II: Kenya and Ethiopia dairy development case studies. PPLPI (Pro-poor Livestock Policy Initiative) Working Paper No. 44-2. ILRI (International Livestock Research Institute), Nairobi, Kenya.
- YONAD Business Promotion Consultancy Group. 2009. *A research report on Value Chain Analysis of Milk and milk products in Borana Pastoralists Area*. Addis Ababa, Ethiopia. pp. 81.
- WWARDO. 2010. *Socio-economic profile of Welmera woreda. Welmera woreda agriculture and rural development office (WWARDO): (unpublished)*.

Livestock Collective Marketing Through The Use Of Collection Centre Beyond Benefiting the Poor: A Case to Oromia & Snnpr Livestock Marketing Cooperatives

Tadesse Assefa Ayane

Livestock value chain expert

SNV Netherlands Development Organisation



Introduction

GRAD is a five-year USAID-funded project designed to help the Government of Ethiopia find sustainable solutions to chronic food insecurity. The project supports households currently enrolled in the government's Productive Safety Net Program (PSNP) so that they may access microfinance, improve on- and off-farm productivity, and have better links to markets. In addition, GRAD improves household and community resilience by: increasing women's empowerment; improving nutritional practices; and introducing local climate change adaptation mechanisms. CARE Ethiopia leads a consortium that includes REST, ORDA, CRS, Agri Service Ethiopia, SNV, and Tufts University. The project works in 16 districts in Amhara, Tigray, and Oromia and SNNP regional states. GRAD is also working in potato, livestock, and honey, pulse and malt barley value chains to increase the income of GRAD households to come out of poverty sustainably.

GRAD aims to contribute to the sustainable graduation of 50,000 chronically food-insecure households by increasing their income by \$365 per year. It is implemented by consortia members CARE, ORDA, REST and CRS.

Livestock value chain is among the five value chains GRAD is promoting to enhance the graduation of safety net supported poor households. Technical and input supply efforts have been done by the project to improve the livestock productivity. In the four regions of the project operational areas 32 agro dealers (2 agro dealer/woreda) are established to ensure input supply mainly feed at their vicinity, reasonable price and packaging size to those engaged in the livestock value chain.

Thus farmers are exercising the improved fattening practices where fattening period shorten from 5-6 to 3 months of the recommended. However among the challenges with the subsector that lessen the return of the households from the engagement are middle men and relying on spot markets. The spot markets operational in few days of a week and give unpredictable price and has little livestock volume absorption. This urges the households to undertake unplanned fattening operation when to

fatten, supply and at what price to buy and sell are the key bottlenecks.

The market transaction is not modern which is characterized by lacking transparency that undertakes on physical observation and judgement, unsafe livestock handling during transportation, etc. Moreover households live remote from the livestock market centre where forced them to spend 2-3 hour on travel .As a result they waste their time and animals are also subject to body weight loss.

So to maximize the profit of the poor households from the livestock value chain engagement GRAD as part of modern marketing system is promoting collective marketing through use of collection centre and livestock marketing cooperatives establishment. To make the approach functional various interventions have been done. Therefore this case dictates the success story happening in two operational regions of GRAD named Oromia and SNNPR livestock marketing cooperatives.

Interventions

Various interventions have been employed to make the livestock collective marketing viable. Before the implementation of the GRAD project no livestock marketing cooperatives exist in the targeted operational woredas. Because it is a new marketing model for the area the following were used for the establishment of the livestock cooperatives.

Creation of awareness on collective livestock marketing importance

Awareness creation has been done to those government officials who are believed to be paramount in one or the way can play a role in the livestock marketing cooperatives establishment. Accordingly the woreda cooperative promotion, livestock agency and trade and industries were let get awareness on the importance of establishment of livestock marketing cooperatives. This was done through the facilitation of exposure visit of those cooperatives engaged in livestock collection which are existing in Borena pastoral areas. Moreover awareness creation has also been done on regional livestock MSPs especially by the abattoirs, Ethiopian Meat exporters association, Ethiopian Meat and Dairy Industry Development Institute.

Livestock marketing cooperatives and collection centres establishment

The respective woreda cooperative promotion office through development of by law organized the livestock marketing cooperatives. These are the FEMA groups who are transformed into livestock marketing cooperatives. The organized and licenced livestock marketing cooperatives have accessed land for the construction of collection centres by Kebele administration.

A guide on the collection centre construction including the design and bill of quantity has been developed by SNV-GRAD. A grant has been given for selected livestock marketing cooperatives which fulfil the set criteria like licence, secure land, access with water source and road and proximity to the livestock producers' households. Accordingly proposal has been submitted by the cooperative with technical support of CARE-Sidama, CRS and SNV.

In the two regions seven collection centres have been established where one for private live animal trader and the remaining to livestock marketing cooperatives. Each collection centre cost 120,000 birr (6000USD).The centre can support 240 goats at once and has facilities for animal where to exercise and feed during day, section for night time spent, feed store, isolation pen and guard house.



Figure 1 collection centre facilities front view, Lonse Lophino LMC,L/ Abaya woreda

Figure 2 Goats in the exercise yard during day time, Luga Godana LMC,A/Negelle

Figure 3 Goats in the animal house section of the collection centre during the night, Luga Godana LMC,A/ Negelle

Capacity building through training and exposure visit

The established livestock marketing cooperatives members have been built their capacity through technical and business skill training by engaging abattoir expertise invited from Luna.

The cooperatives are also exposed to visit the private collection centre located in Modjo owned by Ato Tariku so that can assist them in how to manage their shoats when they commence the collective marketing.

Photos 1-Collection centre visit by the cooperatives, Tariku's live animal trader collection centre, Modjo



Figure 4 Briefing on the collection centre management



Figure 5 Feeding and watering troughs in the collection centre



Figure 6 Feed store in the collection centre

Looking for potential market options

GRAD also facilitated for the cooperatives so they can look for new potential market options through participating them in ALEC2016. Accordingly one of the potential abattoir called Allana was identified. This abattoir is located in Modjo and it's new facilities under construction in Adami Tulu has a slaughtering capacity of 5000 shoats per day. Moreover in terms of proximity and capacity it is the most appropriate to the cooperatives in Oromia and SNNPR.

Market linkage facilitation

A business to business (B2B) meeting was facilitated in bringing the abattoir and livestock marketing cooperatives so as to deal with volume of supply, frequency, quality and price parameters.

Market linkage facilitation

A business to business (B2B) meeting was facilitated in bringing the abattoir and livestock marketing cooperatives so as to deal with volume of supply, frequency, quality and price parameters.

GRAD also facilitated a visit to the abattoir managers to look into the cooperatives collection centre facilities and breed potential exist in the areas. Likewise the cooperatives executive committee members and government partners let to visit the abattoir facilities and learnt the shoats' quality requirement. For the cooperatives have finance shortage to start the collective marketing the model used is through collection of goats from their members. Thereby the cooperatives collected goats on credit base as law give me the right. The credit base purchase was on live weight (14-28kg), body condition (not bony), and age (1-2 years), sex (male) as per the abattoir quality requirement. The cooperatives for their supply of goats to the abattoir the payment was directly transferred to their account.

dressing percentage =(weight of meat and bone/animal live weight)*100



Figure 4 Briefing on the collection centre management



Figure 5 Feeding and watering troughs in the collection centre



Figure 6 Feed store in the collection centre

Result and Discussion

From the collective marketing the cooperatives members obtained a total net profit of 72,291birr (3,615 USD) from the sale of 823 goats (13,933 Kg of live weight) from conditioning their goats for 1-3 weeks.

The selling price per a kg of live weight was 36-42 birr (about 2 USD). Price comparison offered by the abattoir has a difference of 5-10 birr per kg of live weight (in favour of the farmers) from what has been offered by traders a (31birr/kg). Price comparison offered by the abattoir has a difference of 5-10 birr per kg of live weight from what traders are giving (31birr/kg).In this market linkage 446 (112 female) households engaged and each gained a net profit of 162 birr. The cooperatives on the other hand got 27,866 birr (1393 USD) birr from the member's contribution (2birr per a kg of goats live weight) upon on average of two months collective marketing facilitation.

In the collective marketing a total of eight cooperatives from Oromia (2) and SNNPR (6) were participated and each supplied an average of 103 goats. The average body weight of goat supplied was ranging from 16-18kg which is near to the Borena, Jimma and Bale breed (19kg) which are the most preferred for their higher dressing percentage. The goats supplied by the cooperatives to Allana have 40% dressing percentage and hence can yield 5,573kg fresh meat. The goats supplied by the cooperatives to Allana has 40% 5dressing percentage and hence can yield 3,455kg fresh child meat. The meat yield obtained can generate a total 27,866 USD (1kg/5USD) at markets in UAE and Saudi Arabia.

Moreover for the new live animal trading proclamation of the country force a tax payment for animal transportation from one region to other ,the cooperatives committed a tax payment .So they paid a tax of birr 1,420 to the woreda trade and industry for transporting the goats from their operation woreda to the abattoir in Modjo.

So, GRAD through organizing livestock markets cooperatives, establishing collection centre is promoting a modern livestock marketing system that foster the household graduation from safety net support and thereby play their role in the country's development. This modern livestock marketing system exercise sustainability is giving a green light is confirmed by a second collective supply of goats undertaken by the cooperatives from SNNPR /Guraghe zone. Moreover the Allana goats quality interest from those GRAD woredas is also a plus for the linkage to sustain.

Challenges and recommendations

Regardless of the promising achievements has been recorded, financial shortage the cooperatives have is limiting to fully enter into the collection operation that call for timely loan access by local MFIs. Secondly in some cooperatives it was observed that disease occurrence like respiratory that need a close supervision of the woreda livestock agency. Thirdly strengthen the cooperatives with members still remain mainly as an assignment for woreda cooperative marketing and promotion office.

Moreover onsite technical support on animal purchasing, management including feeding and

sanitation is also critical. Double animal taxation request by other region need to be solved through raising the issue in the regional MSP. Lastly payment for the animal supply by the abattoirs based on dressing percentage rather than on live weight as it has been used need a mind preparation work to the cooperatives. This issue can be raised and discussed during the B&B meeting.

Achiviements

- *Cooperative members obtained a total net profit of 72,291birr (3,615 USD) from the sale of 823 goats (13,933 Kg of live weight);*
- *The selling price per a kg of live weight was 36-42 birr (about 2 USD). Price comparison offered by the abattoir has a difference of 5-10 birr per kg of live weight (in favour of the farmers) from what has been offered by traders a (31birr/kg).*
- *In these market linkage 446 (112 female) households engaged and each gained a net profit of 162 birr within a month.*
- *The cooperatives on the other hand got 27,866 birr (1393 USD) from the members' contribution (2birr per a kg of goats live weight) upon on average of two months of collective marketing facilitation.*
- *In the collective marketing a total of eight cooperatives from Oromia (2) and SNNPR (6) were participated and each supplied an average of 103 goats. The average body weight of goat supplied was ranging from 16-18kg which is near to the Borena, Jimma and Bale breed (19kg) which are the most preferred for their higher dressing percentage. The goats supplied by the cooperatives to Allana have 40% dressing percentage and hence can yield 5,573kg fresh meat.*
- *The meat yield obtained can generate a total 27,866 USD (1kg/5USD) at markets in UAE and Saudi Arabia.*

Lessons learnt

Based on the practical experiences outlined above and feedback from numerous stakeholders in MSP and B2B meetings, GRAD strongly believes that introducing collective marketing through use of collection centres play vital role to improve households' income engaged in shoa fattening and are organized into cooperatives. Some of the benefits are:

Income improvement: Households organized into cooperatives through the use of collection centres improved their income from sell of the livestock continuously throughout the year without waiting for specific market days; skipping intervention of middle men who adds no value except elongating the chain and incurring additional transaction cost that reduce profit.

Better awareness of quality requirements: the export abattoirs require body weight of 15-30 kg and uncastrated goats of 1 to 2 years old. Heavy weight and fat animals do not have good export markets though they have high demand in local markets. Thus, households have a better awareness on quality requirements to expand market opportunities.

Positive contribution to national economy: Modern livestock marketing encourages the use of collection centres and improved fattening practices that enable the households contribute to the country's economic growth through new job creation, increased productivity, tax payment and foreign currency generation.

Sustainability: Ethiopia, being the leading in livestock population in Africa, has untapped potential in the sector. The government therefore has paid due attention to the designing, policy and strategy development and investment of abattoirs and live animal exporters. Yet the exporters and abattoirs have difficulties to get animals in the required quality and volume. Since livestock collection centres are highly encouraged approaches by the recent livestock market proclamation, there is hope both for the profitability and sustainability of the business.

Scale up: Livestock collection centre establishment to promote collective marketing can be used as off-farm income generating activities especially for landless and jobless youth and women in creating rural employment opportunity (graduates, school dropout, etc.). Only 120,000 birr with 480 shoats