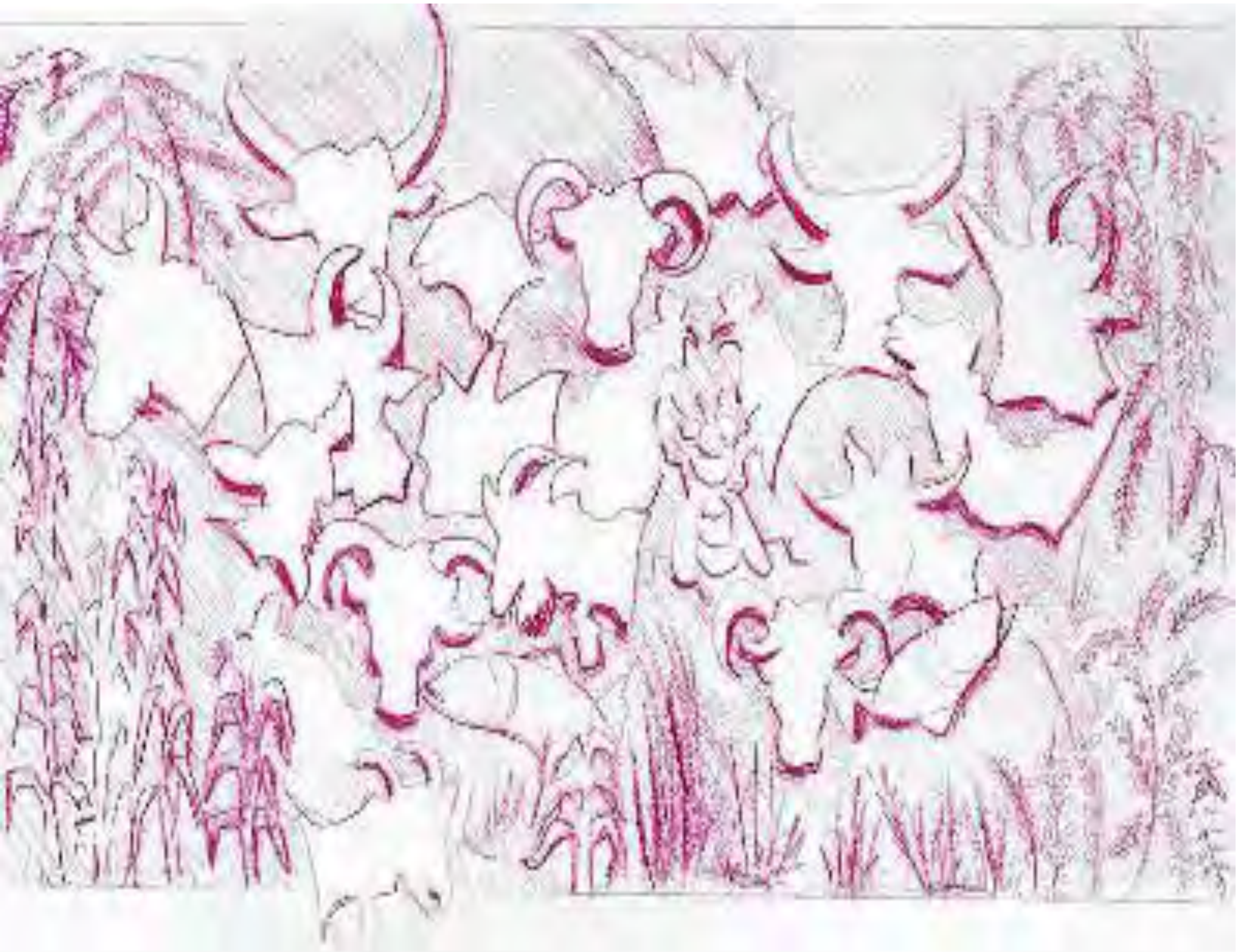
Ethiopian Journal of Animal Production

Volume: 17 Number 1 2017 ISSN: 1607-3835



Official Journal of the Ethiopian Society of Animal Production (ESAP)

Effect of Replacing Wheat Bran with Air Dried *Moringa stenopetala* Pod on Nutrient Intake, Digestibility and Growth Performances of Yearling Sheep

Aberra Melesse[#], Fassil Nigatu, Ajebu Nurfeta

School of Animal and Range Sciences, Hawassa University, Ethiopia
#Corresponding author: P.O. Box 05, Hawassa, Ethiopia. Fax: + 251-462-205421; Email: a_melesse@uni-hohenheim.de; a_melesse@yahoo.com

Abstract

A study was conducted to assess the effect of a partial substitution of wheat bran with air-dried Moringa stenopetala pod meal (MSPM) on nutrient intake, digestibility, growth performance and nitrogen utilization. Twenty-four yearling sheep with initial average body weight of 14.1±0.78 kg were divided into four groups of six animals and randomly allocated to dietary treatments. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) by partially substituting the wheat bran in the control diet The feeding experiment was conducted for 70 days followed by 10 days of digestibility trial. The dry matter (DM) intakes of sheep fed T1 and T2 was higher (p<0.05) than that of T3. Sheep reared in T4 diet had higher (p<0.001) crude protein (CP) intake than those fed with the other treatment diets. The neutral detergent fiber (NDF) intake of sheep fed with T4 diet was higher (p<0.05) than those of the control diet (T1) but did not vary with those fed T2 and T3 diets. The DM and organic matter digestibility was higher (p<0.05) in sheep fed with T4 diet than those of T3. The CP digestibility for T3 and T4 diets was higher (p<0.05) than those fed T1 and T2 diets. The NDF digestibility was higher (p<0.05) for sheep fed with T2 and T4 diets than those of T1. The average daily gain was higher (p<0.05) in sheep reared on T1 and T2 diets than those fed T4 diet. The average daily fain did not differ (p>0.05) among T1, T2 and T3 diets. Feed conversion ratio (FCR, g DM/g weight gain) was higher (p<0.05) in sheep fed with T4 than those of T1 and T2 diets. The FCR was similar (p>0.05) between T1, T2 and T3 diets. Nitrogen retention was higher (p<0.05) in sheep fed with T1 and T3 diets than the other treatment diets. Sheep reared in T2 diet had better nitrogen retention compared with T4 diet. In conclusion, M. stenopetala pod can substitute wheat bran (up to 15%) without affecting the voluntary feed intake and growth performances of yearling sheep.

***Key words**: body weight; digestibility; feed intake; Moringa pod; nitrogen retention*

Introduction

Livestock production is an integral part of Ethiopian agricultural system under heterogeneous agro-ecologies. The sub-sector contributes about 12-16% to the total GDP and 30-35% of total agricultural GDP, and 60-70% livelihoods of the Ethiopia population. Ethiopia's sheep population is about 29.0 million, out of which 22.8 % heads of sheep are under small farmers or landless livestock farmers (CSA, 2015). Sheep production contributes to subsistence and cash income generation for smallholder farmers. Sheep contribute substantially to food (meat supply), hides, wool and manure production. They serve as part of the crop failure risk coping portfolio, and investment as well as many other cultural functions (Markos, 2006).

Sheep production is a function of nutrition, health, genetics, climate and management among which nutrition plays an important role. Inadequate nutrition is the major constraint, for the low productivity of sheep. Sheep production relies on crop residues and natural pasture, which are usually deficient in nitrogen and limit animal performance. Thus, supplementation of low-quality roughages with conventional by-products is required for reasonable levels of animal performance. Farmers traditionally use conventional supplements like noug seed cakes, wheat bran and maize grains to improve the nutritive value of fibrous basal feeds. However, the use of such supplements is usually limited under smallholder livestock production systems due to their limited supply and high cost. Thus, evaluation of potentially useful unconventional feed resources is important in order to increase the resource base for livestock production. In this regard, parts of multipurpose trees have been considered as alternative feed sources during the dry season. Substitution of conventional ingredients by multipurpose tree parts such as leaves as suitable feeds for livestock has been reported (Aberra et al., 2011; 2013; Etana et al., 2011). One of such feed is *Moringa stenopetala*.

Moringa stenopetala is widely cultivated in southern Ethiopia and the leaf parts have been used for human consumption while pods are not; rather they are dried on the tree and became unpalatable to animals by the time they dropped from the tree to the ground (personal observations). Different studies have been shown the importance of *M. stenopetala* leaves in the diets of poultry (Aberra et al., 2011, 2013), sheep (Feleke et al., 2011) and goats (Kholif et al., 2015). However, the leaves of Moringa are also used for human consumption as well as for making tea and medicinal drugs for commercial purposes. Thus, it has been increasingly commercialized and become expensive in the recent times making difficult for smallholder farmers to use it for livestock feeding.

On the other hand, *M. stenopetala* pods are mainly available during most parts of the year and could be used as a good source of feed mainly during the dry season as a protein and energy supplement to low-quality roughages. Recent studies have indicated that the pod part of *M. stenopetala* contained crude protein ranging from 15.4 to 18.5%, which is comparable to that of wheat bran that has been commonly used as livestock feed in Ethiopia (Aberra et al., 2012). It has been further reported that the pods contained reasonable amounts of essential amino acids particularly those limiting amino acids such as lysine, methionine and cystein (Aberra et al., 2012). The same authors also reported that the pod contains 6.8 MJ/kg DM of Metabolizable energy.

However, the potential of the Moringa tree pod for future development and its role as suitable livestock feed resource in general and that of sheep in particular has not yet been investigated. Moreover, wheat bran is costly and thus most smallholder farmers cannot afford it. This study was thus initiated to study the effect of substituting wheat bran with air-dried *Moringa stenopetala* pods on nutrient intake, feed digestibility and growth performances of local sheep fed a basal diet of natural grass hay.

Materials and Methods

Experimental site

The experiment was carried out at Animal Farm of School of Animal and Range Sciences, Hawassa University (Ethiopia), which lies geographically between 7° 5′ N latitude and 38° 29′ E longitude at an elevation of 1700 m above sea level. The average annual rainfall ranges from 800 mm to 1100. The mean minimum and maximum temperatures in the area are 13.5 °C and 27.6 °C, respectively.

Preparation of experimental rations

The fresh green pods bearing seeds of *M. stenopetala* were harvested from available trees regardless of tree age. The green pods were collected at their early maturity and had deep green color when they were collected. The green pods were then chopped by using mortar and pestle (local material) and spread on a plastic sheet for drying in an area protected from direct sun light to prevent loss of vitamins and other volatile nutrients. Regular turning of the feed ingredient was done to facilitate drying and prevent growth of molds. The dried-pods were then ground using locally available materials to produce the *M. stenopetala* pod meal (hereafter referred to as MSPM). A concentrate mix was prepared with the following feed ingredients: wheat bran, maize, noug seed cake, salt and mineral lick. The ground pod was then packed in bags of 100 kg and stored until used. Before the commencement of the trial, the milled pods were mixed with the concentrate mix to prepare the experimental diets. Natural grass hay was bought from a private farm and hand chopped into the size of 3 to 5 cm and offered separately.

Experimental design and treatment diets

Twenty-four yearling local male sheep with initial average body weight of 14.1±0.78 kg were purchased and allowed to be adapted to the experimental environment for three weeks. At the end of the adaptation period, all sheep were ear tagged and blocked according to their body weights and then randomly assigned to the individual pens, which were fitted with individual feeders and watering troughs. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) by partially substituting the wheat bran in the control diet (Table 1). The feeding experiment was conducted for 70 days followed by 10 days of digestibility trial.

Management of experimental animals

About year old (age determined by dentition) male sheep were purchased from local market and transported to the experimental site. Upon arrival, the sheep were adapted to the environment for 3 weeks before the commencement of the actual experiment. During the adaptation period, the sheep were sprayed with acaricide (stalidon) and drenched with antihelminthics (Albendazole 300 mg) according to the dosage recommended by the manufacturers.

Table 1. The design of experimental diets with substitution levels of wheat bran by air-dried *Moringa stenopetala* pod

Feed ingredients	T1	T2	T3	T4
Grass hay	*Ad-libitum*	*Ad-libitum*	*Ad-libitum*	*Ad-libitum*
Wheat bran	62	46.5	34	15.5
Maize	16	16	16	16
Noug cake	20	20	20	20
Air-dried *M. stenopetala* pod	0	15.5	28	46.5
Salt	1	1	1	1
Mineral lick	1	1	1	1
Total	100	100	100	100

All the experimental sheep had *ad libitum* access to natural grass hay and clean water. The supply of natural grass was measured and adjustment was made when the refusal was less than 10% of the feed offered. Pens were cleaned on weekly basis while watering and feeding troughs were cleaned on daily basis.

Data collection procedures

Feed intake and body weight change: The sheep were weighed (prior to being offered any feed) for two consecutive days and the body weight was averaged, which was then considered as initial body weight for individual animals. Three hundred grams of the supplements as fed basis) per sheep and provided twice a day in equal portions at 8:00 a.m and 5:00 p.m. Feed intake was then determined by difference between amounts of feed offered and refused. To monitor body weight change, body weights were recorded every 14 days early in the morning before feed was offered. At the end of the experiment, all sheep were weighed individually for two consecutive days in the morning before feeding, and the average was taken as final body weight. Total body weight gain was then calculated by subtracting the initial body weight from the final. Feed conversion ratio (FCR) was calculated as a ratio of feed intake to weight gain.

Apparent digestibility trial and nitrogen balance: At the end of the growth trial, all sheep were transferred to metabolic cages. They were adapted to the cages, faecal collection bags and urine collection harnesses for three days followed by data collection for 7 days. The feeding regime was the same as in the preceding growth experiment. Details of faeces and urine sampling were according to Ajebu (2010). Faeces from each sheep were collected in faecal bags attached to the sheep every morning before feed offered and weighed. Then, 10% of the daily faecal output for the 7-day collection period was taken and bulked and stored at -20 0C. The daily total urine output of each sheep was collected in bottles containing 100 ml of 10% hydrochloric acid. Ten percent of the samples collected each day was taken and stored at -20 ^{0}C. At the end of the experiment, samples of faeces and urine were kept at room temperature and allowed to thaw for 24 h. After having the results of the chemical analysis, apparent digestibility, and N retention was determined using the following formula:

$$\text{Apparent digestibility} = \frac{\text{nutrient consumed} - \text{nutrient excreted in faeces}}{\text{Nutrient consumed}} \times 100$$

N-retention = N in feed consumed – (N excreted in faeces + N excreted in urine)

Chemical analysis

Dry matter (DM) content of the feed was determined by drying the samples at 105°C overnight. Faecal samples for chemical analysis were oven dried at 60°C for 48 h and milled using cross-beater mill (Thomas Wiley, Philadelphia, PA, USA) to pass through 1-mm sieve and stored in plastic bags for later chemical analysis. Ash was determined by combusting the samples at 550°C for 5 h. The organic matter (OM) content was computed as 100 - ash. Total nitrogen content of the feed, faeces and urine samples was determined using micro-Kjeldahl method. The crude protein (CP) was then calculated as nitrogen × 6.25. The acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents were analyzed using the method of Van Soest et al. (1991) in an ANKOM® 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA). All samples were analyzed in duplicates at Animal Nutrition Laboratory of Animal and Range Sciences, Hawassa University.

Statistical analysis

Data on nutrient intakes, nutrient digestibility, body weight, and nitrogen retention were subjected to one-way ANOVA using the GLM procedures of SAS (SAS, 2012, ver. 9.4) by fitting treatment diet as a single fixed factor. Mean comparisons were conducted using Tukey's Studentized Range Test and values were considered significant at $p<0.05$. The following linear model summarizes the statistics used to analyze the data:

$$Y_{ij} = \mu + A_i + D_j/A_i + e_{ij}$$

where: Y_{ij} = individual values of the dependent variables (feed intake, body weight, etc.); μ = overall mean of the response variable; A_i = the fixed effect of the i^{th} treatment diet (i = 1, 2, 3 and 4) on the dependant variables; Dj/Ai = the effect of the j^{th} animals (j =1, 2, 3, 4, 5, 6) within i^{th} treatment diets; e_{ij} = random variation in the response of individual animals.

Results

Chemical composition of feed ingredients and treatment diets

The chemical composition of the feeds used in this study (Table 2) shows that natural grass hay had low CP but high NDF and ADF contents. The MSPM had higher CP and lower NDF and ADF contents than wheat bran. The CP content was similar across the treatment diets. The DM content was similar for most feed ingredients.

Table 2. Chemical composition of feed ingredients used in the experimental diets (g/kg DM)

Feed ingredients	DM (g/kg feed)	CP	NDF	ADF	Ash
Maize (white)	961	86.4	241	205	35.2
Noug seed cake	961	303	345	215	116
Wheat bran	972	146	425	253	96.2
Air-dried Moringa pod	973	160	323	215	55.5
Natural grass hay	944	28.5	661	337	96.2

Dry matter and nutrient intake

The DM intake was significantly higher in sheep fed with T1 and T2 diets than those of T3 (Table 3). Sheep fed with T2 diet had also higher OM intake than those of T3. On the other hand, sheep reared in T4 diet had higher ($p<0.001$) CP intake than those fed on the other treatment diets. The lowest CP intake was observed in sheep fed with the T2 diet being significantly different from the rest of the treatments. The NDF intake in sheep fed with T4 diet did not vary from those fed T2 and T3 diets but was higher ($p<0.05$) than those reared in the control diet. On the contrary, the ADF intake was lowest in sheep fed with the T4 diet and differed ($p<0.01$) from the other treatments.

Table 3. Dry matter and nutrients intake (g/d) of sheep fed with air-dried *Moringa stenopetala* pod by partial substitution wheat bran

Intake	Treatments				SEM	P-value
	T1	T2	T3	T4		
Dry matter	566[a]	575[a]	522[b]	552[ab]	10.6	0.011
Organic matter	496[ab]	525[a]	487[b]	515[ab]	9.38	0.04
Crude protein	54.7[b]	51.4[c]	54.4[b]	57.1[a]	0.44	<0.001
Neutral detergent fiber	190[b]	206[ab]	207[ab]	216[a]	6.62	0.05
Acid detergent fiber	133[a]	132[a]	135[a]	103[b]	4.68	0.002

[a,b] Row means between treatment diets with different superscript letters are significantly different at p<0.05. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran. SEM = standard error of mean

Apparent digestibility

The DM and OM digestibility coefficients were higher ($p<0.05$) in sheep fed with T4 diet than those of T3 (Table 4). No significant differences were observed in DM and OM digestibility coefficients between T1, T2 and T3. The CP digestibility coefficient was similar for sheep fed with T3 and T4 diets but was higher (P<0.05) than those of T1 and T2. The NDF digestibility coefficient was higher (p<0.05) for sheep fed with T2 and T4 diets than those of T1. No significant differences were observed in ADF digestibility among sheep fed with different levels of treatments diets.

Table 4. Apparent digestibility coefficients of sheep fed with different levels of air-dried Moringa *stenopetala* pod as partial replacement of wheat bran

Digestibility	Treatments				SEM	P-value
	T1	T2	T3	T4		
Dry matter	76.1^{ab}	73.6^{ab}	72.3^{b}	81.2^{a}	1.91	0.019
Organic matter	77.5^{ab}	76.3^{ab}	75.6^{b}	82.3^{a}	1.67	0.025
Crude protein	78.8^{b}	74.2^{b}	86.6^{a}	84.8^{a}	0.87	<0.001
Neutral detergent fiber	51.0^{b}	63.7^{a}	59.4^{ab}	65.7^{a}	2.52	0.025
Acid detergent fiber	61.8	66.6	59.5	62.7	2.37	0.286

[a,b] Row means between treatment diets with different superscript letters are significant at p<0.05. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran
SEM = standard error of mean.

Body weight and feed conversion ratio

The average body weight gain was significantly (p<0.05) higher in sheep fed with T1 and T2 diets than those of T4 (Table 5). Average daily body weight gain of sheep fed with T1, T2 and T3 diets did not vary significantly. Feed conversion ratio was higher (p<0.05) for those sheep fed with T4 diet than those of T1 and T2 diets. No significant difference was noted in feed conversion values between T1, T2 and T3 diets.

Table 5. Body weight, weight gain and feed conversion ratio of sheep fed with air-dried *Moringa stenopetala* pod as a partial replacement of wheat bran

Parameters	Treatments				SEM	P
	T1	T2	T3	T4		
Initial weight (kg)	13.1	13.3	13.0	13.1	0.384	0.918
Final weight (kg)	17.9	18.1	17.4	16.8	0.374	0.087
Total weight gain (kg)	4.80^{a}	4.79^{a}	3.97^{ab}	3.67^{b}	0.269	0.013
Average daily gain (g)	60.0^{a}	59.9^{a}	49.7^{ab}	45.9^{b}	3.365	0.013
Daily DM intake (g)	566^{a}	575^{a}	522^{b}	552^{ab}	10.63	0.011
FCR (g DM/g gain)	9.53^{b}	9.71^{b}	10.8^{ab}	12.3^{a}	0.648	0.023

[a, b] Row means between treatment diets with different superscript letters are significant at p<0.05. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran.
SEM = standard error of mean; FCR = feed conversion ratio

Nitrogen utilization

The nitrogen utilization values of sheep fed with diets containing different levels of *Moringa stenopetala* pod are presented in Table 6. The highest nitrogen intake was noted in those sheep fed with T1 and T3 diets which differed significantly (P<0.05) from those fed with other treatment diets. The amount of fecal nitrogen excreted in sheep fed with T2 diet was higher (P<0.05) than those fed T3 and T4 diets. Sheep fed with T1 and T3 diets had similar fecal nitrogen loss but were significantly higher than those of T4. Urinary nitrogen values were similar among those sheep fed with T3 and T4 diets but were higher (P<0.05) than those of T1 and T2 diets which showed similar values in these parameters. Nitrogen retention values in sheep fed with T1 and T3 diets were higher (p<0.05) than the other treatment diets. Similarly, sheep fed with T2 diet had better nitrogen retention than those of T4.

Table 6. Nitrogen utilization of sheep fed with different levels of *Moringa stenopetala* pod meal as a partial substitution of wheat bran

Parameters	Treatment				SEM	P-value
	T1	T2	T3	T4		
N intake (g/head/d)	8.75^{a}	8.21^{b}	8.70^{a}	4.13^{c}	0.059	<0.001
N excretion (g/head/d)						
Faeces	1.85^{ab}	2.13^{a}	1.79^{b}	0.38^{c}	0.083	<0.001
Urine	0.80^{b}	0.91^{b}	1.09^{a}	1.13^{a}	0.039	<0.001
N retained (g/head/d)	6.11^{a}	5.18^{b}	5.83^{a}	2.63^{c}	0.109	<0.001

^{a,b,c} Row means between treatment diets with different superscript letters are significant at p<0.05. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran; SEM = standard error of the mean

Discussion

Chemical composition

The present findings have proved that natural grass hay that is commonly used as basal roughage cannot support the maintenance requirement of animals due to the high fiber and low crude protein content. Moreover, the CP content below the minimum microbial requirement (70 g CP/kg DM) cannot support microbial activity and the maintenance requirement of animals (McDonald et al., 2002). The CP content of the natural grass hay in this study (2.85%) is lower than those reported by Aberra et al. (2016) and Berhanu et al. (2014). These variations might be due to differences in location, soil type, post harvest handling, leaf to stem ratio and maturity stage of the forage itself at the harvest.

The CP content of *M. stenopetala* pods in the current study was slightly higher than those reported by Aberra et al. (2012) for mid elevation (154 g/kg DM) but was lower than the value reported for low elevation (184 g/kg DM). Etana and Adugna (2013) reported 191 g/kg DM CP that is higher than the result in the current study. These variations could be associated with the elevation where the samples were collected, soil type as well as the stage of maturity of the plant material.

The NDF and ADF values for *M. stenopetala* pod in the current study were lower than those reported by Aberra et al. (2012) and Etana and Adugna (2013). According to Van Soest (1991) the critical ranges of NDF supply to ruminants are 600–650 g/kg DM above which feed intake will be affected. Multipurpose tree parts like *M. stenopetala* pod maintain the initial high level of crude protein for long periods before the protein content drops below the maintenance requirement of animals, with advance in plant maturity (Etana and Adugna, 2013).

Dry matter and nutrient intakes

The chemical composition of feed ingredients supports the variation in feed intake of treatment diets. The *M. stenopetala* pod meal maintained the increased intake of basal and total feed DM at increased levels of inclusion, which may suggest that air-dried pods did not reduce the general intakes of animals. Zemmelink and t'Mannetje (2002) reported that increasing the level of feed offers resulted in higher DM and nutrient intakes by reducing the feed refusal, which may suggest the palpability of the offered feed material. In contrast, Koech et al. (2010) reported increased levels of basal feed refusals at higher levels of supplementation of *Prosopis juliflora* seedpod meal to goats, which might be due to the substitution effect on basal feed DM at increased levels of supplementation (Umunna et al., 1995). Moreover, the negative effect of condensed tannins and soluble phenolics contained in *Prosopis juliflora* pods (Aberra et al., 2017) might have imposed limitations on CP intake, by forming protein-tannins complex and rendering it indigestible.

Increasing levels of MSPM substitution for wheat bran did not have undesirable effect on basal feed DM intake. This suggests that the less likelihood of fast degrading supplements to substitute the basal feed DM, which was in good agreement with the observation of Nsahlai et al. (1998) and Patra (2009). The CP intake was also increased similar to the trends of DM intake, which is in good agreement with the reports of Tegene et al. (2000).

Apparent digestibility of nutrients

The digestibility of feed nutrients influences the speed with which the feed passes through the digestive system. Generally, feedstuffs with higher digestibility will be processed more rapidly, allowing animals to eat more and have higher production. The nutrient composition of the basal feed and supplement consumed together affects digestibility (McDonald et al., 2002). In the current study, sheep fed with high levels of substitution of wheat bran (46.5%) with air-dried pods of *M. stenopetala* had higher DM and OM digestibility coefficients than at 28% level of substitution. The variations in DM and CP digestibility coefficients might be due to the supplementation level (only partial replacement of the control diet). However, the nutrients supplied by the different combination of supplements used in this study were sufficient to make more or less similar effect on the digestibility of DM and nutrients.

The higher CP digestibility of sheep fed with T4 diet compared with that of T1 and T2 could be due to high CP intake of T4 supplied by Moringa pods. The results are consistent with the findings of Feleke et al. (2011), Dougnon et al., (2012) and Khalel et al. (2014) who reported positive effects of *M. stenopetala* and *M. olifera* leaves on the performance of sheep, rabbits, and lactating cows, respectively. The present results are also in good agreement with those reported by Newton et al. (2010), Mendieta-Araica et al. (2011) and Nouman et al. (2014) who suggested that *Moringa* tree parts are rich in most nutrients and thus it can serve as useful source of supplementation to low quality diets so as to increase the nutrients digestibility.

The current results further showed that there is a higher NDF digestibility coefficient as the level of *M. stenopetala* pod meal increased and the results are consistent with Etana and Adugna (2013) and Aberra et al. (2013) who reported higher fermentation characteristics of pods of *M. stenopetala* suggesting improved digestibility and availability of nutrients to ruminant animals. Moreover, Makkar and Becker (1996) reported that about 95% of *Moringa* CP was found to be available either in the rumen or in the post rumen. Kleinschmit et al. (2007) reported the bypass protein that resists degradation in the rumen, which then passes to the lower tract for digestion, is necessary for maximizing production of ruminant animals. It could be thus speculated that an increase in CP content of treatments (as the inclusion level of *M. stenopetala* pod increased) might be beneficial due to the action of fermenting microorganisms in the synthesis of some amino acids. Therefore, increased CP digestibility and CP intake could be the result of improved quality of protein, which is the result of amino acid profiles, physical and chemical characteristics and microbial proliferation initiated by *M. stenopetala* pod inclusion in the diet.

Body weight and feed conversion ratio

In the current study, sheep fed with all treatment diets had a positive weight gain, which indicates the nutritive value of the *M. stenopetala* pod as a potential source of protein and energy. The average daily body weight gains in the current study were higher than those reported by Lemma (1993) for lambs fed with *Leucaena* by substituting Noug seed cake but were lower than those of Feleke et al. (2011) for sheep supplemented with *M. stenopetala* leaves.

The weight gains of the sheep reared in T1, T2 and T3 diets was similar (with increasing levels of *M. stenopetala* pod), which might be associated with higher digestibility coefficients of CP. This observation is consistent with the findings of Nouman et al. (2014) and Adegun and Aye (2013) on West African Dwarf Rams fed *Moringa oleifera* and cotton seed cake.

Animals that convert at a high rate (lower FCR, g DMI / g gain) are more preferred to those with lower ratio as they optimize performance and are economically valuable in environments that have low quality and quantity of feed resources. Feed conversion ratio (g DMI/ g gain) in the current study has increased as the level of *M. stenopetala* pod meal increased. However, the FCR in those sheep fed with T1, T2, and T3 diets had similar values and did not vary significantly from each other. This might be due to the contribution of *M. stenopetala* pod fermentation quality brought into the rumen in the form of available cellulose and hemicelluloses which stimulate fiber digestion and hence nutrient released for growth (Etana and Adugna, 2013).

Nitrogen utilization

All the treatment groups fed with *M. stenopetala* pods have shown a positive nitrogen balance, which suggests that the supply of energy and nitrogen were higher than the maintenance requirement. The results are consistent with the findings of Ajebu (2010), Mendieta-Aracia et al. (2011) and Nouman et al. (2014) who reported improved growth performance as a result of better nitrogen balance in sheep fed with basal diet of wheat straw supplemented with local agricultural by-products and *Moringa* leaves. On the other hand, contradictory results were reported in sheep fed *with Prosopis juliflora* pods and *Cenchrus* grass (Chaturvedi and Sahoo, 2013). In the current study, the urine nitrogen increased with increased levels of *M. stenopetala* pod substitution, which is consistent with the reports of Clark et al. (1992). The positive balance shows the nitrogen (N) availability for microbial protein synthesis and that the captured N from the treatment diets. Moreover, the amount of N excreted with the faeces decreased as the level of pods increased suggesting efficient utilization of the protein in pods. However, the amount of nitrogen retained did not show a consistent trend among treatment diets and was higher only in sheep fed with T3 and T1 diets, which differed with those of T2 and T3. Nitrogen retention for a specific ration might be affected by factors such as increasing presence of fermentable energy, available fermentable energy, and variation in rumen undegradeble nitrogen (Holzer et al., 1986). Moreover optimizing factors for nitrogen retention enhances utilization of ammonia in the rumen and reduces the effect of free fats in protein synthesis (Hagemeister et al., 1981).

Conclusion

The findings of the present study indicated that *M. stenopetala* pod could substitute wheat bran by serving as protein and energy sources without affecting the voluntary feed intake and growth performances of local sheep. *M. stenopetala* pod can thus partially replace wheat bran in the concentrate mixture up to 15% in sheep feeding for improved performances. Smallholder farmers in Moringa growing regions can substitute conventional concentrate supplements by *M. stenopetala* pod due to its year round availability and easy access.

Acknowledgements

This research project was supported by the research fund granted by the Hawssa University of the Vice President for Research and Research and Technology Transfer Office for which the authors are highly grateful. The support received from Mr. Tadesse Bekore in analyzing the feed composition is highly acknowledged.

Refences

Aberra Melesse, Steingass H., Boguhn J., Schollenberger M., Rodehutscord M., 2012. Effects of elevation and season on nutrient composition of leaves and dry green pods of *Moringa stenopetala and Moringa oleifera*. Agroforestry Systems 86(3): 505-518.

Aberra Melesse, Yoseph Getye, Kefyalew Berihun, Banerjee S., 2013. Effect of feeding graded levels of Moringa stenopetala leaf meal on growth performance, carcass traits, and some serum biochemical parameters of Koekoek chickens. Livestock Science 157: 498-505.

Aberra Melesse, Banerjee S., Degnet H/Meskel, Aster Abebe, Amsalu Sisay, 2016. Carcass and meat quality characteristics of Arsi-Bale goats supplemented with different levels of air-dried *Moringa stenopetala* leaf. Journal of Agriculture and Rural Development in the Tropics and Subtropics 117: 233-242.

Aberra Melesse, Steingass H., Schollenberger M., Holstein J., Rodehutscord M., 2017. Nutrient compositions and *in vitro* methane production profiles of leaves and whole pods of twelve tropical multipurpose tree species cultivated in Ethiopia. Agroforestry Systems 71 (3): DOI: 10.1007/s10457-017-0110-9.

Adegun M.K, Aye P.A., 2013. Growth performance and economic analysis of West African Dwarf Rams fed *Moringa oleifera* and cotton seed cake as protein supplements to *Panicum maximum*. American Journal of Food and Nutrition 3(2): 58-63.

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.

Berhanu Alemu, Getachew Animut, Adugna Tolera, 2014. Effect of *Millettia ferruginea* (Birbra) foliage supplementation on feed intake, digestibility, body weight change and carcass characteristics of Washera sheep fed natural pasture grass hay basal diet. SpringerPlus 3: 50. doi: 10.1186/2193-1801-3-50.

Chaturvedi O.H., Sahoo A., 2013. Nutrient utilization and rumen metabolism in sheep fed *Prosopis juliflora* pods and Cenchrus grass. SpringerPlus. 2: 598. doi: 10.1186/2193-1801-2-598.

Clark J.H., Klusmeyer T.H., Cameron M.R., 1992. Microbial protein synthesis and flows of nitrogen fractions to the duodenum of dairy cows. Journal of Dairy Science 75: 2304-2323.

CSA (Centeral Statistical Agency). 2015. Agricultural Sample Survey: Volume II Report On Livestocks And Livestock Characteristics(Private Peasant Hioldings). Sample Survey, CSA:Centeral Statistical Agency, Addis Ababa.

Dougnon T.J, Aboh B.A., Kpodékon T.M., Honvou S., Youssao I., 2012. Effects of substitution of pellet of *Moringa oleifera* to commercial feed on rabbit's digestion, growth performance and carcass trait. Journal of Applied Pharmaceutical Science 2(9): 15-19.

Etana Debela, Adugna Tolera, 2013. Nutritive value of botanical fractions of *Moringa oleifera* and *Moringa stenopetala* grown in the mid-Rift Valley of southern Ethiopia. Agroforestry Systems 87(5): 1147-1155.

Feleke Gebregiorgis, Tegene Negesse, Ajebu Nurfeta, 2011. Feed intake and utilization in sheep fed graded levels of *Moringa stenopetala* leaf as a supplement to Rhodes grass hay. Tropical Animal Health and Production 44 (3): 511-517.

Hagemeister H., lupping W., Kaufmann W., 1981. Microbial synthesis and digestion in high yielding dairy cow. In Developments in Ruminant Nutrition," Eds. Haresign, Cole, D.J.A., Pages 31-48.

Holzer Z., Levy D., Samuel V., Bruckenthal I., 1986. Interactions between supplementary nitrogen source and ration energy density on performance and nitrogen utilization in growing and fattening male cattle. Animal Production 42: 19-28.

Khalel, M.S., Shwerab, A.M., Hassan, A.A., Yacout, M.H., El-Badawi, A.Y., Zaki, M.S., 2014. Nutritional evaluation of *Moringa oleifera* fodder in comparison with *Trifolium alexandrinum* (berseem) and impact of feeding on lactation performance of cows. Life Science Journal 11: 1040-1054.

Kholif A.E., Gouda G.A., Morsy T.A., Salem A.Z.M., Lopez S., Kholif A.M., 2015. *Moringa oleifera* leaf meal as a protein source in lactating goat's diets: Feed intake, digestibility, ruminal fermentation, milk yield and composition, and its fatty acids profile. Small Ruminant Research 129: 129-137.

Kleinschmit D.H., Anderson J.L., Schingoethe D.J., Kalscheur K.F., Hippen A.R., 2007. Ruminal and intestinal degradability of distillers grains plus soluble varies by source. Journal of Dairy Science 90: 2909-2918.

Koech O.K., Kinuthia R.N., Wahome R.G., Choge S.K., 2010. Effects of Prosopis juliflora Seedpod Meal Supplement on Weight Gain of Weaner Galla Goats in Kenya. Research Journal of Animal Sciences 4: 58-62.

Lemma Gizachew, 1991. Comparison of legume hay, urea and noug cake as protein supplements for sheep fed teff straw. pp. 211- 215. In: Proceedings of the Fourth. National Livestock Improvement Conference. 13-15 November, 1991. IAR, Addis Ababa, Ethiopia.

Makkar H.P.S., Becker K., 1996. Nutritional value and anti-nutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Science and Technology 63: 211-228.

Markos Tibbo, 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Ph D. Thesis. Swedish Univ. Uppsala, Sweden.

McDonald P., Edwards R.A., Greenhalgh J.F.D., Morgan C.A. ,2002. Animal nutrition; 6th edn. Harlow: Prentice Hall.

Mendieta-Araica B., Spörndly R., Reyes-Sánchez N., Spörndly E., 2011. *Moringa oleifera* leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. Livestock Science 137(1): 10-17.

Newton K.A., Bennett R.N., Curto R.B., Rosa E.A., Turc V.L., Giuffrida A., Curto A.L., Crea F., Timpo G.M., 2010. Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. Food Chemistry Journal 122: 1047-1064.

Nouman W., Basra S.M., Siddiqui M.T., Yasmeen A., Gull T., Alcayde M.A., 2014. Potential of *Moringa oleifera* L. as livestock fodder crop: a review. Turkish Journal of Agriculture and Forestry 38: 1-14.

Nsahlai I.V., Umunna N.N., 1996. Sesbania and lablab supplementation of oat hay basal diet fed to sheep with or without maize grain. Animal Feed Science and Technology 61(1): 275-289.

Patra A.K., 2009. Responses of intake, digestibility and nitrogen utilisation in goats fed low-quality roughages supplemented with tree foliages. Journal of the Science of Food and Agriculture 89(9): 1462-1472.

Tegene N., Rodehutscord M., Pfeffer, E. 2000. The effect of dietary crude protein level on intake, growth, protein retention and utilization of growing male Saanen kids. Small Ruminant Research 39: 243-251.

Umunna N.N., Osuji P.O., Nsahlai I.V., Khalili H., Mohamed-Saleem M.A., 1995. Effect of supplementing oat hay with *lablab, sesbania, tagasaste* or wheat middlings on voluntary intake, N utilization and weight gain of Ethiopian Menz sheep. Small Ruminant Research 18(2): 113-120.

Van Soest, P.J., Robertson J.B., Lewis B.A., 1991. Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74: 3583-3597.

Zemmelink G.,'t Mannetje L., 2002. Value for animal production (VAP): a new criterion for tropical forage evaluation. Animal Feed Science and Technology 96: 31-42.

Fortified and Powdered Milk Supply in Ethiopia: Concerns and Prospects

Lemma Habtamu

Wolaita Sodo University, P.O. Box 138, Wolaita Sodo, Ethiopia; E-mail: lemmahab2015@gmail.com

Abstract

There have been importations of powder milk to fill milk supply-demand gap in Ethiopia. Milk powder (fortified or not) and liquid milk available in supermarkets and shops include Anchor milk, Nido milk, Coast milk, UHT processed milk, Abay full cream milk and 'Me and My' full cream milk and pasteurized milk. However, prospects and gaps for research, development and policy on fortified milk and other milk powder remain uninvestigated and little information is available for designing strategies for sustainable supply of milk and milk products in Ethiopian/African context. This hindered consumers' informed choices and further intervention in the dairy food industry, which calls for knowledge and experiences from elsewhere. Thus, this paper summarizes the available information on various aspects of dairy products, including pasteurized milk, fortified milk and other powdered milk products through an extensive review of several published articles and gray literature. The imported milk powder is costly and is out of reach of middle and low income people, who are most affected by malnutrition. In addition, there is limited foreign currency and also safety concerns. Therefore, increasing domestic milk supply is crucial to reduce dairy imports. This in turn requires building the capacity of smallholder/medium dairy producers towards improved or good quality milk production and marketing. Moreover, little is known about milk fortification in Ethiopia, which raises issues of fortification policy/strategies, and potential impact of fortification. Research need to be initiated on milk powder, including on its microbial, compositional and adulteration and other aspects of quality and safety. Action is also required for designing and implementing dairy foods import policy and regulation.

Key words: *Milk fortification, extended shelf life products, pasteurized milk, powdered milk, sustainable dairy industry*

Introduction

Milk and milk products play important role to enhance nutrition and livelihood security. According to OECD/FAO, 2016, whole milk and skimmed milk powder will remain the most traded agricultural commodities. Asia will remain the main market for dairy products, accounting for 55 percent of world imports, followed by Africa, with 15 percent. Elevated international prices are projected to reduce imports by Africa as a whole. In Brazil, rising domestic production is expected to lead imports being displaced (FAO FOOD OUTLOOK, 2013). In developing countries, the dairy sector has been negatively affected by the dumping of surplus subsidized dairy products by the EU and USA, which discourage local production (World Bank, 2006). This implies that for local dairy industries to survive, not only production but also productivity, has to increase, in order to stand competition from foreign markets. Restricting imports can only successfully control importation if favorable policies and suitable resources are allocated to the promotion of domestic production (Ndambi et al., 2007) by making use of opportunities for growth of dairy production in countries with great potential, such as China, India, and East Africa (World Bank, 2006).

Quality and safety of imported dairy products also need more caution as on the spot observation at farm is not possible. In this connection, importing countries may ban, as the case of India and Russia who banned dairy products in 2013 due to health and safety concerns (FAO FOOD OUTLOOK, 2013). In this regard, there is a growing concern of quality and safety of milk powder and other dairy products after the occurrence of melamine in the powdered milk in China (Terry, 2011). False labeling of the animal origin of milk, the use of reconstituted powdered milk, and the addition of partially hydrogenated vegetable oils are currently a matter of investigation for milk and dairy products (Tsimidou and Boskou, 2003).

Improved dairy production in Ethiopia began decades ago. There were various reports from the country concerning average daily milk yield/head in urban and peri-urban dairy production systems, where relatively more improved dairy inputs and experience exist. For instance, Azage et al. (2013) reported 10.2-15.9 kg and 9.5 kg of milk per cow per day for crossbred dairy cows in urban and peri-urban dairy production systems, respectively. Therefore, there is great potential to enhance domestic production and reduce the expensive reliance on imported milk products, which also needs close surveillance and testing for their quality.~~,~~ The projection by Zelalem et al., 2011 showed that Ethiopian total demand, supply and deficit of milk for the year 2018 were 6 192, 4 055 and 3 435 million liters, respectively. There are also issues of affordability of imported dairy products by low and middle income groups. Therefore, exploiting the potential will reduce foreign currency expenditure on dairy imports besides addressing sustainable domestic dairy foods supply, livelihood and a need of long-shelf life dairy products during fasting season.

In 2006, household dairy consumption in Ethiopia was 30% raw milk, 38% fermented butter, 15% pasteurized milk, 8% powder milk, and 6% ayib (cottage cheese) (Francesconi et al., 2009). It is also important to note that industrially processed dairy products made in Ethiopia are consistently cheaper than imported ones. For example, one litre of pasteurized milk produced in

Ethiopia is 40% cheaper than one litre of milk reconstituted from imported milk powder (Francesconi et al., 2009). This has also a spillover effect on the price of fluid milk paid for the dairy producers, who cover the costly concentrate feed and private veterinary service. Dairy processers are also complaining about the costly imported packing materials.

'Initiatives' of promotion of nutritional value addition (bio-fortification) to selected staple seeds to ensure availability and consumption of diverse nutritious food was taken in the national nutritional program (FDRE, 2013). In addition, the study by FMOH (2011) found that flour fortification with iron and folic acid, and oil fortification with vitamin A to be among the viable options to address the nutrition program. However, no milk fortification program was considered though milk is fortified in Ethiopia, recently. Moreover, there are no studies conducted on quality of fortified milk and other milk powders. Thus, there is shortage of up-to-date information on this area and gaps for further research and interventions. Therefore, there exists lack of access to scientific information and awareness about these products for consumers' informed choices and for those involved in dairy foods industry. The challenge is to exploit relevant knowledge elsewhere and to benchmark and adopt it to the local situation with regard to current status and future prospects. Hence, this paper summarizes available knowledge on fortified milk and its powdered products through an in-depth review of literature.

Milk

Milk has been known as nature's most complete Food. More than 100 different components have been identified in cow's milk (Jarvis et al., 2007). Intake of cow's milk and milk products contributes to health throughout life. Experimental studies indicate that cow's milk protein may help to increase bone strength, enhance immune function, reduce blood pressure and risk of some cancers, and protect against dental caries (Gobbetti et al., 2007; Jarvis et al., 2007). Milk fat is also a source of energy, essential fatty acids, fat-soluble vitamins, and several health-promoting components such as conjugated linoleic acid (CLA), sphingomyelin, and butyric acid. For example, emerging scientific findings reveal that CLA may protect against certain cancers and cardiovascular disease, enhance immune function, and reduce body fatness by increasing lean body tissue. Milk and other dairy foods are important sources of many vitamins and minerals. Calcium helps to reduce the risk of osteoporosis, hypertension, some cancers, and some types of kidney stones, and may have a beneficial role in weight management (Jarvis et al., 2007).

Milk is processed into various products such as pasteurized and powdered/fortified milk and the safety of milk particularly at farm level is crucial. In this regard, livestock/dairy science professionals and veterinarians need to be forefront to be part of the solution in suggesting ways to alleviate the problems, including designing dairy intervention project, informing policy, dairy extension and other mechanisms that can support the smallholder dairy producers to ensure safe milk production.

Pasteurized milk

The objective of pasteurizing milk is to ensure the safety of fluid milk and to prolong its shelf life. Pasteurization destroys all known pathogens occasionally encountered in raw milk and most spoilage bacteria (Meunier-Goddik and Sandra, 2002). Although milk and dairy products can transmit biological and chemical hazards, there are effective control measures like pasteurization which help to minimize risk to human health. Pasteurization or equivalent processing of milk and milk products and the implementation of validated food-safety programs have been proved to ensure safe milk and dairy products (FAO, 2013).

Pasteurization is originally designed to ensure adequate destruction of common pathogenic micro-organisms (including Mycobacterium bovis, commonly responsible for tuberculosis at the time), and can extend the shelf-life (10-14 days) of milk by destroying almost all yeasts, molds and common spoilage bacteria (Jensen, 1995; Creamer et al., 2002). Pasteurization (heating to 72 °C for 15 seconds) is based on the time–temperature combinations. Vegetative cells of food-borne pathogens are sensitive to heat and are readily killed by the pasteurization process. It also inactivates most enzymes that might cause spoilage through the development of off-flavors. Hence pasteurization both ensures safety and prolongs shelf-life with minimal changes to flavor and nutritional quality of the product (Lewis, 2010; Motairjemi and Lelieveld, 2014).

In Ethiopia, there are around 32 dairy processors which collect raw milk mainly from peri-urban and urban dairy farmers and process into pasteurized dairy product. To this end, processors and other dairy stakeholders have great roles in supporting smallholder and medium farmers to improve raw milk quality at farm level besides reducing or minimizing sources of contamination in processing plants.

Powdered milk

Imports of dairy products have strongly fluctuated over the years. Over the last three recorded years, the variation was between US$ 11–15 million (Table 1) and 80% of this value comes from imported milk powder, widely used in infant formulas. Some of the imported milk powders (Fortified or not) displayed in supermarkets and shops of Addis Ababa include Anchor's milk, Nido milk, Coast milk, UHT processed milk, Abay full cream milk and Me and My full cream milk. There is no Ethiopian company processing milk powder, although some processors are planning to invest in such facilities (Zijlstra et al., 2015). If milk powder is manufactured, it could partially have addressed the concerns of high costs of importing dairy products and the requirement for long-shelf life dairy products.

Powdered milk is usually made from skim milk because having less fat helps the product resist rancidity (Encyclopedia of Foods, 2002).The approximate compositions of the major traditional milk powder products are as follows: skim milk powder (36% protein, <1% fat, 51% lactose, 8% ash water, 3–4% moisture); full-cream milk powder (26% protein, 27% fat, 38% lactose, 6% ash, moisture 3%) (Chandan, 2008). In this regard, the quality of milk products including their packaging materials being imported and the shelf life/expiry dates of the products after their imports need to be controlled or supervised. Food, Medicine, Health Care and Administration Authority is the most appropriate organization to implement these tasks.

Table 1. Ethiopian import of milk and milk products (weight and value)

Product	2011		2012		2013	
	Net wt. (kg)	CIF Value (US$)	Net wt. (kg)	CIFValue (US$)	Net wt. (kg)	CIF Value (US$)
Cheese	102,387	467,840	97,568	497,297	83,532	665,350
Milk, butter and yogurt	1,689,714	9,900,636	1,766,451	9,438,761	1,199,761	4,923,178
Powdered milk	450,642	2,932,581	983,178	5,792,618	810,516	5,413,487
Total	2,242,743	13,301,057	2,847,196	15,728,676	2,093,132	11,002,015

CIF=Cost, Insurance and Freight

Recently, there was occurrence of melamine contamination in Chinese milk powder. Although it has no nutritional value, because of its high nitrogen content melamine is added to watered-down milk to cover up the protein deficiency. Melamine is known to cause stones in the kidneys leading to renal problems and kidney failure in humans and animals. According to the US-FDA, melamine below 2.5 mg/kg is not of much concern. The EU has set 0.5 mg/kg as the safe limit of melamine (Nag, 2010). In August 2013, Fonterra warned that a batch of whey protein (produced in New Zealand) contained botulism. Milk powder from New Zealand was banned due to a Botulism scare (Tajitsu, 2013). China responded with a ban on imports of all Fonterra milk powder and whey protein (Sharma and Rou, 2014).The presence of residues of HCH and DDT in infant food or baby milk powder is of particular concern (Nag, 2010).

The quality of milk powders is markedly determined by the total heat treatment of the operations during processing and the techniques of particular operations, such as concentrating or drying. In addition, the storage time and temperature regime affect the quality characteristics of the powders (Caric, 2002). The properties of milk powders are categorized as physical, functional, biochemical, microbiological and sensory (Caric and Millanoric, 2002). Chemical analysis of milk powders includes control of moisture, total fat, free fat, oxidative changes, hydrolytic changes and the intensity of the Maillard reaction (Caric, 2002).

Aspects of deteriorative changes that may occur in milk powders during transport and distribution have also an impact on the sensory properties of powders and their performance as food ingredients (Kanekanian, 2014).The un-denatured whey proteins (WPNI) are used as an indication of the heat treatment given to the milk during powder manufacture. In general, the WPNI specification is used as an indication of functional properties of milk powders (Chandan, 2008). This effect is also used as an indicator for its suitability to be applied in a diverse array of recombined products (Kanekanian, 2014). Besides these parameters, moisture and fat content, solubility index, bulk density, flowability, wettability, scorched particles, rennetability, emulsification properties, titratable acidity, sensory aspects, and bacteriological requirements are also included in various milk powder specifications (Kanekanian, 2014).

The structure and physical properties of milk powders are most severely affected by the drying techniques and parameters. Low bulk density is a disadvantage to milk powder quality. However, there are modern spraying methods (eg. using a steam swept wheel) that increase the bulk density. The rate of dissolving is one of the most important characteristics (Caric, 2002). The physical properties of milk powder are determined by (a) the heat treatment of the milk and the concentrate; (b) the spray dryer atomizing equipment; (c) the dry matter content of the concentrate; (d) the handling of powder fines; and (e) the air flows and temperatures of the spray dryer (Skanderby et al., 2009).

Concentrated and dried milk products represent a diverse range of dairy products. They vary considerably in chemical composition, which is determined by the composition of the original milk as well as the various heating and dehydration processes involved in their manufacture.

There is also variation in the distribution of chemical components within products, for example between the surface and the interior of powder particles and between the colloidal and soluble phases, which affects the products' properties (Deeth and Hartanto, 2009). Chemical and enzyme changes continue to occur during storage of the concentrated and dried products, which can significantly affect their functional properties and organoleptic qualities. The most important chemical changes that occur or can occur during processing and storage are denaturation of whey proteins, coagulation of caseins, lactosylation of proteins and subsequent Maillard reactions, oxidation of milk fat and crystallization of lactose. Knowledge of the chemical components of the products, their relationship to functional properties, and the changes that can occur in these components is essential for determining the optimal production and storage conditions for these products (Deeth and Hartanto, 2009).

Deterioration of milk powders resulting from Maillard browning, lactose crystallization, and oxidation of fat may lead to flavor and physical defects in the powder. Some of the changes that may occur during storage include the development of a brown color, a reduction in pH, reduced solubility, development of off-flavors, and reduced heat stability of powders (Kanekanian, 2014). It has been suggested that seasonal problem with the heat stability of milk powders may be due to variation in the urea levels. The loss of heat stability can be rectified in some cases by addition of urea. In New Zealand, minimum levels of urea occurs in summer and maximum levels in winter, while in each season, milk from cows in mid-lactation had a lower urea content than milk from cows in early or late lactation (Chandan, 2008).

The microbial quality of milk powder is determined by the quality of the raw material, the nature and extent of processing and by the extent of post-production contamination. More specifically, the microbiological count of milk powder is influenced by both the numbers and types of microorganisms in the raw milk and the processing conditions under which the milk powder is produced. *E. sakazakii* (*Cronobacter*) is a problematic contaminant of milk powder and hence represents a significant health risk to neonates (Chenu and Cox, 2009). Milk powder may also contain large numbers of spore-forming bacilli or may be contaminated by salmonellae (Kambamanoli-Dimou, 2003). Pavic et al. (2005) reported a food poisoning outbreak involving toxigenic *B. subtilis and B. licheniformis* present in milk powder. Contamination of powdered infant formula with Salmonella spp. and *Cronobacter sakazakii* is of special concern, with contamination occurring most often in the spray driers/cracks (Soler et al., 2008; Kanekanian, 2014). Entirely, milk powder has to be tested negative for *Salmonella* spp. according to the Standards for Microbiological Safety of Food (Health Canada, 2008).

Staphylococcus aureus is significant, as certain strains can produce a heat-stable toxin that is not destroyed during powder manufacture. Although *Staphylococcus aureus* is common in raw milk, it does not normally grow to produce toxin unless the milk is stored at a high temperature prior to processing. Although the bacteria will be killed during the process, the toxin remains and can be detected only through specific tests. Large outbreaks of illness have been attributed to the presence of *Staphylococcus aureus* toxin in milk powder (Kanekanian, 2014).Within the factory, application of good manufacturing practice (GMP) including Hazard Analysis Critical Control Point (HACCP) is essential to minimize the risk of milk powder contamination with undesirable types or levels of microorganisms. To achieve this, consideration must be given to the design of the premises and control of staff or vehicular movement to separate raw materials from drying areas (Kanekanian, 2014).

The presence of aflatoxins in milk powder is also a concern. Deveci and Sezgin (2005) found that aflatoxin M1 levels in nonfat dry milk produced in Turkey ranged from 0 to 0.705 μg/kg and that the aflatoxin M1 contents were higher in the winter than in the summer. Mean levels of 0.056 μg/L of aflatoxin M1 were found in goat milk powder from Brazil (Oliveira and Ferraz, 2007). However, no samples of milk powder were found to be contaminated with aflatoxin M1 in Portugal (Martins et al., 2005). Therefore, critical monitoring and controlling aflatoxin exposure of fortified and powdered milk are needed. Pests are often a problem with nonfat dry milk. The subject of insect infestation in various animal products including milk powder and their control has been reviewed by Rajendran and Parveen (2005). These authors listed pests including several types of beetles that can breed in the presence of milk powder, and they discussed the use of phosphine for insect control in milk powder.

Table 2. Microbiological specifications for milk powder, as recommended by the International Dairy Federation (Kanekanian, 2014).

Criteria[a]	Total count (per gram)	*Salmonella* (per 25g)	Coliforms (per gram)	*Staphylococcus aureus* (per gram)
m	50000	0	10	10
M	200000	Na	100	100
n	5	15	5	5
c	2	0	1	1

[a]For a production batch, n=number of samples that must be tested, c=number of samples that may exceed the microbiological limit specified as m, and M is the maximum allowable microbiological limit specified for any of the sample examined, na =not applicable

In order to be acceptable to consumers and users of ingredients, it is essential that milk powders are of a good quality. Milk powders are manufactured to meet certain specifications and standards for composition. These have been developed for milk powders by authorities such as the American Dairy Products Institute, the International Dairy Federation (Table 2), the Food and Agricultural Organization of the United Nations and national food authorities in individual countries. In addition, a range of other technical specifications have been developed for the characterization of milk powders to ensure that they have the required functional performance in specific target applications. Milk powders may be similar in composition but have different functional properties (Kanekanian, 2014).There are Ethiopian quality Standards for whole powder milk, partly skimmed powder milk and skimmed powder milk based on contents of milk fat content, water, milk protein in milk SNF, Titratable acidity (lactic acid) and Solubility -Roller dried -Spray-dried, etc (Ethiopian Standard, 2009). However, no information was obtained on its implementation by regulatory body.

Milk Fortification

The review begins with food fortification as the principles are similar to fortification of milk powder. Thus, summaries of the need for fortification, milk fortifications in practice, advantages, limitations, implementations, monitoring strategies and quality assurances were made.

Food fortification is either a commercial choice for providing extra nutrients in food (market driven fortification), or is a public health policy which aims to reduce the number of people with dietary deficiencies in a population (FAO, 2003; Allen et al., 2006). While fortifying foods with micronutrients is a valid strategy as part of a food-based approach, it is not an alternative to the consumption of a variety of available foods constituting a nutritionally adequate diet. Fortification is acceptable only when necessary food supplies are not available or accessible to provide adequate amounts of certain nutrients and only when the fortified food will be accessible to the targeted population. However, the most needy population group often has restricted access to fortified foods, and it is usually not only one nutrient that is lacking but several which cannot realistically be addressed by fortified foods (FAO, 2003). In a review by Cora et al. (2011), multi-micronutrient food fortification consistently improved micronutrient status and reduced anemia prevalence. Some studies reported positive effects on morbidity, growth, and cognitive outcomes, but the overall effects on these outcomes were equivocal.

Fortification remains controversial as we have seen with the recent folic acid fortification debate in New Zealand (Lawrence, 2013). It is yielding some undesirable consequences. The abundance of high-density, cheap calorie sources and the market competition has facilitated overconsumption and promoted obesity, a problem of global proportions (Venkatesh, 2003). A review by Crider et al. (2011), focused on some safety concerns such as masking of B12 deficiency Anemia, Cancer and Epigenetic Changes, and Un-metabolized Folic Acid, which needs careful monitoring. There are four key principles of food fortification (Haylock, 2002):

1. The demand for the food should be constant and unaffected by fortification.
2. Fortification should not adversely affect the odour, texture, taste or appearance of the food.
3. The nutrient should be absorbed by the body resulting in an increase in bioavailability.
4. There should be a demonstrable positive effect on the consumer's health of adding the nutrient.

Food fortification requires close collaboration with the public sector, ensuring legal aspects, consumer and health organizations to ensure consumer sensitization and acceptance of fortified foods, other private partners to ensure efficient distribution, etc (Dorp et al., 2011). Fortification involves opening new communication channels among the public health community, research institutions, government regulators, food companies, and a variety of civic and consumer organizations. The inputs from these groups could result in a new alliance focused on accomplishing national development through elimination of micronutrient malnutrition (Venkatesh, 2003).The regulation and guidelines for Fortification should include the following (Venkatesh, 2003):A rationale for fortification, recommended minimum and maximum level (s) of nutrient added per serving, establishing RDA (Recommended dietary Allowance), establishing labeling standards, establishing guidelines for making nutritional and health claims, establishing a monitoring and surveillance system and Quality Assurance.

The interest in the development of health promoting foods has led to research in functional milk powders for health and well-being. These include milk powders enriched with well-known nutrients such as minerals (e.g., Fe) and vitamins (e.g., vitamins Aand D) and functional ingredients of more recent interest such as omega-3 oils, probiotics, and phytosterols. Some of these functional ingredients are added as micro encapsulated ingredients while others are directly incorporated into milk powders (Augustin, 2003). Milk powders can also be fortified with calcium (Williams et al., 2005). However, the color, texture, stability, flavor, and processing characteristics of the final product may be potentially influenced by the form of calcium used for fortification (Chandan, 2008). Mineral fortification often does not affect the sensory or physicochemical properties of the dairy product. However, some fortificants can cause unacceptable changes in colour, flavour or texture of dairy products. The long time and high cost required to develop new combinations of suitable minerals, fortificant preparations, and dairy products must be offset by the use of better fortification system and fortification methods (Preedy et al., 2013). Mineral fortification of dairy products must be carefully controlled to ensure the desired level of fortificants in the final products and avoid toxicity. Just as mineral deficiencies can cause complications, excessive mineral intake also has side effects. For example, too much calcium can cause renal disease (Preedy et al., 2013).

Breast milk, of course, is recommended during the first year of life. If the infant is weaned during the first year, the best alternative is to use iron-fortified formula. Formula-fed infants should remain on iron-fortified formula until 1 year of age. After age 1, the American Academy of Pediatrics recommends using whole milk if the use of breast milk or formula is discontinued (Encyclopedia of Foods, 2002). However, some black spots are sometimes observed in milk powder enriched in iron salts. These black spots have different origins such as change in valence of iron ion (Fe^{2+} /Fe^{3+}) or the fact that iron salts are becoming insoluble. For example, if sulphate is added in a matrix where pH ³ 7, iron hydroxide will be produced and a decrease of the iron solubility will be observed (AleixoandNóbrega, 2003). Commercial infant milk powders are often fortified with ferrous sulphate and; moreover, formulas are mixing very reactive iron salts together with Omega 3-rich oils that are highly sensitive to peroxidation. The colour of this type of iron (II) fortified milk is darker than regular milk, which could be an indication of a change of the oxidation degree of Fe (Preedy et al., 2013).

Concluding remarks and implications

Imported milk powder is beyond the purchasing capacity of the great majority of middle and low income people of Ethiopia, who are most affected by malnutrition, because of its high cost. In addition, there is limited foreign currency reserve and safety concern. Therefore, increasing domestic milk supply is crucial to reduce dairy imports. This can be done by collecting milk produced in the high dairy potential highland areas of the country for processing and distribution. The abstinence of some people from milk consumption during fasting season, storage problems, growing preference of urban consumers for variety of dairy products and emerging supermarkets necessitate production of long-shelf life milk products from part of the raw milk collected. This aligns with the second Growth and Transformation Plan (GTP II) of the Government to increase milk production and also aiming at exporting milk powder.

Food fortification is currently under debate with regard to its benefits and limitations. Thus, further information is needed on potentially efficacious amount of fortificant, appropriate levels of fortification, and the extent to which commercially fortified foods could be made accessible to the most nutritionally vulnerable populations. Furthermore, there is no information on the quality of milk powder in Ethiopia, which calls for research efforts on its microbial, compositional/nutritional quality and adulteration concerns. Intervention is also required in dairy/food import policy and regulatory roles in licensing, inspections and surveillance and certification of locally marketed, exported and imported milk to assure consumer safety from physical, biological, chemical or adulteration hazards. While promotion of nutritional/health benefits of pasteurized milk and other milk products regardless of their brands would contribute to enhancing milk consumption and improving dairy productivity, misleading advertisements need to be regulated to avoid confusion among consumers.

References

Aleixo, PC. and Nóbrega, JA. 2003. Direct determination of iron and selenium in bovine milk by graphite furnace atomic absorption spectrometry. Food Chem. 83:457–62.

Allen, L., de Benoist, B., Dary, O. and Hurrell, R.2006.Guidelines on food fortification with micronutrients. Geneva, Switzerland/Rome, Italy: World Health Organization and Food and Agriculture Organization of the United Nations.

Augustin, MA., Clarke, PT. and Craven, H. 2003. Characteristics of milk Powders. Elsevier Science Ltd. Weribee, Victoria, Australia. In: Encyclopedia of food science and nutrition. Academic Press, USA.

AzageTegegne,Berhanu Gebremedihin, Hoekstra, D., Berhanu Belay and Yoseph Mekasha. 2013. Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 31. Nairobi: Kenya. 65p.

Caric, M. and Millanoric, S. 2002. Milk powders. Physical and functional properties. Encyclopedia of dairy sciences. Vol. 3. Elsevier Ltd. USA.

Caric, M. 2002. Milk powders. Types and manufacture. Encyclopedia of dairy sciences. Vol. 3. Elsevier Ltd. USA.

Chandan, RC. 2008. Dairy processing and quality assurance. John Wiley & Sons, Inc. USA.

Chenu, JW. and Cox, JM. 2009. Cronobacter ('Enterobactersakazakii'): current status and future prospects. Letters in Applied Microbiology 49: 153–159.

Cora, B., Neufinger, N., Del Rosso, JM., Transler, C., van den Briel, T. and Osendarp, S. 2011. Can multi-micronutrient food fortification improve the micronutrient status, growth, health, and cognition of schoolchildren? A systematic review. Nutr Rev. 69(4):186-204.

Creamer,LK.,Loveday, SM. and Sawyer, L. 2002. Milk proteins. β-Lacto globulin. . Encyclopedia of dairy sciences. Vol. 3. Elsevier Ltd. USA.

Crider, KS.,Bailey LB. and Berry RJ. 2011. Folic Acid Food Fortification—Its History, Effect, Concerns, and Future Directions. Nutrients 3: 370-384.

Deeth, H.C. and Hartanto, J. 2009. Chemistry of Milk – Role of Constituents in Evaporation and Drying. Dairy powders and concentrated products. 1st ed. Blackwell Publishing Ltd. UK.

Deveci, O. and Sezgin, E. 2005. Aflatoxin M1 levels of skim milk powders produced in Turkey. J. Food Drug Anal. 13:139–142.

Dorp, M. van., Oenema, S. andVerdonk,I. 2011. Agriculture-nutrition linkages: Linking agriculture and food security to nutrition improvement. Desk review Wageningen UR Centre for Development Innovation. The Netherlands.

Encyclopedia of Foods. 2002. A guide to healthy nutrition. Dole Food Company, Inc. Elsevier 3. USA.

Ethiopian Standard. 2009. Whole milk, partly skimmed milk and skimmed milk powder – ES 3459:2009.

FAO FOOD OUTLOOK. 2013. Milk and milk products. Market assessments, Rome, Italy.

FAO. 2003. Fortification of food with micronutrients and meeting dietary micronutrient requirements: Role and position of FAO: Policy Statement. Rome: Food and Agriculture Organization of the United Nations.

FAO.2013. Milk and dairy products in human nutrition. Rome, Italy.

FDRE (Government of the Federal Democratic Republic of Ethiopia).2013. National Nutrition Programme. June 2013-June 2015. Addis Ababa, Ethiopia.

FMOH.2011. Assessment of feasibility and potential benefits of food fortification in Ethiopia, Addis Ababa, Ethiopia.

Francesconi, GN., Heerink, N. and D'Haese, M. 2009. Evolution and challenges of dairy supply chains: Evidence from supermarkets, industries and consumers in Ethiopia. Food Policy 35: 60–68.

Francesconi, GN. 2009. Cooperation for competition: Linking Ethiopian farmers to markets. International Chains and Network Series, vol. 5.Wageningen, the Netherlands: Wageningen Academic Publisher.

Gobbetti, M., Minervini, F. and Rizzello, CG. 2007. Bioactive peptides in dairy products. In: Handbook of food products manufacturing Y.H. Hui (ed). John Wiley and Sons, Inc., Hoboken, NJ, pp. 489 – 517.

Haylock, SJ. 2002. Fortification of consumer milk products. Bulletin of the International Dairy Federation (375).Brussels: IDF.

Health Canada. 2008. Standards and guidelines for microbiological safety of food, an interpretive Summary. Ottawa, Health Canada and Food Directorate, Health Protection Branch, 1-16.

Jarvis, JK., Lois, D. and Mc Bean, GDM. 2007. Handbook of dairy foods and nutrition. 3rd eds. National Dairy council.CRC Press. USA.

Jensen, RG., Ed. 1995. Handbook of milk composition, Academic Press, New York.

Kambamanoli-Dimou. 2003. Microbiology. Encyclopedia of food science and nutrition. Elsevier Science Ltd. USA.

Kanekanian, A.2014. The Health Benefits of Bioactive Compounds from Milk and Dairy Products. Milk and dairy products as functional foods.1st ed. John Wiley & Sons, Ltd. Cardiff Metropolitan University, UK.

Lawrence, M.2013. Food Fortification. The evidence, ethics, and politics of adding nutrients to food. Oxford University Press, Oxford, UK.

Lewis, M. 2010. Improving pasteurized and extended shelf-life milk. In: Improving the safety and quality of milk. Vol 1.Woodhead Publishing limited, UK.

Martins, HM., Guerra, MM. and Bernardo, F. 2005. A six year survey (1999–2004) of the occurrence of aflatoxin M1 in dairy products produced in Portugal. Mycot. Res. 21:192–195.

Meunier-Goddik, L. and Sandra, S. 2002. Pasteurized milk. Encyclopedia of dairy science. Vol. 3. Elsevier Sc. Ltd. USA.

Motairjemi, Y. and Lelieveld, H. 2014. Food safety management practical guide for the food industry. Elsevier Inc. UK.

Nag, SK. 2010. Contaminants in milk: routes of contamination, analytical techniques and methods of control. In: Improving the safety and quality of milk. Vol. 1. Wood head Publishing limited, UK.

Ndambi, OA., Hemme, T. and Latacz-Lohmann, U. 2007. Dairying in Africa - status and recent developments. Livestock Research for Rural Development.19:8.

OECD/FAO. 2016. OECD-FAO Agricultural Outlook 2016-2025, OECD Publishing, Paris.

Oliveira, CAF. and Ferraz, JCO. 2007. Occurrence of aflatoxin M1 in pasteurized, UHT milk and milk powder from goat origin. Food Control. 18:375–378.

Pavic, S., Brett, M., Petric, I., Laˇstre, D., Smoljanovic, M., Atkinson, M., Kovaˇcic, A., Cetinic, E. and Ropac, D. 2005. An outbreak of food poisoning in a kindergarten caused by milk powder containing toxigenic Bacillus subtilis and Bacillus licheniformis. Archivf¨urLebensmittel hygiene. 56:20–22.

Preedy,VR., Patel, VB. and Srirajaskanthan, R. 2013. Handbook of food fortification and Health. Springer Science+ Business Media, New York.

Rajendran, S. andParveen, KMH. 2005. Insect infestation in stored animal products. J. Stored Prod. Res. 41:1–30.

Sharma, S. and Rou, Z. 2014.China's dairy dilemma. The evolution and future trends of china's dairy industry. Institute for agriculture and trade policy. China.

Skanderby, M., Westergaard,V., Partridge, A.and Muir, D.D. 2009. Dried Milk Products. Dairy powders and concentrated products. 1st ed. Blackwell Publishing Ltd. UK.

Soler, P., Herrera, S., RodriÂguez, J., Cascante, J., Cabral, R., Echeita-Sarriondia, A. and Mateo S. 2008. Nationwide outbreak of Salmonella enterica serotype Kedougou infection in infants linked to infant formula milk, Spain, Euro Surveill, 13, pii=18963.

Tajitsu, N. 2013. China bans New Zealand milk powder imports on Botulism Scare: NZ Trade Minister. http://www.reuters.com/article/ us-newzealand-milk-idUSBRE97301K20130804

Terry, SL. 2011. Healthy eating: a guide to Nutrition. Nutrition and food safety. Infobase Publishing. USA.Tsimidou, M. and Boskou, D. 2003.Adulteration of foods. Encyclopedia of food science and nutrition. Academic Press, USA.

Venkatesh Mannar, MG. 2003. Food fortification. The Micronutrient Initiative. Elsevier Science Ltd, Ottawa, Canada. In: Encyclopedia of food science and nutrition. Academic Press, USA.

Williams, RPW., Ath, LD. And Augustin, MA. 2005. Production of calcium-fortified milk powders using soluble calcium salts. Lait. 85:369–381.

World Bank. 2006. Agriculture Investment Sourcebook. Washington, DC.

Zelalem Yilma, Guerne Bleich, E. and Amha Sebsibie. 2011. A Review of the Ethiopian Dairy Sector. Eds. Rudolf Fombad, Brian Dugdill and Olaf Thieme, Food and Agriculture Organization of the United Nations, Sub Regional Office for Eastern Africa (FAO/SFE), Addis Ababa, Ethiopia, pp 82.

Zijlstra, J., Tinsae, B., Vernooij, A., Boere, A. and van der Lee J. 2015. Business opportunities Report Dairy #2 in the series written for the "Ethiopian Netherlands business event 5–6 November 2015, Rijswijk, The Netherlands.

Assessment of Goat Production System in Burie District, West Gojjam Zone, Ethiopia

Yenesew Abebe[1], Solomon Melaku[2] and Azage Tegegne[3]

[1] Andassa Livestock Research Center, P.O.Box 27, Bahir Dar, Ethiopia
E-mail:yenesew_abebe@yahoo.com
[2] Haramaya University, P.O.Box 138, Dire Dawa, Ethiopia
[3] International Livestock Research Institute, P.O.Box 5689, Addis Ababa, Ethiopia

Abstract

This study was conducted in four selected rural kebeles (divisions of a district) namely, Woheni Durebetie, Woyenema Ambaye, Denbun and Boko Tabo in Burie district to assess goat production system, and to identify and prioritize goat production constraints. Informal and formal surveys were conducted in the selected kebeles. Purposive sampling method was used for the informal survey and random sampling method was used for the formal survey to select the respondents. A total of 36 and 75 respondents were interviewed for the informal and formal survey, respectively. Farmers in the study area rear goats for home consumption (1%), cash income (29%) and home consumption & cash income (69%) purposes. The mean number of goats owned by one household was 4.8±3.33 heads (n = 75). From the current study, about 25% of the goats in the flock were males and the remaining 75% were females. Browse species found in natural pasture and crop lands are the main feed resources for goats. In addition, farmers usually supplement their goats with common salt, maize grain, food left over and atella (a by-product of home brewed drink). Generally, there is feed shortage problem for goats during the dry and rainy seasons especially in the highland kebeles. Goat diseases and provision of inadequate veterinary service were reported to be major constraints affecting goat production in the study area. To improve the goat productivity and make the goat production sustainable in the study area establishment of new veterinary clinics, provision of adequate veterinary service and improving the goat marketing system should be given more emphasis in future research and development activities. Furthermore, feed production in the highland study kebeles should be improved.

Key words: Goat, production system, production constraints, Ethiopia

Introduction

Ethiopia possesses about 29.7 million goats in rural sedentary areas of the country (CSA, 2016) and they are diverse genetically. According to Tesfaye Alemu (2004), goats in Ethiopia are classified into eight breeds. These are Arsi-Bale, Gumuz, Keffa, Woyto-Guji, Abergelle, Afar, Highland goats and the Somali goats. Goat productivity in Ethiopia is low compared with the apparent potential (EARO, 2000; Solomon Gizaw *et al*., 2010). Goats are found in all agro-climatic zones of the country. Generally, inadequate feed supply both in quantity and quality, diseases and parasites, inadequate management and low genetic potential are among the technical constraints that limit the small ruminant productivity in the country. Based on recent reports, poor feeds, animal health and inferior genotypes are the input side constraints in goat production in Ethiopia while lack of standardized marketing system and infrastructure to access markets are the main constraints on the output side (Solomon *et al*., 2014).

Ethiopia is home for diverse indigenous sheep and goat populations and favourable production environments (Solomon Gizaw *et al*., 2010). Based on the above source, sheep and goat in Ethiopia are kept under traditional extensive systems with no or minimal inputs and improved technologies. In Ethiopia, the small ruminant production system in different agro-ecological zones is not studied fully and farmers' needs and production constraints have not been identified (EARO, 2000). Currently, several on-farm studies describing production systems have been conducted in Ethiopia (Solomon *et al*., 2014). Assessment of the goat production system and identification and prioritization of the constraints of production is a prerequisite to bring improvement in goat productivity in the country.

Understanding the production system also helps to design appropriate technologies which are compatible with the system. In general, assessment of the goat production system is important to plan development and research activities and bring improvements in goat productivity. In Burie District, the goat production system is not studied and precisely known and goat production constraints are not identified and prioritized. Therefore, this study was conducted to assess the goat production system, to identify and prioritize the goat production system constraints in the district. This study will be useful for other areas with similar agro-ecological zones.

Materials and Methods

Description of the study area

This study was conducted in 2007 (started) and 2008 (completed) in Burie district, in Amhara National Regional State, North Western Ethiopia. Burie district is located between 10˚15′ N and 10˚42′ N and between 36˚52′ E and 37˚7′ E. Burie district has an estimated area of 838.9 square kilometers with altitude range of 713 – 2604 masl (BOFED, 2008; IPMS, 2007). The rainy season in Burie district is from May to September with a mono-modal pattern and a mean annual rainfall of 1386 – 1757 mm (IPMS, 2007). According to IPMS (2007), the long term annual temperature of Burie ranges from 14 ºC to 24 ºC. As the district has different ecological settings, it is suitable for different crops and livestock species production. The land use pattern in the district consisted of about 46.6% cultivated land, 16.3% wasteland, 14.8% shrub, 8.4% natural forest, 6% construction (roads and houses), 6% pasture land, 1% perennial crops and 0.3% water bodies (IPMS, 2007).

Human population of the district is estimated at 174,957, of which 143,558 (82%) lives in rural areas (BOFED, 2008). There are 22 rural kebeles and 2 towns in the district. There are about 21,793 and 2,786 households in rural and urban kebeles of Burie District (IPMS, 2007), respectively. Secondary data were collected from different sources. The study kebeles were selected before beginning the informal survey. Four representative rural kebeles were selected for the study by using secondary data and participation of district livestock and crop experts. The criteria used for selection of the study kebeles were agro-climatic and agro-ecological zone of the kebele, goat population and density, accessibility of the kebeles by vehicle and non-adjacent kebeles to one another. The selected kebeles for the study were Woheni Durebetie (*Dega*), Woyenema Ambaye (*Woina Dega*), Denbun (*Woina Dega*) and Boko Tabo (*Kolla*).

Informal survey

Informal survey was conducted in the selected kebeles (Roeleveld and Broek, 1996). Informal surveys are conducted using a checklist to ascertain and complement the preliminary systems understanding which was made based on secondary data analysis. During this study mostly qualitative data were collected from the respondents. But formal surveys are conducted using a questionnaire to provide a quantitative figure for conclusions drawn from earlier phases, to redefine target groups and to test hypotheses about relationships (Roeleveld and Broek, 1996). For the informal survey checklist was prepared and used. The main components of the checklist were breeds and breeding, feeds and feeding, diseases and disease control, housing, meat consumption and production constraints. Farmers to be interviewed from each kebele were selected purposively based on ownership of goats, economic status and living in the kebele for several years. Kebele administrators and religious leaders were selected as key informants and interviewed. For the group interview, farmers from different age, economic status and gender groups were included and interviewed. A total of 36 respondents were interviewed for the informal survey. Goat production constraints were prioritized using pair-wise ranking method for each kebele and single list ordinal ranking method for the district (ARARI, 2005).

To assess the flock composition, data were collected from each kebele during the informal survey field work. Goat flocks in each kebele were selected purposively (based on age and sex composition of the flock) in the grazing fields and every animal in the flock was caught, identified and data were recorded. Body weight of the animals was measured using hanging scale. According to Girma Abebe and Alemu Yami (2008), for light animals hanging scale can be used to measure the body weight of animals. Age of the animals was estimated based on observation of their dentition (Girma Abebe and Alemu Yami, 2008).

Formal survey

A structured questionnaire was prepared based on the informal survey result. The major components of the questionnaire were breeds and breeding, feed resources and feeding, housing, diseases and disease control, meat consumption and production constraints. The questionnaire was pretested before conducting the actual formal survey data collection. The study kebeles that were selected and used for the informal survey were used for the formal survey study. Respondents were selected by using random sampling technique. From each kebele enumerators were selected, given training on data collection and collected the formal survey data from the randomly selected individuals. A total of 75 farmers were selected and interviewed. The goat production constraints for the formal survey result were prioritized using single list weighted category based ranking method (ARARI, 2005). The statistical analysis was done by using SPSS (2003) statistical software. Descriptive statistics were used to summarize the data and ANOVA was done for mean comparison.

Results

Goat characteristics in the study area

Farmers in the study area rear goats for the following main purposes, for home consumption (1%), cash income (29%) and home consumption & cash income (69%). Milking of goats and consumption of goat milk in the study area is not common. Goat producing farmers in the highland study kebeles were concentrated in areas where more natural browse in the vicinity of their homes was found. According to FARM-Africa (1996), the goat types found in the study area were Western Highland goat types. Western Highland goat types are one of the 14 goat types found in Ethiopia and Eritrea. According to FARM-Africa (1996), the mean flock size owned is 8 (SD = 6). In the current study, one household owns on average 4.8 heads of goats (n = 75, SD = 3.33). On average, one household sells 1.7 heads of goats (n = 75, SD = 1.72) per year. According to the current study, one animal in the flock on average weighs 21.6 kg (n = 248, SE = 0.65). Based on mean body weight (BW) of an animal in the flock, the *Dega* kebele goats were heavier ($P<0.05$) in BW (25.0 kg) than the *Woina Dega* and *Kolla* kebele goats (Table 1). This difference may be due to age composition, environmental effect or genotype. According to FARM-Africa (1996), the mean BW of male and female goats in Western Highland goat types were 48.4±9.9 kg and 33.0±6.0 kg, respectively. This result is higher than the current study result.

Farmers usually get their first breeding goats from buying from the market (77%), gift from parents/ relatives (8%) or buying from their residence kebeles. From the current study result, females (75%) were more in number in the flock than males (Table 2). This is comparable with the result of FARM-Africa (1996). It is reported in this source that about 27% of the animals in the flock are males and 73% of the animals in the flock of Western Highland Goats are females. Those females which were mature predominate in the flock while for males; young males predominate in the flock (Table 2). This may be due to the purpose of goat production in the study area. As the main objective of goat production in the area is for meat production either for sale or home consumption, most of the males are slaughtered or sold at young age. Females predominate in the production system as they are retained for breeding purpose.

Table 1. Mean body weight (mean±SE)measure of goats in the flocks in the different agro-ecological zones in Burie district

Agro-climatic zone	Body weight (kg)	N
Dega	25.0±1.21[a]	61
Woina Dega	21.3±0.92[b]	125
Kolla	18.6±1.24[b]	62

SE = Standard error; kg = kilogram; Means with different superscript letters within a column are significantly different (P<0.05)

Table 2. Sex and age composition of the goat flocks in the study kebeles of Burie district

Estimated age (year)	Sex of the goat					
	Male		Female		Total	
	N	%	N	%	N	%
< 1	44	71	65	35	109	44
1	1	2	0	0	1	0.4
1 to 2	7	11	21	11	28	11
2	2	3	27	15	29	12
3	4	7	19	10	23	9
> 3	4	7	54	29	58	23
Total	62	25	186	75	248	100

N = Number of animals

Goat feed resources and feeding

The main feed resources for goats are browse species found in natural pasture and crop land during the dry season (Table 3). In addition, most farmers supplement common salt, food leftover, maize grain and *Atella* (a local beer residue, *Tella*) to their goats (Table 4). Supplementation of growing kids is not common in the study area. Farmers supplement common salt or boiled salt solution to the dam to make the animals produce more milk to the new born kid. It is not common feeding crop residues to goats in the study area.

Farmers buy several materials from the market for their goats. Most of the farmers in the area buy salt (69% of the respondents) to feed their goats. In addition, some farmers buy noug seed cake (9% of the respondents) for their goats.

Table 3. Major feeds for goat production during different seasons in the study kebeles of Burie district (N = 75)

Major feed resources	Sept. – Nov.		Dec. – Feb.		March – May		June – August	
	N	%	N	%	N	%	N	%
BNPO	57	76	48	64	55	73	56	75
BSO	7	9	13	17	12	16	10	13
BNPS	11	15	13	17	7	9	8	11
Other	0	0	1	1	1	1	0	0
NR	0	0	0	0	0	0	1	1

N = Number of respondents; BNPO = Browse in natural pasture only; BNPS = Browse in natural pasture and stubble; BSO = Browse in stubble only; NR = No response

There was feed shortage (browse) problem for goat production in the study area especially in the highland kebeles (29% of the respondents). In general, there was feed shortage problem in the dry season from March to May. During this period the browse species shed their leaves and there is less leaves available to be consumed by the goats. In addition, in the rainy season, as the crop land will be covered with food crops, goats will be confined to browse species found in communal grazing lands only. The browse species found in the communal grazing lands are limited in amount and do not supply adequate amount of feed to the animals during the rainy season. Generally, feed is abundant for goats in the area from November to January.

Table 4. Feed supplements for goats during different seasons in the study kebeles of Burie district (N = 75)

Feed supplement type	Sept. – Nov.		Dec. – Feb.		March – May		June – August	
	N	%	N	%	N	%	N	%
MGO	3	4.0	4	5.3	3	4.0	4	5.3
AO	6	8.0	16	21.3	13	17.3	13	17.3
FLO	9	12.0	4	5.3	8	10.7	5	6.7
MGA	7	9.3	9	12.0	3	4.0	1	1.3
MGAFL	10	13.3	7	9.3	6	8.0	4	5.3
AFL	4	5.3	9	12.0	6	8.0	7	9.3
Other	7	9.3	6	8.0	14	18.7	14	18.7
NR	29	38.7	20	26.7	22	29.3	27	36.0

N = Number of respondents; ALF = *Atella* and food leftover; AO = *Atella* only; FLO = Food leftover only; MGA = Maize grain and *Atella*; MGAFL = Maize grain, *Atella* and food leftover; MGO = Maize grain only; NR = No response

Housing of goats

Farmers use different types of goat houses in the study area. Farmers use the main house, house attached to the main house and a separately constructed goat house for goat housing (Table 5). If the goats are housed in the main house, the room will be separated and partitioned by walls made of locally available materials. Farmers house all sex and age groups of goats together. But bucks (5% of respondents), fattening goats (16% of respondents) and kids (64% of respondents) are usually separated from the others. Locally available materials are used to build goat houses. The roof is usually made of corrugated iron sheet (72%), and the wall in the highlands is made of eucalyptus tree and it is usually plastered with mud. Some farmers have a goat house with a roof made of grass (25%). The wall of the lowland goat houses is made of lowland woods and it is not usually plastered with mud as the ambient temperature in the area is very high.

Table 5. Type of goat houses used by farmers in the study kebeles of Burie district

Type of goat house	N	%
Main house	21	28
House attached to the main house	26	35
Separately constructed goat house	27	36

N = Number of respondents

Diseases and disease control

Goat diseases are the main constraints in goat production in the study area. Foot rot, skin disease, internal parasites, pasteurellosis and diarrhea (blood stained) are some of the main goat diseases in the area. Abortion is also one problem in the study area. When goats get sick, farmers in the highland kebeles take their animals to the nearest public veterinary clinics. But in the lowland kebele, farmers medicate their goats buying drugs themselves from the market (75%). This is due to absence of veterinary clinic in the kebele. Generally, there is inadequate veterinary service in the study area. Most of the veterinary clinics are remote to farmers' residences. Vaccination of goats is not common in the study area. Traditional medicine is also used for sick goat treatment.

Farmers buy different drugs to treat their sick goats. Most of the farmers in the study area buy anthelminitics (92% of the respondents) for the treatment of their sick goats. Other drugs bought and used for sick goats' treatment were Ampicillin, Penicillin and Oxytetracycline. The farmers buy the drugs from the local market and treat their animals themselves. This has a serious impact on the development of drug resistant microbes in animal production. Buying drugs for sick goats' treatment is especially common in the lowland kebele (*Kolla*) as the veterinary service in the area is too far from farmers' residences.

Goat meat consumption per household

Farmers slaughter goats in different occasions. Easter, Christmas and before the fasting period of Easter (Lent) are the main occasions on which farmers slaughter goats at home. Sometimes goats are slaughtered by households before and after fasting periods (Easter and August), on weddings, during religious festivals and when a households likes to consume goat meat at home. On average, about 57% of the respondents slaughtered goats at home the previous year. Based on the data from the formal survey, one household slaughtered 0.9 heads of goats (n = 75, SD = 0.98) the previous year. Young male goats are slaughtered mostly. Females at young age, sterile females, old age females or fattened goats are also slaughtered occasionally. Usually, there is no colour preference for the goats that are going to be slaughtered at home. In some cases, farmers rear goats but they do not slaughter and consume goat meat due to cultural problems. According to FARM-Africa (1996), there is a cultural taboo against goat meat and milk consumption in the study area.

Goat production constraints in the study area

There are several constraints in goat production in the study kebeles of Burie District. From all the goat production constraints identified, goat diseases, lack of adequate veterinary service, feed (browse) shortage, predators and marketing problem are the main goat production constraints in the study area (Tables 6 and 7). But there were differences in the priority of constraints among the different kebeles. For example, in Woheni Durebetie kebele, lack of adequate veterinary service, goat diseases and feed shortage were the first, second and third priority constraints, respectively. However, in Denbun kebele, goat diseases and feed shortage were the first and second priority constraints. In this kebeles, those constraints that have the same figure are considered to be equal priority constraints. There was a difference in the priority of goat production constraints between the informal and formal survey results (Table 6 and 7). This may be due to the number of farmers interviewed during the informal and formal surveys. As the number of farmers interviewed during the formal survey is large (i.e. 75), the priority of constraints from this result may be more realistic than the informal survey.

Table 6. Rank of goat production constraints in the study kebeles in Burie district (informal survey result)

Constraint identified	Woheni Durebetie	Woyenema Ambaye	Denbun	Boko Tabo	Total score	District Priority
Goat diseases	2	1	1	1	5	1
Lack of adequate vet service	1	5	4	6	16	3
Feed shortage (browse shortage)	3	3	2	6	14	2
Leech	6	2	4	6	18	6
Water shortage	6	5	4	4	19	8
Technical Knowledge shortage	6	5	4	2	17	5
Marketing problem	6	4	4	5	19	7
Predators	4	5	4	3	16	4

Table 7. Rank of goat production constraints in the study kebeles of Burie district (formal survey result)

Constraint identified	1st Priority (5)	2nd Priority (4)	3rd Priority (3)	4th priority (2)	5th priority (1)	Weighted score	District Priority
Goat diseases	37	18	5	3	0	278	1
Lack of adequate vet service	2	5	11	4	2	73	4
Feed shortage	0	6	1	1	0	29	7
Labour shortage	3	5	6	4	0	61	5
Financial shortage	6	3	4	1	2	58	6
Technical knowledge shortage	0	2	3	4	4	29	8
Marketing problem	1	4	13	10	1	81	3
Predators	23	20	4	2	1	212	2

Discussion

The largest goat population of the world is found in Africa (41%) and in the Indian sub-continent (32%) (Steele, 1996). Goats are reared for several purposes in the world depending on the breed, environment and socio-economic circumstances. Generally, goats provide meat, milk, fibre and cash income to their owners. Goat owners in the study area get cash income and meat for household consumption from goat production. Consumption of goat milk and use of fibre is not common in the study area. In some cases, there are households that rear goats and do not consume goat meat due to cultural constraints. According to Kassahun Awigchew *et al*. (1991), small ruminants provide 12.5% of the value of livestock products consumed on the farms and 48% of the cash income generated by livestock, though they represent only 6.6% of the capital invested in farm livestock.

Goat diseases were one of the main constraints in goat production in the study area. Foot rot, skin disease, internal parasites, pasteurellosis and diarrhea were the main diseases in the study area. According to Aklilu Feleke (2008), pasteurellosis, goat pox and orf are the main goat diseases in Burie District. Based on different recent research reports in Ethiopia, goat diseases are the main constraints in goat production in several production systems (Arse Gebeyehu *et al*., 2013; Gebreegziabher Zereu *et al*., 2016; Netsanet Zergaw *et al*., 2016; Tegegn Fantahun and Askale G/Michael, 2017). According to Solomon *et al*. (2014), poor feeds, animal health, inferior genotypes, lack of standardized marketing system and infrastructure to access markets are the main constraints in goat production in Ethiopia recently. Based on another report, prevalence of diseases and parasites is the major constraint in sheep and goat production in Ethiopia (Solomon Gizaw *et al.,* 2010). According to the same source, high mortality is the main factor for the observed low off-take rates of sheep and goat in Ethiopia.

In Burie District veterinary service is provided by both the public and the private sector. These services are specially found in urban areas. There was poor veterinary service provision in rural and very remote areas. According to Aklilu Feleke (2008), about 48.1% of the respondents do not have access to modern veterinary services in the study area. The veterinary service provision was inadequate and it was especially very poor in the lowland kebele. To avoid animal losses, farmers buy drugs from the market and treat animals themselves. This is especially common in the lowland kebele as the veterinary service provision site was remote to their residences. Treating animals by buying drugs from the market is also reported in other parts of the country (Alganesh Tola *et al.*, 2004). Provision of adequate veterinary service to rural and very remote areas will save animal losses as well as illegal use of drugs by farmers. This practice will encourage the development of disease resistant microbes in livestock diseases. According to Aklilu Feleke

(2008), expansion of the veterinary service and detailed epidemiological study is recommended in the study area.

Based on the informal survey result, the market price of goats was low compared with sheep in the study area. During the study the market price per head in Burie town market was 248.1 and 289.8 Birr for goats and sheep, respectively. In addition, the market price per kg of animal was 9.6 and 10.9 Birr for goats and sheep, respectively. There is also seasonal demand for meat and price of goats. It is reported that there is a high fluctuation in goat market supply and demand in the country (Solomon *et al*., 2014). According to EARO (2000), there is small ruminant demand and price increases during festivals. Different reports in the country reveal that there is a presence of marketing problem in goat production (Solomon Gizaw *et al.,* 2010; Solomon *et al*., 2014).

There was feed shortage problem for goat production in the highland study kebeles (Woheni Durebetie, Woyenema Ambaye and Denbun) (Table 6). Feed shortage was not a severe problem in the lowland (*Kolla*) study kebele (Boko Tabo). Feed shortage is common both during the dry and rainy seasons in the study area. Several reports reveal the presence of feed (browse) shortage in goat production in different production systems. According to Agajie Tesfaye *et al.* (2002), critical months of feed shortages for livestock production occurred especially in June and July. As the browse species have decreased recently due to crop production expansion in the highland mixed farming systems of the area, this problem made the goat production system less sustainable. Currently, the main constraint for livestock production in the country is feed shortage. According to Kassahun Awigchew *et al*. (1991), small ruminant production in the country is constrained by disease, parasite and feed shortage. It is estimated that there is a 40% deficit in the national feed balance (Kassahun Awigchew *et al*., 1991). A recent study in the Amhara Region shows that the feed produced in the region only satisfies 83% of the maintenance requirement (17% deficit) and 69% of the production requirement (31% deficit) of the livestock population found in the region (Firew Tegegne and Getnet Assefa, 2010). Generally, there is feed (browse) shortage problem in goat production in the country in different production systems (Arse Gebeyehu *et al*., 2013; Gebreegziabher Zereu *et al*., 2016; Netsanet Zergaw *et al*., 2016; Tegegn Fantahun and Askale G/Michael, 2017). Introduction of an alternative feed source is recommended in Burie District (Aklilu Feleke, 2008).

There is seasonal fluctuation in the availability and quality of feed supply in the country in general. According to Alganesh Tola *et al*. (2004), from a study conducted in the Western part of the country, the livestock production constraints are identified to be feed shortage, disease, poor genetic potential of indigenous livestock species and wild life damage on small ruminants. Among these constraints, feed shortage was found to be the most threatening. According to Agajie Tesfaye *et al.* (2002), from a study conducted in the central highlands of Ethiopia, the livestock production constraints are feed shortage, animal disease, inadequate veterinary service, shortage of cash and shortage of water supplies. Currently, as the human population is increasing, pasture and grazing lands are being converted to crop lands for food production to feed the increasing human population (Agajie Tesfaye *et al*., 2002; Alemayehu Mengistu, 2005). This trend is contributing for the feed shortage problem for livestock production in the country.

There is a decline in browse species in the highland study kebeles of the study area. Due to the feed (browse) shortage and marketing constraints in the highland study kebeles the goat production at the small holder level is getting less sustainable. Farmers lack interest to continue rearing goats in the highland kebeles of the study area.

Conclusions

Diseases and predators, marketing problems and lack of adequate veterinary service are the main constraints affecting goat production in the study area. Thus, veterinary service provision needs to be improved and aware needs to be created on the consequences of using drugs purchased from the local market for the treatment of sick goats and this should be augmented by regulatory control of such practices. Improvement in market information and creation of market linkage would be essential to alleviate the prevailing marketing problems. Moreover, attention should be given to improved feed production because of its effect on animal health, productivity and survival.

References

Agajie Tesfaye, Chilot Yirga, Mengistu Alemayehu, Elias Zerfu and Aster Yohannes. 2002. Smallholder livestock production systems and constraints in the highlands of North and West Shewa Zones. Proceedings of the 9th annual conference of the Ethiopian Society of Animal Production (ESAP), August 30 – 31, 2001, Addis Ababa, Ethiopia, pp. 49 – 71.

Aklilu Feleke. 2008. Major animal health problems of market oriented livestock development in Bure Woreda. A thesis submitted to the faculty of veterinary medicine as a partial fulfillment for the requirement of the Doctor of Veterinary Medicine (DVM), Haramaya University, Ethiopia.

Alemayehu Mengistu. 2005. Feed resources base of Ethiopia: Status and opportunities for integrated development. Proceedings of the 12th Annual Conference of the Ethiopian Society of Animal Production (ESAP), August 12 – 14, 2004, Addis Ababa, Ethiopia, pp. 377 – 386.

Alganesh Tola, Mathewos Belissa and Gizaw Kebede. 2004. Survey on traditional livestock production systems in Manasibu District of West Wallaga, Ethiopia. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP), August 28 – 30, 2003, Addis Ababa, Ethiopia, pp. 141 – 150.

ARARI (Amhara Regional Agricultural Research Institute). 2005. Diagnosis- Training notes prepared for the diagnostic and planning workshop. July 24 – August 5, 2005. ARARI (Amhara Regional Agricultural Research Institute), Bahir Dar.

Arse Gebeyehu, Feyisa Hundessa, Gurmessa Umeta, 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. *African Journal of Agricultural Research.* 8(1): 26 – 31.

BOFED (Bureau of Finance and Economic Development). 2008. The Amhara National Regional State Bureau of Finance and Economic Development 2006/ 2007 Budget Year Annual Statistical Bulletin. Bureau of Finance and Economic Development, Bahir Dar.

CSA (Central Statistics Agency). 2016. Federal Democratic Republic of Ethiopia Central Statistical Agency. Agricultural Sample Survey 2015/2016 (2008 E.C.). Volume II, Report on Livestock and Livestock Characteristics (Private Peasant Holdings).

EARO (Ethiopian Agricultural Research Organization). 2000. Small ruminant research strategy. EARO (Ethiopian Agricultural Research Organization), Addis Ababa. 59p.

FARM-Africa. 1996. Goat types of Ethiopia and Eritrea – Physical description and management systems. Published jointly by FARM-Africa, London, UK and ILRI (International Livestock Research Institute), Nairobi, Kenya. 76p.

Firew Tegegne and Getnet Assefa. 2010. Feed resources assessment in Amhara National Regional State. Ethiopia Sanitary & Phytosanitary Standards and Livestock & Meat Marketing Program (SPS-LMM) Texas A&M University System, Addis Ababa.

Gebreegziabher Zereu, Merkine Meshka and Mathewos Shanka. 2016. Assessment of goat production systems and factors affecting goat production and goat's milk consumption in Humbo District of Wolaita Zone, Southern Ethiopia. *Global Journal of Animal Science, Livestock Prodcution and Animal Breeding.* 4(1): 248 – 253.

Girma Abebe and Alemu Yami. 2008. Sheep and goat management. In: Alemu Yami and R.C. Merkel (eds). Sheep and goat production handbook for Ethiopia. Ethiopian sheep and goat productivity improvement program. pp. 33 – 56.

IPMS (Improving Productivity and Market Success of Ethiopian Farmers). 2007. Burie pilot learning district diagnosis and program design: Final draft. 95p.

Kassahun Awigchew, Getachew Gebru, Zelalem Alemayehu, Negussie Akalework and Ian Fletcher. 1991. Small ruminant production in Ethiopia: Constraints and future prospects. Proceedings of the third national livestock improvement conference. 24 – 26 May 1989, Addis Ababa, Ethiopia, Institute of agricultural Research (IAR), pp. 37 – 48.

Netsanet Zergaw, Tadelle Dessie and Kefelegn Kebede. 2016. Goat production constraints and Ethno-veterinary practices in Konso and Meta-Robi districts, Ethiopia. *International Journal of Research and Reviews in Pharmacy and Applied Sciences.* 6 (1): 1308 – 1317.

Roeleveld, A.C. and A. Van den Broek. 1996. Focusing livestock systems research. Royal tropical institute, Amsterdam. 150p.

Solomon, A.K., Mwai, O., Grum, G., Haile, A., Rischkowsky, B.A., Solomon, G. and Dessie, T. 2014. Review of goat research and development projects in Ethiopia. ILRI Project Report, Nairobi, Kenya: International Livestock Research Institute.

Solomon Gizaw, Azage Tegegne, Berhanu Gebremedhin and Dirk Hoekstra. 2010. Sheep and goat production and marketing in Ethiopia: Characteristics and strategies for improvement. IPMS (Improving Productivity and Market Success of Ethiopian Farmers Project) Working Paper 23. ILRI (International Livestock Research Institute), Nairobi, Kenya. 58pp.

SPSS (Statistical Package for Social Sciences), 2003. SPSS 12.0 for Windows, SPSS Inc.

Steele, M., 1996. Goats. Macmillan education LTD, London and Basingstoke, The Technical Centre for Agricultural and Rural Co-operation (CTA). 152p.

Tegegn Fantahun and Askale G/Michael. 2017. Goat production system and breeding practices in pastoral and mixed crop livestock production system in south western part of Ethiopia. *Agriculture and Biology Journal of North America*. 8(3): 67 – 71.

Tesfaye Alemu Tucho. 2004. Genetic characterization of indigenous Goat Populations of Ethiopia using microsatellite DNA markers. PhD thesis, NDRI, India.

Comparison of Dairy Performance of F_1 (Borana X Holstein-Friesian) Crossbred Heifers under On-Farm and On-Station Management

Yohannes Gojjam[1]*, Direba Hunde[1], Molla Shumiye[1], Fekede Feyissa[2], Tadesse Bekele[1] and Roman Haile-Silassie[1]

[1]Holetta Agricultural Research Centre, P.O.Box 31, Holetta, Ethiopia
[2]Ethiopian Institute of Agricultural Research, P.O.Box 2003, Addis Ababa, Ethiopia
*Corresponding author:

Abstract

This study was conducted to compare the dairy performance of F_1 (Borana x Holstein-Friesian) crossbred heifers reared at Holetta Agricultural Research Centre (HARC) with their contemporaries distributed to smallholders (SH) in Walmara district. The experimental animals were born during 2010 to 2013 at HARC and distributed within the same time frame. Fifty two SH (42 male and 10 female) purposively identified were involved in the on-farm study. The overall least squares mean of age at first calving (AFC) was 37.7 months while that of on-farm and on-station were 42.09 ± 1.04 and 33.55 ± 1.01 months, respectively. The AFC of crossbred heifers reared on-farm was delayed by 9 months compared to the on-station result (p<0.001). The overall daily milk yield (DMY) was 9.5, 7 and 4.5 kg at early, mid and late lactations, respectively. The average on-farm daily milk yield was 9.67 ± 0.18, 7.3 ± 0.16, and 5.49 ± 0.17 kg while that of the on-station result was 9.30 ± 0.17, 6.7± 0.15 and 4.13 ± 0.16 kg respectively, during early, mid and late lactations. The milk yield of crossbred heifers did not show significant difference between on-farm and on-station during the early stage of lactation (p = 0.1446). However, there was about 8.2% to 23.5% higher milk yield (p<0.001) under on-farm condition from mid to late lactation, which may be attributed to better management by farmers in order to maximize their benefit from milk. The initial body condition score (BC) of heifers was 3.29 which was closer to the on station value (3.49). Loss of BC after calving (2.82±0.09) is a reflection of level of management. This study showed that first calving of crossbred heifers was more delayed under the management of SH compared to those managed on-station. This results in longer periods to bring the heifers into production (calf, milk) at smallholder's level of management. Hence, it can be inferred that sending young crossbred heifers to SHs at earlier ages (< 18 months) as technology transfer scheme is less desirable.

Key words: Crossbred heifer, smallholder farmers, technology transfer

Introduction

Potential for dairy development in Ethiopia could be expressed by large cattle population, favorable climate conditions for improved dairy cows, and the relatively less disease occurrence for dairy production. Dairy development in Ethiopia has a considerable advantage for smallholder income generation which can contribute significantly to food security and poverty reduction. Reviews on the development of dairy sector in Ethiopia shows that there is a need to focus on integration of crossbred dairy to the smallholder sector through improving their access to improved technology (Hiskiyas and Tsehay, 1995; Amanuel and Tesfahun, 2006; Azage et al., 2010). Dairy technology transfer and dissemination in Ethiopia has lagged behind due to various reasons including limited number of exotic breeds and their crosses, high cost of dairy inputs combined with poor livestock extension system in the country. Mulugeta and Belayeneh (2013) suggested the need for attention to be given to strong extension service and training of farmers in breeding, feeding, health care, and housing as intervention measures in order to exploit the potential of dairy cattle by improving the lactation performances.

The number of highly productive exotic breeds (0.13%) and their crosses with local breeds (0.64%) that currently exist does not even reach 1% of the total cattle population of the country (CSA, 2011). Reports before ten years confirm similar data indicating that closer to half a million heads of cattle in Ethiopia is exotic or crossbred dairy cows (Muriuki and Thorpe, 2001).

Dairy development projects implemented in Ethiopia in minimum package program (MPP, 1972-1980) was aimed to raise the income and agricultural output of smallholder farmers with minimum reliance on scarce resources. The project has dealt with distribution of crossbred heifers, bull and AI service to selected farmers almost all over the country except the lowlands. However, it did not succeed to establish sustainable improved dairy production system in the country.

Searching for proven technologies and management options with the smallholder dairy farmers can have contributions in realizing increased supply of crossbred dairy cows in the country. Accelerated heifer rearing method can be applied to bring heifers to early puberty for milk production and improved reproduction performances. Various management options can be used to improve and maintain post weaning management level for better daily growth rate until early puberty is reached. Studies made in Ethiopia have proved that heifers fed on diet with high concentrate to roughage ratio came in heat earlier than those fed on diets with lower concentrate to roughage supplementation ratio.

Age at first heat of crossbred heifers have reached 14.7 to 17.86 months by ensuring the level of concentrate feed in the daily ration (Yohannes et al., 2010). Similarly, heifers that had 1 kg of concentrate supplement per day in addition to grazing and 2 kg of hay showed estrus at a younger age than those that had only 2 kg of hay supplement in addition to grazing. The objective of this study was therefore to compare the performances of crossbred heifers distributed to smallholders at younger age with the ones managed at on station conditions in high dairy potential areas in the central highlands of Ethiopia.

Materials and Methods

Study site selection

This study was conducted in Walmara district at selected villages around Holetta Agricultural Research Centre (HARC) which is located 30 km west of Addis Ababa, Ethiopia. The study area is located at 3°24'N to 14°53'N and 33°00'E to 48°00'E with an average altitude of 2400 masl; annual rainfall of 1100mm; and average minimum and maximum temperatures of 6°C, 24°C, respectively. The area experiences two major seasons, the wet season (June to September) and the dry season (October to May). A total of seventy two smallholder farmers selected from five villages in the vicinity of HARC were initially considered. Preliminary field visits were made by a team of researchers to locate the specific sites. Purposive sampling technique was used to select study sites considering accessibility for monitoring and data collections and willingness of the farmers to participate in the verification of the technology.

Animals and management at on farm and on station

On station management: Recommendations were made from research centre to realize different management options for dairy cattle production and management in the highlands (Zelalem et al., 2006; Yohannes et al., 2007). During the pre-weaning period, all F_1 crossbred calves produced from Boran dam breeds were allowed to suckle freely and are weaned at approximately 6 months of age. Heifers were left to grazing from early morning (8:00 AM) to 4:00 PM in the afternoon and are fed with natural pasture hay as required at night. After weaning, they are fed on hay free choice and are supplemented with concentrate, based on body weight change as already recommended until the age of 9 months. Concentrate mixture composed of wheat middling (32%), wheat bran (32%), noug (*Guizocia abyssinica*) cake (34%), and salt (2%) was supplemented to the heifers based on their body weight changes. Prior to distribution to smallholder farmers, the heifer claves attained 9 months of age and weighed between 90 to 110 kg.

On farm management: At on farm, heifer calves were expected to be managed with the farmer as recommended and guided during the trainings. However, farmers use all possible means of supplementations and native grass hay, wheat, barley and teff straws for their cows and heifers. In most cases participant farmers use different improved forage crops (mainly of oats/vetch mixture). Moreover, almost all farmers use native grass hay. Some farmers use easily available concentrate feeds like wheat bran and noug cake. However, many farmers refrain from using concentrates because of its high cost. The farmers were properly oriented with the basic principles and necessary requirements including feed production and utilization, housing, health care and product handling before introduction of the heifers.

Packages

The comparison trial constitutes full packages of young crossbred heifers reared with appropriate breeding methods and managed under on station improved management conditions before distribution. Feeds and feedings incorporating forage development and animal health management practices were also employed.

Farmer selection

Fifty two enlightened farmers were selected purposively with full participations of the district agricultural offices, researchers and development agents based on resource ownership (land, feed etc), physical accessibility (both for market and monitoring) and ability to keep records at household level.

Trainings

Farmers were trained on all aspects of heifer management practices, including estrus detection, feeding, husbandry practices, health management and related reproductive management systems prior to distribution of the heifers. Moreover, the farmers had exposure to management practices related to previous on station recommendations.

Table 1. Number and status of heifers used for the trial at 6 sites

Site	Status and number of heifers				
	Distributed	Calved	Still open	Died	sterile
Guntuta	10	8	2	0	0
Galgal	12	6	5	1	0
Walmara	10	6	0	3	1
Mada gudina	3	3	0	0	0
Bshan Dimo	13	11	0	1	1
Saadmo	4	3	0	1	0
Total	**52**	**37**	**7**	**6**	**2**

Note: - A total of 153 F_1 (50%) crossbred heifers were born and maintained at on station contemporary to those distributed to the smallholders. Out of those heifers, 37 were randomly picked and used for comparison with the ones managed under smallholders management

Data collection

- Heifers' body condition once in three months (in wet and dry seasons)

- Reproduction data (service date, PD and calving date)
- Age at first calving
- Milk production in early, mid and late lactation periods

Statistical Analysis

Data collected on milk yield (DMY), age at first calving (AFC) and body condition (BC), were subjected to statistical analysis using the General Linear Model (GLM) procedure of the

Statistical Analysis System (SAS, 2002). The independent variables considered in the study include AFC, DMY and BC both on farm and on station.

Results

Age at first calving

The overall least square means (LSM) of age at 1st calving (AFC) was 37.7 months in the present study (Table 2). The LSM for age at first calving at smallholder (on farm) condition was 42.09 ± 1.04 months, while the age at first calving during the same period under on-station management was 33.55 ± 1.01 months. In previous study, AFC was attained at an earlier age of 28 months (Figure 1). Significantly ($p < 0.001$) more prolonged age at first calving was recorded under smallholder management level. Young heifers distributed to farmers for evaluation had eight and half (8.54) months delay in age at first calving than those managed on-station during the same period.

Replacement pure bred heifers should be bred to calve at 24 months of age in order to maximize lifetime productivity of breeding stocks. For heifers to achieve puberty at earlier age, adequate nutrition is required to provide better rates of gain such that heifers can achieve a critical body weight prior to achieving puberty. In general, the on-station study showed that underfeeding results in prolonged age at first calving.

Table 2. Least square means ± se ± se of age at forst calving for crossbred heifers on-farm and on-station

Treatments	N	Age at first calving Ls means ±se
Overall	72	37.7
On-farm	35	42.09 ± 1.04 a
On-station	37	33.55 ± 1.01b

Figure 1. Age at first calving on-farm versus on-station

Milk production

Least square means of daily milk yields (DMY) recorded at on farm and on station from this study are presented in Table 3. The daily milk yield at on farm and on station did not significantly vary ($p > 0.05$). However, better daily milk yield was obtained during early lactation stage at on farm (9.67± 0.18 kg) than at on station (9.30 ± 0.17 kg).The data for milk production did not take into account the amount supplied to calves during each milking. Most smallholder farmers in the study area use partial suckling methods during milking, while very few farmers practice bucket feeding of calves.

Table 3. Least square means ± se of daily milk yield (kg) of crossbred heifers under on farm and on station management

Treatments	N	Lactation stage		
		Early lactation	Mid lactation	Late lactation
Overall	72	9.47	6.99	4.67
On farm	35	9.67± 0.18	7.3±0.16	5.49 ±0.17 [a]
On station	37	9.30 ± 0.17	6.7± 0.15	4.13 ± 0.16 [b]
P value		0.1446	0.0108	0.0001

Body condition scores of crossbred heifers under smallholders' management

Least square means and standard errors (LSM± se) of body condition scores of heifers at initial and subsequent quarters of the year for animals that are kept and fed under shade during most of their time (better managed group) and those that are sent out for grazing with other herd (poorly managed group) under on farm condition is presented in Table 4.

Table 4. Body conditions of heifers from distribution to early calving at smallholders` management

Scoring Interval	Overall	Better managed group BCS (N=27)	Poorly managed group BCS (N=25)
At Initial score	3.29	3.49 ±0.14a	3.10±0.15a
After 3 -6 months	3.15	3.29 ±0.83a	3.01±0.85a
After 6 - 9 months	3.4	3.47±0.10a	3.22±0.11a
After 9 – 12 months	3.39	3.61±0.10a	3.17±0.11b
After > 12 months	3.39	3.67±0.12a	3.11±0.13b
After calving	3.30	3.27±0.09a	2.82±0.09b

The overall BC sore of crossbred heifers was 3.29 (ranging from 3.10 ± 0.15 to 3.49 ± 0.14) during initial stages of distribution. The conditions of the two groups were maintained under similar BC from initial stage to 9 months (p>0.05). A significant change in BC score has appeared after the heifers have stayed with the farmer from 9 months onwards. Better body condition scores were observed with the farmers who kept their heifer separately around the homestead with concentrate supplementation.

Figure 2. F_1 Crossbred heifer calved at smallholder farms

Discussion

The ultimate goal of heifer rearing is to economically raise the heifers to bring them to proper weight (size) and body condition for first service and calving at earlier age. The current management level being practiced at the smallholders and even at on station condition needs further improvement. Nutritional manipulation of crossbred dairy heifers in the post-weaning period at HARC (on station management) accelerated the growth rate and improved reproductive performance of the heifers enabling them to calve at the age of less than 30 months (27 to 29 months) (Yohannes et al., 2010).

Early reproductive performances of crossbred heifers at the smallholder level of management seem to delay more than expected. Even though no adequate information was generated on some reproduction performances of crossbred heifers at farmers' management, comprehensive data collected at on station from Assella, Debre Zeit and Holletta showed that AFC in Holstein Frisian (HF) crosses to be 42.6 months (Million et al., 2006). In a study conducted at Metekel Ranch by Andassa Agricultural Research Centre, AFC for Fogera crosses (Fresian x Fogera) was reported to be 40.46 ± 0.93 months (Addisu et al., 2003). Data collected for the period of 30 years (1974 to 2005) at Holetta on Frisian crosses showed AFC of 43.4 ± 0.6 months (Kefena et al., 2011).

Compared to these results, early reproductive performances of Frisian Boran (FB) crossbred heifers under smallholders management is prolonged (42.09 months) compared to previous on station result (40.32 months). From the current study it could be noted that AFC did not improve at smallholders' management, rather it was delayed by 20.3% compared to the on station result which is 33.55 months in the current study.

Despite the inadequacy of information on milk production under smallholders management, some data at on-farm evaluation of crossbred dairy cattle owned by smallholder farmers around Holetta, Debre Zeit, Arsi and Bako previously indicated that the level of milk production of crossbred cows was lower than that of on-station yield even under improved management (Gryseels and De Boodt, 1986; Kiwuwa et al., 1983; Tesfaye, 1993). This might be due to low awareness that the farmers had in the past than the present scenario.

The current result of DMY (9.67± 0.18 kg) at on farm is better than the figure reported by Million et al., 2010 in central highlands of Ethiopia. The authors reported a lactation milk yield of 2520 litters in 321 lactation length (LL) which equates to 7.85 kg/day. It could be noted that in the central highlands of Ethiopia, because of the favorable environmental and climatic conditions, selected crossbred cows can continue to out-yield earlier crosses provided that appropriate husbandry practices and technological supports, trainings and other interventions are made.

Body condition score is a management tool that can be used to evaluate the nutritional status of an animal. It indicates the energy reserves of calf, heifer and cow, as a vital indicator of excessive loss of weight while the animal is under considerable nutritional pressures to influence subsequent reproductive and growth performance.

Conclusion and Recommendations

The study revealed that the AFC of heifers under farmers' management was delayed by 9 months compapred to those managed on-station (42 vs 33.6 months). Delayed AFC has negative economic impact on the smallholder gains from production of calves and milk at earlier age, and subsequent contribution for genetic improvement. For smallholder farmers to keep profitable crossbred heifers, provision of improved management practices, sustainable inputs (feed, health care, AI delivery system etc), workable extension services and farmers training are important requirements. It was, therefore, concluded that sending young crossbred heifers to smallholders during their active growing periods (< 18 months) may not be desirable as it takes longer periods to bring the heifers into production (calf, milk) under such management. Hence, beginner farmers should be well trained and evaluated for their preparedness to ensure that they could properly deal with dairy technology. Moreover, it is more feasible to distribute heifers with confirmed pregnancy to smallholders than distributing under age heifers.

Acknowledgements

The authors are grateful to Ethiopian Institute of Agricultural Research (EIAR) for the support provided to undertake this activity. We are also thankful to the management of Holetta Agricultural Research Centre (HARC) for the continued support in providing transportation facility and support in training farmers and development workers. We would like to extend our thanks to the key stakeholders including farmers and district Agriculture offices for their continued cooperation in providing information and working with us.

References

Addisu Bitew and Prabhakar Hagde. 2003. Reproductive and growth performance of Fogera cattle and their F1 Friesian crosses at Metekel ranch, Ethiopia. In: Challenges and opportunities of livestock marketing in Ethiopia. Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production, held in Addis Ababa, Ethiopia, 22-24 Aug 2002. Ethiopian Society of Animal Production, Addis Ababa (Ethiopia) ESAP, pp111-117.

Amanuel Assefa and Tesfahun Fenta. 2006. Harnessing local and outsiders' knowledge: Experiences of multi-stakeholder partnership to promote farmer innovation in Ethiopia. PROLINNOVA working paper 12 http://www.prolinnova.net/ethiopia/WP12 Accessed on 20 Nov 2012.

Azage Tegegne, Brhanu Gebremedhin and Hoekstra, D. 2010. Livestock input supply and service provision in Ethiopia: challenges and opportunities for market-oriented development. IPMS Working Paper 20, Nairobi (Kenya).

Central Statistical Agency- Ethiopia. 2011. Agricultural sample survey 2010/11. Volume II Report on livestock and livestock characteristics.

Gryseels G and de Boodt K. 1986. Integration of crossbred cows (Boran and Friesian) on smallholder farms in the Debre Zeit area of the Ethiopian highlands. ILCA Highlands Programme Report, ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Kiwuwa, G. H., J.C.M. Trail, M. Y. Kurtu, G. Worku, F.M. Anderson and J Durkin. 1983. Crossbred dairy cattle productivity in Arsi Region, Ethiopia. International Livestock Center for Africa (ILCA) Research report No. 11, PP. 1-29.

Hiskiyas Ketema and Tsehay Reda. 1995. Dairy production system in Ethiopia. In: strategies for market orientation of small scale milk producers and their organizations. FAO (Food and Agricultural Organization of the United Nation). Proceeding of the workshop held at 20 - 24th march, Morogoro, Tanzania, Pp 125.

Kefena Effa, Zewde Wondatir, Tadelle Dessie and Aynalem Haile. 2011. Genetic and Environmental trends in long-term dairy cattle genetic improvement programs in the central tropical highlands of Ethiopia. Journal of Cell and Animal Biology Vol. 5 (6) Pp. 96 – 104.

Mulugeta Ayalew and Belayeneh Asefa. 2013. Reproductive and lactation performances of dairy cows in Chacha Town and nearby selected kebeles, North Shoa Zone, Amhara Region, Ethiopia. World Journal of Agricultural Sciences Vol. 1(1), pp. 008-017, February 2013 Available online at http://wsrjournals.org/journal/wjas

Million Tadesse, Tadelle Dassie, Gifawesen Tesema, Tamirat Degefa and Yohannes Gojjam. 2006. Study on Age at first Calving, Calving Interval and Breeding Efficiency of Bos Taurus, Bos indicus and their Crosses in the Highlands of Ethiopia. Ethiopian Journal of Animal production Vol. 6 (2) pp 1 – 16, 2006.

Million Tadesse, Thiengtham J, Pinyopummin A and Prasanpanich S. 2010. Productive and reproductive performance of Holstein Friesian dairy cows in Ethiopia. Livestock Research for Rural Development Volume 22, Article #34 Retrieved May 26, 2017, from http://www.lrrd.org/lrrd22/2/tade22034.htm

Muriuki, H.G. and Thorpe, W,. 2001. Smallholder dairy production and marketing in Eastern and Southern Africa. In the Proceedings of the South & South Workshop on Smallholder Dairy Production and Marketing & Constraints and Opportunities. March 12 & 16 Annand, India.

SAS, 2002. Statistical Analysis System, version 9.0, SAS Institute, Inc., Cary, NC, USA.

Tesfaye Kumsa. 1993. Smallholder dairy in Ethiopia. In: Kategile J A and Mubi S (eds). 1992. *Future of livestock industries in East and southern Africa*. Proceedings of a workshop held at Kadoma Ranch Hotel, Zimbabwe, 20-23 July 1992. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 227 pp.

Yohannes Gojjam, Seyoum Bediye, Adugna Tolera and Rehrahe Mesfin. 2007. Performance of Borana and Crossbred Cows fed a Basal diet of Native grass hay Supplemented with Different Protein Source Concentrate feeds. Animal production Research Animal production research Advances 3 (3): 174 – 180.

Yohannes Gojjam, Adugna Tolera and Reherahie Mesfin. 2010. Management options to accelerate growth rate and reduce age at first calving in Friesian–Boran crossbred heifers; Tropical animal Health and Production, 43:393–399.

Zelalem Yilma, Yohannes Gojjam and Mola Shumye. 2006. Milk production level and calf-rearing system affecting Boran, Ethiopian zebu cattle breed, cow-calf performance. *Livestock Research for Rural Development Volume 18, Article #71* Retrieved May 26, 2017, from http://www.lrrd.org/lrrd18/5/yilm18071.htm

Ewe Body Condition Determines Oestrus Response to Hormonal Oestrus Synchronization in Smallholders Village Flocks

Debir Legesse[1], Yosef Mekasha[2], Sunkurta Digessa[1], Tesfaye Wechage[2], Bereket Zeleke[1], Solomon Gizaw[2] and Azage Tegegne[2].

[1]South Agricultural Research Institute, Hawassa Agricultural Research Center, Hawassa, Ethiopia
[2]International Livestock Research Institute, Addis Ababa, Ethiopia.

Abstract

The objective of this study was to investigate the effects of ewe associated factors on hormonal oestrus synchronization in village sheep flocks in Sidama zone, Southern Ethiopia. Initially, for synchronization fifty-five Sidama ewes were selected and checked for pregnancy status using pregnancy diagnosis device (Preg-Tone). The ewes were injected with a single shot of $PGF_2\alpha$ (Lutalyse®) hormone at the rate of 2.5 ml per ewe. Thirty-eight of the 55 ewes treated with hormone showed oestrous signs. The ewes were then joined with active selected four breeding rams for four consecutive days. Oestrous response and conception rates were analyzed using multinomial logistic regression model. The overall oestrous response rate and conception rate were 69.1% and 89.2%, respectively. The average time to onset of oestrus was 54.1 hrs, ranging from 19.1 to 97.5 hrs. Neither ewe body weight ($P = 0.902$), age ($P = 0.127$) nor parity ($P = 0.968$-0.084) had significant effect on the oestrus response rate of ewes to hormonal oestrus synchronization. The only significant factor determining oestrus response was ewe body condition. Ewes with body condition score of 2.5 and below were significantly more likely not to respond to hormonal treatment (odds ratio = 2.15E-09, $P = 0.000$) compared to ewes with body condition score of 3.0. However, none of the factors studied (body condition, body weight, age and parity of the ewe) affected the time of onset of estrus after hormone administration and conception rate. It could be concluded that body condition, regardless of the other ewe associated factors (i.e. body weight, age and parity), dictates oestrus response of ewes to hormonal treatment in synchronization of oestrous cycles in village ewe flocks. It is thus imperative to pay attention to nutrition of ewes for successful synchronized breeding in villages where supplementary feeding is rarely practiced.

Key words: *Synchronization, oestrous response, body condition, sheep, Sidama*

Introduction

In traditional uncontrolled continuous mating systems under smallholder small ruminant farming systems, lambing is commonly distributed throughout the year, with only a small proportion (13% to 15%) of the lambings occurring in a peak lambing season during the favorable rainy season in Ethiopia (Legesse, 2008) and elsewhere (Setiadi *et al*., 1995). Flock performance is negatively affected if lambing/kidding do not match with appropriate seasons in terms of feed availability and disease load. Year-round dispersed lambings has also been found to limit village-based genetic improvement efforts since only a few selection candidates would be available in each round of selection resulting in low selection intensity (Gizaw *et al*., 2014).

Hormonal oestrus synchronization has been introduced in Ethiopia to accelerate delivery of improved dairy genetics (Tegegne *et al*., 2012) and its application in small ruminant breeding has been under investigation (Zeleke, 2009; Zelelke *et al*., 2016). However, Oestrus responses to hormonal synchronization ranging from 65 to 100% have been reported for Ethiopian sheep breeds (Zeleke 2009; Zeleke *et al*. 2016) and from 4.3– 100% for village flocks elsewhere depending on the synchronization protocol (Omontese *et al*. 2016). Oestrus response is also affected by various ewe associated factors such as body condition, age, body weight and parity and as well as environmental stresses (Santoralia *et al*., 2011). These factors could be confounded and there is a need to single out the predominant factor determining the success of oestrus synchronization under village conditions. This study investigates the effects of ewe-associated factors on hormonal oestrus synchronization and to introduce pregnancy diagnosis device (Preg-Tone) for early stage of pregnancy in village sheep flocks in Sidama zone of Southern Region, Ethiopia.

Materials and Methods

Study area

The study was conducted at Bensa woreda of Sidama zone, Ethiopia. Sidama is one of the zones in Southern Nations and Nationalities and Peoples' Region (SNNPR). The capital is Hawass town located 275 km south of Addis Abeba. Sidama zone is located at $5^0$45' and $6^0$45' N latitude and $38^0$39' and $38^0$29' E longitude. It has highlands, midlands and semi-dry lowlands agro-ecologies accounting for 30%, 60% and 10% of the area, respectively. The farming system of the zone is characterized as mixed farming system. Among the three agro-ecological zones, this study was conducted only in high land parts of Bensa *woreda*[1].

Study animals

The study animal belonged to a cooperative village sheep breeding groups. Through discussion with the farmers, 55 ewes were selected for the study. Prior to synchronization the ewe flocks were checked for their pregnancy status using an ultrasound pregnancy diagnosis device (Preg-Tone®). The selected ewes were 16 to 36 months of age with 1-3 parity level and weighing 18-34 kg. The ewes were scored for their body condition on a 1-5 scale (1=thin/emaciated; 2= thin/poor; 3= acceptable; 4= fat; 5=very fat) following Srinivas (2013). Experimental breeding ewes and rams were used from the same location. A total of four mature active rams with similar age and BCS and which has higher body weight were subjected for 38 ewes which have responded oestrus. Thus, the two rams were allocated for 19 ewes and the rest two rams were used for 19 ewes.

Oestrous synchronization and mating

A single shot of $PGF_2\alpha$ (Lutalyse®) hormone was administered at the rate of 2.5 ml per ewe. Synchronization was carried out in to two cluster (FTC and village level), but mating was made at their nearest village where rams are placed. Following synchronization, the ewes were then joined with active selected mature and similar age group rams for four consecutive days from 8:00 am to 6:00 pm. After 6:00 pm the ewes were returned back to their home. Mating time (estrus) of each ewe was observed by the sheepherders and rams also detect ewes heat. When the rams are mounting the ewe doesn’t move, indicating ewe's status of heat. The breeding rams were flushed 400 gm of concentrate feed once daily for a month so as to increase libido. Selected ewes were managed according to the farmers’ practice with no special feeding or any other management intervention throughout the study period. Preventive treatment was administrated against internal parasites. Sixty days post-joining ewe pregnancy status was diagnosed using Preg-Tone®.

[1] *woreda* is the lowest administrative level equivalent to district.

Statistical analysis

Oestrous response and conception rates were analyzed using multinomial logistic regression analysis and SPSS version 20 (2011) was employed for the analysis. Oestrous response and conception rates were modeled as dependent variable. Parity as categorical and body condition score, body weight and age were considered as as continuous independent variables. For the dependent variables, there exist two continuous variables Z_k (Z_1 and Z_2) each of which can be thought of as the likelihood of oestrus response and conception, with larger values of Z_k corresponding to greater probabilities of oestrous response or conception. Mathematically, the relationship between the Z's and the probability of a particular outcome is described in the formula: $\pi_{ik} = (ez_{ik}) / (ez_{i1} + ez_{i2} + ... + ez_{ik})$, where π_{ik} is the probability the i_{th} ewe falls in category k and z_{ik} is the value of the k_{th} unobserved continuous variable for the i_{th} ewe. Time of onset of response was analyzed fitting body condition score and parity as categorical and body weight and age as continuous independent variables in a general linear model.

Results and Discussion

Oestrus response and conception rate

Thirty-eight of the 55 ewes treated with hormone showed oestrous signs, resulting in oestrous response rate of 69.1% (Table 1). This could be considered a moderate response compared to oestrous an average response rate of 76.5% achieved in four local breeds (Gizaw *et al*., 2016), ranging from 93.2% in the Horro type sheep to 57.5% in the Atsbi sheep type. Similarly, Zeleke (2016) reported 55–65% oestrous response rate for the local Ethiopian Menz and Awassi-Menz crossbred sheep. Oestrous response varies significantly across experiments due to variation in ewe factors, breed differences, age, environments and managements. Omontese *et al* (2016) reported response rates ranging between 20 and 100% for Nigerian goat breeds. The average time of onset of oestrus after hormone administration in the current study was 54.1 hrs ranging from 19.1 to 97.5 hrs (Table 1). The percentage of ewes showing oestrus within 72 hrs was 74.5% (Fig. 1), which was close to the average 76.5% reported for four Ethiopian sheep breeds (Gizaw *et al*., 2016).

Table 1. Estrus response, onset of response and conception rate of ewes treated with Lutylaze hormone

Variables	No. of ewes synchronized	No. of ewes responded	Oestrus response (%)	Time to onset of oestrus (hrs.)	Conception (%)
Overall	55	38	69.1	54.1±3.5	89.2
Parity					
First	18	16	88.89	59.7±5.7	87.50
Second	23	13	56.52	50.1±4.9	92.85
Third	14	9	64.28	49.5±7.9	77.78
Body condition score					
2.0	23	12	56.5	53.3±6.8	75.0
2.5	18	11	61.1	57.6±4.5	90.9
3.0	14	14	100	52.1±6.6	100.0

Pregnancy diagnosis using ultra sound detector confirmed that 34 (89.4%) of the 38 ewes that showed oestrus signs and joined with rams were pregnant. This conception rate could be considered high given conception rates following artificially induced oestrus is usually reported to be low. For instance, Kumar *et al*. (2016) reported low conception rates in three hormonal oestrus induction protocols (37.5%, 53.3 and 56.3%) compared to the oestrus response achieved (81.3%, 100%, and 93.7%). On the other hand, Cairoli *et al*., (2006) reported similar conception rates between cows inseminated after induced-oestrus and spontaneous oestrus (59% vs 54.5%).

The anestrous ewes that did not respond to hormone treatment were also run with the ewes that showed oestrous during the mating period. The percentage of the anoestrus ewes that started to cycle and conceived during the mating period was only 5.9%. Effect of ram exposure is known to affect oestrus behavior (Nugent *et al*., 1988), but the ram effect is more effective with sudden introduction of rams and when ewes have had no contact with rams for a period of time, which was not the case in the current study.

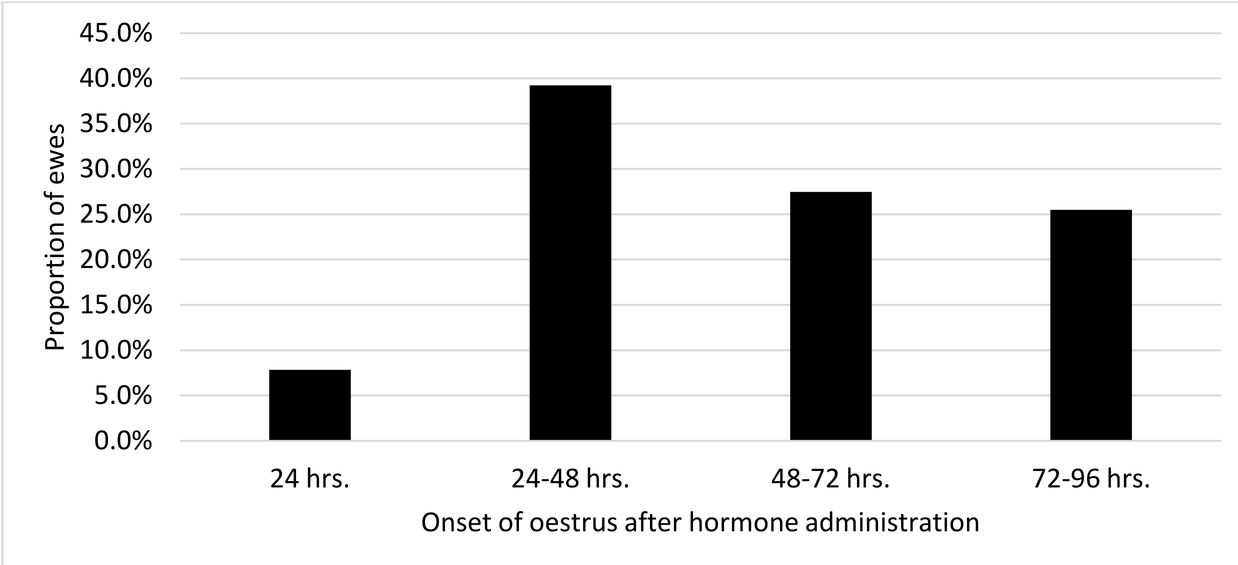


Fig. 1 Distribution of onset of oestrus in hours after Lutylaze hormone administration

Determinants of oestrous response, onset of oestrus and conception rate

Neither ewe body weight (*P* = 0.902), age (*P* = 0.127) nor parity (*P* = 0.968-0.084) had significant effect on the oestrus response rate of ewes to hormonal oestrus synchronization (Table 2). However, there are some reports (Véliz *et al*., 2009; Ungerfeld and Sanchez-Davila, 2012) where parity showed significant influence on oestrus response, though not on pregnancy rate, a unit increase in body weight resulted in an increase of 14.7% in oestrus response (Gizaw *et al*., 2016), and heavier goats showed more oestrus response and shorter time to onset of oestrus than lighter goats (Véliz *et al*., 2006).

However, the studies reporting significant effects of parity and body weight (Véliz *et al*., 2006; Véliz *et al*., 2009; Ungerfeld and Sanchez-Davila, 2012) did not include the effects of body condition in their analysis models. In the current study the effects of ewe parity, body weight, age and body conditions were investigated in a multivariate model. The results showed that the only significant factor determining oestrus response was ewe body condition (Table 2). Ewes with body condition score of 2.5 and below were significantly more likely not to respond to hormonal treatment (odds ratio = 2.15E-09, *P* = 0.000) compared to ewes with body condition score of 3.0. This is in agreement with other studies in which the analyses models included body condition together with other ewe associated factors such as parity and body weight. In these studies, neither body weight nor age of ewes significantly influenced their fertility (Aliyari *et al*., 2012) and estrus responses were not significantly different between nulliparous, primiparous and multiparous does (Mat *et al*., 2015), whereas body condition had significant influence on oestrous responses. A similar result was reported for cattle where body condition rather than parity and age had a significant effect on oestrous response and conception (Gebrehiwot *et al*., 2015). These findings indicate that body condition is the overriding determinant of oestrous response to hormonal oestrus synchronization in ewes.

Table 2. Likelihood of oestrus response following treatment with Lutylaze hormone in ewes differing in age, body weight, body condition and parity

Variable name	Estimated coefficient (β)	Std. error	P value	Odds ratio (exp *B*)
Intercept	23.734	3.119	0.000	
Age (months)	-0.104	0.068	0.127	0.902
Weight (kg)	0.012	0.095	0.902	1.012
Body condition score 2.0	-19.957	0.764	0.000	2.15E-09
Body condition score 2.5	-19.635	0	.	2.97E-09
Body condition score 3.0	0[b]	.	.	.
Parity 1	-0.047	1.19	0.968	0.954
Parity 2	-1.565	0.905	0.084	0.209
Parity 3	0[b]	.	.	.

a. The reference category is ‘no oestrous response’. b. This parameter is set to zero because it is redundant.

Both the current and previous findings indicate that a body condition score of 3.0 results in maximum oestrous response to hormonal oestrous synchronization. Mat *et al.* (2015) found oestrous response rates of 0%, 77.8% and 0% in ewes with body condition scores of <2.0, 2.5-4.0 and >4.0, respectively. Aliyari *et al.* (2012) reported a normal oestrous cycle in ewes with body condition score of 3, whereas ewes with body condition score of 2 and 2.5 showed shorter and irregular oestrous cycle duration. Body condition scores of 2.5 to 3.0 have been recommended by some authors (Husein & Ababneh, 2008; Contreras-Solis, *et al*., 2009).

Body condition directly affects hypothalamic activity and GnRH secretion and effects on reproductive performance are mediated through changes in ovarian hormones or in hypothalamo-pituitary sensitivity to ovarian hormones (Rhind, *et al*., 1989) and the impact of body condition was quantified to reach as high as a 2.4-fold increase in pregnancy loss for a unit reduction in condition score (López-Gatius *et al*., 2002).

None of the factors studied in the present study (body condition, body weight, age or parity of the ewe) affected the time of onset of estrus after hormone administration and conception rate (Table 3). Similarly, Mat *et al*. (2015) reported a non-significant influence of body condition on pregnancy rate and time of onset of oestrus. However, in some cases the effect of body condition could be expressed in lower pregnancy rate (Maqhashu *et al.,* 2016) and feed restriction, through its effect on body condition, could delay onset of oestrus (Mani *et al.,* 1992). These difference among different studies could be the availability of flush feeding for ewes response in synchronization and conception; age of ewe, body condition, parity, breed type, ewe factors and environmental conditions.

Table 3 Likelihood of conception of hormonally-induced ewes differing in age, body weight, body condition, parity and differences in time of onset of oestrus after hormone treatment.

	Conception rate			Onset of oestrus (hr)		
	B	Sig.	Exp(*B*)	*B*	Sig.	Exp(*B*)
Intercept	221.71	0.977		28.35	0.467	
Age (months)	-5.628	.	0.004	0.868	0.263	2.383
Weight (kg)	-0.062	0.780	0.940	-0.401	0.675	0.67
Body condition score 2.0	-18.177	0.998	1.28E-08	-0.596	0.943	0.551
Body condition score 2.5	0.496	1.000	1.642	7.966	0.362	2881.99
Body condition score 3.0	0 [b]	.	.	0 [b]	.	1.000
Parity 1	-47.791	0.995	1.76E-21	18.734	0.115	1.37E+08
Parity 2	6.973	0.999	1067.764	5.327	0.625	205.744
Parity 3	0 [b]	.	.	0 [b]	.	1.000

a. The reference category is no conception, b. This parameter is set to zero because it is redundant.

Conclusion

It could be concluded that body condition, regardless of the other ewe associated factors (i.e. body weight, age and parity), dictates oestrus response of ewes to hormonal treatment in synchronization of oestrous cycles in village ewe flocks. It is thus imperative to pay attention to nutrition of ewes for successful synchronized breeding in villages where supplementary feeding is rarely practiced.

Acknowledgement

This study was financially and technically supported by the Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) project of the International Livestock Research Institute (ILRI). LIVES project is financed by Global Affairs Canada (GAC). Hawassa Agricultural Research Center and Bensa woreda Livestock and Fishery Development Office are duly acknowledged for their facilitation and support during the field work.

References

Aliyari, D., Moeini, M. M., Shahir, M. H. & Sirjani, M. A. (2012). Effect of body condition score, live weight and age on reproductive performance of Afshari ewes. *Asian Journal of Animal and veterinary Advances*, 7, 904-909.

Cairoli, F., Mollo, A., Veronesi, M. C., Renaville, B., Faustini, M. & Battocchio, M. (2006). Comparison between cloprostenol-induced and spontaneous oestrus fertility in dairy cows. *Reprod Domest Anim.*, 41, 175-9.

Contreras-Solis, I., Vasquez, B., Diaz, T., Letelier, C., Lopez-Sebastian, A. & Gonzalez-Bulnes, A. (2009). Efficiency of estrous synchronization in tropical sheep by combining short-interval cloprostenol-based protocols and "male effect". *Theriogenology*, 71, 1018-1025.

Gebrehiwot, G., Gebrekidan, B. & Weldegebriall, B. (2015). The Effect of One Shot Prostaglandin on Estrus Synchronization of Local and Holstein Friesian Cattle in and around Wukro Kilte Awulaelo District, Northern Ethiopia. *Journal of Biology, Agriculture and Healthcare,* 5, 99-105.

Gizaw, S., Getachew, T., Goshme, S., Valle-Zárate, A., van Arendonk, J. A. M., Kemp, S. S., Mwai, A. O. & Dessie, T. (2014). Efficiency of selection for body weight in a cooperative 2 village breeding program of Menz sheep under smallholder farming system. *Animal,* 8, 249–1254.

Gizaw, S., Tesfay, Y., Mekasha, Y., Mekuriaw, Z., Gugsa, T., Ebro, A., Gebremedhin. B., Hoekstra, D. & Tegegne, A. (2016). Hormonal oestrus synchronization in four sheep breeds in Ethiopia: Impacts on genetic improvement and flock productivity. LIVES Working Paper 25. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Husein, M.Q. & Ababneh, M.M. (2008). A new strategy for superior reproductive performance of ewes bred out-of-season utilizing progestagen supplement prior to withdrawal of intravaginal pessaries. *Theriogenology*, 69, 376-383.

Kumar, L, Phogat, J. B., Pandey, A. K., Phulia, S. K., Kumar, S. & Dalal, J. (2016). Estrus induction and fertility response following different treatment protocols in Murrah buffaloes under field conditions. *Veterinary World*, 9, 1466-1470.

Legesse, G. 2008. Productive and Economic Performance of Small Ruminants in Two Production systems in the highlands of Ethiopia. PhD thesis, Gottingen. Light, J.E., Silvia, W.J. and Reid, R.C. 1994. Luteolytic effect of prostaglandin-f2-alpha and 2 metabolites in ewes. *Journal of Animal Science,* 2718–2721.

López-Gatius, F., Santolaria, P., Yániz, J., Rutllant, J. & López-Béjar, M. (2002). Factors affecting pregnancy loss from gestation day 38 to 90 in lactating dairy cows from a single herd. *Anim. Reprod*. Sci., 57, 1251–1261.

Maqhashu, A., Mphaphathi, M. L., Seshoka, M. M., Ramukhithi, F. V., Seolwana, F. L., Masenya, M. B., Netshirovha, T. R., Mapeka, M. H., Nengovhela, N. B., Kanuya, N. L., Muchenje & V., Nedambale, T. L. 2016. Comparison of oestrous synchronization response and pregnancy rate of village cows following timed artificial insemination in kwazulu-Natal and Limpopo Provinces. *Open Journal of Animal Sciences*, 6, 9-15.

Mani, A.U., McKelvey, W.A.C. & Watson, E.D. (1992). The effects of low level of feeding on response to synchronization of estrus, ovulation rate and embryo loss in goats. *Theriogenology,* 38*,* 1013-1022.

Mat, K.B., Panadi, M.B., Victor, S.S., Rusli, N.D., Hasnita, C.H. & Fuad, I.S.A. (2015). Preliminary Study on Influence of Parity and Body Condition Score (BCS) on Estrus Response and Conception Rate of Saanen-Cross by Estrus Synchronization with CIDR. *Advances in Environmental Biology*, 9, 307-316.

Nugent, R. A., Notter D. R. & Beal, W. E. (1988). Effects of ewe breed and ram exposure on estrous behavior in May and June. *J Anim Sci.,* 66, 1363-70.

Omontese, B.O., Rekwot, P.I., Ate, I.U., Ayo, J.O., Kawu, M.U., Rwuaan, J.S., Nwannenna, A.I., Mustapha, R.A. & Bello, A.A. (2016). An update on oestrus synchronisation of goats in Nigeria. *Asian Pacific Journal of Reproduction*, 5, 96–101.

Rhind, S.M., McMillen, S., McKelvey, W.A.C., Rodriguezherrejon, F.F. & McNeilly, A.S. (1989). Effect of the body condition of ewes on the secretion of LH and FSH and the pituitary response to gonadotrophin-releasing hormone. *Journal of Endocrinology*, 120, 497-502.

Santolaria, P., Palacin, I. and Yániz, J. 2011. Management Factors Affecting Fertility in Sheep. In: Artificial Insemination in farm animals. http://www.intechopen.com/books/artificial-insemination-in-farm-animals/management-factors-affectingfertility-in-sheep .

Setiadi, B., Subandriyo, L.C. & Iniguez (1995). Reproductive performance of small ruminants in an outreach pilot project in West Java. *Jurnal Ilmu Ternak dan Vcteriner* 1, 73–80.

Srinivas, G. (2013). Conception Rates in Estrus Synchronized Deccani Ewes Inseminated with Fresh and Preserved Semen. Thesis, Master of Vet. Sci., Sri Venkateswara Veterinary University.

Tegegne, A., Estifanos, A., Tera, T. & Hoekstra, D. (2012). Technological options and approaches to improve smallholder access to desirable animal genetic material for dairy development: IPMS Experience with hormonal oestrus synchronization and mass insemination in Ethiopia. Paper presented at the conference on Resilience of agricultural systems against crises, Tropentag, 19–21September 2012, Göttingen.

Ungerfeld, R. & Sanchez-Davila, F. (2012). Oestrus synchronization in postpartum autumn-lambing ewes: effect of postpartum time, parity, and early weaning. *Spanish Journal of Agricultural Research*, 10, 62-68.

Véliz, F. G., Poindron, P., Malpaux, B. & Delgadillo, J. A. (2006). Positive correlation between the body weight of anestrous goats and their response to the male effect with sexually active bucks. *Reprod Nutr Dev.*, 46, 657-61.

Véliz, F.G., Meza-Herrera, C.A., De Santiago-Miramontes, M.A. , Arellano-Rodriguez, G., Leyva, C., Rivas-Muñoz, R. & Mellado, M. (2009). Effect of parity and progesterone priming on induction of reproductive function in Saanen goats by buck exposure. *Livestock Science,* 125, 261–265.

Zeleke, M. (2009). Effect of time of Pregnant Mare Serum Gonadotrophin Administration on Oestrus Synchronization Efficiency and Fertility in Blackhead Ogaden Ewes. *Ethiopian Journal of Animal Production,* 9, 135–145

Zeleke, M., Habtemariam, A., Tegegne, A. & Muluneh, D. (2016). Estrus response and fertility of Menz and crossbred ewes to single prostaglandin injection protocol. *Tropical Animal Health and Production,* 48, 53-7.

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Ethiopian Journal of Animal Production

An Official Journal of the Ethiopian Society of Animal Production (ESAP)

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Cover page by Wossene Abay

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Effect of Replacing Wheat Bran with Air Dried *Moringa stenopetala* Pod on Nutrient Intake, Digestibility and Growth Performances of Yearling Sheep

Aberra Melesse[#], Fassil Nigatu, Ajebu Nurfeta

School of Animal and Range Sciences, Hawassa University, Ethiopia
#Corresponding author: P.O. Box 05, Hawassa, Ethiopia. Fax: + 251-462-205421; Email: a_melesse@uni-hohenheim.de; a_melesse@yahoo.com

Abstract

A study was conducted to assess the effect of a partial substitution of wheat bran with air-dried Moringa stenopetala pod meal (MSPM) on nutrient intake, digestibility, growth performance and nitrogen utilization. Twenty-four yearling sheep with initial average body weight of 14.1±0.78 kg were divided into four groups of six animals and randomly allocated to dietary treatments. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) by partially substituting the wheat bran in the control diet The feeding experiment was conducted for 70 days followed by 10 days of digestibility trial. The dry matter (DM) intakes of sheep fed T1 and T2 was higher (p<0.05) than that of T3. Sheep reared in T4 diet had higher (p<0.001) crude protein (CP) intake than those fed with the other treatment diets. The neutral detergent fiber (NDF) intake of sheep fed with T4 diet was higher (p<0.05) than those of the control diet (T1) but did not vary with those fed T2 and T3 diets. The DM and organic matter digestibility was higher (p<0.05) in sheep fed with T4 diet than those of T3. The CP digestibility for T3 and T4 diets was higher (p<0.05) than those fed T1 and T2 diets. The NDF digestibility was higher (p<0.05) for sheep fed with T2 and T4 diets than those of T1. The average daily gain was higher (p<0.05) in sheep reared on T1 and T2 diets than those fed T4 diet. The average daily fain did not differ (p>0.05) among T1, T2 and T3 diets. Feed conversion ratio (FCR, g DM/g weight gain) was higher (p<0.05) in sheep fed with T4 than those of T1 and T2 diets. The FCR was similar (p>0.05) between T1, T2 and T3 diets. Nitrogen retention was higher (p<0.05) in sheep fed with T1 and T3 diets than the other treatment diets. Sheep reared in T2 diet had better nitrogen retention compared with T4 diet. In conclusion, M. stenopetala pod can substitute wheat bran (up to 15%) without affecting the voluntary feed intake and growth performances of yearling sheep.

Key words: *body weight; digestibility; feed intake; Moringa pod; nitrogen retention*

Introduction

Livestock production is an integral part of Ethiopian agricultural system under heterogeneous agro-ecologies. The sub-sector contributes about 12-16% to the total GDP and 30-35% of total agricultural GDP, and 60-70% livelihoods of the Ethiopia population. Ethiopia's sheep population is about 29.0 million, out of which 22.8 % heads of sheep are under small farmers or landless livestock farmers (CSA, 2015). Sheep production contributes to subsistence and cash income generation for smallholder farmers. Sheep contribute substantially to food (meat supply), hides, wool and manure production. They serve as part of the crop failure risk coping portfolio, and investment as well as many other cultural functions (Markos, 2006).

Sheep production is a function of nutrition, health, genetics, climate and management among which nutrition plays an important role. Inadequate nutrition is the major constraint, for the low productivity of sheep. Sheep production relies on crop residues and natural pasture, which are usually deficient in nitrogen and limit animal performance. Thus, supplementation of low-quality roughages with conventional by-products is required for reasonable levels of animal performance. Farmers traditionally use conventional supplements like noug seed cakes, wheat bran and maize grains to improve the nutritive value of fibrous basal feeds. However, the use of such supplements is usually limited under smallholder livestock production systems due to their limited supply and high cost. Thus, evaluation of potentially useful unconventional feed resources is important in order to increase the resource base for livestock production. In this regard, parts of multipurpose trees have been considered as alternative feed sources during the dry season. Substitution of conventional ingredients by multipurpose tree parts such as leaves as suitable feeds for livestock has been reported (Aberra et al., 2011; 2013; Etana et al., 2011). One of such feed is *Moringa stenopetala*.

Moringa stenopetala is widely cultivated in southern Ethiopia and the leaf parts have been used for human consumption while pods are not; rather they are dried on the tree and became unpalatable to animals by the time they dropped from the tree to the ground (personal observations). Different studies have been shown the importance of *M. stenopetala* leaves in the diets of poultry (Aberra et al., 2011, 2013), sheep (Feleke et al., 2011) and goats (Kholif et al., 2015). However, the leaves of Moringa are also used for human consumption as well as for making tea and medicinal drugs for commercial purposes. Thus, it has been increasingly commercialized and become expensive in the recent times making difficult for smallholder farmers to use it for livestock feeding.

On the other hand, *M. stenopetala* pods are mainly available during most parts of the year and could be used as a good source of feed mainly during the dry season as a protein and energy supplement to low-quality roughages. Recent studies have indicated that the pod part of *M. stenopetala* contained crude protein ranging from 15.4 to 18.5%, which is comparable to that of wheat bran that has been commonly used as livestock feed in Ethiopia (Aberra et al., 2012). It has been further reported that the pods contained reasonable amounts of essential amino acids particularly those limiting amino acids such as lysine, methionine and cystein (Aberra et al., 2012). The same authors also reported that the pod contains 6.8 MJ/kg DM of Metabolizable energy.

However, the potential of the Moringa tree pod for future development and its role as suitable livestock feed resource in general and that of sheep in particular has not yet been investigated. Moreover, wheat bran is costly and thus most smallholder farmers cannot afford it. This study was thus initiated to study the effect of substituting wheat bran with air-dried *Moringa stenopetala* pods on nutrient intake, feed digestibility and growth performances of local sheep fed a basal diet of natural grass hay.

Materials and Methods

Experimental site

The experiment was carried out at Animal Farm of School of Animal and Range Sciences, Hawassa University (Ethiopia), which lies geographically between 7° 5′ N latitude and 38° 29′ E longitude at an elevation of 1700 m above sea level. The average annual rainfall ranges from 800 mm to 1100. The mean minimum and maximum temperatures in the area are 13.5 °C and 27.6 °C, respectively.

Preparation of experimental rations

The fresh green pods bearing seeds of *M. stenopetala* were harvested from available trees regardless of tree age. The green pods were collected at their early maturity and had deep green color when they were collected. The green pods were then chopped by using mortar and pestle (local material) and spread on a plastic sheet for drying in an area protected from direct sun light to prevent loss of vitamins and other volatile nutrients. Regular turning of the feed ingredient was done to facilitate drying and prevent growth of molds. The dried-pods were then ground using locally available materials to produce the *M. stenopetala* pod meal (hereafter referred to as MSPM). A concentrate mix was prepared with the following feed ingredients: wheat bran, maize, noug seed cake, salt and mineral lick. The ground pod was then packed in bags of 100 kg and stored until used. Before the commencement of the trial, the milled pods were mixed with the concentrate mix to prepare the experimental diets. Natural grass hay was bought from a private farm and hand chopped into the size of 3 to 5 cm and offered separately.

Experimental design and treatment diets

Twenty-four yearling local male sheep with initial average body weight of 14.1±0.78 kg were purchased and allowed to be adapted to the experimental environment for three weeks. At the end of the adaptation period, all sheep were ear tagged and blocked according to their body weights and then randomly assigned to the individual pens, which were fitted with individual feeders and watering troughs. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) by partially substituting the wheat bran in the control diet (Table 1). The feeding experiment was conducted for 70 days followed by 10 days of digestibility trial.

Management of experimental animals

About year old (age determined by dentition) male sheep were purchased from local market and transported to the experimental site. Upon arrival, the sheep were adapted to the environment for 3 weeks before the commencement of the actual experiment. During the adaptation period, the sheep were sprayed with acaricide (stalidon) and drenched with antihelminthics (Albendazole 300 mg) according to the dosage recommended by the manufacturers.

Table 1. The design of experimental diets with substitution levels of wheat bran by air-dried *Moringa stenopetala* pod

Feed ingredients	T1	T2	T3	T4
Grass hay	*Ad-libitum*	*Ad-libitum*	*Ad-libitum*	*Ad-libitum*
Wheat bran	62	46.5	34	15.5
Maize	16	16	16	16
Noug cake	20	20	20	20
Air-dried *M. stenopetala* pod	0	15.5	28	46.5
Salt	1	1	1	1
Mineral lick	1	1	1	1
Total	100	100	100	100

All the experimental sheep had *ad libitum* access to natural grass hay and clean water. The supply of natural grass was measured and adjustment was made when the refusal was less than 10% of the feed offered. Pens were cleaned on weekly basis while watering and feeding troughs were cleaned on daily basis.

Data collection procedures

Feed intake and body weight change: The sheep were weighed (prior to being offered any feed) for two consecutive days and the body weight was averaged, which was then considered as initial body weight for individual animals. Three hundred grams of the supplements as fed basis) per sheep and provided twice a day in equal portions at 8:00 a.m and 5:00 p.m. Feed intake was then determined by difference between amounts of feed offered and refused. To monitor body weight change, body weights were recorded every 14 days early in the morning before feed was offered. At the end of the experiment, all sheep were weighed individually for two consecutive days in the morning before feeding, and the average was taken as final body weight. Total body weight gain was then calculated by subtracting the initial body weight from the final. Feed conversion ratio (FCR) was calculated as a ratio of feed intake to weight gain.

Apparent digestibility trial and nitrogen balance: At the end of the growth trial, all sheep were transferred to metabolic cages. They were adapted to the cages, faecal collection bags and urine collection harnesses for three days followed by data collection for 7 days. The feeding regime was the same as in the preceding growth experiment. Details of faeces and urine sampling were according to Ajebu (2010). Faeces from each sheep were collected in faecal bags attached to the sheep every morning before feed offered and weighed. Then, 10% of the daily faecal output for the 7-day collection period was taken and bulked and stored at -20 0C. The daily total urine output of each sheep was collected in bottles containing 100 ml of 10% hydrochloric acid. Ten percent of the samples collected each day was taken and stored at -20 ^{0}C. At the end of the experiment, samples of faeces and urine were kept at room temperature and allowed to thaw for 24 h. After having the results of the chemical analysis, apparent digestibility, and N retention was determined using the following formula:

$$\text{Apparent digestibility} = \frac{\text{nutrient consumed} - \text{nutrient excreted in faeces}}{\text{Nutrient consumed}} \times 100$$

N-retention = N in feed consumed – (N excreted in faeces + N excreted in urine)

Chemical analysis

Dry matter (DM) content of the feed was determined by drying the samples at 105°C overnight. Faecal samples for chemical analysis were oven dried at 60°C for 48 h and milled using cross-beater mill (Thomas Wiley, Philadelphia, PA, USA) to pass through 1-mm sieve and stored in plastic bags for later chemical analysis. Ash was determined by combusting the samples at 550°C for 5 h. The organic matter (OM) content was computed as 100 - ash. Total nitrogen content of the feed, faeces and urine samples was determined using micro-Kjeldahl method. The crude protein (CP) was then calculated as nitrogen × 6.25. The acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents were analyzed using the method of Van Soest et al. (1991) in an ANKOM® 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA). All samples were analyzed in duplicates at Animal Nutrition Laboratory of Animal and Range Sciences, Hawassa University.

Statistical analysis

Data on nutrient intakes, nutrient digestibility, body weight, and nitrogen retention were subjected to one-way ANOVA using the GLM procedures of SAS (SAS, 2012, ver. 9.4) by fitting treatment diet as a single fixed factor. Mean comparisons were conducted using Tukey's Studentized Range Test and values were considered significant at $p<0.05$. The following linear model summarizes the statistics used to analyze the data:

$Y_{ij} = \mu + A_i + D_j/A_i + e_{ij}$

where: Y_{ij} = individual values of the dependent variables (feed intake, body weight, etc.); μ = overall mean of the response variable; A_i = the fixed effect of the i^{th} treatment diet (i = 1, 2, 3 and 4) on the dependant variables; Dj/Ai = the effect of the j^{th} animals (j =1, 2, 3, 4, 5, 6) within i^{th} treatment diets; e_{ij} = random variation in the response of individual animals.

Results

Chemical composition of feed ingredients and treatment diets

The chemical composition of the feeds used in this study (Table 2) shows that natural grass hay had low CP but high NDF and ADF contents. The MSPM had higher CP and lower NDF and ADF contents than wheat bran. The CP content was similar across the treatment diets. The DM content was similar for most feed ingredients.

Table 2. Chemical composition of feed ingredients used in the experimental diets (g/kg DM)

Feed ingredients	DM (g/kg feed)	CP	NDF	ADF	Ash
Maize (white)	961	86.4	241	205	35.2
Noug seed cake	961	303	345	215	116
Wheat bran	972	146	425	253	96.2
Air-dried Moringa pod	973	160	323	215	55.5
Natural grass hay	944	28.5	661	337	96.2

Dry matter and nutrient intake

The DM intake was significantly higher in sheep fed with T1 and T2 diets than those of T3 (Table 3). Sheep fed with T2 diet had also higher OM intake than those of T3. On the other hand, sheep reared in T4 diet had higher ($p<0.001$) CP intake than those fed on the other treatment diets. The lowest CP intake was observed in sheep fed with the T2 diet being significantly different from the rest of the treatments. The NDF intake in sheep fed with T4 diet did not vary from those fed T2 and T3 diets but was higher ($p<0.05$) than those reared in the control diet. On the contrary, the ADF intake was lowest in sheep fed with the T4 diet and differed ($p<0.01$) from the other treatments.

Table 3. Dry matter and nutrients intake (g/d) of sheep fed with air-dried *Moringa stenopetala* pod by partial substitution wheat bran

Intake	Treatments				SEM	P-value
	T1	T2	T3	T4		
Dry matter	566^{a}	575^{a}	522^{b}	552^{ab}	10.6	0.011
Organic matter	496^{ab}	525^{a}	487^{b}	515^{ab}	9.38	0.04
Crude protein	54.7^{b}	51.4^{c}	54.4^{b}	57.1^{a}	0.44	<0.001
Neutral detergent fiber	190^{b}	206^{ab}	207^{ab}	216^{a}	6.62	0.05
Acid detergent fiber	133^{a}	132^{a}	135^{a}	103^{b}	4.68	0.002

^{a,b} Row means between treatment diets with different superscript letters are significantly different at $p<0.05$. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran. SEM = standard error of mean

Apparent digestibility

The DM and OM digestibility coefficients were higher ($p<0.05$) in sheep fed with T4 diet than those of T3 (Table 4). No significant differences were observed in DM and OM digestibility coefficients between T1, T2 and T3. The CP digestibility coefficient was similar for sheep fed with T3 and T4 diets but was higher (P<0.05) than those of T1 and T2. The NDF digestibility coefficient was higher (p<0.05) for sheep fed with T2 and T4 diets than those of T1. No significant differences were observed in ADF digestibility among sheep fed with different levels of treatments diets.

Table 4. Apparent digestibility coefficients of sheep fed with different levels of air-dried Moringa *stenopetala* pod as partial replacement of wheat bran

Digestibility	Treatments				SEM	P-value
	T1	T2	T3	T4		
Dry matter	76.1^{ab}	73.6^{ab}	72.3^{b}	81.2^{a}	1.91	0.019
Organic matter	77.5^{ab}	76.3^{ab}	75.6^{b}	82.3^{a}	1.67	0.025
Crude protein	78.8^{b}	74.2^{b}	86.6^{a}	84.8^{a}	0.87	<0.001
Neutral detergent fiber	51.0^{b}	63.7^{a}	59.4^{ab}	65.7^{a}	2.52	0.025
Acid detergent fiber	61.8	66.6	59.5	62.7	2.37	0.286

^{a,b} Row means between treatment diets with different superscript letters are significant at p<0.05. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran
SEM = standard error of mean.

Body weight and feed conversion ratio

The average body weight gain was significantly (p<0.05) higher in sheep fed with T1 and T2 diets than those of T4 (Table 5). Average daily body weight gain of sheep fed with T1, T2 and T3 diets did not vary significantly. Feed conversion ratio was higher (p<0.05) for those sheep fed with T4 diet than those of T1 and T2 diets. No significant difference was noted in feed conversion values between T1, T2 and T3 diets.

Table 5. Body weight, weight gain and feed conversion ratio of sheep fed with air-dried *Moringa stenopetala* pod as a partial replacement of wheat bran

Parameters	Treatments				SEM	P
	T1	T2	T3	T4		
Initial weight (kg)	13.1	13.3	13.0	13.1	0.384	0.918
Final weight (kg)	17.9	18.1	17.4	16.8	0.374	0.087
Total weight gain (kg)	4.80^{a}	4.79^{a}	3.97^{ab}	3.67^{b}	0.269	0.013
Average daily gain (g)	60.0^{a}	59.9^{a}	49.7^{ab}	45.9^{b}	3.365	0.013
Daily DM intake (g)	566^{a}	575^{a}	522^{b}	552^{ab}	10.63	0.011
FCR (g DM/g gain)	9.53^{b}	9.71^{b}	10.8^{ab}	12.3^{a}	0.648	0.023

^{a,b} Row means between treatment diets with different superscript letters are significant at p<0.05. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran.
SEM = standard error of mean; FCR = feed conversion ratio

Nitrogen utilization

The nitrogen utilization values of sheep fed with diets containing different levels of *Moringa stenopetala* pod are presented in Table 6. The highest nitrogen intake was noted in those sheep fed with T1 and T3 diets which differed significantly (P<0.05) from those fed with other treatment diets. The amount of fecal nitrogen excreted in sheep fed with T2 diet was higher (P<0.05) than those fed T3 and T4 diets. Sheep fed with T1 and T3 diets had similar fecal nitrogen loss but were significantly higher than those of T4. Urinary nitrogen values were similar among those sheep fed with T3 and T4 diets but were higher (P<0.05) than those of T1 and T2 diets which showed similar values in these parameters. Nitrogen retention values in sheep fed with T1 and T3 diets were higher (p<0.05) than the other treatment diets. Similarly, sheep fed with T2 diet had better nitrogen retention than those of T4.

Table 6. Nitrogen utilization of sheep fed with different levels of *Moringa stenopetala* pod meal as a partial substitution of wheat bran

Parameters	Treatment				SEM	P-value
	T1	T2	T3	T4		
N intake (g/head/d)	8.75^{a}	8.21^{b}	8.70^{a}	4.13^{c}	0.059	<0.001
N excretion (g/head/d)						
Faeces	1.85^{ab}	2.13^{a}	1.79^{b}	0.38^{c}	0.083	<0.001
Urine	0.80^{b}	0.91^{b}	1.09^{a}	1.13^{a}	0.039	<0.001
N retained (g/head/d)	6.11^{a}	5.18^{b}	5.83^{a}	2.63^{c}	0.109	<0.001

[a,b,c] Row means between treatment diets with different superscript letters are significant at p<0.05. The treatment diets contained the control diet (T1) without MSPM, and diets containing MSPM at the level of 15.5% (T2), 28% (T3) and 46.5% (T4) as a partial substitute to wheat bran; SEM = standard error of the mean

Discussion

Chemical composition

The present findings have proved that natural grass hay that is commonly used as basal roughage cannot support the maintenance requirement of animals due to the high fiber and low crude protein content. Moreover, the CP content below the minimum microbial requirement (70 g CP/kg DM) cannot support microbial activity and the maintenance requirement of animals (McDonald et al., 2002). The CP content of the natural grass hay in this study (2.85%) is lower than those reported by Aberra et al. (2016) and Berhanu et al. (2014). These variations might be due to differences in location, soil type, post harvest handling, leaf to stem ratio and maturity stage of the forage itself at the harvest.

The CP content of *M. stenopetala* pods in the current study was slightly higher than those reported by Aberra et al. (2012) for mid elevation (154 g/kg DM) but was lower than the value reported for low elevation (184 g/kg DM). Etana and Adugna (2013) reported 191 g/kg DM CP that is higher than the result in the current study. These variations could be associated with the elevation where the samples were collected, soil type as well as the stage of maturity of the plant material.

The NDF and ADF values for *M. stenopetala* pod in the current study were lower than those reported by Aberra et al. (2012) and Etana and Adugna (2013). According to Van Soest (1991) the critical ranges of NDF supply to ruminants are 600–650 g/kg DM above which feed intake will be affected. Multipurpose tree parts like *M. stenopetala* pod maintain the initial high level of crude protein for long periods before the protein content drops below the maintenance requirement of animals, with advance in plant maturity (Etana and Adugna, 2013).

Dry matter and nutrient intakes

The chemical composition of feed ingredients supports the variation in feed intake of treatment diets. The *M. stenopetala* pod meal maintained the increased intake of basal and total feed DM at increased levels of inclusion, which may suggest that air-dried pods did not reduce the general intakes of animals. Zemmelink and t'Mannetje (2002) reported that increasing the level of feed offers resulted in higher DM and nutrient intakes by reducing the feed refusal, which may suggest the palpability of the offered feed material. In contrast, Koech et al. (2010) reported increased levels of basal feed refusals at higher levels of supplementation of *Prosopis juliflora* seedpod meal to goats, which might be due to the substitution effect on basal feed DM at increased levels of supplementation (Umunna et al., 1995). Moreover, the negative effect of condensed tannins and soluble phenolics contained in *Prosopis juliflora* pods (Aberra et al., 2017) might have imposed limitations on CP intake, by forming protein-tannins complex and rendering it indigestible.

Increasing levels of MSPM substitution for wheat bran did not have undesirable effect on basal feed DM intake. This suggests that the less likelihood of fast degrading supplements to substitute the basal feed DM, which was in good agreement with the observation of Nsahlai et al. (1998) and Patra (2009). The CP intake was also increased similar to the trends of DM intake, which is in good agreement with the reports of Tegene et al. (2000).

Apparent digestibility of nutrients

The digestibility of feed nutrients influences the speed with which the feed passes through the digestive system. Generally, feedstuffs with higher digestibility will be processed more rapidly, allowing animals to eat more and have higher production. The nutrient composition of the basal feed and supplement consumed together affects digestibility (McDonald et al., 2002). In the current study, sheep fed with high levels of substitution of wheat bran (46.5%) with air-dried pods of *M. stenopetala* had higher DM and OM digestibility coefficients than at 28% level of substitution. The variations in DM and CP digestibility coefficients might be due to the supplementation level (only partial replacement of the control diet). However, the nutrients supplied by the different combination of supplements used in this study were sufficient to make more or less similar effect on the digestibility of DM and nutrients.

The higher CP digestibility of sheep fed with T4 diet compared with that of T1 and T2 could be due to high CP intake of T4 supplied by Moringa pods. The results are consistent with the findings of Feleke et al. (2011), Dougnon et al., (2012) and Khalel et al. (2014) who reported positive effects of *M. stenopetala* and *M. olifera* leaves on the performance of sheep, rabbits, and lactating cows, respectively. The present results are also in good agreement with those reported by Newton et al. (2010), Mendieta-Araica et al. (2011) and Nouman et al. (2014) who suggested that *Moringa* tree parts are rich in most nutrients and thus it can serve as useful source of supplementation to low quality diets so as to increase the nutrients digestibility.

The current results further showed that there is a higher NDF digestibility coefficient as the level of *M. stenopetala* pod meal increased and the results are consistent with Etana and Adugna (2013) and Aberra et al. (2013) who reported higher fermentation characteristics of pods of *M. stenopetala* suggesting improved digestibility and availability of nutrients to ruminant animals. Moreover, Makkar and Becker (1996) reported that about 95% of *Moringa* CP was found to be available either in the rumen or in the post rumen. Kleinschmit et al. (2007) reported the bypass protein that resists degradation in the rumen, which then passes to the lower tract for digestion, is necessary for maximizing production of ruminant animals. It could be thus speculated that an increase in CP content of treatments (as the inclusion level of *M. stenopetala* pod increased) might be beneficial due to the action of fermenting microorganisms in the synthesis of some amino acids. Therefore, increased CP digestibility and CP intake could be the result of improved quality of protein, which is the result of amino acid profiles, physical and chemical characteristics and microbial proliferation initiated by *M. stenopetala* pod inclusion in the diet.

Body weight and feed conversion ratio

In the current study, sheep fed with all treatment diets had a positive weight gain, which indicates the nutritive value of the *M. stenopetala* pod as a potential source of protein and energy. The average daily body weight gains in the current study were higher than those reported by Lemma (1993) for lambs fed with *Leucaena* by substituting Noug seed cake but were lower than those of Feleke et al. (2011) for sheep supplemented with *M. stenopetala* leaves.

The weight gains of the sheep reared in T1, T2 and T3 diets was similar (with increasing levels of *M. stenopetala* pod), which might be associated with higher digestibility coefficients of CP. This observation is consistent with the findings of Nouman et al. (2014) and Adegun and Aye (2013) on West African Dwarf Rams fed *Moringa oleifera* and cotton seed cake.

Animals that convert at a high rate (lower FCR, g DMI / g gain) are more preferred to those with lower ratio as they optimize performance and are economically valuable in environments that have low quality and quantity of feed resources. Feed conversion ratio (g DMI/ g gain) in the current study has increased as the level of *M. stenopetala* pod meal increased. However, the FCR in those sheep fed with T1, T2, and T3 diets had similar values and did not vary significantly from each other. This might be due to the contribution of *M. stenopetala* pod fermentation quality brought into the rumen in the form of available cellulose and hemicelluloses which stimulate fiber digestion and hence nutrient released for growth (Etana and Adugna, 2013).

Nitrogen utilization

All the treatment groups fed with *M. stenopetala* pods have shown a positive nitrogen balance, which suggests that the supply of energy and nitrogen were higher than the maintenance requirement. The results are consistent with the findings of Ajebu (2010), Mendieta-Aracia et al. (2011) and Nouman et al. (2014) who reported improved growth performance as a result of better nitrogen balance in sheep fed with basal diet of wheat straw supplemented with local agricultural by-products and *Moringa* leaves. On the other hand, contradictory results were reported in sheep fed *with Prosopis juliflora* pods and *Cenchrus* grass (Chaturvedi and Sahoo, 2013). In the current study, the urine nitrogen increased with increased levels of *M. stenopetala* pod substitution, which is consistent with the reports of Clark et al. (1992). The positive balance shows the nitrogen (N) availability for microbial protein synthesis and that the captured N from the treatment diets. Moreover, the amount of N excreted with the faeces decreased as the level of pods increased suggesting efficient utilization of the protein in pods. However, the amount of nitrogen retained did not show a consistent trend among treatment diets and was higher only in sheep fed with T3 and T1 diets, which differed with those of T2 and T3. Nitrogen retention for a specific ration might be affected by factors such as increasing presence of fermentable energy, available fermentable energy, and variation in rumen undegradeble nitrogen (Holzer et al., 1986). Moreover optimizing factors for nitrogen retention enhances utilization of ammonia in the rumen and reduces the effect of free fats in protein synthesis (Hagemeister et al., 1981).

Conclusion

The findings of the present study indicated that *M. stenopetala* pod could substitute wheat bran by serving as protein and energy sources without affecting the voluntary feed intake and growth performances of local sheep. *M. stenopetala* pod can thus partially replace wheat bran in the concentrate mixture up to 15% in sheep feeding for improved performances. Smallholder farmers in Moringa growing regions can substitute conventional concentrate supplements by *M. stenopetala* pod due to its year round availability and easy access.

Acknowledgements

This research project was supported by the research fund granted by the Hawssa University of the Vice President for Research and Research and Technology Transfer Office for which the authors are highly grateful. The support received from Mr. Tadesse Bekore in analyzing the feed composition is highly acknowledged.

Refences

Aberra Melesse, Steingass H., Boguhn J., Schollenberger M., Rodehutscord M., 2012. Effects of elevation and season on nutrient composition of leaves and dry green pods of *Moringa stenopetala and Moringa oleifera*. Agroforestry Systems 86(3): 505-518.

Aberra Melesse, Yoseph Getye, Kefyalew Berihun, Banerjee S., 2013. Effect of feeding graded levels of Moringa stenopetala leaf meal on growth performance, carcass traits, and some serum biochemical parameters of Koekoek chickens. Livestock Science 157: 498-505.

Aberra Melesse, Banerjee S., Degnet H/Meskel, Aster Abebe, Amsalu Sisay, 2016. Carcass and meat quality characteristics of Arsi-Bale goats supplemented with different levels of air-dried *Moringa stenopetala* leaf. Journal of Agriculture and Rural Development in the Tropics and Subtropics 117: 233-242.

Aberra Melesse, Steingass H., Schollenberger M., Holstein J., Rodehutscord M., 2017. Nutrient compositions and *in vitro* methane production profiles of leaves and whole pods of twelve tropical multipurpose tree species cultivated in Ethiopia. Agroforestry Systems 71 (3): DOI: 10.1007/s10457-017-0110-9.

Adegun M.K, Aye P.A., 2013. Growth performance and economic analysis of West African Dwarf Rams fed *Moringa oleifera* and cotton seed cake as protein supplements to *Panicum maximum*. American Journal of Food and Nutrition 3(2): 58-63.

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.

Berhanu Alemu, Getachew Animut, Adugna Tolera, 2014. Effect of *Millettia ferruginea* (Birbra) foliage supplementation on feed intake, digestibility, body weight change and carcass characteristics of Washera sheep fed natural pasture grass hay basal diet. SpringerPlus 3: 50. doi: 10.1186/2193-1801-3-50.

Chaturvedi O.H., Sahoo A., 2013. Nutrient utilization and rumen metabolism in sheep fed *Prosopis juliflora* pods and Cenchrus grass. SpringerPlus. 2: 598. doi: 10.1186/2193-1801-2-598.

Clark J.H., Klusmeyer T.H., Cameron M.R., 1992. Microbial protein synthesis and flows of nitrogen fractions to the duodenum of dairy cows. Journal of Dairy Science 75: 2304-2323.

CSA (Centeral Statistical Agency). 2015. Agricultural Sample Survey: Volume II Report On Livestocks And Livestock Characteristics(Private Peasant Hioldings). Sample Survey, CSA:Centeral Statistical Agency, Addis Ababa.

Dougnon T.J, Aboh B.A., Kpodékon T.M., Honvou S., Youssao I., 2012. Effects of substitution of pellet of *Moringa oleifera* to commercial feed on rabbit's digestion, growth performance and carcass trait. Journal of Applied Pharmaceutical Science 2(9): 15-19.

Etana Debela, Adugna Tolera, 2013. Nutritive value of botanical fractions of *Moringa oleifera* and *Moringa stenopetala* grown in the mid-Rift Valley of southern Ethiopia. Agroforestry Systems 87(5): 1147-1155.

Feleke Gebregiorgis, Tegene Negesse, Ajebu Nurfeta, 2011. Feed intake and utilization in sheep fed graded levels of *Moringa stenopetala* leaf as a supplement to Rhodes grass hay. Tropical Animal Health and Production 44 (3): 511-517.

Hagemeister H., lupping W., Kaufmann W., 1981. Microbial synthesis and digestion in high yielding dairy cow. In Developments in Ruminant Nutrition," Eds. Haresign, Cole, D.J.A., Pages 31-48.

Holzer Z., Levy D., Samuel V., Bruckenthal I., 1986. Interactions between supplementary nitrogen source and ration energy density on performance and nitrogen utilization in growing and fattening male cattle. Animal Production 42: 19-28.

Khalel, M.S., Shwerab, A.M., Hassan, A.A., Yacout, M.H., El-Badawi, A.Y., Zaki, M.S., 2014. Nutritional evaluation of *Moringa oleifera* fodder in comparison with *Trifolium alexandrinum* (berseem) and impact of feeding on lactation performance of cows. Life Science Journal 11: 1040-1054.

Kholif A.E., Gouda G.A., Morsy T.A., Salem A.Z.M., Lopez S., Kholif A.M., 2015. *Moringa oleifera* leaf meal as a protein source in lactating goat's diets: Feed intake, digestibility, ruminal fermentation, milk yield and composition, and its fatty acids profile. Small Ruminant Research 129: 129-137.

Kleinschmit D.H., Anderson J.L., Schingoethe D.J., Kalscheur K.F., Hippen A.R., 2007. Ruminal and intestinal degradability of distillers grains plus soluble varies by source. Journal of Dairy Science 90: 2909-2918.

Koech O.K., Kinuthia R.N., Wahome R.G., Choge S.K., 2010. Effects of Prosopis juliflora Seedpod Meal Supplement on Weight Gain of Weaner Galla Goats in Kenya. Research Journal of Animal Sciences 4: 58-62.

Lemma Gizachew, 1991. Comparison of legume hay, urea and noug cake as protein supplements for sheep fed teff straw. pp. 211- 215. In: Proceedings of the Fourth. National Livestock Improvement Conference. 13-15 November, 1991. IAR, Addis Ababa, Ethiopia.

Makkar H.P.S., Becker K., 1996. Nutritional value and anti-nutritional components of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Science and Technology 63: 211-228.

Markos Tibbo, 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Ph D. Thesis. Swedish Univ. Uppsala, Sweden.

McDonald P., Edwards R.A., Greenhalgh J.F.D., Morgan C.A. ,2002. Animal nutrition; 6th edn. Harlow: Prentice Hall.

Mendieta-Araica B., Spörndly R., Reyes-Sánchez N., Spörndly E., 2011. *Moringa oleifera* leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. Livestock Science 137(1): 10-17.

Newton K.A., Bennett R.N., Curto R.B., Rosa E.A., Turc V.L., Giuffrida A., Curto A.L., Crea F., Timpo G.M., 2010. Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. Food Chemistry Journal 122: 1047-1064.

Nouman W., Basra S.M., Siddiqui M.T., Yasmeen A., Gull T., Alcayde M.A., 2014. Potential of *Moringa oleifera* L. as livestock fodder crop: a review. Turkish Journal of Agriculture and Forestry 38: 1-14.

Nsahlai I.V., Umunna N.N., 1996. Sesbania and lablab supplementation of oat hay basal diet fed to sheep with or without maize grain. Animal Feed Science and Technology 61(1): 275-289.

Patra A.K., 2009. Responses of intake, digestibility and nitrogen utilisation in goats fed low-quality roughages supplemented with tree foliages. Journal of the Science of Food and Agriculture 89(9): 1462-1472.

Tegene N., Rodehutscord M., Pfeffer, E. 2000. The effect of dietary crude protein level on intake, growth, protein retention and utilization of growing male Saanen kids. Small Ruminant Research 39: 243-251.

Umunna N.N., Osuji P.O., Nsahlai I.V., Khalili H., Mohamed-Saleem M.A., 1995. Effect of supplementing oat hay with *lablab, sesbania, tagasaste* or wheat middlings on voluntary intake, N utilization and weight gain of Ethiopian Menz sheep. Small Ruminant Research 18(2): 113-120.

Van Soest, P.J., Robertson J.B., Lewis B.A., 1991. Methods for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74: 3583-3597.

Zemmelink G.,'t Mannetje L., 2002. Value for animal production (VAP): a new criterion for tropical forage evaluation. Animal Feed Science and Technology 96: 31-42.

Fortified and Powdered Milk Supply in Ethiopia: Concerns and Prospects

Lemma Habtamu

Wolaita Sodo University, P.O. Box 138, Wolaita Sodo, Ethiopia; E-mail: lemmahab2015@gmail.com

Abstract

There have been importations of powder milk to fill milk supply-demand gap in Ethiopia. Milk powder (fortified or not) and liquid milk available in supermarkets and shops include Anchor milk, Nido milk, Coast milk, UHT processed milk, Abay full cream milk and 'Me and My' full cream milk and pasteurized milk. However, prospects and gaps for research, development and policy on fortified milk and other milk powder remain uninvestigated and little information is available for designing strategies for sustainable supply of milk and milk products in Ethiopian/African context. This hindered consumers' informed choices and further intervention in the dairy food industry, which calls for knowledge and experiences from elsewhere. Thus, this paper summarizes the available information on various aspects of dairy products, including pasteurized milk, fortified milk and other powdered milk products through an extensive review of several published articles and gray literature. The imported milk powder is costly and is out of reach of middle and low income people, who are most affected by malnutrition. In addition, there is limited foreign currency and also safety concerns. Therefore, increasing domestic milk supply is crucial to reduce dairy imports. This in turn requires building the capacity of smallholder/medium dairy producers towards improved or good quality milk production and marketing. Moreover, little is known about milk fortification in Ethiopia, which raises issues of fortification policy/strategies, and potential impact of fortification. Research need to be initiated on milk powder, including on its microbial, compositional and adulteration and other aspects of quality and safety. Action is also required for designing and implementing dairy foods import policy and regulation.

Key words: *Milk fortification, extended shelf life products, pasteurized milk, powdered milk, sustainable dairy industry*

Introduction

Milk and milk products play important role to enhance nutrition and livelihood security. According to OECD/FAO, 2016, whole milk and skimmed milk powder will remain the most traded agricultural commodities. Asia will remain the main market for dairy products, accounting for 55 percent of world imports, followed by Africa, with 15 percent. Elevated international prices are projected to reduce imports by Africa as a whole. In Brazil, rising domestic production is expected to lead imports being displaced (FAO FOOD OUTLOOK, 2013). In developing countries, the dairy sector has been negatively affected by the dumping of surplus subsidized dairy products by the EU and USA, which discourage local production (World Bank, 2006). This implies that for local dairy industries to survive, not only production but also productivity, has to increase, in order to stand competition from foreign markets. Restricting imports can only successfully control importation if favorable policies and suitable resources are allocated to the promotion of domestic production (Ndambi et al., 2007) by making use of opportunities for growth of dairy production in countries with great potential, such as China, India, and East Africa (World Bank, 2006).

Quality and safety of imported dairy products also need more caution as on the spot observation at farm is not possible. In this connection, importing countries may ban, as the case of India and Russia who banned dairy products in 2013 due to health and safety concerns (FAO FOOD OUTLOOK, 2013). In this regard, there is a growing concern of quality and safety of milk powder and other dairy products after the occurrence of melamine in the powdered milk in China (Terry, 2011). False labeling of the animal origin of milk, the use of reconstituted powdered milk, and the addition of partially hydrogenated vegetable oils are currently a matter of investigation for milk and dairy products (Tsimidou and Boskou, 2003).

Improved dairy production in Ethiopia began decades ago. There were various reports from the country concerning average daily milk yield/head in urban and peri-urban dairy production systems, where relatively more improved dairy inputs and experience exist. For instance, Azage et al. (2013) reported 10.2-15.9 kg and 9.5 kg of milk per cow per day for crossbred dairy cows in urban and peri-urban dairy production systems, respectively. Therefore, there is great potential to enhance domestic production and reduce the expensive reliance on imported milk products, which also needs close surveillance and testing for their quality. The projection by Zelalem et al., 2011 showed that Ethiopian total demand, supply and deficit of milk for the year 2018 were 6 192, 4 055 and 3 435 million liters, respectively. There are also issues of affordability of imported dairy products by low and middle income groups. Therefore, exploiting the potential will reduce foreign currency expenditure on dairy imports besides addressing sustainable domestic dairy foods supply, livelihood and a need of long-shelf life dairy products during fasting season.

In 2006, household dairy consumption in Ethiopia was 30% raw milk, 38% fermented butter, 15% pasteurized milk, 8% powder milk, and 6% ayib (cottage cheese) (Francesconi et al., 2009). It is also important to note that industrially processed dairy products made in Ethiopia are consistently cheaper than imported ones. For example, one litre of pasteurized milk produced in

Ethiopia is 40% cheaper than one litre of milk reconstituted from imported milk powder (Francesconi et al., 2009). This has also a spillover effect on the price of fluid milk paid for the dairy producers, who cover the costly concentrate feed and private veterinary service. Dairy processers are also complaining about the costly imported packing materials.

‘Initiatives’ of promotion of nutritional value addition (bio-fortification) to selected staple seeds to ensure availability and consumption of diverse nutritious food was taken in the national nutritional program (FDRE, 2013). In addition, the study by FMOH (2011) found that flour fortification with iron and folic acid, and oil fortification with vitamin A to be among the viable options to address the nutrition program. However, no milk fortification program was considered though milk is fortified in Ethiopia, recently. Moreover, there are no studies conducted on quality of fortified milk and other milk powders. Thus, there is shortage of up-to-date information on this area and gaps for further research and interventions. Therefore, there exists lack of access to scientific information and awareness about these products for consumers’ informed choices and for those involved in dairy foods industry. The challenge is to exploit relevant knowledge elsewhere and to benchmark and adopt it to the local situation with regard to current status and future prospects. Hence, this paper summarizes available knowledge on fortified milk and its powdered products through an in-depth review of literature.

Milk

Milk has been known as nature’s most complete Food. More than 100 different components have been identified in cow’s milk (Jarvis et al., 2007). Intake of cow’s milk and milk products contributes to health throughout life. Experimental studies indicate that cow’s milk protein may help to increase bone strength, enhance immune function, reduce blood pressure and risk of some cancers, and protect against dental caries (Gobbetti et al., 2007; Jarvis et al., 2007). Milk fat is also a source of energy, essential fatty acids, fat-soluble vitamins, and several health-promoting components such as conjugated linoleic acid (CLA), sphingomyelin, and butyric acid. For example, emerging scientific findings reveal that CLA may protect against certain cancers and cardiovascular disease, enhance immune function, and reduce body fatness by increasing lean body tissue. Milk and other dairy foods are important sources of many vitamins and minerals. Calcium helps to reduce the risk of osteoporosis, hypertension, some cancers, and some types of kidney stones, and may have a beneficial role in weight management (Jarvis et al., 2007).

Milk is processed into various products such as pasteurized and powdered/fortified milk and the safety of milk particularly at farm level is crucial. In this regard, livestock/dairy science professionals and veterinarians need to be forefront to be part of the solution in suggesting ways to alleviate the problems, including designing dairy intervention project, informing policy, dairy extension and other mechanisms that can support the smallholder dairy producers to ensure safe milk production.

Pasteurized milk

The objective of pasteurizing milk is to ensure the safety of fluid milk and to prolong its shelf life. Pasteurization destroys all known pathogens occasionally encountered in raw milk and most spoilage bacteria (Meunier-Goddik and Sandra, 2002). Although milk and dairy products can transmit biological and chemical hazards, there are effective control measures like pasteurization which help to minimize risk to human health. Pasteurization or equivalent processing of milk and milk products and the implementation of validated food-safety programs have been proved to ensure safe milk and dairy products (FAO, 2013).

Pasteurization is originally designed to ensure adequate destruction of common pathogenic micro-organisms (including Mycobacterium bovis, commonly responsible for tuberculosis at the time), and can extend the shelf-life (10-14 days) of milk by destroying almost all yeasts, molds and common spoilage bacteria (Jensen, 1995; Creamer et al., 2002). Pasteurization (heating to 72 °C for 15 seconds) is based on the time–temperature combinations. Vegetative cells of food-borne pathogens are sensitive to heat and are readily killed by the pasteurization process. It also inactivates most enzymes that might cause spoilage through the development of off-flavors. Hence pasteurization both ensures safety and prolongs shelf-life with minimal changes to flavor and nutritional quality of the product (Lewis, 2010; Motairjemi and Lelieveld, 2014).

In Ethiopia, there are around 32 dairy processors which collect raw milk mainly from peri-urban and urban dairy farmers and process into pasteurized dairy product. To this end, processors and other dairy stakeholders have great roles in supporting smallholder and medium farmers to improve raw milk quality at farm level besides reducing or minimizing sources of contamination in processing plants.

Powdered milk

Imports of dairy products have strongly fluctuated over the years. Over the last three recorded years, the variation was between US$ 11–15 million (Table 1) and 80% of this value comes from imported milk powder, widely used in infant formulas. Some of the imported milk powders (Fortified or not) displayed in supermarkets and shops of Addis Ababa include Anchor's milk, Nido milk, Coast milk, UHT processed milk, Abay full cream milk and Me and My full cream milk. There is no Ethiopian company processing milk powder, although some processors are planning to invest in such facilities (Zijlstra et al., 2015). If milk powder is manufactured, it could partially have addressed the concerns of high costs of importing dairy products and the requirement for long-shelf life dairy products.

Powdered milk is usually made from skim milk because having less fat helps the product resist rancidity (Encyclopedia of Foods, 2002).The approximate compositions of the major traditional milk powder products are as follows: skim milk powder (36% protein, <1% fat, 51% lactose, 8% ash water, 3–4% moisture); full-cream milk powder (26% protein, 27% fat, 38% lactose, 6% ash, moisture 3%) (Chandan, 2008). In this regard, the quality of milk products including their packaging materials being imported and the shelf life/expiry dates of the products after their imports need to be controlled or supervised. Food, Medicine, Health Care and Administration Authority is the most appropriate organization to implement these tasks.

Table 1. Ethiopian import of milk and milk products (weight and value)

Product	**2011**		**2012**		**2013**	
	Net wt. (kg)	CIF Value (US$)	Net wt. (kg)	CIFValue (US$)	Net wt. (kg)	CIF Value (US$)
Cheese	102,387	467,840	97,568	497,297	83,532	665,350
Milk, butter and yogurt	1,689,714	9,900,636	1,766,451	9,438,761	1,199,761	4,923,178
Powdered milk	450,642	2,932,581	983,178	5,792,618	810,516	5,413,487
Total	2,242,743	13,301,057	2,847,196	15,728,676	2,093,132	11,002,015

CIF=Cost, Insurance and Freight

Recently, there was occurrence of melamine contamination in Chinese milk powder. Although it has no nutritional value, because of its high nitrogen content melamine is added to watered-down milk to cover up the protein deficiency. Melamine is known to cause stones in the kidneys leading to renal problems and kidney failure in humans and animals. According to the US-FDA, melamine below 2.5 mg/kg is not of much concern. The EU has set 0.5 mg/kg as the safe limit of melamine (Nag, 2010). In August 2013, Fonterra warned that a batch of whey protein (produced in New Zealand) contained botulism. Milk powder from New Zealand was banned due to a Botulism scare (Tajitsu, 2013). China responded with a ban on imports of all Fonterra milk powder and whey protein (Sharma and Rou, 2014).The presence of residues of HCH and DDT in infant food or baby milk powder is of particular concern (Nag, 2010).

The quality of milk powders is markedly determined by the total heat treatment of the operations during processing and the techniques of particular operations, such as concentrating or drying. In addition, the storage time and temperature regime affect the quality characteristics of the powders (Caric, 2002). The properties of milk powders are categorized as physical, functional, biochemical, microbiological and sensory (Caric and Millanoric, 2002). Chemical analysis of milk powders includes control of moisture, total fat, free fat, oxidative changes, hydrolytic changes and the intensity of the Maillard reaction (Caric, 2002).

Aspects of deteriorative changes that may occur in milk powders during transport and distribution have also an impact on the sensory properties of powders and their performance as food ingredients (Kanekanian, 2014).The un-denatured whey proteins (WPNI) are used as an indication of the heat treatment given to the milk during powder manufacture. In general, the WPNI specification is used as an indication of functional properties of milk powders (Chandan, 2008). This effect is also used as an indicator for its suitability to be applied in a diverse array of recombined products (Kanekanian, 2014). Besides these parameters, moisture and fat content, solubility index, bulk density, flowability, wettability, scorched particles, rennetability, emulsification properties, titratable acidity, sensory aspects, and bacteriological requirements are also included in various milk powder specifications (Kanekanian, 2014).

The structure and physical properties of milk powders are most severely affected by the drying techniques and parameters. Low bulk density is a disadvantage to milk powder quality. However, there are modern spraying methods (eg. using a steam swept wheel) that increase the bulk density. The rate of dissolving is one of the most important characteristics (Caric, 2002). The physical properties of milk powder are determined by (a) the heat treatment of the milk and the concentrate; (b) the spray dryer atomizing equipment; (c) the dry matter content of the concentrate; (d) the handling of powder fines; and (e) the air flows and temperatures of the spray dryer (Skanderby et al., 2009).

Concentrated and dried milk products represent a diverse range of dairy products. They vary considerably in chemical composition, which is determined by the composition of the original milk as well as the various heating and dehydration processes involved in their manufacture.

There is also variation in the distribution of chemical components within products, for example between the surface and the interior of powder particles and between the colloidal and soluble phases, which affects the products' properties (Deeth and Hartanto, 2009). Chemical and enzyme changes continue to occur during storage of the concentrated and dried products, which can significantly affect their functional properties and organoleptic qualities. The most important chemical changes that occur or can occur during processing and storage are denaturation of whey proteins, coagulation of caseins, lactosylation of proteins and subsequent Maillard reactions, oxidation of milk fat and crystallization of lactose. Knowledge of the chemical components of the products, their relationship to functional properties, and the changes that can occur in these components is essential for determining the optimal production and storage conditions for these products (Deeth and Hartanto, 2009).

Deterioration of milk powders resulting from Maillard browning, lactose crystallization, and oxidation of fat may lead to flavor and physical defects in the powder. Some of the changes that may occur during storage include the development of a brown color, a reduction in pH, reduced solubility, development of off-flavors, and reduced heat stability of powders (Kanekanian, 2014). It has been suggested that seasonal problem with the heat stability of milk powders may be due to variation in the urea levels. The loss of heat stability can be rectified in some cases by addition of urea. In New Zealand, minimum levels of urea occurs in summer and maximum levels in winter, while in each season, milk from cows in mid-lactation had a lower urea content than milk from cows in early or late lactation (Chandan, 2008).

The microbial quality of milk powder is determined by the quality of the raw material, the nature and extent of processing and by the extent of post-production contamination. More specifically, the microbiological count of milk powder is influenced by both the numbers and types of microorganisms in the raw milk and the processing conditions under which the milk powder is produced. *E. sakazakii* (*Cronobacter*) is a problematic contaminant of milk powder and hence represents a significant health risk to neonates (Chenu and Cox, 2009). Milk powder may also contain large numbers of spore-forming bacilli or may be contaminated by salmonellae (Kambamanoli-Dimou, 2003). Pavic et al. (2005) reported a food poisoning outbreak involving toxigenic *B. subtilis and B. licheniformis* present in milk powder. Contamination of powdered infant formula with Salmonella spp. and *Cronobacter sakazakii* is of special concern, with contamination occurring most often in the spray driers/cracks (Soler et al., 2008; Kanekanian, 2014). Entirely, milk powder has to be tested negative for *Salmonella* spp. according to the Standards for Microbiological Safety of Food (Health Canada, 2008).

Staphylococcus aureus is significant, as certain strains can produce a heat-stable toxin that is not destroyed during powder manufacture. Although *Staphylococcus aureus* is common in raw milk, it does not normally grow to produce toxin unless the milk is stored at a high temperature prior to processing. Although the bacteria will be killed during the process, the toxin remains and can be detected only through specific tests. Large outbreaks of illness have been attributed to the presence of *Staphylococcus aureus* toxin in milk powder (Kanekanian, 2014).Within the factory, application of good manufacturing practice (GMP) including Hazard Analysis Critical Control Point (HACCP) is essential to minimize the risk of milk powder contamination with undesirable types or levels of microorganisms. To achieve this, consideration must be given to the design of the premises and control of staff or vehicular movement to separate raw materials from drying areas (Kanekanian, 2014).

The presence of aflatoxins in milk powder is also a concern. Deveci and Sezgin (2005) found that aflatoxin M1 levels in nonfat dry milk produced in Turkey ranged from 0 to 0.705 μg/kg and that the aflatoxin M1 contents were higher in the winter than in the summer. Mean levels of 0.056 μg/L of aflatoxin M1 were found in goat milk powder from Brazil (Oliveira and Ferraz, 2007). However, no samples of milk powder were found to be contaminated with aflatoxin M1 in Portugal (Martins et al., 2005). Therefore, critical monitoring and controlling aflatoxin exposure of fortified and powdered milk are needed. Pests are often a problem with nonfat dry milk. The subject of insect infestation in various animal products including milk powder and their control has been reviewed by Rajendran and Parveen (2005). These authors listed pests including several types of beetles that can breed in the presence of milk powder, and they discussed the use of phosphine for insect control in milk powder.

Table 2. Microbiological specifications for milk powder, as recommended by the International Dairy Federation (Kanekanian, 2014).

Criteria[a]	Total count (per gram)	*Salmonella* (per 25g)	Coliforms (per gram)	*Staphylococcus aureus* (per gram)
m	50000	0	10	10
M	200000	Na	100	100
n	5	15	5	5
c	2	0	1	1

[a]For a production batch, n=number of samples that must be tested, c=number of samples that may exceed the microbiological limit specified as m, and M is the maximum allowable microbiological limit specified for any of the sample examined, na =not applicable

In order to be acceptable to consumers and users of ingredients, it is essential that milk powders are of a good quality. Milk powders are manufactured to meet certain specifications and standards for composition. These have been developed for milk powders by authorities such as the American Dairy Products Institute, the International Dairy Federation (Table 2), the Food and Agricultural Organization of the United Nations and national food authorities in individual countries. In addition, a range of other technical specifications have been developed for the characterization of milk powders to ensure that they have the required functional performance in specific target applications. Milk powders may be similar in composition but have different functional properties (Kanekanian, 2014).There are Ethiopian quality Standards for whole powder milk, partly skimmed powder milk and skimmed powder milk based on contents of milk fat content, water, milk protein in milk SNF, Titratable acidity (lactic acid) and Solubility -Roller dried -Spray-dried, etc (Ethiopian Standard, 2009). However, no information was obtained on its implementation by regulatory body.

Milk Fortification

The review begins with food fortification as the principles are similar to fortification of milk powder. Thus, summaries of the need for fortification, milk fortifications in practice, advantages, limitations, implementations, monitoring strategies and quality assurances were made.

Food fortification is either a commercial choice for providing extra nutrients in food (market driven fortification), or is a public health policy which aims to reduce the number of people with dietary deficiencies in a population (FAO, 2003; Allen et al., 2006). While fortifying foods with micronutrients is a valid strategy as part of a food-based approach, it is not an alternative to the consumption of a variety of available foods constituting a nutritionally adequate diet. Fortification is acceptable only when necessary food supplies are not available or accessible to provide adequate amounts of certain nutrients and only when the fortified food will be accessible to the targeted population. However, the most needy population group often has restricted access to fortified foods, and it is usually not only one nutrient that is lacking but several which cannot realistically be addressed by fortified foods (FAO, 2003). In a review by Cora et al. (2011), multi-micronutrient food fortification consistently improved micronutrient status and reduced anemia prevalence. Some studies reported positive effects on morbidity, growth, and cognitive outcomes, but the overall effects on these outcomes were equivocal.

Fortification remains controversial as we have seen with the recent folic acid fortification debate in New Zealand (Lawrence, 2013). It is yielding some undesirable consequences. The abundance of high-density, cheap calorie sources and the market competition has facilitated overconsumption and promoted obesity, a problem of global proportions (Venkatesh, 2003). A review by Crider et al. (2011), focused on some safety concerns such as masking of B12 deficiency Anemia, Cancer and Epigenetic Changes, and Un-metabolized Folic Acid, which needs careful monitoring. There are four key principles of food fortification (Haylock, 2002):

1. The demand for the food should be constant and unaffected by fortification.
2. Fortification should not adversely affect the odour, texture, taste or appearance of the food.
3. The nutrient should be absorbed by the body resulting in an increase in bioavailability.
4. There should be a demonstrable positive effect on the consumer's health of adding the nutrient.

Food fortification requires close collaboration with the public sector, ensuring legal aspects, consumer and health organizations to ensure consumer sensitization and acceptance of fortified foods, other private partners to ensure efficient distribution, etc (Dorp et al., 2011). Fortification involves opening new communication channels among the public health community, research institutions, government regulators, food companies, and a variety of civic and consumer organizations. The inputs from these groups could result in a new alliance focused on accomplishing national development through elimination of micronutrient malnutrition (Venkatesh, 2003).The regulation and guidelines for Fortification should include the following (Venkatesh, 2003):A rationale for fortification, recommended minimum and maximum level (s) of nutrient added per serving, establishing RDA (Recommended dietary Allowance), establishing labeling standards, establishing guidelines for making nutritional and health claims, establishing a monitoring and surveillance system and Quality Assurance.

The interest in the development of health promoting foods has led to research in functional milk powders for health and well-being. These include milk powders enriched with well-known nutrients such as minerals (e.g., Fe) and vitamins (e.g., vitamins Aand D) and functional ingredients of more recent interest such as omega-3 oils, probiotics, and phytosterols. Some of these functional ingredients are added as micro encapsulated ingredients while others are directly incorporated into milk powders (Augustin, 2003). Milk powders can also be fortified with calcium (Williams et al., 2005). However, the color, texture, stability, flavor, and processing characteristics of the final product may be potentially influenced by the form of calcium used for fortification (Chandan, 2008). Mineral fortification often does not affect the sensory or physicochemical properties of the dairy product. However, some fortificants can cause unacceptable changes in colour, flavour or texture of dairy products. The long time and high cost required to develop new combinations of suitable minerals, fortificant preparations, and dairy products must be offset by the use of better fortification system and fortification methods (Preedy et al., 2013). Mineral fortification of dairy products must be carefully controlled to ensure the desired level of fortificants in the final products and avoid toxicity. Just as mineral deficiencies can cause complications, excessive mineral intake also has side effects. For example, too much calcium can cause renal disease (Preedy et al., 2013).

Breast milk, of course, is recommended during the first year of life. If the infant is weaned during the first year, the best alternative is to use iron-fortified formula. Formula-fed infants should remain on iron-fortified formula until 1 year of age. After age 1, the American Academy of Pediatrics recommends using whole milk if the use of breast milk or formula is discontinued (Encyclopedia of Foods, 2002). However, some black spots are sometimes observed in milk powder enriched in iron salts. These black spots have different origins such as change in valence of iron ion (Fe^{2+} /Fe^{3+}) or the fact that iron salts are becoming insoluble. For example, if sulphate is added in a matrix where pH ³ 7, iron hydroxide will be produced and a decrease of the iron solubility will be observed (AleixoandNóbrega, 2003). Commercial infant milk powders are often fortified with ferrous sulphate and; moreover, formulas are mixing very reactive iron salts together with Omega 3-rich oils that are highly sensitive to peroxidation. The colour of this type of iron (II) fortified milk is darker than regular milk, which could be an indication of a change of the oxidation degree of Fe (Preedy et al., 2013).

Concluding remarks and implications

Imported milk powder is beyond the purchasing capacity of the great majority of middle and low income people of Ethiopia, who are most affected by malnutrition, because of its high cost. In addition, there is limited foreign currency reserve and safety concern. Therefore, increasing domestic milk supply is crucial to reduce dairy imports. This can be done by collecting milk produced in the high dairy potential highland areas of the country for processing and distribution. The abstinence of some people from milk consumption during fasting season, storage problems, growing preference of urban consumers for variety of dairy products and emerging supermarkets necessitate production of long-shelf life milk products from part of the raw milk collected. This aligns with the second Growth and Transformation Plan (GTP II) of the Government to increase milk production and also aiming at exporting milk powder.

Food fortification is currently under debate with regard to its benefits and limitations. Thus, further information is needed on potentially efficacious amount of fortificant, appropriate levels of fortification, and the extent to which commercially fortified foods could be made accessible to the most nutritionally vulnerable populations. Furthermore, there is no information on the quality of milk powder in Ethiopia, which calls for research efforts on its microbial, compositional/nutritional quality and adulteration concerns. Intervention is also required in dairy/food import policy and regulatory roles in licensing, inspections and surveillance and certification of locally marketed, exported and imported milk to assure consumer safety from physical, biological, chemical or adulteration hazards. While promotion of nutritional/health benefits of pasteurized milk and other milk products regardless of their brands would contribute to enhancing milk consumption and improving dairy productivity, misleading advertisements need to be regulated to avoid confusion among consumers.

References

Aleixo, PC. and Nóbrega, JA. 2003. Direct determination of iron and selenium in bovine milk by graphite furnace atomic absorption spectrometry. Food Chem. 83:457–62.

Allen, L., de Benoist, B., Dary, O. and Hurrell, R.2006.Guidelines on food fortification with micronutrients. Geneva, Switzerland/Rome, Italy: World Health Organization and Food and Agriculture Organization of the United Nations.

Augustin, MA., Clarke, PT. and Craven, H. 2003. Characteristics of milk Powders. Elsevier Science Ltd. Weribee, Victoria, Australia. In: Encyclopedia of food science and nutrition. Academic Press, USA.

AzageTegegne,Berhanu Gebremedihin, Hoekstra, D., Berhanu Belay and Yoseph Mekasha. 2013. Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. IPMS (Improving Productivity and Market Success) of Ethiopian Farmers Project Working Paper 31. Nairobi: Kenya. 65p.

Caric, M. and Millanoric, S. 2002. Milk powders. Physical and functional properties. Encyclopedia of dairy sciences. Vol. 3. Elsevier Ltd. USA.

Caric, M. 2002. Milk powders. Types and manufacture. Encyclopedia of dairy sciences. Vol. 3. Elsevier Ltd. USA.

Chandan, RC. 2008. Dairy processing and quality assurance. John Wiley & Sons, Inc. USA.

Chenu, JW. and Cox, JM. 2009. Cronobacter ('Enterobactersakazakii'): current status and future prospects. Letters in Applied Microbiology 49: 153–159.

Cora, B., Neufinger, N., Del Rosso, JM., Transler, C., van den Briel, T. and Osendarp, S. 2011. Can multi-micronutrient food fortification improve the micronutrient status, growth, health, and cognition of schoolchildren? A systematic review. Nutr Rev. 69(4):186-204.

Creamer,LK.,Loveday, SM. and Sawyer, L. 2002. Milk proteins. β-Lacto globulin. . Encyclopedia of dairy sciences. Vol. 3. Elsevier Ltd. USA.

Crider, KS.,Bailey LB. and Berry RJ. 2011. Folic Acid Food Fortification—Its History, Effect, Concerns, and Future Directions. Nutrients 3: 370-384.

Deeth, H.C. and Hartanto, J. 2009. Chemistry of Milk – Role of Constituents in Evaporation and Drying. Dairy powders and concentrated products. 1st ed. Blackwell Publishing Ltd. UK.

Deveci, O. and Sezgin, E. 2005. Aflatoxin M1 levels of skim milk powders produced in Turkey. J. Food Drug Anal. 13:139–142.

Dorp, M. van., Oenema, S. andVerdonk,I. 2011. Agriculture-nutrition linkages: Linking agriculture and food security to nutrition improvement. Desk review Wageningen UR Centre for Development Innovation. The Netherlands.

Encyclopedia of Foods. 2002. A guide to healthy nutrition. Dole Food Company, Inc. Elsevier 3. USA.

Ethiopian Standard. 2009. Whole milk, partly skimmed milk and skimmed milk powder – ES 3459:2009.

FAO FOOD OUTLOOK. 2013. Milk and milk products. Market assessments, Rome, Italy.

FAO. 2003. Fortification of food with micronutrients and meeting dietary micronutrient requirements: Role and position of FAO: Policy Statement. Rome: Food and Agriculture Organization of the United Nations.

FAO.2013. Milk and dairy products in human nutrition. Rome, Italy.

FDRE (Government of the Federal Democratic Republic of Ethiopia).2013. National Nutrition Programme. June 2013-June 2015. Addis Ababa, Ethiopia.

FMOH.2011. Assessment of feasibility and potential benefits of food fortification in Ethiopia, Addis Ababa, Ethiopia.

Francesconi, GN., Heerink, N. and D'Haese, M. 2009. Evolution and challenges of dairy supply chains: Evidence from supermarkets, industries and consumers in Ethiopia. Food Policy 35: 60–68.

Francesconi, GN. 2009. Cooperation for competition: Linking Ethiopian farmers to markets. International Chains and Network Series, vol. 5.Wageningen, the Netherlands: Wageningen Academic Publisher.

Gobbetti, M., Minervini, F. and Rizzello, CG. 2007. Bioactive peptides in dairy products. In: Handbook of food products manufacturing Y.H. Hui (ed). John Wiley and Sons, Inc., Hoboken, NJ, pp. 489 – 517.

Haylock, SJ. 2002. Fortification of consumer milk products. Bulletin of the International Dairy Federation (375).Brussels: IDF.

Health Canada. 2008. Standards and guidelines for microbiological safety of food, an interpretive Summary. Ottawa, Health Canada and Food Directorate, Health Protection Branch, 1-16.

Jarvis, JK., Lois, D. and Mc Bean, GDM. 2007. Handbook of dairy foods and nutrition. 3rd eds. National Dairy council.CRC Press. USA.

Jensen, RG., Ed. 1995. Handbook of milk composition, Academic Press, New York.

Kambamanoli-Dimou. 2003. Microbiology. Encyclopedia of food science and nutrition. Elsevier Science Ltd. USA.

Kanekanian, A.2014. The Health Benefits of Bioactive Compounds from Milk and Dairy Products. Milk and dairy products as functional foods.1st ed. John Wiley & Sons, Ltd. Cardiff Metropolitan University, UK.

Lawrence, M.2013. Food Fortification. The evidence, ethics, and politics of adding nutrients to food. Oxford University Press, Oxford, UK.

Lewis, M. 2010. Improving pasteurized and extended shelf-life milk. In: Improving the safety and quality of milk. Vol 1.Woodhead Publishing limited, UK.

Martins, HM., Guerra, MM. and Bernardo, F. 2005. A six year survey (1999–2004) of the occurrence of aflatoxin M1 in dairy products produced in Portugal. Mycot. Res. 21:192–195.

Meunier-Goddik, L. and Sandra, S. 2002. Pasteurized milk. Encyclopedia of dairy science. Vol. 3. Elsevier Sc. Ltd. USA.

Motairjemi, Y. and Lelieveld, H. 2014. Food safety management practical guide for the food industry. Elsevier Inc. UK.

Nag, SK. 2010. Contaminants in milk: routes of contamination, analytical techniques and methods of control. In: Improving the safety and quality of milk. Vol. 1. Wood head Publishing limited, UK.

Ndambi, OA., Hemme, T. and Latacz-Lohmann, U. 2007. Dairying in Africa - status and recent developments. Livestock Research for Rural Development.19:8.

OECD/FAO. 2016. OECD-FAO Agricultural Outlook 2016-2025, OECD Publishing, Paris.

Oliveira, CAF. and Ferraz, JCO. 2007. Occurrence of aflatoxin M1 in pasteurized, UHT milk and milk powder from goat origin. Food Control. 18:375–378.

Pavic, S., Brett, M., Petric, I., Laˇstre, D., Smoljanovic, M., Atkinson, M., Kovaˇcic, A., Cetinic, E. and Ropac, D. 2005. An outbreak of food poisoning in a kindergarten caused by milk powder containing toxigenic Bacillus subtilis and Bacillus licheniformis. Archivf¨urLebensmittel hygiene. 56:20–22.

Preedy,VR., Patel, VB. and Srirajaskanthan, R. 2013. Handbook of food fortification and Health. Springer Science+ Business Media, New York.

Rajendran, S. andParveen, KMH. 2005. Insect infestation in stored animal products. J. Stored Prod. Res. 41:1–30.

Sharma, S. and Rou, Z. 2014.China's dairy dilemma. The evolution and future trends of china's dairy industry. Institute for agriculture and trade policy. China.

Skanderby, M., Westergaard,V., Partridge, A.and Muir, D.D. 2009. Dried Milk Products. Dairy powders and concentrated products. 1st ed. Blackwell Publishing Ltd. UK.

Soler, P., Herrera, S., RodriÂguez, J., Cascante, J., Cabral, R., Echeita-Sarriondia, A. and Mateo S. 2008. Nationwide outbreak of Salmonella enterica serotype Kedougou infection in infants linked to infant formula milk, Spain, Euro Surveill, 13, pii=18963.

Tajitsu, N. 2013. China bans New Zealand milk powder imports on Botulism Scare: NZ Trade Minister. http://www.reuters.com/article/ us-newzealand-milk-idUSBRE97301K20130804

Terry, SL. 2011. Healthy eating: a guide to Nutrition. Nutrition and food safety. Infobase Publishing. USA.Tsimidou, M. and Boskou, D. 2003.Adulteration of foods. Encyclopedia of food science and nutrition. Academic Press, USA.

Venkatesh Mannar, MG. 2003. Food fortification. The Micronutrient Initiative. Elsevier Science Ltd, Ottawa, Canada. In: Encyclopedia of food science and nutrition. Academic Press, USA.

Williams, RPW., Ath, LD. And Augustin, MA. 2005. Production of calcium-fortified milk powders using soluble calcium salts. Lait. 85:369–381.

World Bank. 2006. Agriculture Investment Sourcebook. Washington, DC.

Zelalem Yilma, Guerne Bleich, E. and Amha Sebsibie. 2011. A Review of the Ethiopian Dairy Sector. Eds. Rudolf Fombad, Brian Dugdill and Olaf Thieme, Food and Agriculture Organization of the United Nations, Sub Regional Office for Eastern Africa (FAO/SFE), Addis Ababa, Ethiopia, pp 82.

Zijlstra, J., Tinsae, B., Vernooij, A., Boere, A. and van der Lee J. 2015. Business opportunities Report Dairy #2 in the series written for the "Ethiopian Netherlands business event 5–6 November 2015, Rijswijk, The Netherlands.

Assessment of Goat Production System in Burie District, West Gojjam Zone, Ethiopia

Yenesew Abebe[1], Solomon Melaku[2] and Azage Tegegne[3]

[1] Andassa Livestock Research Center, P.O.Box 27, Bahir Dar, Ethiopia
E-mail:yenesew_abebe@yahoo.com
[2] Haramaya University, P.O.Box 138, Dire Dawa, Ethiopia
[3] International Livestock Research Institute, P.O.Box 5689, Addis Ababa, Ethiopia

Abstract

This study was conducted in four selected rural kebeles (divisions of a district) namely, Woheni Durebetie, Woyenema Ambaye, Denbun and Boko Tabo in Burie district to assess goat production system, and to identify and prioritize goat production constraints. Informal and formal surveys were conducted in the selected kebeles. Purposive sampling method was used for the informal survey and random sampling method was used for the formal survey to select the respondents. A total of 36 and 75 respondents were interviewed for the informal and formal survey, respectively. Farmers in the study area rear goats for home consumption (1%), cash income (29%) and home consumption & cash income (69%) purposes. The mean number of goats owned by one household was 4.8±3.33 heads (n = 75). From the current study, about 25% of the goats in the flock were males and the remaining 75% were females. Browse species found in natural pasture and crop lands are the main feed resources for goats. In addition, farmers usually supplement their goats with common salt, maize grain, food left over and atella (a by-product of home brewed drink). Generally, there is feed shortage problem for goats during the dry and rainy seasons especially in the highland kebeles. Goat diseases and provision of inadequate veterinary service were reported to be major constraints affecting goat production in the study area. To improve the goat productivity and make the goat production sustainable in the study area establishment of new veterinary clinics, provision of adequate veterinary service and improving the goat marketing system should be given more emphasis in future research and development activities. Furthermore, feed production in the highland study kebeles should be improved.

Key words: Goat, production system, production constraints, Ethiopia

Introduction

Ethiopia possesses about 29.7 million goats in rural sedentary areas of the country (CSA, 2016) and they are diverse genetically. According to Tesfaye Alemu (2004), goats in Ethiopia are classified into eight breeds. These are Arsi-Bale, Gumuz, Keffa, Woyto-Guji, Abergelle, Afar, Highland goats and the Somali goats. Goat productivity in Ethiopia is low compared with the apparent potential (EARO, 2000; Solomon Gizaw *et al*., 2010). Goats are found in all agro-climatic zones of the country. Generally, inadequate feed supply both in quantity and quality, diseases and parasites, inadequate management and low genetic potential are among the technical constraints that limit the small ruminant productivity in the country. Based on recent reports, poor feeds, animal health and inferior genotypes are the input side constraints in goat production in Ethiopia while lack of standardized marketing system and infrastructure to access markets are the main constraints on the output side (Solomon *et al*., 2014).

Ethiopia is home for diverse indigenous sheep and goat populations and favourable production environments (Solomon Gizaw *et al*., 2010). Based on the above source, sheep and goat in Ethiopia are kept under traditional extensive systems with no or minimal inputs and improved technologies. In Ethiopia, the small ruminant production system in different agro-ecological zones is not studied fully and farmers' needs and production constraints have not been identified (EARO, 2000). Currently, several on-farm studies describing production systems have been conducted in Ethiopia (Solomon *et al*., 2014). Assessment of the goat production system and identification and prioritization of the constraints of production is a prerequisite to bring improvement in goat productivity in the country.

Understanding the production system also helps to design appropriate technologies which are compatible with the system. In general, assessment of the goat production system is important to plan development and research activities and bring improvements in goat productivity. In Burie District, the goat production system is not studied and precisely known and goat production constraints are not identified and prioritized. Therefore, this study was conducted to assess the goat production system, to identify and prioritize the goat production system constraints in the district. This study will be useful for other areas with similar agro-ecological zones.

Materials and Methods

Description of the study area

This study was conducted in 2007 (started) and 2008 (completed) in Burie district, in Amhara National Regional State, North Western Ethiopia. Burie district is located between 10˚15′ N and 10˚42′ N and between 36˚52′ E and 37˚7′ E. Burie district has an estimated area of 838.9 square kilometers with altitude range of 713 – 2604 masl (BOFED, 2008; IPMS, 2007). The rainy season in Burie district is from May to September with a mono-modal pattern and a mean annual rainfall of 1386 – 1757 mm (IPMS, 2007). According to IPMS (2007), the long term annual temperature of Burie ranges from 14 ºC to 24 ºC. As the district has different ecological settings, it is suitable for different crops and livestock species production. The land use pattern in the district consisted of about 46.6% cultivated land, 16.3% wasteland, 14.8% shrub, 8.4% natural forest, 6% construction (roads and houses), 6% pasture land, 1% perennial crops and 0.3% water bodies (IPMS, 2007).

Human population of the district is estimated at 174,957, of which 143,558 (82%) lives in rural areas (BOFED, 2008). There are 22 rural kebeles and 2 towns in the district. There are about 21,793 and 2,786 households in rural and urban kebeles of Burie District (IPMS, 2007), respectively. Secondary data were collected from different sources. The study kebeles were selected before beginning the informal survey. Four representative rural kebeles were selected for the study by using secondary data and participation of district livestock and crop experts. The criteria used for selection of the study kebeles were agro-climatic and agro-ecological zone of the kebele, goat population and density, accessibility of the kebeles by vehicle and non-adjacent kebeles to one another. The selected kebeles for the study were Woheni Durebetie (*Dega*), Woyenema Ambaye (*Woina Dega*), Denbun (*Woina Dega*) and Boko Tabo (*Kolla*).

Informal survey

Informal survey was conducted in the selected kebeles (Roeleveld and Broek, 1996). Informal surveys are conducted using a checklist to ascertain and complement the preliminary systems understanding which was made based on secondary data analysis. During this study mostly qualitative data were collected from the respondents. But formal surveys are conducted using a questionnaire to provide a quantitative figure for conclusions drawn from earlier phases, to redefine target groups and to test hypotheses about relationships (Roeleveld and Broek, 1996). For the informal survey checklist was prepared and used. The main components of the checklist were breeds and breeding, feeds and feeding, diseases and disease control, housing, meat consumption and production constraints. Farmers to be interviewed from each kebele were selected purposively based on ownership of goats, economic status and living in the kebele for several years. Kebele administrators and religious leaders were selected as key informants and interviewed. For the group interview, farmers from different age, economic status and gender groups were included and interviewed. A total of 36 respondents were interviewed for the informal survey. Goat production constraints were prioritized using pair-wise ranking method for each kebele and single list ordinal ranking method for the district (ARARI, 2005).

To assess the flock composition, data were collected from each kebele during the informal survey field work. Goat flocks in each kebele were selected purposively (based on age and sex composition of the flock) in the grazing fields and every animal in the flock was caught, identified and data were recorded. Body weight of the animals was measured using hanging scale. According to Girma Abebe and Alemu Yami (2008), for light animals hanging scale can be used to measure the body weight of animals. Age of the animals was estimated based on observation of their dentition (Girma Abebe and Alemu Yami, 2008).

Formal survey

A structured questionnaire was prepared based on the informal survey result. The major components of the questionnaire were breeds and breeding, feed resources and feeding, housing, diseases and disease control, meat consumption and production constraints. The questionnaire was pretested before conducting the actual formal survey data collection. The study kebeles that were selected and used for the informal survey were used for the formal survey study. Respondents were selected by using random sampling technique. From each kebele enumerators were selected, given training on data collection and collected the formal survey data from the randomly selected individuals. A total of 75 farmers were selected and interviewed. The goat production constraints for the formal survey result were prioritized using single list weighted category based ranking method (ARARI, 2005). The statistical analysis was done by using SPSS (2003) statistical software. Descriptive statistics were used to summarize the data and ANOVA was done for mean comparison.

Results

Goat characteristics in the study area

Farmers in the study area rear goats for the following main purposes, for home consumption (1%), cash income (29%) and home consumption & cash income (69%). Milking of goats and consumption of goat milk in the study area is not common. Goat producing farmers in the highland study kebeles were concentrated in areas where more natural browse in the vicinity of their homes was found. According to FARM-Africa (1996), the goat types found in the study area were Western Highland goat types. Western Highland goat types are one of the 14 goat types found in Ethiopia and Eritrea. According to FARM-Africa (1996), the mean flock size owned is 8 (SD = 6). In the current study, one household owns on average 4.8 heads of goats (n = 75, SD = 3.33). On average, one household sells 1.7 heads of goats (n = 75, SD = 1.72) per year. According to the current study, one animal in the flock on average weighs 21.6 kg (n = 248, SE = 0.65). Based on mean body weight (BW) of an animal in the flock, the *Dega* kebele goats were heavier ($P<0.05$) in BW (25.0 kg) than the *Woina Dega* and *Kolla* kebele goats (Table 1). This difference may be due to age composition, environmental effect or genotype. According to FARM-Africa (1996), the mean BW of male and female goats in Western Highland goat types were 48.4±9.9 kg and 33.0±6.0 kg, respectively. This result is higher than the current study result.

Farmers usually get their first breeding goats from buying from the market (77%), gift from parents/ relatives (8%) or buying from their residence kebeles. From the current study result, females (75%) were more in number in the flock than males (Table 2). This is comparable with the result of FARM-Africa (1996). It is reported in this source that about 27% of the animals in the flock are males and 73% of the animals in the flock of Western Highland Goats are females. Those females which were mature predominate in the flock while for males; young males predominate in the flock (Table 2). This may be due to the purpose of goat production in the study area. As the main objective of goat production in the area is for meat production either for sale or home consumption, most of the males are slaughtered or sold at young age. Females predominate in the production system as they are retained for breeding purpose.

Table 1. Mean body weight (mean±SE)measure of goats in the flocks in the different agro-ecological zones in Burie district

Agro-climatic zone	Body weight (kg)	N
Dega	25.0±1.21[a]	61
Woina Dega	21.3±0.92[b]	125
Kolla	18.6±1.24[b]	62

SE = Standard error; kg = kilogram; Means with different superscript letters within a column are significantly different (P<0.05)

Table 2. Sex and age composition of the goat flocks in the study kebeles of Burie district

Estimated age (year)	Sex of the goat					
	Male		Female		Total	
	N	%	N	%	N	%
< 1	44	71	65	35	109	44
1	1	2	0	0	1	0.4
1 to 2	7	11	21	11	28	11
2	2	3	27	15	29	12
3	4	7	19	10	23	9
> 3	4	7	54	29	58	23
Total	62	25	186	75	248	100

N = Number of animals

Goat feed resources and feeding

The main feed resources for goats are browse species found in natural pasture and crop land during the dry season (Table 3). In addition, most farmers supplement common salt, food leftover, maize grain and *Atella* (a local beer residue, *Tella*) to their goats (Table 4). Supplementation of growing kids is not common in the study area. Farmers supplement common salt or boiled salt solution to the dam to make the animals produce more milk to the new born kid. It is not common feeding crop residues to goats in the study area.

Farmers buy several materials from the market for their goats. Most of the farmers in the area buy salt (69% of the respondents) to feed their goats. In addition, some farmers buy noug seed cake (9% of the respondents) for their goats.

Table 3. Major feeds for goat production during different seasons in the study kebeles of Burie district (N = 75)

Major feed resources	Sept. – Nov.		Dec. – Feb.		March – May		June – August	
	N	%	N	%	N	%	N	%
BNPO	57	76	48	64	55	73	56	75
BSO	7	9	13	17	12	16	10	13
BNPS	11	15	13	17	7	9	8	11
Other	0	0	1	1	1	1	0	0
NR	0	0	0	0	0	0	1	1

N = Number of respondents; BNPO = Browse in natural pasture only; BNPS = Browse in natural pasture and stubble; BSO = Browse in stubble only; NR = No response

There was feed shortage (browse) problem for goat production in the study area especially in the highland kebeles (29% of the respondents). In general, there was feed shortage problem in the dry season from March to May. During this period the browse species shed their leaves and there is less leaves available to be consumed by the goats. In addition, in the rainy season, as the crop land will be covered with food crops, goats will be confined to browse species found in communal grazing lands only. The browse species found in the communal grazing lands are limited in amount and do not supply adequate amount of feed to the animals during the rainy season. Generally, feed is abundant for goats in the area from November to January.

Table 4. Feed supplements for goats during different seasons in the study kebeles of Burie district (N = 75)

Feed supplement type	Sept. – Nov.		Dec. – Feb.		March – May		June – August	
	N	%	N	%	N	%	N	%
MGO	3	4.0	4	5.3	3	4.0	4	5.3
AO	6	8.0	16	21.3	13	17.3	13	17.3
FLO	9	12.0	4	5.3	8	10.7	5	6.7
MGA	7	9.3	9	12.0	3	4.0	1	1.3
MGAFL	10	13.3	7	9.3	6	8.0	4	5.3
AFL	4	5.3	9	12.0	6	8.0	7	9.3
Other	7	9.3	6	8.0	14	18.7	14	18.7
NR	29	38.7	20	26.7	22	29.3	27	36.0

N = Number of respondents; ALF = *Atella* and food leftover; AO = *Atella* only; FLO = Food leftover only; MGA = Maize grain and *Atella*; MGAFL = Maize grain, *Atella* and food leftover; MGO = Maize grain only; NR = No response

Housing of goats

Farmers use different types of goat houses in the study area. Farmers use the main house, house attached to the main house and a separately constructed goat house for goat housing (Table 5). If the goats are housed in the main house, the room will be separated and partitioned by walls made of locally available materials. Farmers house all sex and age groups of goats together. But bucks (5% of respondents), fattening goats (16% of respondents) and kids (64% of respondents) are usually separated from the others. Locally available materials are used to build goat houses. The roof is usually made of corrugated iron sheet (72%), and the wall in the highlands is made of eucalyptus tree and it is usually plastered with mud. Some farmers have a goat house with a roof made of grass (25%). The wall of the lowland goat houses is made of lowland woods and it is not usually plastered with mud as the ambient temperature in the area is very high.

Table 5. Type of goat houses used by farmers in the study kebeles of Burie district

Type of goat house	N	%
Main house	21	28
House attached to the main house	26	35
Separately constructed goat house	27	36

N = Number of respondents

Diseases and disease control

Goat diseases are the main constraints in goat production in the study area. Foot rot, skin disease, internal parasites, pasteurellosis and diarrhea (blood stained) are some of the main goat diseases in the area. Abortion is also one problem in the study area. When goats get sick, farmers in the highland kebeles take their animals to the nearest public veterinary clinics. But in the lowland kebele, farmers medicate their goats buying drugs themselves from the market (75%). This is due to absence of veterinary clinic in the kebele. Generally, there is inadequate veterinary service in the study area. Most of the veterinary clinics are remote to farmers' residences. Vaccination of goats is not common in the study area. Traditional medicine is also used for sick goat treatment.

Farmers buy different drugs to treat their sick goats. Most of the farmers in the study area buy anthelminitics (92% of the respondents) for the treatment of their sick goats. Other drugs bought and used for sick goats' treatment were Ampicillin, Penicillin and Oxytetracycline. The farmers buy the drugs from the local market and treat their animals themselves. This has a serious impact on the development of drug resistant microbes in animal production. Buying drugs for sick goats' treatment is especially common in the lowland kebele (*Kolla*) as the veterinary service in the area is too far from farmers' residences.

Goat meat consumption per household

Farmers slaughter goats in different occasions. Easter, Christmas and before the fasting period of Easter (Lent) are the main occasions on which farmers slaughter goats at home. Sometimes goats are slaughtered by households before and after fasting periods (Easter and August), on weddings, during religious festivals and when a households likes to consume goat meat at home. On average, about 57% of the respondents slaughtered goats at home the previous year. Based on the data from the formal survey, one household slaughtered 0.9 heads of goats (n = 75, SD = 0.98) the previous year. Young male goats are slaughtered mostly. Females at young age, sterile females, old age females or fattened goats are also slaughtered occasionally. Usually, there is no colour preference for the goats that are going to be slaughtered at home. In some cases, farmers rear goats but they do not slaughter and consume goat meat due to cultural problems. According to FARM-Africa (1996), there is a cultural taboo against goat meat and milk consumption in the study area.

Goat production constraints in the study area

There are several constraints in goat production in the study kebeles of Burie District. From all the goat production constraints identified, goat diseases, lack of adequate veterinary service, feed (browse) shortage, predators and marketing problem are the main goat production constraints in the study area (Tables 6 and 7). But there were differences in the priority of constraints among the different kebeles. For example, in Woheni Durebetie kebele, lack of adequate veterinary service, goat diseases and feed shortage were the first, second and third priority constraints, respectively. However, in Denbun kebele, goat diseases and feed shortage were the first and second priority constraints. In this kebeles, those constraints that have the same figure are considered to be equal priority constraints. There was a difference in the priority of goat production constraints between the informal and formal survey results (Table 6 and 7). This may be due to the number of farmers interviewed during the informal and formal surveys. As the number of farmers interviewed during the formal survey is large (i.e. 75), the priority of constraints from this result may be more realistic than the informal survey.

Table 6. Rank of goat production constraints in the study kebeles in Burie district (informal survey result)

Constraint identified	Woheni Durebetie	Woyenema Ambaye	Denbun	Boko Tabo	Total score	District Priority
Goat diseases	2	1	1	1	5	1
Lack of adequate vet service	1	5	4	6	16	3
Feed shortage (browse shortage)	3	3	2	6	14	2
Leech	6	2	4	6	18	6
Water shortage	6	5	4	4	19	8
Technical Knowledge shortage	6	5	4	2	17	5
Marketing problem	6	4	4	5	19	7
Predators	4	5	4	3	16	4

Table 7. Rank of goat production constraints in the study kebeles of Burie district (formal survey result)

Constraint identified	1^{st} Priority (5)	2^{nd} Priority (4)	3^{rd} Priority (3)	4^{th} priority (2)	5^{th} priority (1)	Weighted score	District Priority
Goat diseases	37	18	5	3	0	278	1
Lack of adequate vet service	2	5	11	4	2	73	4
Feed shortage	0	6	1	1	0	29	7
Labour shortage	3	5	6	4	0	61	5
Financial shortage	6	3	4	1	2	58	6
Technical knowledge shortage	0	2	3	4	4	29	8
Marketing problem	1	4	13	10	1	81	3
Predators	23	20	4	2	1	212	2

Discussion

The largest goat population of the world is found in Africa (41%) and in the Indian sub-continent (32%) (Steele, 1996). Goats are reared for several purposes in the world depending on the breed, environment and socio-economic circumstances. Generally, goats provide meat, milk, fibre and cash income to their owners. Goat owners in the study area get cash income and meat for household consumption from goat production. Consumption of goat milk and use of fibre is not common in the study area. In some cases, there are households that rear goats and do not consume goat meat due to cultural constraints. According to Kassahun Awigchew *et al*. (1991), small ruminants provide 12.5% of the value of livestock products consumed on the farms and 48% of the cash income generated by livestock, though they represent only 6.6% of the capital invested in farm livestock.

Goat diseases were one of the main constraints in goat production in the study area. Foot rot, skin disease, internal parasites, pasteurellosis and diarrhea were the main diseases in the study area. According to Aklilu Feleke (2008), pasteurellosis, goat pox and orf are the main goat diseases in Burie District. Based on different recent research reports in Ethiopia, goat diseases are the main constraints in goat production in several production systems (Arse Gebeyehu *et al*., 2013; Gebreegziabher Zereu *et al*., 2016; Netsanet Zergaw *et al*., 2016; Tegegn Fantahun and Askale G/Michael, 2017). According to Solomon *et al*. (2014), poor feeds, animal health, inferior genotypes, lack of standardized marketing system and infrastructure to access markets are the main constraints in goat production in Ethiopia recently. Based on another report, prevalence of diseases and parasites is the major constraint in sheep and goat production in Ethiopia (Solomon Gizaw *et al.,* 2010). According to the same source, high mortality is the main factor for the observed low off-take rates of sheep and goat in Ethiopia.

In Burie District veterinary service is provided by both the public and the private sector. These services are specially found in urban areas. There was poor veterinary service provision in rural and very remote areas. According to Aklilu Feleke (2008), about 48.1% of the respondents do not have access to modern veterinary services in the study area. The veterinary service provision was inadequate and it was especially very poor in the lowland kebele. To avoid animal losses, farmers buy drugs from the market and treat animals themselves. This is especially common in the lowland kebele as the veterinary service provision site was remote to their residences. Treating animals by buying drugs from the market is also reported in other parts of the country (Alganesh Tola *et al.*, 2004). Provision of adequate veterinary service to rural and very remote areas will save animal losses as well as illegal use of drugs by farmers. This practice will encourage the development of disease resistant microbes in livestock diseases. According to Aklilu Feleke

(2008), expansion of the veterinary service and detailed epidemiological study is recommended in the study area.

Based on the informal survey result, the market price of goats was low compared with sheep in the study area. During the study the market price per head in Burie town market was 248.1 and 289.8 Birr for goats and sheep, respectively. In addition, the market price per kg of animal was 9.6 and 10.9 Birr for goats and sheep, respectively. There is also seasonal demand for meat and price of goats. It is reported that there is a high fluctuation in goat market supply and demand in the country (Solomon *et al*., 2014). According to EARO (2000), there is small ruminant demand and price increases during festivals. Different reports in the country reveal that there is a presence of marketing problem in goat production (Solomon Gizaw *et al.,* 2010; Solomon *et al*., 2014).

There was feed shortage problem for goat production in the highland study kebeles (Woheni Durebetie, Woyenema Ambaye and Denbun) (Table 6). Feed shortage was not a severe problem in the lowland (*Kolla*) study kebele (Boko Tabo). Feed shortage is common both during the dry and rainy seasons in the study area. Several reports reveal the presence of feed (browse) shortage in goat production in different production systems. According to Agajie Tesfaye *et al.* (2002), critical months of feed shortages for livestock production occurred especially in June and July. As the browse species have decreased recently due to crop production expansion in the highland mixed farming systems of the area, this problem made the goat production system less sustainable. Currently, the main constraint for livestock production in the country is feed shortage. According to Kassahun Awigchew *et al*. (1991), small ruminant production in the country is constrained by disease, parasite and feed shortage. It is estimated that there is a 40% deficit in the national feed balance (Kassahun Awigchew *et al*., 1991). A recent study in the Amhara Region shows that the feed produced in the region only satisfies 83% of the maintenance requirement (17% deficit) and 69% of the production requirement (31% deficit) of the livestock population found in the region (Firew Tegegne and Getnet Assefa, 2010). Generally, there is feed (browse) shortage problem in goat production in the country in different production systems (Arse Gebeyehu *et al*., 2013; Gebreegziabher Zereu *et al*., 2016; Netsanet Zergaw *et al*., 2016; Tegegn Fantahun and Askale G/Michael, 2017). Introduction of an alternative feed source is recommended in Burie District (Aklilu Feleke, 2008).

There is seasonal fluctuation in the availability and quality of feed supply in the country in general. According to Alganesh Tola *et al*. (2004), from a study conducted in the Western part of the country, the livestock production constraints are identified to be feed shortage, disease, poor genetic potential of indigenous livestock species and wild life damage on small ruminants. Among these constraints, feed shortage was found to be the most threatening. According to Agajie Tesfaye *et al.* (2002), from a study conducted in the central highlands of Ethiopia, the livestock production constraints are feed shortage, animal disease, inadequate veterinary service, shortage of cash and shortage of water supplies. Currently, as the human population is increasing, pasture and grazing lands are being converted to crop lands for food production to feed the increasing human population (Agajie Tesfaye *et al*., 2002; Alemayehu Mengistu, 2005). This trend is contributing for the feed shortage problem for livestock production in the country.

There is a decline in browse species in the highland study kebeles of the study area. Due to the feed (browse) shortage and marketing constraints in the highland study kebeles the goat production at the small holder level is getting less sustainable. Farmers lack interest to continue rearing goats in the highland kebeles of the study area.

Conclusions

Diseases and predators, marketing problems and lack of adequate veterinary service are the main constraints affecting goat production in the study area. Thus, veterinary service provision needs to be improved and aware needs to be created on the consequences of using drugs purchased from the local market for the treatment of sick goats and this should be augmented by regulatory control of such practices. Improvement in market information and creation of market linkage would be essential to alleviate the prevailing marketing problems. Moreover, attention should be given to improved feed production because of its effect on animal health, productivity and survival.

References

Agajie Tesfaye, Chilot Yirga, Mengistu Alemayehu, Elias Zerfu and Aster Yohannes. 2002. Smallholder livestock production systems and constraints in the highlands of North and West Shewa Zones. Proceedings of the 9th annual conference of the Ethiopian Society of Animal Production (ESAP), August 30 – 31, 2001, Addis Ababa, Ethiopia, pp. 49 – 71.

Aklilu Feleke. 2008. Major animal health problems of market oriented livestock development in Bure Woreda. A thesis submitted to the faculty of veterinary medicine as a partial fulfillment for the requirement of the Doctor of Veterinary Medicine (DVM), Haramaya University, Ethiopia.

Alemayehu Mengistu. 2005. Feed resources base of Ethiopia: Status and opportunities for integrated development. Proceedings of the 12th Annual Conference of the Ethiopian Society of Animal Production (ESAP), August 12 – 14, 2004, Addis Ababa, Ethiopia, pp. 377 – 386.

Alganesh Tola, Mathewos Belissa and Gizaw Kebede. 2004. Survey on traditional livestock production systems in Manasibu District of West Wallaga, Ethiopia. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP), August 28 – 30, 2003, Addis Ababa, Ethiopia, pp. 141 – 150.

ARARI (Amhara Regional Agricultural Research Institute). 2005. Diagnosis- Training notes prepared for the diagnostic and planning workshop. July 24 – August 5, 2005. ARARI (Amhara Regional Agricultural Research Institute), Bahir Dar.

Arse Gebeyehu, Feyisa Hundessa, Gurmessa Umeta, 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. *African Journal of Agricultural Research.* 8(1): 26 – 31.

BOFED (Bureau of Finance and Economic Development). 2008. The Amhara National Regional State Bureau of Finance and Economic Development 2006/ 2007 Budget Year Annual Statistical Bulletin. Bureau of Finance and Economic Development, Bahir Dar.

CSA (Central Statistics Agency). 2016. Federal Democratic Republic of Ethiopia Central Statistical Agency. Agricultural Sample Survey 2015/2016 (2008 E.C.). Volume II, Report on Livestock and Livestock Characteristics (Private Peasant Holdings).

EARO (Ethiopian Agricultural Research Organization). 2000. Small ruminant research strategy. EARO (Ethiopian Agricultural Research Organization), Addis Ababa. 59p.

FARM-Africa. 1996. Goat types of Ethiopia and Eritrea – Physical description and management systems. Published jointly by FARM-Africa, London, UK and ILRI (International Livestock Research Institute), Nairobi, Kenya. 76p.

Firew Tegegne and Getnet Assefa. 2010. Feed resources assessment in Amhara National Regional State. Ethiopia Sanitary & Phytosanitary Standards and Livestock & Meat Marketing Program (SPS-LMM) Texas A&M University System, Addis Ababa.

Gebreegziabher Zereu, Merkine Meshka and Mathewos Shanka. 2016. Assessment of goat production systems and factors affecting goat production and goat's milk consumption in Humbo District of Wolaita Zone, Southern Ethiopia. *Global Journal of Animal Science, Livestock Prodcution and Animal Breeding.* 4(1): 248 – 253.

Girma Abebe and Alemu Yami. 2008. Sheep and goat management. In: Alemu Yami and R.C. Merkel (eds). Sheep and goat production handbook for Ethiopia. Ethiopian sheep and goat productivity improvement program. pp. 33 – 56.

IPMS (Improving Productivity and Market Success of Ethiopian Farmers). 2007. Burie pilot learning district diagnosis and program design: Final draft. 95p.

Kassahun Awigchew, Getachew Gebru, Zelalem Alemayehu, Negussie Akalework and Ian Fletcher. 1991. Small ruminant production in Ethiopia: Constraints and future prospects. Proceedings of the third national livestock improvement conference. 24 – 26 May 1989, Addis Ababa, Ethiopia, Institute of agricultural Research (IAR), pp. 37 – 48.

Netsanet Zergaw, Tadelle Dessie and Kefelegn Kebede. 2016. Goat production constraints and Ethno-veterinary practices in Konso and Meta-Robi districts, Ethiopia. *International Journal of Research and Reviews in Pharmacy and Applied Sciences.* 6 (1): 1308 – 1317.

Roeleveld, A.C. and A. Van den Broek. 1996. Focusing livestock systems research. Royal tropical institute, Amsterdam. 150p.

Solomon, A.K., Mwai, O., Grum, G., Haile, A., Rischkowsky, B.A., Solomon, G. and Dessie, T. 2014. Review of goat research and development projects in Ethiopia. ILRI Project Report, Nairobi, Kenya: International Livestock Research Institute.

Solomon Gizaw, Azage Tegegne, Berhanu Gebremedhin and Dirk Hoekstra. 2010. Sheep and goat production and marketing in Ethiopia: Characteristics and strategies for improvement. IPMS (Improving Productivity and Market Success of Ethiopian Farmers Project) Working Paper 23. ILRI (International Livestock Research Institute), Nairobi, Kenya. 58pp.

SPSS (Statistical Package for Social Sciences), 2003. SPSS 12.0 for Windows, SPSS Inc.

Steele, M., 1996. Goats. Macmillan education LTD, London and Basingstoke, The Technical Centre for Agricultural and Rural Co-operation (CTA). 152p.

Tegegn Fantahun and Askale G/Michael. 2017. Goat production system and breeding practices in pastoral and mixed crop livestock production system in south western part of Ethiopia. *Agriculture and Biology Journal of North America*. 8(3): 67 – 71.

Tesfaye Alemu Tucho. 2004. Genetic characterization of indigenous Goat Populations of Ethiopia using microsatellite DNA markers. PhD thesis, NDRI, India.

Comparison of Dairy Performance of F_1 (Borana X Holstein-Friesian) Crossbred Heifers under On-Farm and On-Station Management

Yohannes Gojjam[1]*, Direba Hunde[1], Molla Shumiye[1], Fekede Feyissa[2], Tadesse Bekele[1] and Roman Haile-Silassie[1]

[1]Holetta Agricultural Research Centre, P.O.Box 31, Holetta, Ethiopia
[2]Ethiopian Institute of Agricultural Research, P.O.Box 2003, Addis Ababa, Ethiopia
*Corresponding author:

Abstract

This study was conducted to compare the dairy performance of F_1 (Borana x Holstein-Friesian) crossbred heifers reared at Holetta Agricultural Research Centre (HARC) with their contemporaries distributed to smallholders (SH) in Walmara district. The experimental animals were born during 2010 to 2013 at HARC and distributed within the same time frame. Fifty two SH (42 male and 10 female) purposively identified were involved in the on-farm study. The overall least squares mean of age at first calving (AFC) was 37.7 months while that of on-farm and on-station were 42.09 ± 1.04 and 33.55 ± 1.01 months, respectively. The AFC of crossbred heifers reared on-farm was delayed by 9 months compared to the on-station result ($p<0.001$). The overall daily milk yield (DMY) was 9.5, 7 and 4.5 kg at early, mid and late lactations, respectively. The average on-farm daily milk yield was 9.67 ± 0.18, 7.3 ± 0.16, and 5.49 ± 0.17 kg while that of the on-station result was 9.30 ± 0.17, 6.7± 0.15 and 4.13 ± 0.16 kg respectively, during early, mid and late lactations. The milk yield of crossbred heifers did not show significant difference between on-farm and on-station during the early stage of lactation ($p = 0.1446$). However, there was about 8.2% to 23.5% higher milk yield ($p<0.001$) under on-farm condition from mid to late lactation, which may be attributed to better management by farmers in order to maximize their benefit from milk. The initial body condition score (BC) of heifers was 3.29 which was closer to the on station value (3.49). Loss of BC after calving (2.82±0.09) is a reflection of level of management. This study showed that first calving of crossbred heifers was more delayed under the management of SH compared to those managed on-station. This results in longer periods to bring the heifers into production (calf, milk) at smallholder's level of management. Hence, it can be inferred that sending young crossbred heifers to SHs at earlier ages (< 18 months) as technology transfer scheme is less desirable.

Key words: Crossbred heifer, smallholder farmers, technology transfer

Introduction

Potential for dairy development in Ethiopia could be expressed by large cattle population, favorable climate conditions for improved dairy cows, and the relatively less disease occurrence for dairy production. Dairy development in Ethiopia has a considerable advantage for smallholder income generation which can contribute significantly to food security and poverty reduction. Reviews on the development of dairy sector in Ethiopia shows that there is a need to focus on integration of crossbred dairy to the smallholder sector through improving their access to improved technology (Hiskiyas and Tsehay, 1995; Amanuel and Tesfahun, 2006; Azage et al., 2010). Dairy technology transfer and dissemination in Ethiopia has lagged behind due to various reasons including limited number of exotic breeds and their crosses, high cost of dairy inputs combined with poor livestock extension system in the country. Mulugeta and Belayeneh (2013) suggested the need for attention to be given to strong extension service and training of farmers in breeding, feeding, health care, and housing as intervention measures in order to exploit the potential of dairy cattle by improving the lactation performances.

The number of highly productive exotic breeds (0.13%) and their crosses with local breeds (0.64%) that currently exist does not even reach 1% of the total cattle population of the country (CSA, 2011). Reports before ten years confirm similar data indicating that closer to half a million heads of cattle in Ethiopia is exotic or crossbred dairy cows (Muriuki and Thorpe, 2001).

Dairy development projects implemented in Ethiopia in minimum package program (MPP, 1972-1980) was aimed to raise the income and agricultural output of smallholder farmers with minimum reliance on scarce resources. The project has dealt with distribution of crossbred heifers, bull and AI service to selected farmers almost all over the country except the lowlands. However, it did not succeed to establish sustainable improved dairy production system in the country.

Searching for proven technologies and management options with the smallholder dairy farmers can have contributions in realizing increased supply of crossbred dairy cows in the country. Accelerated heifer rearing method can be applied to bring heifers to early puberty for milk production and improved reproduction performances. Various management options can be used to improve and maintain post weaning management level for better daily growth rate until early puberty is reached. Studies made in Ethiopia have proved that heifers fed on diet with high concentrate to roughage ratio came in heat earlier than those fed on diets with lower concentrate to roughage supplementation ratio.

Age at first heat of crossbred heifers have reached 14.7 to 17.86 months by ensuring the level of concentrate feed in the daily ration (Yohannes et al., 2010). Similarly, heifers that had 1 kg of concentrate supplement per day in addition to grazing and 2 kg of hay showed estrus at a younger age than those that had only 2 kg of hay supplement in addition to grazing. The objective of this study was therefore to compare the performances of crossbred heifers distributed to smallholders at younger age with the ones managed at on station conditions in high dairy potential areas in the central highlands of Ethiopia.

Materials and Methods

Study site selection

This study was conducted in Walmara district at selected villages around Holetta Agricultural Research Centre (HARC) which is located 30 km west of Addis Ababa, Ethiopia. The study area is located at 3°24'N to 14°53'N and 33°00'E to 48°00'E with an average altitude of 2400 masl; annual rainfall of 1100mm; and average minimum and maximum temperatures of 6°C, 24°C, respectively. The area experiences two major seasons, the wet season (June to September) and the dry season (October to May). A total of seventy two smallholder farmers selected from five villages in the vicinity of HARC were initially considered. Preliminary field visits were made by a team of researchers to locate the specific sites. Purposive sampling technique was used to select study sites considering accessibility for monitoring and data collections and willingness of the farmers to participate in the verification of the technology.

Animals and management at on farm and on station

On station management: Recommendations were made from research centre to realize different management options for dairy cattle production and management in the highlands (Zelalem et al., 2006; Yohannes et al., 2007). During the pre-weaning period, all F_1 crossbred calves produced from Boran dam breeds were allowed to suckle freely and are weaned at approximately 6 months of age. Heifers were left to grazing from early morning (8:00 AM) to 4:00 PM in the afternoon and are fed with natural pasture hay as required at night. After weaning, they are fed on hay free choice and are supplemented with concentrate, based on body weight change as already recommended until the age of 9 months. Concentrate mixture composed of wheat middling (32%), wheat bran (32%), noug (*Guizocia abyssinica*) cake (34%), and salt (2%) was supplemented to the heifers based on their body weight changes. Prior to distribution to smallholder farmers, the heifer claves attained 9 months of age and weighed between 90 to 110 kg.

On farm management: At on farm, heifer calves were expected to be managed with the farmer as recommended and guided during the trainings. However, farmers use all possible means of supplementations and native grass hay, wheat, barley and teff straws for their cows and heifers. In most cases participant farmers use different improved forage crops (mainly of oats/vetch mixture). Moreover, almost all farmers use native grass hay. Some farmers use easily available concentrate feeds like wheat bran and noug cake. However, many farmers refrain from using concentrates because of its high cost. The farmers were properly oriented with the basic principles and necessary requirements including feed production and utilization, housing, health care and product handling before introduction of the heifers.

Packages

The comparison trial constitutes full packages of young crossbred heifers reared with appropriate breeding methods and managed under on station improved management conditions before distribution. Feeds and feedings incorporating forage development and animal health management practices were also employed.

Farmer selection

Fifty two enlightened farmers were selected purposively with full participations of the district agricultural offices, researchers and development agents based on resource ownership (land, feed etc), physical accessibility (both for market and monitoring) and ability to keep records at household level.

Trainings

Farmers were trained on all aspects of heifer management practices, including estrus detection, feeding, husbandry practices, health management and related reproductive management systems prior to distribution of the heifers. Moreover, the farmers had exposure to management practices related to previous on station recommendations.

Table 1. Number and status of heifers used for the trial at 6 sites

Site	Status and number of heifers				
	Distributed	Calved	Still open	Died	sterile
Guntuta	10	8	2	0	0
Galgal	12	6	5	1	0
Walmara	10	6	0	3	1
Mada gudina	3	3	0	0	0
Bshan Dimo	13	11	0	1	1
Saadmo	4	3	0	1	0
Total	**52**	**37**	**7**	**6**	**2**

Note: - A total of 153 F_1 (50%) crossbred heifers were born and maintained at on station contemporary to those distributed to the smallholders. Out of those heifers, 37 were randomly picked and used for comparison with the ones managed under smallholders management

Data collection

- Heifers' body condition once in three months (in wet and dry seasons)
- Reproduction data (service date, PD and calving date)
- Age at first calving
- Milk production in early, mid and late lactation periods

Statistical Analysis

Data collected on milk yield (DMY), age at first calving (AFC) and body condition (BC), were subjected to statistical analysis using the General Linear Model (GLM) procedure of the

Statistical Analysis System (SAS, 2002). The independent variables considered in the study include AFC, DMY and BC both on farm and on station.

Results

Age at first calving

The overall least square means (LSM) of age at 1st calving (AFC) was 37.7 months in the present study (Table 2). The LSM for age at first calving at smallholder (on farm) condition was 42.09 ± 1.04 months, while the age at first calving during the same period under on-station management was 33.55 ± 1.01 months. In previous study, AFC was attained at an earlier age of 28 months (Figure 1). Significantly ($p < 0.001$) more prolonged age at first calving was recorded under smallholder management level. Young heifers distributed to farmers for evaluation had eight and half (8.54) months delay in age at first calving than those managed on-station during the same period.

Replacement pure bred heifers should be bred to calve at 24 months of age in order to maximize lifetime productivity of breeding stocks. For heifers to achieve puberty at earlier age, adequate nutrition is required to provide better rates of gain such that heifers can achieve a critical body weight prior to achieving puberty. In general, the on-station study showed that underfeeding results in prolonged age at first calving.

Table 2. Least square means ± se ± se of age at forst calving for crossbred heifers on-farm and on-station

Treatments	N	Age at first calving Ls means ±se
Overall	72	37.7
On-farm	35	42.09 ± 1.04 a
On-station	37	33.55 ± 1.01b

Figure 1. Age at first calving on-farm versus on-station

Milk production

Least square means of daily milk yields (DMY) recorded at on farm and on station from this study are presented in Table 3. The daily milk yield at on farm and on station did not significantly vary ($p > 0.05$). However, better daily milk yield was obtained during early lactation stage at on farm (9.67± 0.18 kg) than at on station (9.30 ± 0.17 kg).The data for milk production did not take into account the amount supplied to calves during each milking. Most smallholder farmers in the study area use partial suckling methods during milking, while very few farmers practice bucket feeding of calves.

Table 3. Least square means ± se of daily milk yield (kg) of crossbred heifers under on farm and on station management

Treatments	N	Lactation stage		
		Early lactation	Mid lactation	Late lactation
Overall	72	9.47	6.99	4.67
On farm	35	9.67± 0.18	7.3±0.16	5.49 ±0.17 [a]
On station	37	9.30 ± 0.17	6.7± 0.15	4.13 ± 0.16 [b]
P value		0.1446	0.0108	0.0001

Body condition scores of crossbred heifers under smallholders' management

Least square means and standard errors (LSM± se) of body condition scores of heifers at initial and subsequent quarters of the year for animals that are kept and fed under shade during most of their time (better managed group) and those that are sent out for grazing with other herd (poorly managed group) under on farm condition is presented in Table 4.

Table 4. Body conditions of heifers from distribution to early calving at smallholders` management

Scoring Interval	Overall	Better managed group BCS (N=27)	Poorly managed group BCS (N=25)
At Initial score	3.29	3.49 ±0.14a	3.10±0.15a
After 3 -6 months	3.15	3.29 ±0.83a	3.01±0.85a
After 6 - 9 months	3.4	3.47±0.10a	3.22±0.11a
After 9 – 12 months	3.39	3.61±0.10a	3.17±0.11b
After > 12 months	3.39	3.67±0.12a	3.11±0.13b
After calving	3.30	3.27±0.09a	2.82±0.09b

The overall BC sore of crossbred heifers was 3.29 (ranging from 3.10 ± 0.15 to 3.49 ± 0.14) during initial stages of distribution. The conditions of the two groups were maintained under similar BC from initial stage to 9 months ($p>0.05$). A significant change in BC score has appeared after the heifers have stayed with the farmer from 9 months onwards. Better body condition scores were observed with the farmers who kept their heifer separately around the homestead with concentrate supplementation.

Figure 2. F_1 Crossbred heifer calved at smallholder farms

Discussion

The ultimate goal of heifer rearing is to economically raise the heifers to bring them to proper weight (size) and body condition for first service and calving at earlier age. The current management level being practiced at the smallholders and even at on station condition needs further improvement. Nutritional manipulation of crossbred dairy heifers in the post-weaning period at HARC (on station management) accelerated the growth rate and improved reproductive performance of the heifers enabling them to calve at the age of less than 30 months (27 to 29 months) (Yohannes et al., 2010).

Early reproductive performances of crossbred heifers at the smallholder level of management seem to delay more than expected. Even though no adequate information was generated on some reproduction performances of crossbred heifers at farmers' management, comprehensive data collected at on station from Assella, Debre Zeit and Holletta showed that AFC in Holstein Frisian (HF) crosses to be 42.6 months (Million et al., 2006). In a study conducted at Metekel Ranch by Andassa Agricultural Research Centre, AFC for Fogera crosses (Fresian x Fogera) was reported to be 40.46 ± 0.93 months (Addisu et al., 2003). Data collected for the period of 30 years (1974 to 2005) at Holetta on Frisian crosses showed AFC of 43.4 ± 0.6 months (Kefena et al., 2011).

Compared to these results, early reproductive performances of Frisian Boran (FB) crossbred heifers under smallholders management is prolonged (42.09 months) compared to previous on station result (40.32 months). From the current study it could be noted that AFC did not improve at smallholders' management, rather it was delayed by 20.3% compared to the on station result which is 33.55 months in the current study.

Despite the inadequacy of information on milk production under smallholders management, some data at on-farm evaluation of crossbred dairy cattle owned by smallholder farmers around Holetta, Debre Zeit, Arsi and Bako previously indicated that the level of milk production of crossbred cows was lower than that of on-station yield even under improved management (Gryseels and De Boodt, 1986; Kiwuwa et al., 1983; Tesfaye, 1993). This might be due to low awareness that the farmers had in the past than the present scenario.

The current result of DMY (9.67± 0.18 kg) at on farm is better than the figure reported by Million et al., 2010 in central highlands of Ethiopia. The authors reported a lactation milk yield of 2520 litters in 321 lactation length (LL) which equates to 7.85 kg/day. It could be noted that in the central highlands of Ethiopia, because of the favorable environmental and climatic conditions, selected crossbred cows can continue to out-yield earlier crosses provided that appropriate husbandry practices and technological supports, trainings and other interventions are made.

Body condition score is a management tool that can be used to evaluate the nutritional status of an animal. It indicates the energy reserves of calf, heifer and cow, as a vital indicator of excessive loss of weight while the animal is under considerable nutritional pressures to influence subsequent reproductive and growth performance.

Conclusion and Recommendations

The study revealed that the AFC of heifers under farmers' management was delayed by 9 months compapred to those managed on-station (42 vs 33.6 months). Delayed AFC has negative economic impact on the smallholder gains from production of calves and milk at earlier age, and subsequent contribution for genetic improvement. For smallholder farmers to keep profitable crossbred heifers, provision of improved management practices, sustainable inputs (feed, health care, AI delivery system etc), workable extension services and farmers training are important requirements. It was, therefore, concluded that sending young crossbred heifers to smallholders during their active growing periods (< 18 months) may not be desirable as it takes longer periods to bring the heifers into production (calf, milk) under such management. Hence, beginner farmers should be well trained and evaluated for their preparedness to ensure that they could properly deal with dairy technology. Moreover, it is more feasible to distribute heifers with confirmed pregnancy to smallholders than distributing under age heifers.

Acknowledgements

The authors are grateful to Ethiopian Institute of Agricultural Research (EIAR) for the support provided to undertake this activity. We are also thankful to the management of Holetta Agricultural Research Centre (HARC) for the continued support in providing transportation facility and support in training farmers and development workers. We would like to extend our thanks to the key stakeholders including farmers and district Agriculture offices for their continued cooperation in providing information and working with us.

References

Addisu Bitew and Prabhakar Hagde. 2003. Reproductive and growth performance of Fogera cattle and their F1 Friesian crosses at Metekel ranch, Ethiopia. In: Challenges and opportunities of livestock marketing in Ethiopia. Proceedings of the 10th annual conference of the Ethiopian Society of Animal Production, held in Addis Ababa, Ethiopia, 22-24 Aug 2002. Ethiopian Society of Animal Production, Addis Ababa (Ethiopia) ESAP, pp111-117.

Amanuel Assefa and Tesfahun Fenta. 2006. Harnessing local and outsiders' knowledge: Experiences of multi-stakeholder partnership to promote farmer innovation in Ethiopia. PROLINNOVA working paper 12 http://www.prolinnova.net/ethiopia/WP12 Accessed on 20 Nov 2012.

Azage Tegegne, Brhanu Gebremedhin and Hoekstra, D. 2010. Livestock input supply and service provision in Ethiopia: challenges and opportunities for market-oriented development. IPMS Working Paper 20, Nairobi (Kenya).

Central Statistical Agency- Ethiopia. 2011. Agricultural sample survey 2010/11. Volume II Report on livestock and livestock characteristics.

Gryseels G and de Boodt K. 1986. Integration of crossbred cows (Boran and Friesian) on smallholder farms in the Debre Zeit area of the Ethiopian highlands. ILCA Highlands Programme Report, ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Kiwuwa, G. H., J.C.M. Trail, M. Y. Kurtu, G. Worku, F.M. Anderson and J Durkin. 1983. Crossbred dairy cattle productivity in Arsi Region, Ethiopia. International Livestock Center for Africa (ILCA) Research report No. 11, PP. 1-29.

Hiskiyas Ketema and Tsehay Reda. 1995. Dairy production system in Ethiopia. In: strategies for market orientation of small scale milk producers and their organizations. FAO (Food and Agricultural Organization of the United Nation). Proceeding of the workshop held at 20 - 24th march, Morogoro, Tanzania, Pp 125.

Kefena Effa, Zewde Wondatir, Tadelle Dessie and Aynalem Haile. 2011. Genetic and Environmental trends in long-term dairy cattle genetic improvement programs in the central tropical highlands of Ethiopia. Journal of Cell and Animal Biology Vol. 5 (6) Pp. 96 – 104.

Mulugeta Ayalew and Belayeneh Asefa. 2013. Reproductive and lactation performances of dairy cows in Chacha Town and nearby selected kebeles, North Shoa Zone, Amhara Region, Ethiopia. World Journal of Agricultural Sciences Vol. 1(1), pp. 008-017, February 2013 Available online at http://wsrjournals.org/journal/wjas

Million Tadesse, Tadelle Dassie, Gifawesen Tesema, Tamirat Degefa and Yohannes Gojjam. 2006. Study on Age at first Calving, Calving Interval and Breeding Efficiency of Bos Taurus, Bos indicus and their Crosses in the Highlands of Ethiopia. Ethiopian Journal of Animal production Vol. 6 (2) pp 1 – 16, 2006.

Million Tadesse, Thiengtham J, Pinyopummin A and Prasanpanich S. 2010. Productive and reproductive performance of Holstein Friesian dairy cows in Ethiopia. Livestock Research for Rural Development Volume 22, Article #34 Retrieved May 26, 2017, from http://www.lrrd.org/lrrd22/2/tade22034.htm

Muriuki, H.G. and Thorpe, W,. 2001. Smallholder dairy production and marketing in Eastern and Southern Africa. In the Proceedings of the South & South Workshop on Smallholder Dairy Production and Marketing & Constraints and Opportunities. March 12 & 16 Annand, India.

SAS, 2002. Statistical Analysis System, version 9.0, SAS Institute, Inc., Cary, NC, USA.

Tesfaye Kumsa. 1993. Smallholder dairy in Ethiopia. In: Kategile J A and Mubi S (eds). 1992. *Future of livestock industries in East and southern Africa*. Proceedings of a workshop held at Kadoma Ranch Hotel, Zimbabwe, 20-23 July 1992. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 227 pp.

Yohannes Gojjam, Seyoum Bediye, Adugna Tolera and Rehrahe Mesfin. 2007. Performance of Borana and Crossbred Cows fed a Basal diet of Native grass hay Supplemented with Different Protein Source Concentrate feeds. Animal production Research Animal production research Advances 3 (3): 174 – 180.

Yohannes Gojjam, Adugna Tolera and Reherahie Mesfin. 2010. Management options to accelerate growth rate and reduce age at first calving in Friesian–Boran crossbred heifers; Tropical animal Health and Production, 43:393–399.

Zelalem Yilma, Yohannes Gojjam and Mola Shumye. 2006. Milk production level and calf-rearing system affecting Boran, Ethiopian zebu cattle breed, cow-calf performance. *Livestock Research for Rural Development Volume 18, Article #71* Retrieved May 26, 2017, from http://www.lrrd.org/lrrd18/5/yilm18071.htm

Ewe Body Condition Determines Oestrus Response to Hormonal Oestrus Synchronization in Smallholders Village Flocks

Debir Legesse[1], Yosef Mekasha[2], Sunkurta Digessa[1], Tesfaye Wechage[2], Bereket Zeleke[1], Solomon Gizaw[2] and Azage Tegegne[2].

[1]South Agricultural Research Institute, Hawassa Agricultural Research Center, Hawassa, Ethiopia
[2]International Livestock Research Institute, Addis Ababa, Ethiopia.

Abstract

The objective of this study was to investigate the effects of ewe associated factors on hormonal oestrus synchronization in village sheep flocks in Sidama zone, Southern Ethiopia. Initially, for synchronization fifty-five Sidama ewes were selected and checked for pregnancy status using pregnancy diagnosis device (Preg-Tone). The ewes were injected with a single shot of $PGF_2\alpha$ (Lutalyse®) hormone at the rate of 2.5 ml per ewe. Thirty-eight of the 55 ewes treated with hormone showed oestrous signs. The ewes were then joined with active selected four breeding rams for four consecutive days. Oestrous response and conception rates were analyzed using multinomial logistic regression model. The overall oestrous response rate and conception rate were 69.1% and 89.2%, respectively. The average time to onset of oestrus was 54.1 hrs, ranging from 19.1 to 97.5 hrs. Neither ewe body weight (P = 0.902), age (P = 0.127) nor parity (P = 0.968-0.084) had significant effect on the oestrus response rate of ewes to hormonal oestrus synchronization. The only significant factor determining oestrus response was ewe body condition. Ewes with body condition score of 2.5 and below were significantly more likely not to respond to hormonal treatment (odds ratio = 2.15E-09, P = 0.000) compared to ewes with body condition score of 3.0. However, none of the factors studied (body condition, body weight, age and parity of the ewe) affected the time of onset of estrus after hormone administration and conception rate. It could be concluded that body condition, regardless of the other ewe associated factors (i.e. body weight, age and parity), dictates oestrus response of ewes to hormonal treatment in synchronization of oestrous cycles in village ewe flocks. It is thus imperative to pay attention to nutrition of ewes for successful synchronized breeding in villages where supplementary feeding is rarely practiced.

Key words: *Synchronization, oestrous response, body condition, sheep, Sidama*

Introduction

In traditional uncontrolled continuous mating systems under smallholder small ruminant farming systems, lambing is commonly distributed throughout the year, with only a small proportion (13% to 15%) of the lambings occurring in a peak lambing season during the favorable rainy season in Ethiopia (Legesse, 2008) and elsewhere (Setiadi *et al*., 1995). Flock performance is negatively affected if lambing/kidding do not match with appropriate seasons in terms of feed availability and disease load. Year-round dispersed lambings has also been found to limit village-based genetic improvement efforts since only a few selection candidates would be available in each round of selection resulting in low selection intensity (Gizaw *et al*., 2014).

Hormonal oestrus synchronization has been introduced in Ethiopia to accelerate delivery of improved dairy genetics (Tegegne *et al*., 2012) and its application in small ruminant breeding has been under investigation (Zeleke, 2009; Zelelke *et al*., 2016). However, Oestrus responses to hormonal synchronization ranging from 65 to 100% have been reported for Ethiopian sheep breeds (Zeleke 2009; Zeleke *et al*. 2016) and from 4.3– 100% for village flocks elsewhere depending on the synchronization protocol (Omontese *et al*. 2016). Oestrus response is also affected by various ewe associated factors such as body condition, age, body weight and parity and as well as environmental stresses (Santoralia *et al*., 2011). These factors could be confounded and there is a need to single out the predominant factor determining the success of oestrus synchronization under village conditions. This study investigates the effects of ewe-associated factors on hormonal oestrus synchronization and to introduce pregnancy diagnosis device (Preg-Tone) for early stage of pregnancy in village sheep flocks in Sidama zone of Southern Region, Ethiopia.

Materials and Methods

Study area

The study was conducted at Bensa woreda of Sidama zone, Ethiopia. Sidama is one of the zones in Southern Nations and Nationalities and Peoples' Region (SNNPR). The capital is Hawass town located 275 km south of Addis Abeba. Sidama zone is located at $5^0 45'$ and $6^0 45'$ N latitude and $38^0 39'$ and $38^0 29'$ E longitude. It has highlands, midlands and semi-dry lowlands agro-ecologies accounting for 30%, 60% and 10% of the area, respectively. The farming system of the zone is characterized as mixed farming system. Among the three agro-ecological zones, this study was conducted only in high land parts of Bensa *woreda*[1].

Study animals

The study animal belonged to a cooperative village sheep breeding groups. Through discussion with the farmers, 55 ewes were selected for the study. Prior to synchronization the ewe flocks were checked for their pregnancy status using an ultrasound pregnancy diagnosis device (Preg-Tone®). The selected ewes were 16 to 36 months of age with 1-3 parity level and weighing 18-34 kg. The ewes were scored for their body condition on a 1-5 scale (1=thin/emaciated; 2= thin/poor; 3= acceptable; 4= fat; 5=very fat) following Srinivas (2013). Experimental breeding ewes and rams were used from the same location. A total of four mature active rams with similar age and BCS and which has higher body weight were subjected for 38 ewes which have responded oestrus. Thus, the two rams were allocated for 19 ewes and the rest two rams were used for 19 ewes.

Oestrous synchronization and mating

A single shot of $PGF_2\alpha$ (Lutalyse®) hormone was administered at the rate of 2.5 ml per ewe. Synchronization was carried out in to two cluster (FTC and village level), but mating was made at their nearest village where rams are placed. Following synchronization, the ewes were then joined with active selected mature and similar age group rams for four consecutive days from 8:00 am to 6:00 pm. After 6:00 pm the ewes were returned back to their home. Mating time (estrus) of each ewe was observed by the sheepherders and rams also detect ewes heat. When the rams are mounting the ewe doesn't move, indicating ewe's status of heat. The breeding rams were flushed 400 gm of concentrate feed once daily for a month so as to increase libido. Selected ewes were managed according to the farmers' practice with no special feeding or any other management intervention throughout the study period. Preventive treatment was administrated against internal parasites. Sixty days post-joining ewe pregnancy status was diagnosed using Preg-Tone®.

[1] *woreda* is the lowest administrative level equivalent to district.

Statistical analysis

Oestrous response and conception rates were analyzed using multinomial logistic regression analysis and SPSS version 20 (2011) was employed for the analysis. Oestrous response and conception rates were modeled as dependent variable. Parity as categorical and body condition score, body weight and age were considered as as continuous independent variables. For the dependent variables, there exist two continuous variables Z_k (Z_1 and Z_2) each of which can be thought of as the likelihood of oestrus response and conception, with larger values of Z_k corresponding to greater probabilities of oestrous response or conception. Mathematically, the relationship between the Z's and the probability of a particular outcome is described in the formula: $\pi_{ik} = (ez_{ik}) / (ez_{i1} + ez_{i2} + ... + ez_{ik})$, where π_{ik} is the probability the i_{th} ewe falls in category k and z_{ik} is the value of the k_{th} unobserved continuous variable for the i_{th} ewe. Time of onset of response was analyzed fitting body condition score and parity as categorical and body weight and age as continuous independent variables in a general linear model.

Results and Discussion

Oestrus response and conception rate

Thirty-eight of the 55 ewes treated with hormone showed oestrous signs, resulting in oestrous response rate of 69.1% (Table 1). This could be considered a moderate response compared to oestrous an average response rate of 76.5% achieved in four local breeds (Gizaw *et al*., 2016), ranging from 93.2% in the Horro type sheep to 57.5% in the Atsbi sheep type. Similarly, Zeleke (2016) reported 55–65% oestrous response rate for the local Ethiopian Menz and Awassi-Menz crossbred sheep. Oestrous response varies significantly across experiments due to variation in ewe factors, breed differences, age, environments and managements. Omontese *et al* (2016) reported response rates ranging between 20 and 100% for Nigerian goat breeds. The average time of onset of oestrus after hormone administration in the current study was 54.1 hrs ranging from 19.1 to 97.5 hrs (Table 1). The percentage of ewes showing oestrus within 72 hrs was 74.5% (Fig. 1), which was close to the average 76.5% reported for four Ethiopian sheep breeds (Gizaw *et al*., 2016).

Table 1. Estrus response, onset of response and conception rate of ewes treated with Lutylaze hormone

Variables	No. of ewes synchronized	No. of ewes responded	Oestrus response (%)	Time to onset of oestrus (hrs.)	Conception (%)
Overall	55	38	69.1	54.1±3.5	89.2
Parity					
First	18	16	88.89	59.7±5.7	87.50
Second	23	13	56.52	50.1±4.9	92.85
Third	14	9	64.28	49.5±7.9	77.78
Body condition score					
2.0	23	12	56.5	53.3±6.8	75.0
2.5	18	11	61.1	57.6±4.5	90.9
3.0	14	14	100	52.1±6.6	100.0

Pregnancy diagnosis using ultra sound detector confirmed that 34 (89.4%) of the 38 ewes that showed oestrus signs and joined with rams were pregnant. This conception rate could be considered high given conception rates following artificially induced oestrus is usually reported to be low. For instance, Kumar *et al*. (2016) reported low conception rates in three hormonal oestrus induction protocols (37.5%, 53.3 and 56.3%) compared to the oestrus response achieved (81.3%, 100%, and 93.7%). On the other hand, Cairoli *et al*., (2006) reported similar conception rates between cows inseminated after induced-oestrus and spontaneous oestrus (59% vs 54.5%).

The anestrous ewes that did not respond to hormone treatment were also run with the ewes that showed oestrous during the mating period. The percentage of the anoestrus ewes that started to cycle and conceived during the mating period was only 5.9%. Effect of ram exposure is known to affect oestrus behavior (Nugent *et al*., 1988), but the ram effect is more effective with sudden introduction of rams and when ewes have had no contact with rams for a period of time, which was not the case in the current study.

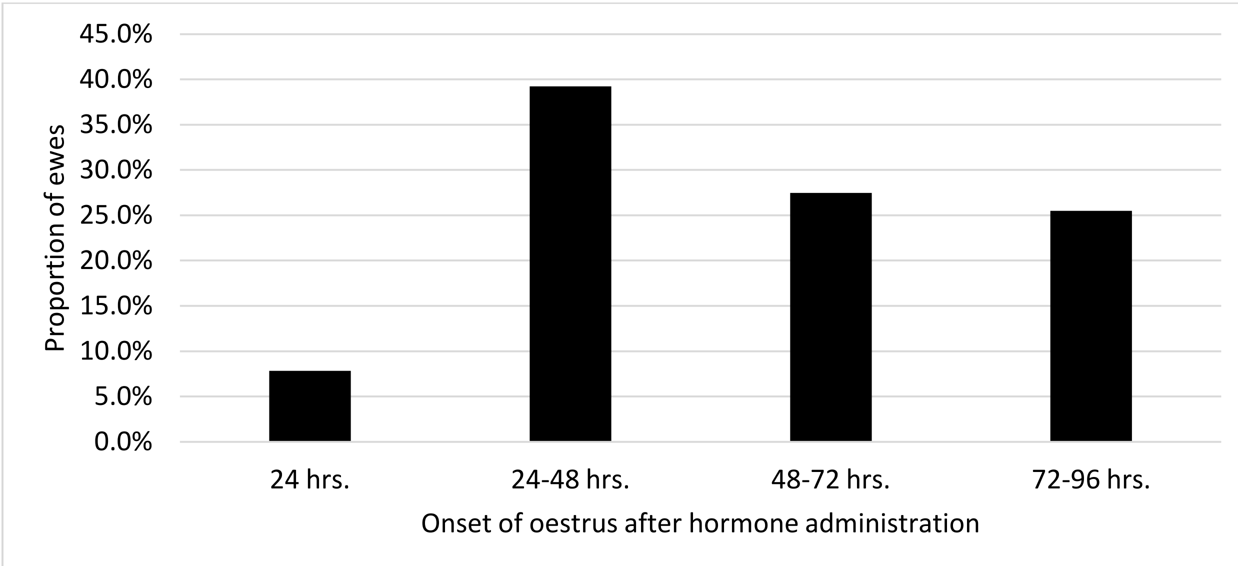

Fig. 1 Distribution of onset of oestrus in hours after Lutylaze hormone administration

Determinants of oestrous response, onset of oestrus and conception rate

Neither ewe body weight (*P* = 0.902), age (*P* = 0.127) nor parity (*P* = 0.968-0.084) had significant effect on the oestrus response rate of ewes to hormonal oestrus synchronization (Table 2). However, there are some reports (Véliz *et al*., 2009; Ungerfeld and Sanchez-Davila, 2012) where parity showed significant influence on oestrus response, though not on pregnancy rate, a unit increase in body weight resulted in an increase of 14.7% in oestrus response (Gizaw *et al*., 2016), and heavier goats showed more oestrus response and shorter time to onset of oestrus than lighter goats (Véliz *et al*., 2006).

However, the studies reporting significant effects of parity and body weight (Véliz *et al*., 2006; Véliz *et al*., 2009; Ungerfeld and Sanchez-Davila, 2012) did not include the effects of body condition in their analysis models. In the current study the effects of ewe parity, body weight, age and body conditions were investigated in a multivariate model. The results showed that the only significant factor determining oestrus response was ewe body condition (Table 2). Ewes with body condition score of 2.5 and below were significantly more likely not to respond to hormonal treatment (odds ratio = 2.15E-09, *P* = 0.000) compared to ewes with body condition score of 3.0. This is in agreement with other studies in which the analyses models included body condition together with other ewe associated factors such as parity and body weight. In these studies, neither body weight nor age of ewes significantly influenced their fertility (Aliyari *et al*., 2012) and estrus responses were not significantly different between nulliparous, primiparous and multiparous does (Mat *et al*., 2015), whereas body condition had significant influence on oestrous responses. A similar result was reported for cattle where body condition rather than parity and age had a significant effect on oestrous response and conception (Gebrehiwot *et al*., 2015). These findings indicate that body condition is the overriding determinant of oestrous response to hormonal oestrus synchronization in ewes.

Table 2. Likelihood of oestrus response following treatment with Lutylaze hormone in ewes differing in age, body weight, body condition and parity

Variable name	Estimated coefficient (β)	Std. error	P value	Odds ratio (exp *B*)
Intercept	23.734	3.119	0.000	
Age (months)	-0.104	0.068	0.127	0.902
Weight (kg)	0.012	0.095	0.902	1.012
Body condition score 2.0	-19.957	0.764	0.000	2.15E-09
Body condition score 2.5	-19.635	0	.	2.97E-09
Body condition score 3.0	0[b]	.	.	.
Parity 1	-0.047	1.19	0.968	0.954
Parity 2	-1.565	0.905	0.084	0.209
Parity 3	0[b]	.	.	.

a. The reference category is ‘no oestrous response’. b. This parameter is set to zero because it is redundant.

Both the current and previous findings indicate that a body condition score of 3.0 results in maximum oestrous response to hormonal oestrous synchronization. Mat *et al.* (2015) found oestrous response rates of 0%, 77.8% and 0% in ewes with body condition scores of <2.0, 2.5-4.0 and >4.0, respectively. Aliyari *et al.* (2012) reported a normal oestrous cycle in ewes with body condition score of 3, whereas ewes with body condition score of 2 and 2.5 showed shorter and irregular oestrous cycle duration. Body condition scores of 2.5 to 3.0 have been recommended by some authors (Husein & Ababneh, 2008; Contreras-Solis, *et al*., 2009).

Body condition directly affects hypothalamic activity and GnRH secretion and effects on reproductive performance are mediated through changes in ovarian hormones or in hypothalamo-pituitary sensitivity to ovarian hormones (Rhind, *et al*., 1989) and the impact of body condition was quantified to reach as high as a 2.4-fold increase in pregnancy loss for a unit reduction in condition score (López-Gatius *et al*., 2002).

None of the factors studied in the present study (body condition, body weight, age or parity of the ewe) affected the time of onset of estrus after hormone administration and conception rate (Table 3). Similarly, Mat *et al*. (2015) reported a non-significant influence of body condition on pregnancy rate and time of onset of oestrus. However, in some cases the effect of body condition could be expressed in lower pregnancy rate (Maqhashu *et al.,* 2016) and feed restriction, through its effect on body condition, could delay onset of oestrus (Mani *et al.,* 1992). These difference among different studies could be the availability of flush feeding for ewes response in synchronization and conception; age of ewe, body condition, parity, breed type, ewe factors and environmental conditions.

Table 3 Likelihood of conception of hormonally-induced ewes differing in age, body weight, body condition, parity and differences in time of onset of oestrus after hormone treatment.

	Conception rate			Onset of oestrus (hr)		
	B	Sig.	Exp(*B*)	*B*	Sig.	Exp(*B*)
Intercept	221.71	0.977		28.35	0.467	
Age (months)	-5.628	.	0.004	0.868	0.263	2.383
Weight (kg)	-0.062	0.780	0.940	-0.401	0.675	0.67
Body condition score 2.0	-18.177	0.998	1.28E-08	-0.596	0.943	0.551
Body condition score 2.5	0.496	1.000	1.642	7.966	0.362	2881.99
Body condition score 3.0	0 [b]	.	.	0 [b]	.	1.000
Parity 1	-47.791	0.995	1.76E-21	18.734	0.115	1.37E+08
Parity 2	6.973	0.999	1067.764	5.327	0.625	205.744
Parity 3	0 [b]	.	.	0 [b]	.	1.000

a. The reference category is no conception, b. This parameter is set to zero because it is redundant.

Conclusion

It could be concluded that body condition, regardless of the other ewe associated factors (i.e. body weight, age and parity), dictates oestrus response of ewes to hormonal treatment in synchronization of oestrous cycles in village ewe flocks. It is thus imperative to pay attention to nutrition of ewes for successful synchronized breeding in villages where supplementary feeding is rarely practiced.

Acknowledgement

This study was financially and technically supported by the Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) project of the International Livestock Research Institute (ILRI). LIVES project is financed by Global Affairs Canada (GAC). Hawassa Agricultural Research Center and Bensa woreda Livestock and Fishery Development Office are duly acknowledged for their facilitation and support during the field work.

References

Aliyari, D., Moeini, M. M., Shahir, M. H. & Sirjani, M. A. (2012). Effect of body condition score, live weight and age on reproductive performance of Afshari ewes. *Asian Journal of Animal and veterinary Advances*, 7, 904-909.

Cairoli, F., Mollo, A., Veronesi, M. C., Renaville, B., Faustini, M. & Battocchio, M. (2006). Comparison between cloprostenol-induced and spontaneous oestrus fertility in dairy cows. *Reprod Domest Anim.*, 41, 175-9.

Contreras-Solis, I., Vasquez, B., Diaz, T., Letelier, C., Lopez-Sebastian, A. & Gonzalez-Bulnes, A. (2009). Efficiency of estrous synchronization in tropical sheep by combining short-interval cloprostenol-based protocols and "male effect". *Theriogenology*, 71, 1018-1025.

Gebrehiwot, G., Gebrekidan, B. & Weldegebriall, B. (2015). The Effect of One Shot Prostaglandin on Estrus Synchronization of Local and Holstein Friesian Cattle in and around Wukro Kilte Awulaelo District, Northern Ethiopia. *Journal of Biology, Agriculture and Healthcare,* 5, 99-105.

Gizaw, S., Getachew, T., Goshme, S., Valle-Zárate, A., van Arendonk, J. A. M., Kemp, S. S., Mwai, A. O. & Dessie, T. (2014). Efficiency of selection for body weight in a cooperative 2 village breeding program of Menz sheep under smallholder farming system. *Animal,* 8, 249–1254.

Gizaw, S., Tesfay, Y., Mekasha, Y., Mekuriaw, Z., Gugsa, T., Ebro, A., Gebremedhin. B., Hoekstra, D. & Tegegne, A. (2016). Hormonal oestrus synchronization in four sheep breeds in Ethiopia: Impacts on genetic improvement and flock productivity. LIVES Working Paper 25. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Husein, M.Q. & Ababneh, M.M. (2008). A new strategy for superior reproductive performance of ewes bred out-of-season utilizing progestagen supplement prior to withdrawal of intravaginal pessaries. *Theriogenology*, 69, 376-383.

Kumar, L, Phogat, J. B., Pandey, A. K., Phulia, S. K., Kumar, S. & Dalal, J. (2016). Estrus induction and fertility response following different treatment protocols in Murrah buffaloes under field conditions. *Veterinary World*, 9, 1466-1470.

Legesse, G. 2008. Productive and Economic Performance of Small Ruminants in Two Production systems in the highlands of Ethiopia. PhD thesis, Gottingen. Light, J.E., Silvia, W.J. and Reid, R.C. 1994. Luteolytic effect of prostaglandin-f2-alpha and 2 metabolites in ewes. *Journal of Animal Science,* 2718–2721.

López-Gatius, F., Santolaria, P., Yániz, J., Rutllant, J. & López-Béjar, M. (2002). Factors affecting pregnancy loss from gestation day 38 to 90 in lactating dairy cows from a single herd. *Anim. Reprod*. Sci., 57, 1251–1261.

Maqhashu, A., Mphaphathi, M. L., Seshoka, M. M., Ramukhithi, F. V., Seolwana, F. L., Masenya, M. B., Netshirovha, T. R., Mapeka, M. H., Nengovhela, N. B., Kanuya, N. L., Muchenje & V., Nedambale, T. L. 2016. Comparison of oestrous synchronization response and pregnancy rate of village cows following timed artificial insemination in kwazulu-Natal and Limpopo Provinces. *Open Journal of Animal Sciences*, 6, 9-15.

Mani, A.U., McKelvey, W.A.C. & Watson, E.D. (1992). The effects of low level of feeding on response to synchronization of estrus, ovulation rate and embryo loss in goats. *Theriogenology,* 38*,* 1013-1022.

Mat, K.B., Panadi, M.B., Victor, S.S., Rusli, N.D., Hasnita, C.H. & Fuad, I.S.A. (2015). Preliminary Study on Influence of Parity and Body Condition Score (BCS) on Estrus Response and Conception Rate of Saanen-Cross by Estrus Synchronization with CIDR. *Advances in Environmental Biology*, 9, 307-316.

Nugent, R. A., Notter D. R. & Beal, W. E. (1988). Effects of ewe breed and ram exposure on estrous behavior in May and June. *J Anim Sci.,* 66, 1363-70.

Omontese, B.O., Rekwot, P.I., Ate, I.U., Ayo, J.O., Kawu, M.U., Rwuaan, J.S., Nwannenna, A.I., Mustapha, R.A. & Bello, A.A. (2016). An update on oestrus synchronisation of goats in Nigeria. *Asian Pacific Journal of Reproduction*, 5, 96–101.

Rhind, S.M., McMillen, S., McKelvey, W.A.C., Rodriguezherrejon, F.F. & McNeilly, A.S. (1989). Effect of the body condition of ewes on the secretion of LH and FSH and the pituitary response to gonadotrophin-releasing hormone. *Journal of Endocrinology*, 120, 497-502.

Santolaria, P., Palacin, I. and Yániz, J. 2011. Management Factors Affecting Fertility in Sheep. In: Artificial Insemination in farm animals. http://www.intechopen.com/books/artificial-insemination-in-farm-animals/management-factors-affectingfertility-in-sheep .

Setiadi, B., Subandriyo, L.C. & Iniguez (1995). Reproductive performance of small ruminants in an outreach pilot project in West Java. *Jurnal Ilmu Ternak dan Vcteriner* 1, 73–80.

Srinivas, G. (2013). Conception Rates in Estrus Synchronized Deccani Ewes Inseminated with Fresh and Preserved Semen. Thesis, Master of Vet. Sci., Sri Venkateswara Veterinary University.

Tegegne, A., Estifanos, A., Tera, T. & Hoekstra, D. (2012). Technological options and approaches to improve smallholder access to desirable animal genetic material for dairy development: IPMS Experience with hormonal oestrus synchronization and mass insemination in Ethiopia. Paper presented at the conference on Resilience of agricultural systems against crises, Tropentag, 19–21September 2012, Göttingen.

Ungerfeld, R. & Sanchez-Davila, F. (2012). Oestrus synchronization in postpartum autumn-lambing ewes: effect of postpartum time, parity, and early weaning. *Spanish Journal of Agricultural Research*, 10, 62-68.

Véliz, F. G., Poindron, P., Malpaux, B. & Delgadillo, J. A. (2006). Positive correlation between the body weight of anestrous goats and their response to the male effect with sexually active bucks. *Reprod Nutr Dev.*, 46, 657-61.

Véliz, F.G., Meza-Herrera, C.A., De Santiago-Miramontes, M.A. , Arellano-Rodriguez, G., Leyva, C., Rivas-Muñoz, R. & Mellado, M. (2009). Effect of parity and progesterone priming on induction of reproductive function in Saanen goats by buck exposure. *Livestock Science,* 125, 261–265.

Zeleke, M. (2009). Effect of time of Pregnant Mare Serum Gonadotrophin Administration on Oestrus Synchronization Efficiency and Fertility in Blackhead Ogaden Ewes. *Ethiopian Journal of Animal Production,* 9, 135–145

Zeleke, M., Habtemariam, A., Tegegne, A. & Muluneh, D. (2016). Estrus response and fertility of Menz and crossbred ewes to single prostaglandin injection protocol. *Tropical Animal Health and Production,* 48, 53-7.

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Thesis/Dissertation

Trent, J.W. 1975. Experimental acute renal failure. Dissertation, University of California

Online document

Tekle, D., Gebru, G. and Redae, M. 2018. Growth performance of Abergelle goats fed grass hay supplemented with pigeon pea (*Cajanus cajun* (L.) Millsp) leaves. *Livestock Research for Rural Development. Volume 30, Article #149.* Retrieved August 2, 2018, from http://www.lrrd.org/lrrd30/8/desta30149.html

Cartwright, J. 2007. Big stars have weather too. IOP Publishing PhysicsWeb. http://physicsweb.org/articles/news/11/6/16/1. Accessed 26 June 2007

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Follow standard procedures.

Units

All measurements should be reported in SI units. (e.g., g, kg, m, cm)

Table 1. The following are examples of SI units for use in *EJAP*

Quantity	Application	Unit	Symbol or expression of unit
Absorption	Balance trials	Grams per day	g d^{-1}
Activity	Enzyme	Micromoles per minute per gram	μmol min^{-1} g^{-1}
Area	Land	Hectare	ha
	Carcass	Square centimetre	cm^2
Backfat	Carcass	Millimetres	mm
Concentration	Diet	Percent	%
	Blood	Gram per kilogram	g kg^{-1}
		International unites per kilogram	IU kg^{-1}
			mg dL-^{1}
		Milligram per 100 mL	Mequiv L^{-1}
		Milliequivalents per litre	
Density	Feeds	Kilogram per hectolitre	kg hL^{-1}
Flow	Digesta	Grams per day	g d^{-1}
	Blood	Milligrams per minute	mg min^{-1}
Growth rate	Animal	Kilogram per day	kg d^{-1}
		Grams per day	g d^{-1}
Intake	Animal	Kilograms per day	Kg d^{-1}
		Grams per day	g d^{-1}
		Grams per day per kg bodyweight0.75	g d^{-1} $kg^{-0.75}$
Metabolic rate	Animal	Megajoules per day	MJ d^{-1}
		Watts per kg bodyweight	W kg^{-1}
Pressure	Atmosphere	Kilopascal	KPa
Temperature	Animal	Kelvin or degree Celsius	K or ^{o}C
Volume	Solutions	Litre	L
		Millilitre	ML
Yield	Milk production	Litres per day	L d^{-1}
Radioactivity	Metabolism	Curie or Becquerel	Ci (=37 GBq)

Units with two divisors should be written with negative indices (e.g., kg ha^{-1} yr^{-1}). The use of solidus (/) should be reserved for units written in full (e.g., mole/kilogram) or to separate a physical quantity and unit (e.g., yield/ha). Units should be chosen so that the numeric component falls between 1 and 10 or 1 and 100 when using one or two significant figures, respectively (e.g., use 31.2 mg than 0.0312 g).

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Gebre Wold, A., Alemayhu, M., Tegegne, A., Zerbini,E. and Larsen, C. 1998. On-farm performance of crossbred cows used as dairy-draught in Holetta area. Proceedings of the 6th National Conference of the Ethiopian Society of Animal Production (ESAP), May 14-15, 1998, Addis Ababa, Ethiopia, pp. 232-240.

Thesis/Dissertation

Trent, J.W. 1975. Experimental acute renal failure. Dissertation, University of California

Online document

Tekle, D., Gebru, G. and Redae, M. 2018. Growth performance of Abergelle goats fed grass hay supplemented with pigeon pea (*Cajanus cajun* (L.) Millsp) leaves. *Livestock Research for Rural Development. Volume 30, Article #149.* Retrieved August 2, 2018, from http://www.lrrd.org/lrrd30/8/desta30149.html

Cartwright, J. 2007. Big stars have weather too. IOP Publishing PhysicsWeb. http://physicsweb.org/articles/news/11/6/16/1. Accessed 26 June 2007

Abbreviations

Follow standard procedures.

Units

All measurements should be reported in SI units. (e.g., g, kg, m, cm)

Table 1. The following are examples of SI units for use in *EJAP*

Quantity	Application	Unit	Symbol or expression of unit
Absorption	Balance trials	Grams per day	g d^{-1}
Activity	Enzyme	Micromoles per minute per gram	µmol min^{-1} g^{-1}
Area	Land	Hectare	ha
	Carcass	Square centimetre	cm^2
Backfat	Carcass	Millimetres	mm
Concentration	Diet	Percent	%
	Blood	Gram per kilogram	g kg^{-1}
		International unites per kilogram	IU kg^{-1} mg dL-^{1}
		Milligram per 100 mL	Mequiv L^{-1}
		Milliequivalents per litre	
Density	Feeds	Kilogram per hectolitre	kg hL^{-1}
Flow	Digesta	Grams per day	g d^{-1}
	Blood	Milligrams per minute	mg min^{-1}
Growth rate	Animal	Kilogram per day	kg d^{-1}
		Grams per day	g d^{-1}
Intake	Animal	Kilograms per day	Kg d^{-1}
		Grams per day	g d^{-1}
		Grams per day per kg bodyweight0.75	g d^{-1} $kg^{-0.75}$
Metabolic rate	Animal	Megajoules per day	MJ d^{-1}
		Watts per kg bodyweight	W kg^{-1}
Pressure	Atmosphere	Kilopascal	KPa
Temperature	Animal	Kelvin or degree Celsius	K or ^{o}C
Volume	Solutions	Litre	L
		Millilitre	ML
Yield	Milk production	Litres per day	L d^{-1}
Radioactivity	Metabolism	Curie or Becquerel	Ci (=37 GBq)

Units with two divisors should be written with negative indices (e.g., kg ha^{-1} yr^{-1}). The use of solidus (/) should be reserved for units written in full (e.g., mole/kilogram) or to separate a physical quantity and unit (e.g., yield/ha). Units should be chosen so that the numeric component falls between 1 and 10 or 1 and 100 when using one or two significant figures, respectively (e.g., use 31.2 mg than 0.0312 g).

Membership to the Ethiopian Society of Animal Production (ESAP)

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Some of the personal benefits afforded to active members of the Ethiopian Society of Animal Production (ESAP) include the following:

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- Eligibility to present abstracts at national meetings and to submit manuscripts for publication in the Ethiopian Journal of Animal Production (EJAP);
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Membership is open to individuals interested in research, instruction or extension in Animal Science or associated with the production, processing, marketing and distribution of livestock and livestock products.

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Application form for Membership

Ethiopian Society of Animal Production (ESAP)

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The Editorial Office
Ethiopian Journal of Animal Production (EJAP)
C/o Ethiopian Society of Animal Production (ESAP)
P.O.Box 62863
Addis Ababa
Ethiopia
Tel: (+251-1) 15547498
Email: esapeth@yahoo.com

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