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# International Journal of Livestock Production

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Full Length Research Paper

# Productive and reproductive performance of local dairy cows in selected districts of Sidama Zone, Southern Ethiopia

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The aim of the study was to assess the productive and reproductive performance of local dairy cows and constraints and opportunities of dairy production in selected districts of Sidama zone, Southern Ethiopia. Multistage sampling technique were employed in three districts selected representing highland (Wenisho), midland (Dale) and lowland (Loka Abaya) from Sidama Zone. One hundred and thirty five households who owned local cows were purposively selected from three *kebeles* from each agro ecology (45 from each agro ecology). Data were collected using semi-structured formal questionnaires and focus group discussions. The overall mean for daily milk yield, lactation length, age at first service, age at first calving, calving interval and number of services per conception, were  $1.51 \pm 0.08$  liter/day,  $8.21 \pm 0.99$  months,  $42.61 \pm 2.82$  months,  $52.30 \pm 2.73$  months,  $20.08 \pm 0.90$  months and  $2.44 \pm 0.73$ , respectively. The major constraints identified includes feed shortage, disease, lack of improved breed, water scarcity and market problem while increasing demand for milk and milk products from time to time, access for veterinary services, implementation of vaccination before the outbreak of the diseases, availability of different feed resources, and the infrastructure development in the area were the major opportunity for dairy production. The current study revealed that the productive and reproductive performance of local cows is poor and thus, strong extension and interventions from responsible agents are mandatory to overcome identified problems and enhance productivity of dairy sector to ensure effectiveness of smallholder farmers in the study area.

**Key words:** Agro ecology, local cows, productive performance, reproductive performance.

## INTRODUCTION

Livestock provides a significant nutritional supplement to vulnerable groups, increase the resilience of smallholder

households in the face of food crises, and help to maintain traditional social safety nets (Randolph et al.,

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2007). Dairy production, among the sector of livestock production, is a critical issue in Ethiopia where livestock and its products are important sources of food and income, and dairying has not been fully exploited and promoted in the country. Dairy production is traditional in most parts of Ethiopia. Depending on the area under consideration cattle, goats, camels and sheep all provide milk for human consumption. However, cattle are the main source of milk production capabilities in the country particularly under smallholder production system (Ketema, 2000; Zegeye, 2003).

Ethiopia has the largest livestock population in Africa and the cattle population was estimated to be about 55.03 million, out of this 55.38% were female and the remaining 44.62% were male cattle. From this, 98.71% were local breeds while the remaining were cross and exotic breeds that accounted for about 1.15 and 0.14%, respectively. A total cow milk production for the country was about 2.9 billion liters with milk consumption of only about 19 kg/year, which is much lower than Africa and the world per capital average of 40 and 105 kg/year, respectively (CSA, 2014). In the country, dairy production depends mainly on local livestock genetic resources, and its production, among livestock sector is important in providing milk and its product.

The reproductive performance of the breeding female is probably the single most important factor that is a prerequisite for sustainable dairy production system and influencing the productivity. According to LeBlanc (2007) cattle profitability is mainly determined by dairy cows reproductive performance which is a major determinant for overall productivity of dairy production systems by affecting the efficiency of milk production, the number of calves produced per cow and lifetime milk production (De Varies, 2006).

An understanding of the productive and reproductive performance provides guidance as to which of the possible new technologies are appropriate and worth pursuing, and which is not. Some works have been undertaken in Sidama Zone in different areas regarding performance, production system and breeding practice of dairy cattle (Beriso et al., 2015; Debir, 2016; Tsegaye et al., 2016). However, there is gap in the present study areas in line with works available in particular concerning the productive and reproductive performances of local dairy cows and identifying constraints and opportunities of dairy production under smallholder production system. This demands the need for generating site specific database under specific production scenarios. Thus, studying productive and reproductive performances and identifying constraints and its opportunity for dairy production is imperative in order to generate baseline information for use primarily by livestock owners, the extension agents and researchers to design improvement and development strategies to improve the productivity of local cows in the area. On the basis of this, the present study was undertaken to study productive and

reproductive performance of local dairy cows and constraints and opportunities of dairy production in selected districts of Sidama Zone, Southern Ethiopia.

## MATERIALS AND METHODS

The study was undertaken in three Districts, namely Wenisho, Dale and Loka Abaya of Sidama Zone, Southern Nations Nationalities and Peoples' Region (SNNPR), Ethiopia. Sidama Zone is located at 5°45' and 6°45' N latitude and 38°39' and 38°29' E longitude with altitude ranging from 1100 to 3500 m above sea level (masl) (SDC, 2000). The zone is characterized by mixed crop livestock farming. Rainfall pattern of the zone is bimodal type with small rainfall during the months of February to April followed by the main rainy season from July to September.

Dale District is partly located in the Great Rift Valley. The District is situated at 40 km south of Hawassa and at about 320 km south of Addis Ababa. It is located at 6°44' to 6°84'N and 37°92' to 38°60' E with an altitude range of 1001 to 2500 masl (average 1624 masl). The District receives an annual mean average rainfall of 1170 mm and the average annual temperature of 19°C (SEDPSZ, 2004). The district occupies major soil type of Haptic Luvisols and Chromic and also Luvisols Humic Nitisols, Eutic Vertisols, and Eutric Vertisols (IPMS, 2005). The district is characterized by food crops like *enset* (*Ensete ventricosum*) and maize and diversified cash crops like coffee, fruits (such as banana, avocado, guava), haricot bean and root crops like potato and sweet potato (DWARD, 2006).

Wenisho is one of the districts in Sidama zone, the Southern Nations, Nationalities, and Peoples' Region of Ethiopia. According to ENMA (2008), the district has a mean annual rainfall and temperature ranging from 832 to 1658 mm and 18 to 21°C, respectively. The pattern of rainfall distribution is bimodal. *Enset* (*Ensete ventricosum*) which is a staple food and an income source and Coffee and *Chat*, and fruit trees (papaya, banana, avocado and mango) are also among the widely cultivated crops.

Loka Abaya district is lowland which is situated at about 50 km southwest of Hawassa. The District has low rainfall with an erratic pattern during the two rainy seasons; the *belg* (February to April), and the *kiremt* rains (July to early October) (USAID, 2005). The district is endowed with food crop like *Enset*, maize, *teff* and cash crops like *Chat*, coffee among crops cultivated in the district.

### Sampling procedure and sample size

In the current study, multistage and purposive sampling technique was used. Initially, three districts were selected based on agro-climatic distribution namely Wenisho (Highland, 2300 up to 3200 masl), Dale (midland, 1500 to 2300) and Loka Abaya (Lowland, 1170 up to 1500 masl). In the second stage representative Kebeles (lowest administration) from respective strata (agro-ecology or district) were selected based on production potential and accessibility and a total of 9, that is, 3 Kebeles from each agro-ecological zone were selected. Finally, a total of 135 households (15 from each Kebeles or 45 from each strata) who own local cows were selected using purposive sampling method. A structured questionnaire were used to obtain information on productive and reproductive performance such as daily milk yield, lactation length, age at first service, age at first calving, calving interval, and number of services per conception and major constraints hindering dairy production in the study area.

### Data types and methods of data collection

For the current study, both primary and secondary data were used

**Table 1.** Herd size and herd structure in TLU.

Variable	Agro-ecology			
	Highland (N=45)	Midland (N=45)	Lowland (N=45)	Overall (135)
Cow	3.53±1.31 <sup>b</sup>	2.79±1.28 <sup>b</sup>	7.87±2.95 <sup>a</sup>	4.73±0.25
Oxen	0.83±0.78 <sup>b</sup>	1.17±0.79 <sup>a</sup>	0.88±0.83 <sup>b</sup>	0.96±0.81
Heifer	1.27±0.56 <sup>b</sup>	1.04±0.46 <sup>b</sup>	3.26±1.18 <sup>a</sup>	1.86±1.37
Bull	1.5±0.97	1.29±1.05	1.51±1.31	1.44±1.12
Calves	0.44±0.26 <sup>b</sup>	0.25±0.19 <sup>c</sup>	0.91±0.36 <sup>a</sup>	0.54±0.39
Sheep	0.11±0.89 <sup>b</sup>	0.78±0.97 <sup>a</sup>	0.16±0.12 <sup>b</sup>	0.12±0.11
Goats	0.19±0.13 <sup>b</sup>	0.19±0.12 <sup>b</sup>	0.74±0.47 <sup>a</sup>	0.37±0.38
Horse	0.89±0.54 <sup>a</sup>	0.64±0.58 <sup>b</sup>	0.72±0.61 <sup>a</sup>	0.75±0.58
Donkey	0.63±0.50 <sup>a</sup>	0.6±0.39 <sup>a</sup>	0.34±0.35 <sup>b</sup>	0.52±0.44
Total Herd Size	9.44±1.88 <sup>b</sup>	8.07±2.00 <sup>c</sup>	16.42±3.79 <sup>a</sup>	11.31±4.55

TLU = Tropical Livestock Unit. Means with different letters of superscripts in the same row differ significantly at  $P < 0.05$ .

to attain the objectives of the study. Primary data were collected from all purposively selected 135 households who owned local dairy cattle by using semi-structured questionnaire, focus group discussion and field observation. Semi structured questionnaires were prepared and translated into local language, and administered to collect relevant information for the study by trained enumerators who were indigenous to the community with close supervision of researcher. Focus group discussions were held with clan or village leaders, district agricultural experts (extension agents), local dairy cow owners and elderly female and male member of the society who are known to have better knowledge on the dairy production status of the area. Secondary data were also collected from written and unpublished documents of agricultural office of each respective districts, books and journals.

#### Data management and analysis

Data on productive and reproductive performances were subjected to General Linear Model of SAS (2002) version 9. ANOVA, One-way Analysis of Variance, was applied to observe fixed effects of agro ecology on quantitative dependent variables such as daily milk yield, lactation length, age at first service, age at first calving, calving interval, and number of services per conception. Differences were considered statistically significant at 5% level of significance. Tukey's Studentized Range (HSD) test was used to separate the means based on their significant difference.

Index analysis was used for ranking constraints hindering dairy production according to the method suggested by Kosgey (2004). The ranking was expressed as an Index = the sum of (5 times first order + 4 times second order + 3 times third order + 2 times fourth order + 1 times fifth order) given for an individual variables divided by the sum of (5 times first order + 4 times second order + 3 times third order + 2 times fourth order + 1 times fifth order) for all variables.

The following model was used for the analysis of productive and reproductive performance:

$$Y_{fk} = \mu + df + e_{fk}$$

Where;  $Y_{fk}$  = the observed productive and reproductive performance;  $\mu$  = the overall mean;  $df$  = the effect of the  $f^{\text{th}}$  location (Agro ecology) (1. Highland, 2. Midland, 3. Lowland) and  $e_{fk}$  = random residual error.

## RESULTS AND DISCUSSION

### Herd size, herd structure and purpose of livestock keeping

The livestock composition in the study area is illustrated in Table 1. The overall mean herd size kept in the study area differ significantly among agro-ecologies ( $P < 0.05$ ). The mean value of cows kept in lowland were higher than midland and highland which could be due to the practice that highland and midland farmers kept few and selected dairy cows particularly for milk production and also shortage of grazing land as compared to lowland. However, farmers in lowland keep higher numbers of livestock and their number have been considered as indicator of the status of the farmers in addition to the multipurpose use provided by livestock to their owners. Oxen are used for traction purpose in the area whereas horse and donkey are mainly used for transport of goods and people from one place to another. Goat and sheep provides immediate cash in the area.

The present finding indicated that the livestock in the study area were kept for provision of multipurpose service, including milk production, draught power, transport, meat and organic fertilizer through provision of dung and also for financial and social value according to the feedback obtained from focus group discussion. Moreover, focus group discussion also revealed that there was strong association between crop production and livestock in providing manure as organic fertilizer for different crops since inorganic fertilizers are costly and thus farmers rely more on manure rather than other fertilizer. Andualem (2015) also showed that in the mixed crop-livestock production of the Ethiopian highlands, livestock are subordinate but economically complementary to crop production in providing draft power, which is a vital contribution to the overall farm labor requirement. Cattle also provide meat, milk, cash income



**Table 2.** Constraints of dairy production in the study area.

Constraint	Priority level					Index	Rank
	1	2	3	4	5		
Feed shortage	84.4	15.5	0	0	0	0.32	1
Disease	15.5	13.3	11.1	0	0	0.27	2
Lack of improved breed	0	8.9	82.2	6.7	2.2	0.21	3
Water scarcity	0	0	2.2	40	57.8	0.16	4
Market problem	0	4.4	4.4	51.1	40	0.12	5
<b>Midland (45)</b>							
Feed shortage	86.7	13.3	0	0	0	0.32	1
Disease	11.1	53.3	35.6	0	0	0.25	2
Lack of improved breed	0	35.6	64.4	0	0	0.22	3
Water scarcity	0	0	0	62.2	37.8	0.11	4
Market problem	0	0	0	37.8	62.2	0.09	5
<b>Lowland (45)</b>							
Feed shortage	20	80	0	0	0	0.28	2
Disease	80	20	0	0	0	0.33	1
Lack of improved breed	0	0	86.7	13.3	0	0.19	3
Water scarcity	0	0	13.3	44.4	42.2	0.08	4
Market problem	0	0	0	40	60	0.09	5

Index = the sum of (5 times first order + 4 times second order +3 times third order + 2 times fourth order + 1 times fifth order) for individual variables divided by the sum of (5 times first order + 4 times second order +3 times third order + 2 times fourth order + 1 times fifth order) for all variables.

and manure, and serve as capital asset against risk. The result of the current finding was comparable with finding of Zewidie (2010) who reported provision of multipurpose functions by livestock.

### Constraints and opportunity for dairy production

The major constraints affecting dairy production in the area are presented in Table 2. Accordingly, feed shortage, disease, lack of improved dairy cow breed, water scarcity and market problem were identified and ranked with their priorities using index method. In highland (Wenisho) and midland (Dale), feed shortage occupied the first position followed by disease, lack of improved breed, water scarcity and market problem in that order. On the other hand, disease was ranked first as major constraints for dairy cow production in lowland (Loka Abaya) followed by feed shortage, lack of improved breed, water scarcity and market problem. The difference in the position of rank of disease in lowland area compared to the two agro ecologies could be due to inadequate extension service provided and management practice of dairy cows. Furthermore, Loka Abaya district was also conducive area for multiplication of Tsetse fly particularly during wet season and encouraged the occurrence of trypanosomiasis in lowland area as information obtained from focus group discussion

revealed. Accordingly, the major constraints hindering dairy production in current study area were feed shortage, disease, lack of improved breed, water scarcity and market problem and the study finding was in line with Tsegaye et al. (2015) who illustrated shortage of feed, health problem, water scarcity and labor scarcity as major challenges, which affect dairy cattle production and productivity in selected district of Sidama Zone, Southern Ethiopia.

Even though the dairy cow production was constrained with various problems mentioned earlier, opportunity raised during focus group discussion in the area were increasing demand for milk and milk products from time to time, access for veterinary services, implementation of vaccination before the outbreak of the diseases, availability of different feed resources although it vary seasonally, and the infrastructure development in the area. Moreover, the area practiced integrated crop livestock production, which could contribute to the future improvement prospect, via introduction of intercropping of improved forage species even though land holding was small across the study area particularly in midland. Asrat et al. (2013) also demonstrated similar results with the current study in Bodit, Southern Ethiopia and described the major opportunities of dairy industry as rapid urbanization, substantial population growth and change in the living standard of the dwellers and the increased demand for milk and milk products in the area.

**Table 3.** Productive and reproductive performance of indigenous dairy cows (Mean±SD).

Variable	Agro ecology			Overall (135)
	Highland (N=45)	Midland (N=45)	Lowland (N=45)	
DMY (liter)	1.49±0.06 <sup>b</sup>	1.59±0.07 <sup>a</sup>	1.43±0.17 <sup>c</sup>	1.51±0.08
LL (Month)	8.00±1.14	8.3±0.86	8.2±0.957	8.21±0.99
AFS (Month)	42.2±2.70	42.96±3.23	42.58±2.32	42.61±2.82
AFC (Month)	52.2±2.41 <sup>ab</sup>	51.4± 3.12 <sup>b</sup>	53.28±2.61 <sup>a</sup>	52.30±2.73
CI (Month)	19.94±0.76 <sup>b</sup>	19.32±0.56 <sup>c</sup>	20.97±1.28 <sup>a</sup>	20.08± 0.90
NSPC	2.04±0.73 <sup>a</sup>	2.15±0.71 <sup>a</sup>	3.13±0.75 <sup>b</sup>	2.44±0.73

Mean values represented with different superscripts in the same row differs significantly ( $P<0.05$ ). N = Numbers of respondents. DMY = Daily milk yield, LL = Lactation length, AFS = Age at first service, CI = Calving interval, NSPC = Number of services per conception.

### Productive and reproductive performance of local cows in the study area

#### Daily milk yield and lactation length

The estimated mean daily milk yield based on the farmers response varied significantly ( $P<0.05$ ) among the agro ecologies (Table 3). The variation in daily milk yield could be due to availability of feed and the difference in the practice of keeping selected cows among farmers in different agro ecologies. The present estimated daily milk yield of local dairy cows was 1.51±0.08 liter/day and the result was in agreement with Zewidie (2010) who reported 1.5±0.3 kg/day for indigenous dairy cows in Ziway area. The result is also comparable with overall mean estimated milk yield of 1.45 liter/day reported by Beriso et al. (2015) in Chuko district, southern Ethiopia and also with that of Demissu et al. (2014) who reported 1.52±0.86 liter/day at Guduru livestock production and research center and its surroundings indigenous cows. On the other hand, the result of the current finding was higher than the report by Merha (2006) who noted average daily milk yield of 0.75 liters for Abergele cattle and 1.15 ± 0.386 liters estimated by Ketema (2014) for cows under smallholder farmers in Kersa Malima district.

The estimated overall mean lactation length in present study was 8.21±0.99 months and there was no significant difference among agro ecologies ( $P>0.05$ ). The lactation length reported in the present study area was comparable with the result of 8.96 month reported by Belay et al., (2012) for smallholder livestock production system in Dandi district, Oromia Regional State, Central Ethiopia and also with 9.93± 0.2 months (Beriso et al., 2015) in Chuko district, Southern Ethiopia. However, it was longer than the national average of 7 months (CSA, 2005) and 203.54 days or 6.78 month for Simada cattle in Tach Gayint district (Assefa et al., 2015).

#### Age at first service

The overall estimated age at first service (AFS) by the

respondents in the current study was 42.61±2.82 months and not differed significantly ( $p>0.05$ ) across agro ecology (Table 3). The current result of AFS was in agreement with Adebabay (2009) who noted 42.48 months in Bure district and also comparable with 40.74 months for Simada cattle in Tach Gayint district (Assefa et al., 2015). The current finding is slightly lower than AFS of 44.1±5.9 months reported by Debir (2016) in Sidama Zone, Southern Ethiopia and 44.8 months for Fogera cattle (Gidey, 2001). On the other hand, the result of the current study is higher than 27.5 months reported by Zewidie (2010).

#### Age at first calving

The overall estimated age at first calving (AFC) was 52.30±2.73 months and higher for lowland agro ecology ( $P<0.05$ ). These could be due to availability of feed resources since environmental factors particularly nutrition may affect the growth and maturity of heifers and development of reproductive organ properly in order to undertake its function properly.

The result of the current study was comparable with 51.9±5.9 months reported by Debir (2016) in Sidama Zone and 51.24±0.55 month reported by Beriso et al. (2015). However, the result revealed in the current study is significantly higher than 39.8±5.6 months reported by Tadele and Nibret (2014) at smallholder farm conditions in and around Maksegnit town and 46.22±12.15 months reported by Demissu et al. (2014).

#### Calving interval

The overall estimated mean calving interval (CI) in the current study was 20.08± 0.90 months and differs significantly among agro ecology of study area ( $P<0.05$ ). The differences in calving interval could be due to longer time taken by dairy cows to conceive due to the effect of nutrition and other managemental aspects like health care within consecutive calving among agro ecology.

The result of the current finding was in line with CI of  $19.93 \pm 0.2$  months estimated by Beriso et al. (2015) for local breed cows, in Aleta Chuko district, 21.18 months reported by Dessalegn (2015) from Benchi-Maji Zone, South West Ethiopia. However, the result of the current finding is lower than  $26.04 \pm 0.01$  months reported by Assefa et al. (2015) and higher than 472 days (15.7 months) reported by Zewidie (2010),  $16.01 \pm 0.49$  months reported by Kedija (2007) in Mieso district and 401 days reported by Alemselem et al. (2015) in and around Mekele.

### **Number of services per conception (NSPC)**

The overall estimated mean for number of service per conception (Mean $\pm$ SD) by the respondent in the current study was  $2.44 \pm 0.73$ . The mean value for NSPC was significantly higher for lowland than highland and midland. The differences may be attributed to differences in management practices such as mating practice in the lowland. The result is comparable with  $2.2 \pm 0.2$  for indigenous cows of Gondar city of Ethiopia (Kumar, 2014) and  $2.0 \pm 0.65$  reported in smallholder farm conditions in and around Maksegnit town (Tadelle and Nibret, 2014).

### **CONCLUSION AND RECOMMENDATIONS**

In general, the study revealed that dairy production in the current study area was hindered with various constraints limiting full exploitation of the productive and reproductive potential of dairy cows even though the area was gifted with varied opportunities. The productive and reproductive performance of local cows in the study area is generally low indicating the need for strong intervention to get to the bottom of the constraints identified to assure increased productivity of dairy cows in the area.

### **CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.

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## Full Length Research Paper

# Feeding value potential of mulberry (*Morus alba*) leaf meal to replace concentrate mix

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The experiment was carried out to estimate the feeding value of mulberry (*Morus alba*) leaf meal by evaluating its chemical composition *in vitro* organic matter digestibility and *in sacco* dry matter (DM) degradability. This study aimed to assess the potential of mulberry foliage in supplementing the feed of ruminant animals during the dry season, when other feed resources are scarce and their quality generally fall short of animal requirements. Dry matter (DM), crude protein (CP), ash, ether extract (EE), crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents of the different diets were determined. *In vitro* organic matter digestibility was determined by two-stage method. *In sacco* rumen degradability was measured using three rumen fistulated Boran-Holstein Friesian cross steers at 0, 6, 12, 24, 48, 72, and 96 h. The composition of mulberry leaf meal compares favorably with that of the concentrate mixture in most of the nutrients. The ash content of mulberry leaf meal was more than double that of the concentrate mixture. Similarly, the calcium value of mulberry leaf meal was more than threefold to that of calcium content of concentrate mixture. Mulberry leaf meal alone had the greatest values for slowly degradable fraction (b) than the diets with less proportion of mulberry, whereas mulberry leaf meal alone (T5) and 75 g concentrate mix + 259.7 g mulberry leaf (T4) had significantly ( $p>0.05$ ) less soluble fraction (a), and effective degradability (ED) values as compared to the diets with less proportion of mulberry. In a nutshell, all treatment diets recorded more than 66% DM degradability at 24 h, which implied that they were all greatly degradable in the rumen.

**Key words:** Chemical composition, degradability, digestibility, *Morus alba*.

## INTRODUCTION

In areas like Ethiopia where livestock are closely integrated with crop production, crop residues are considered as valuable sources of ruminant feeds. However, crop residues are fibrous having low digestible

organic matter and low crude protein content, and generally are low in nutritive value. This low nutritive values restrict its utilization by rumen microorganisms and consequently by the host animal. An adequate

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supply of nitrogen (N) to rumen microbes is crucial to obtain maximum rate of plant cell digestion as well as a high microbial protein synthesis (Adugna, 2008; Gül et al., 2010; Gizaw et al., 2010).

There are several alternatives for improving the performance of ruminants fed with low nutritional quality fibrous diets. Supplementation with concentrate could improve the nutritional value of low quality roughage such as straws which could be an alternative. However, the concentrate diets are often expensive and not accessible to smallholder farmers. In many tropical countries and regions, there has been a focus on indentifying and using locally available shrubs and tree leaves as cheaper alternative supplements for ruminants because of their high nutritive value and positive effects on rumen function (Yao et al., 2000).

Additionally, several works in different places have reported the potential of the mulberry (*Morus alba*) forage for sustainable ruminant production (Yulistiani et al., 2008; Martín et al., 2007; Kandylis et al., 2009; Soca et al., 2010; Salinas et al., 2011; González and Martín, 2016). Hence, mulberry might be potentially used as supplement to low quality roughage diets due to its high protein content (Sanchez, 2002) and degradability (Saddul et al., 2005). Beside its high protein content, the degradability of its organic matter is also high (Saddul et al., 2005) thus, can supply fermentable energy in the rumen. Moreover, this can create favorable condition in the rumen for plant cell wall degrading microorganisms (Yulistiani et al., 2008).

Therefore, this research was carried out to compare the chemical composition, *in vitro* digestibility as well as *in sacco* degradability of sole mulberry leaf meal, concentrate mix and their mixtures.

## MATERIALS AND METHODS

### Sample preparation and experimental design

Leaves from mulberry that were harvested from nearby farmers and nursery areas were dried under a shade for 4 to 5 days until the leaves were easily crushed when pressed in the hand and packed in a sack for later use. The concentrate mixture which was purchased from animal feed shop comprised of wheat bran and noug seedcake at the ratio of 2:1 on dry matter (DM) bases, in that order.

Five treatment diets were designed in such a way that concentrate mix was progressively replaced by mulberry leaf meal from 0 to 100% at iso-nitrogenous level. The diets include, 300 g concentrate mix alone (T1), 225 g concentrate mix + 86.55 g mulberry leaf (T2), 150 g concentrate mix + 173.1 g mulberry leaf (T3), 75 g concentrate mix + 259.7 g mulberry leaf (T4) and 346.2 g mulberry leaf alone (T5).

### Chemical analysis

Chemical composition of the feed samples was determined at HOLETA Agricultural Research Center, animal nutrition laboratory, Ethiopia. Samples of partially dried feeds were dried overnight at

105°C in a forced draft oven for determination of total dry matter content. Samples were analyzed for DM, ash, and nitrogen (N) using the procedure of AOAC (1990) and crude protein (CP) was calculated as N x 6.25.

Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed using the procedures of Van Soest et al., (1991).

### *In vitro* organic matter digestibility

*In vitro* organic matter digestibility was determined by the two-stage method of Tilley and Terry (1963). Samples were incubated for 48 h with rumen fluid and buffer followed by additional 48 h digestion with pepsin and HCl. The residue was ashed in a muffle furnace at 550°C for 5 h.

Rumen fluid was obtained from rumen fistulated Boran x Holstein Friesian steers kept at maintenance dietary condition with diets containing hay supplemented daily with 4 kg of concentrate mixture, which involved 74, 25 and 1% wheat bran, noug seed cake and salt, respectively.

### *In sacco* dry matter degradability

Rumen degradability of the samples was determined by incubating about 3 gm of sample in a nylon bag (41µm pore size and 6.5x14 cm dimension) in three rumen fistulated Boran x Holstein Friesian steers kept at HOLETA Agricultural Research Station. The steers were offered grass hay supplemented daily with 4 kg of concentrate mixture, comprised of 74, 25 and 1% wheat bran, noug seed cake and salt, respectively and kept in individual pens. The feed samples were incubated for 0, 6, 12, 24, 48, 72 and 96 h. Duplicate nylon bag containing samples were incubated in three rumen fistulated animals by placing the samples at different hours and taking them out at the same time (sequential addition).

At the end of the incubation period, sample containing bags, including zero hour bags were hand washed in a running tap water. The washed bags were then dried in an oven at 105°C for 24 h to determine dry matter. The dried bags were taken out of the oven and allowed to cool down in desiccators and weighed immediately. The ruminal *in sacco* DM degradability at each incubation time was determined as follows;

$$\text{DMD (g/kg DM)} = (\text{DM in feed sample} - \text{DM in residue}) / \text{DM in feed sample}$$

DMD data was fitted to the exponential equation  $p = a + b(1 - e^{-ct})$  as described by Ørskov and McDonald (1979), where p is the amount of nutrient degraded (%) at time t, a is the intercept of the degradation curve at time zero and represent as degradability of soluble fraction (%), b is the rumen-insoluble, but slowly degradable fraction (%), e is base for natural logarithm, c is the rate constant for degradation of b fraction (%/h), t is the incubation time (h) and the lag phase (L) represented as;

$$L = (1/c) \log_e [b/(a+b - A)] \quad (\text{Ørskov and Ryle, 1990})$$

Potential degradation (PD) was estimated as (A + B), while effective degradability (ED) of DM was calculated using the formula:

$$\text{ED} = A + [B * c / (c + k)]$$

Where A, B and C are described above and k is rumen outflow rate which is assumed to be 0.03/ h for roughage feeds (Ørskov and McDonald, 1979). The calculation of the equation was carried out using the Neway program (Chen, 1996).

**Table 1.** Chemical composition of the feed ingredients.

Chemical composition	Treatments				
	T1	T2	T3	T4	T5
DM (%)	90.2	89.5	89.2	89.5	91.8
OM (%DM)	92.34	89.70	86.06	85.59	84.30
Ash (%DM)	7.66	10.30	13.94	14.41	15.70
CP (%DM)	22.03	22.13	20.01	18.51	18.49
CF (%DM)	13.27	12.84	13.56	13.78	14.17
NDF (%DM)	35.18	34.19	35.23	36.78	37.98
ADF (%DM)	20.17	19.47	21.66	19.91	22.32
ADL (%DM)	3.39	3.42	3.36	3.83	4.19
EE (%DM)	7.16	6.33	5.91	5.34	4.15
Ca (%DM)	0.6	0.76	1.08	1.45	2.11
P (%DM)	1.02	0.81	0.94	0.84	0.77

MLM= Mulberry leaf meal; CM= Concentrate mix (2:1 of wheat bran to noug seed cake); DM=Dry matter; OM=Organic matter; CP=Crude protein; CF= Crude fiber; NDF=Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin; EE= ether extract; Ca= calcium; P= phosphorus.

### Statistical analysis

Data from the experiments on *in vitro* organic matter digestibility and *in sacco* dry matter degradability were subjected to the analysis of variance (ANOVA) in a randomized complete block design, using the general linear model procedure of SAS (2008). Individual differences between means were tested using Tukey HSD test. In all comparisons, the level of significance was set at  $\alpha = 0.05$ .

## RESULTS

### Chemical composition of the feeds used in the experiment

The diets were formulated to meet the Crude protein (CP) requirements of yearling Tigray highland lambs. The composition of mulberry leaf meal compares favorably with that of the concentrate mixture in most of the nutrients which were better in its ash content than the concentrate mixture (Table 1).

The dry matter content seems similar across the different treatments, whereas the organic matter content declined as the proportion of concentrate mixture decreases. Ash content of mulberry leaf meal in the current study was more than double to that of the concentrate mixture. Similarly, the calcium value of mulberry leaf meal was more than threefold to that of concentrate mixture.

### *In vitro* organic matter digestibility and *in sacco* dry matter degradability

There was less difference in *in vitro* organic matter digestibility (76.42 to 77.78%) across the different

treatments in the current study. All tested diets resulted more than 76% *in vitro* organic matter digestibility. The *in sacco* dry matter degradability characteristics of sole mulberry foliage and concentrate mix or their mixtures are presented in Table 2.

The greatest and least soluble fraction (A) was recorded in the diet with higher proportion of concentrate mix and in sole mulberry leaf meal, respectively. The amount of washable materials (A) significantly increased as the proportion of concentrate mix increases.

The washable materials were significantly higher in T1 and T2, than the remaining treatments. Unlike the washable materials, the reverse is true in the case of potential degradation for non-water soluble materials (B). The insoluble but fermentable fractions increased as the proportion of mulberry leaf meal advanced. The slowly degradable fraction (B) value obtained in mulberry leaf meal was superior (53.2%) as compared to values recorded for the sole concentrate mix.

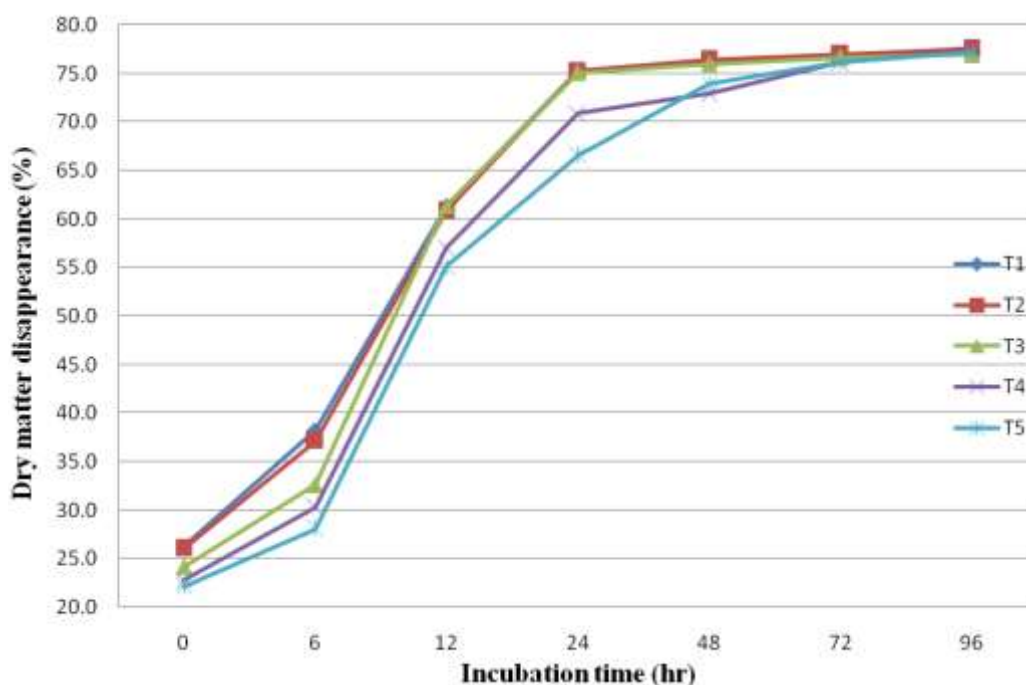
Potential degradability of T4 and T5 in the current study was significantly less than those of T1, T2 and T3. There was less difference in the rate of degradation across the different treatments in this study. Slight increase in degradation rate constant was observed until T3, which declined steadily at higher mulberry leaf meal level.

The trend of degradation of different levels of mulberry leaf meal in combinations with concentrate mixture showed a time dependent increase (Figure 1). This trend (T1 and T2) increased consistently up to 24 h but continues steadily up to 48 h. However, the progress seems constant beyond 48 h. Nevertheless, the trend of degradation for T3, T4 and T5 was slow up to 6 h; subsequent, T3 increased rapidly to 12 h compared to T4 and T5 which continues to increase exactly the same as T1 and T2. From 6 to 24 h, T4 and T5 showed similar increment. After 24 h T1, T2, T3 and T4 started to

**Table 2.** *In sacco* dry matter degradability characteristics of sole mulberry foliage and concentrate mix or their mixtures (%DM).

Parameter	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
A	26.2 <sup>a</sup>	26.1 <sup>a</sup>	24.1 <sup>b</sup>	22.7 <sup>c</sup>	22.2 <sup>c</sup>	0.25	***
B	51.1 <sup>b</sup>	51.1 <sup>b</sup>	52.5 <sup>ab</sup>	52.6 <sup>ab</sup>	53.2 <sup>a</sup>	0.52	*
PD	77.0 <sup>a</sup>	77.2 <sup>a</sup>	76.6 <sup>a</sup>	75.3 <sup>b</sup>	75.3 <sup>b</sup>	0.30	***
ED	63.6 <sup>a</sup>	63.5 <sup>a</sup>	62.8 <sup>a</sup>	60.5 <sup>b</sup>	58.9 <sup>c</sup>	0.36	***
C/hr	0.087	0.089	0.090	0.086	0.084	0.00	NS
L (hr)	4.27 <sup>a</sup>	4.43 <sup>a</sup>	5.03 <sup>b</sup>	4.90 <sup>b</sup>	4.87 <sup>b</sup>	0.08	***
<i>In vitro</i> DOM	77.46	77.47	76.98	77.78	76.42	1.34	0.861

<sup>a-c</sup> Means with different superscripts in a column within a category differ; \*\*\* = P<0.001; \* = P<0.05; NS = not significant; SEM = standard error of the mean; SL= significant level A = rapidly soluble fraction; B = insoluble but fermentable fraction; PD = potential degradability; C = the rate of degradation of B; L = lag time; ED = effective degradability; DOM = Digestibility of organic matter; h = hour.

**Figure 1.** *In sacco* dry matter disappearances of the different treatment feeds.

decrease their degradation rate, while T5 (sole mulberry leaf meal) keeps increasing up to 48 h which continued increasing slowly until 72 h. As shown in Figure 1, the extent of degradation for all treatment diets beyond 72 h seems similar. After 48 h incubation the total dry matter degradability values showed non-significant effect across the different treatment diets.

Additionally, T1, T2 and T3 showed significantly higher degradability values than that of T4 and T5 in 12 to 48 h incubation. In a nutshell, all treatment diets recorded more than 66% DM degradability at 24 h, which implied that they were all potentially degradable in rumen.

## DISCUSSION

### Chemical composition

Since the feeds used in the current experiment were dried under sun, their dry matter was expectedly high (Table 1). The organic matter content declined as the proportion of concentrate mixture decreases. This might be due to higher ash content of mulberry leaf meal. The NDF, ADF and ADL compositions of the treatment diets were not deviated largely, justifying the comparable potential of mulberry foliage to that of concentrate mix.



The CP content of mulberry leaf meal obtained in this study was within the range of values (18 to 25%) obtained by Ba et al. (2005), Kandylis et al. (2009) and Vu et al. (2011).

The NDF content of sole mulberry leaf meal was to some extent higher than 31.1 and 26.4% reported by Vu et al. (2011) and Habib et al. (2016) respectively, whereas, its ADF content was within the range values (17.4 to 24.7 %) detected by Kabi and Bareeba (2008) as well as Habib et al. (2016). The ADL content of mulberry leaf meal in the present study is in accordance with the results that Kandylis et al. (2009) and Atiso et al. (2012) have reported 4.1 and 4.65%, respectively. In three clones of mulberry leaves, Schmiddek et al. (2000) noted comparable NDF (30.2 to 39.3%) and ADF (17.2 to 21.7%) results with the present finding.

Feeds with high ADF content could lower the availability of nutrients since there is a negative relationship between ADF and digestibility of feeds (McDonald et al., 2002). Moreover, Kabi and Bareeba (2008) also demonstrated that NDF, ADF and ADL contents increased with increasing maturity. However, the values for fiber fractions of mulberry leaf meal obtained in this experiment were low. This idea further corroborated the comparative supplementary feeding value of mulberry for ruminants. According to Lonsdale (1989) feeds that have <12, 12 to 20 and >20% CP are classified as low, medium and high protein sources, respectively. Hence, mulberry leaf meal in the current study could be categorized among the medium upper limit protein source feed that can serve as a protein supplement for low quality crop residues, particularly during the dry season. Similarly, Benavides (2000) also noted that mulberry leaves have a high potential as protein-rich forage supplement which is used in feed for ruminants, monogastrics and rabbits.

The ash content (15.4%) of mulberry reported by Habib et al. (2016) was comparable with the current finding. Similarly, Singh and Makkar (2002) stated that since mulberry leaves are rich in mineral matters like calcium, nitrogen, sulphur and other minerals they have the potential to be used as a supplementary feed for improving livestock productivity which conforms to the current study.

According to McDowell (1997), the recommended Ca to P ratio for ruminants is 2:1 to 4:1. Hence, the ratio obtained in the current study was within this range and the good mineral contents of mulberry foliage in this study further provoke its use as good alternative source of feed for ruminants. Ether extract obtained from the current study was higher than the value reported by Hurtado et al. (2012) (2.1%) whereas, it was comparable with 4.21 and 3.69% as reported by Wang et al. (2012) and Doran et al. (2007), respectively. This suggests that, mulberry is not an energy deficient plant. Therefore, the leaf from this plant can be considered as a cheap and affordable supplement for ruminant animals particularly in

herds of small scale rural farmers.

### ***In vitro* organic matter digestibility**

The comparable digestibility of mulberry with the commercial concentrate mixture ensures the potential of the leaf, supplementing the less quality crop residues in ruminant production. The results that *in vitro* organic matter digestibility have been obtained, which are relatively higher than the results for *in vitro* digestibility of browse species during wet (68%) and dry season (72%) as reported by Solomon et al. (2010).

Moreover, Shayo (1997) reported that *in vitro* digestibility of mulberry leaves was 82.1% which is to some extent larger than the current study. Similarly, Bakshi and Wadhwa (2007) also noted that *in vitro* digestibility of mulberry leaves was higher than other forage species. The better digestibility of mulberry could be attributed to high CP level and increased concentration of ammonia nitrogen in rumen (Hristov et al., 2004). Higher ammonia nitrogen in rumen improves microbial activity and growth of fibrolytic bacteria resulting in more DM digestibility (Griswold et al., 2003). The narrow range of *in vitro* digestibility observed in the current study among the different treatment feeds might be a reflection of similarities in their chemical composition and potential of the mulberry being comparable with concentrate mix.

The threshold level of NDF in tropical plants beyond which feed intake of ruminants is affected is 60% (Meissner et al., 1991). Tree forages with a low NDF concentration (20 to 35%) are usually of great digestibility (Bakshi and Wadhwa, 2007). The NDF result of this study is in accordance with the results reported by Schmiddek et al. (2000) and Cheema et al. (2011) for multipurpose trees and shrub species. Therefore, the NDF (37.98%) value obtained in the present experiment could be regarded as medium. This attribute can induce even greater fermentation rate, thus, improving its digestibility (Van Soest, 1994).

### ***In sacco* degradability**

In sole mulberry leaf meal, T5 had the greatest value for slowly degradable fraction (*b*) than the diets with less proportion of mulberry. Additionally, T5 and T4 had significantly ( $p < 0.05$ ) less soluble fraction (*a*) and effective degradability (ED) values compared to the diets with less proportion of mulberry (Table 1). The higher washable materials in T1 than T5 might indicate relatively higher content of dusty and small particles which could easily pass or wash from the bag, rather than a greater solubility. Similarly, Promkot and Wanapat (2003) reported that the result of the rumen bag technique depends on the way the feed is prepared and the pore

size of the material from which the bag is made. Unlike the washable materials, the opposite is true in the case of the potential degradation for non-water soluble materials (B).

According to Belachew et al. (2013), multipurpose trees could be assigned to great (> 450 g/kgDM), medium (400 to 450 g/kgDM), and low (< 400 g/kgDM) quality groups based on their ED values. All the experimental diets in the current study including the mulberry foliage belonged to great quality group (Table 2). This further clarifies the comparable nutritional potential of mulberry foliage with that of concentrate mix and justifies the nutritive potential of mulberry which could supplement the less quality cereal crop residues in ruminant feed.

6 h post incubation; the greatest DM disappearance was recorded for T1 and T2, which have higher proportion of concentrate mix in the diet. Even though DM disappearances of mulberry leaf meal were lower compared to concentrate mix, 6 h post incubation; these results were comparable with other multipurpose trees. Belachew et al. (2013) noted that 6 h post incubation, the greatest DM disappearances was recorded for the leaves of multipurpose trees like *Ekebergia capensis* (32.12%) and *Melaleuca lanceolata* (32.60%) and the least DM disappearances was determined for *Ficus sycamoros* (15.82%) and *Rehmannia glutinosa* (16.87%) leaves. In the present study, dry matter disappearance increased with rumen incubation time for all experimental feeds. This is in accordance with the findings of Belachew et al. (2013), Lebopa et al. (2011), Vranic et al. (2009), Lanyasunya et al. (2006) and Tesema et al. (2003) which confirmed that *in sacco* degradation of dry matter increase as incubation time advances.

The obtained results for potentially degradable and rate of degradation are higher than the results reported by Suchitra and Wanapat (2008). However, the washable (39.2), potential degradability (84.7), and effective degradability (64.2) values were higher than the values obtained in the current study. The rate of degradations obtained in the current study (0.084 to 0.090) were higher than most of the multipurpose trees reported by Belachew et al. (2013) and to some extent is in accordance with that of Suchitra and Wanapat (2008). They have reported that the rate of degradation for Cassava hay (0.086) was highest compared to the other treatments, resulting in low gut fill which could lead to higher intake and animal production.

Furthermore, the lag time was at its minimum for T1 (4.27 h) and then increased which showed maximum value for T3 (5.03 h). In short, the amount of dry matter found degraded in all tested feeds at 12 and 24 h which are more than 50 and 66%, respectively, and implied that they were all greatly degradable in the rumen.

Generally, the results of the current study indicated that mulberry foliage appears to be rich in protein and minerals and low in fiber contents. Mulberry leaf meal by virtue of having high CP, good Ca to P ratio, promising

digestibility and digestion rate as well as good extent of digestion is compatible to concentrate mix.

## Conclusion

Mulberry leaf meal could potentially be used as a supplement to poor quality roughage diets, particularly during the dry season which could substitute the costly and not easily accessible protein concentrates by poor farmers in Ethiopia.

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## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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