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Table of Contents

Application of Morphometric Traits and Body Indices in Assessing the Type and Function of Local Goats Reared in Two Districts of Gamo-Gofa Zone, South Ethiopia

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ABSTRACT

The present study was conducted with the objectives of applying the morphometric traits and their indices in assessing the type and function of indigenous goats reared in Arbaminch-Zuria (AMZ) and Mirab-Abaya (MA) districts of Gamo-Gofa zone. For this study, 151 bucks and 464 does were scored for morphometric measurements from which fourteen body indices were calculated. The results indicated that the AMZ bucks had higher ($p<0.05$) wither height (WH), chest girth (CG), rump width (RW) and head width (HW) values than those of MA. Conversely, chest depth (CD), rump length (RL), head length (HL) and ear length (EL) of MA bucks were higher ($p<0.05$) than those of AMZ. The body weight (BW), body length (BL), CG, RW and HW values were higher ($p<0.05$) in does of AMZ than those of MA. However, does in MA had higher ($p<0.05$) wither height (WH), CD, RL and EL values than those of AMZ. Except at 0PPI, goats in MA had higher ($p<0.05$) CD, RL and EL values than those of AMZ at all age ranges. Goats in AMZ at 2PPI and above had higher ($p<0.05$) BL, CG, RW and HW values than those of MA. Goats in AMZ were heavier ($p<0.05$) than those of MA at 1PPI and 3PPI. Irrespective of 1PPI, goats in AMZ had higher ($p<0.05$) CG than those of MA and their RW was higher ($p<0.05$) than those of MA at all age ranges. The BW of bucks was strongly ($p<0.001$) and positively correlated with BL, WH, CG and HL. In does, a positive and moderate ($p<0.01$) correlation of BW was observed with BL, CG, RW and HL. Rump width was identified as suitable predictor of BW in does at 3PPI (R^2 = 93.9). Wither height and CG were the best predictor of BW in bucks at 2PPI (R^2 = 99.6). At 3PPI, CG was a single predictor of bucks' BW (R^2 = 94.8). Goats in AMZ had higher values than those of MA for cephalic index, thoracic development, pelvic index, transversal pelvic, length index, area index compact index, conformation index, foreleg index and weight. Conversely, goats in MA had higher values in relative depth of thorax, longitudinal pelvic and proportionality than those of AMZ. In conclusion, morphometric traits and their indices suggested that goats reared in AMZ can be classified as a medium-sized and long-shaped body frame, with a marked orientation for meat production, while goats in MA were characterized as medium-sized animal whose morphology corresponds to dairy type

Key words*:* Arbaminch-Zuria; indigenous goat; Mirab-Abaya; morphometric traits; zoometric indices

INTRODUCTION

Small ruminant in general and goat production in particular, significantly contribute to the national and household economy and is considered as the most important agricultural activity in Ethiopia. According to CSA (2018), Ethiopia has 32.74 million heads of goats of which 70.5% are females and about 29.5% are males and almost all of them (99.97%) are pure indigenous. The country is home to genetically diverse goat populations that are widely distributed across all agro-ecologies (Hassen *et al.,* 2012). According to FAOSTAT (2016), Ethiopia stands third in Africa and sixth in the world accounting for 9% and 3% of the African and global goat population, respectively. According to DAGRIS (2007), there are four families and 13 different indigenous goat types in Ethiopia based on their phenotypic characterization. However, recent genetic characterization studies revealed only the presence of seven different breed types in the country (Mekuriaw, 2016). However, such reports may not necessarily be comprehensive as some remote parts of the country that have the potential for goat production might have not been broadly represented.

Phenotypic characterization of farm animal genetic resources is the process of identifying distinct breeds or populations by describing their external and production characteristics in a given production environment. Morphological measurements have been traditionally used for characterization of local sheep and goat breeds by many researchers (Hassen *et al*., 2012; Melesse *et al*., 2013; Lorato *et al*., 2015) as well as to predict carcass characteristics (Agamy *et al*., 2015). Production performances, especially the function of meat production can be also assessed from morphometric traits such as chest girth, body length, chest width, rump width and chest depth, which are more closely associated with bone or muscle development. Furthermore, the information generated by characterization studies is essential for planning the management of animal genetic resources at local, national, regional and global levels (FAO, 2012).

To identify the type and function of goat breed, morphometric indices could be calculated from linear body measurements. Morphometric indices are relationships among linear body measurements that are used to describe the proportions and general size of animals. These indices are a combination of several linear body measurements that are used to assess the type, weight, and function of the breeds of animals and further enhance the ability of breeders to select potential breeding stock in the existing production system (Chacón *et al*., 2011). Such indices provide tested empirical values which are limited in the use of single measurements and calculated from morphometric traits (Chacón *et al*., 2011; Khargharia *et al*., 2015; Barragán, 2017). These authors suggested that indices that are produced from morphometric measurements that are more closely associated with bone growth such as foreleg length, height slope, and length index are more appropriate for assessment of type.

Gamo-Gofa zone is characterized by diverse agro-ecological locations where goats play increasingly significant role for communities that rear them. There is a long tradition of goat production and huge goat resources in the zone, particularly in the studied districts. Despite having huge benefits for the society of the zone, studies on goat's physical traits and documented information on phenotypic characterization and structural indices of goat in the studied area is lacking. Thus, this study was conducted to apply the morphometric traits and their structural indices in the assessment of type and function in local goats reared in two potential districts of Gamo-Gofa Zone.

MATERIALS AND METHODS

Description of Study Areas

The study was conducted in Arbaminch-Zuria (AMZ) and Mirab-Abaya (MA) districts that are found in Gamo-Gofa zone, southern Ethiopia. The AMZ district has an elevation that ranges from 1200 m a.s.l at the northern end to 1320 m a.s.l at the southern end. According to the Arbaminch Meteorological Station, the area receives bimodal rainfall of 830 mm per annum. The mean minimum, mean maximum and average temperatures are 15.1, 29.9 and 22.5^{o}C, respectively. The MA district has an altitude of 1193 m a.s.l and is characterized by bimodal rainy seasons as well receiving an average annual rainfall of 800-1200 mm. The average annual temperature ranges from 25 to 32 ^{0}C. The two districts are characterized by mixed livestock-crop farming system.

Sampling and Data Collection Procedures

Morphometric characterization

A multistage sampling procedure was used to select representative samples from the study zone. From 15 districts, two districts were selected purposively based on their potential in goat population. Three kebeles (Peasant Associations; smallest administrative unit) were then randomly selected from each district. Accordingly, Wozeka, Elgo and Dargo kebeles were selected from AMZ district and Yaike, Fetele and Faragosa kebeles from MA. Two hundred households that possess a minimum of five goats and above were purposely identified from all kebeles from which 120 households were randomly selected from both districts.

Morphometric traits were taken from 151 males and 464 females following the phenotypic descriptor list of FAO (2012). Kids and pregnant animals were excluded from the measurement to avoid under and over estimation, respectively. All measurements were taken early in the morning to avoid the effect of feeding and watering on the animal's body size and when they are on normal standing position. The linear traits were taken using plastic tape and caliper, while body weight was measured using suspended weighing scale with 50 kg capacity of 0.2 kg precision. Body weight (BW), body length (BL), height at wither (WH), chest girth (CG), Chest depth (CD), rump length (RL), rump width (RW), head length (HL), head width (HW) and ear length (EL) were assessed. To avoid genetic similarity, less than or equal to 4 goats per household were used. Each animal was identified by its sex, dentition, and sampling site. Dentition together with the information obtained from the owner was used to classify the goats by their age group. Accordingly, goats were classified as 0PPI (no pair of permanent incisor), 1PPI (one pair of permanent incisor), 2PPI (two pair of permanent incisor), 3PPI (three pair of permanent incisor) and 4PPI (four pair of permanent incisor) by representing 0-1 year, 1-2 years, 2-3 years, 3-4 years and 4-5 years old, respectively (FAO, 2012).

Calculation of body indices

To assess the type and function of indigenous goat population in the study area, five structural (ethnological) and nine functional indices were calculated from the morphometric traits according to the method of Chacón *et al*. (2011), Khargharia *et al*. (2015) and Barragán (2017).

Statistical Analysis

All morphometric data were analyzed using GLM procedure of SAS (SAS, 2012; ver. 9.4) by fitting district, sex and age as main effects. Means were separated by using Duncan's Multiple Range Test. The stepwise multiple regression procedure was used to obtain models for estimation of body weight from the morphometric traits. Model used for the analysis of body weight and linear body measurements traits:

$y_{ijk} = \mu + A_i + S_j + D_k + e_{ijk}$

y_{ijk} = the observation of measured variables

μ = overall mean

A_i = the effect due to i^{th} age group (i = 0PPI, 1PPI, 2PPI, 3PPI, 4PPI)

S_j= the effect due to j^{th} sex (j = female and male)

D_k= the effect due to k^{th} district (k = AMZ and MA)

e_{ijk} = random residual error

Pearson's correlation coefficients were performed between body weight and linear body measurements for the population with in all age groups and both sexes. The body weight of the animals within age groups and sex was predicted using stepwise multiple regression procedure with the following model:

$Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots.. \beta_9 X_9 + e_j$

Y_j = the response variable (body weight)

α = the intercept

$X_1 \ldots., X_9$= the explanatory variables (BL, WH, CG, …)

$\beta_1 \ldots, \beta_9$= regression coefficients of the variables $X_1 \ldots, X_9$

e_j= random error

RESULTS

Morphometric Traits

The average value of body weight (BW) and morphometric traits of bucks and does in AMZ and MA are presented in Table1.The AMZ bucks had higher ($p<0.05$) wither height (WH), chest girth (CG), rump width (RW) and head width (HW) than those of MA. Conversely, bucks of MA showed higher ($p<0.05$) chest depth (CD), rump length (RL), head length (HL) and ear length (EL) than those of AMZ. Values of BW, body length (BL), CG, RW and HW in AMZ does were higher ($p<0.05$) than those of MA. However, MA females had higher ($p<0.05$) WH, chest depth (CD), RL and EL values than those of AMZ. The overall mean values indicated that AMZ goats were superior ($p<0.05$) in BW, BL, CG, RW and HW than those of MA. Conversely, MA goats were better ($p<0.05$) in CD, RL and EL traits than those of AMZ.

Average morphometric traits of local goats at different age groups reared in both districts has been presented in Table 2. Except at 0PPI, the CD, RL and EL values of MA goats were higher ($p<0.05$) than those of AMZ. AMZ goats at 2PPI and above had higher ($p<0.05$) BL, CG, RW and HW values than those of MA. The AMZ goats were heavier ($p<0.05$) than those of MA at 1PPI and 3PPI. The AMZ goats had higher ($p<0.05$) CG than those of MA in all age ranges (irrespective of goats at 1PPI). The RW in AMZ goats at all age ranges was higher ($p<0.05$) than those of MA. Body weight and WH consistently increased with the age of goats in both districts. The CG in AMZ goats and the BL in MA linearly increased with the age of the animals. However, the increase of both morphometric traits with age was inconsistent among goats of both districts.

Phenotypic correlations

The Pearson correlation coefficients of body weight with morphometric traits in does and bucks are presented in Table 3. Among quantitative traits measured on bucks, BW was strongly ($p<0.001$) and positively correlated with BL, WH, CG and HL. A strong and positive ($p<0.001$) association of WH was also observed with CG and HL in bucks. The BL of bucks was moderately and positively ($p<0.01$) correlated with WH and HL. The RL in bucks also showed a positive correlation ($p<0.01$) with RW and HL.

In does, a moderate and positive ($p<0.01$) correlation of BW was observed with BL, CG, RW and HL. Body weight of does was also positively correlated ($p<0.05$) with WH and HW. A strong and positive association ($p<0.001$) of RW with HL and HW was recorded in does. The CD in does was also strongly and positively associated with RL. The association of BL of does with CG, RW, HL and HW was positive while it was negative with CD and RL. Similarly, CG correlated negatively with CD while its correlation with RW and HW was positive.

Table 1. Average values of morphometric traits of male and female goats reared in Arbaminch-Zuria and Mirab-Abaya districts (does N = 464; bucks N = 151)

Sex	district	Body weight	Body length	Height at wither	Chest girth	Chest depth	Rump length	Rump width	Head length	Head width	Ear length
Male	AMZ	30.9	57.1	62.2^{a}	72.1^{a}	41.3^{b}	16.3^{b}	16.3^{a}	18.4^{b}	16.9^{a}	12.9^{b}
	MA	29.7	57.3	59.4^{b}	65.9^{b}	48.3^{a}	17.6^{a}	14.9^{b}	19.0^{a}	14.7^{b}	14.0^{a}
Female	AMZ	30.4^{a}	68.6^{a}	58.5^{b}	69.8^{a}	42.2^{b}	15.7^{b}	16.4^{a}	18.9	15.1^{a}	12.4^{b}
	MA	29.1^{b}	60.4^{b}	61.0^{a}	66.6^{b}	46.5^{a}	17.6^{a}	15.2^{b}	18.7	13.5^{b}	14.5^{a}
Overall mean	AMZ	30.9^{a}	62.9^{a}	60.5	71.0^{a}	41.7^{b}	16.0^{b}	16.3^{a}	18.6	16.1^{a}	12.7^{b}
	MA	29.0^{b}	58.9^{b}	60.2	66.0^{b}	47.4^{a}	17.6^{a}	15.1^{b}	18.9	14.1^{b}	14.3^{a}
S.E.M		0.394	2.691	0.824	1.443	1.682	0.478	0.381	0.132	0.704	0.484

^{a,b} Means between districts within sex group bearing different superscript letters are significant at $p<0.05$

AMZ = Arbaminch-Zuria; MA = Mirab-Abaya; S.E.M = standard error of the mean

Table 2. Average morphometric traits of local goats at different age groups reared in Arbaminch-Zuria and Mirab-Abaya districts

Age	district	Body weight	Body length	Height at wither	Chest girth	Chest depth	Rump length	Rump width	Head length	Head width	Ear length
0PPI	AMZ	25.5	53.8	56.2	67.0^{a}	41.5	16.2	15.6^{a}	17.6	16.1	12.9
(N = 33)	MA	24.4	53.7	55.2	61.6^{b}	47.6	16.8	14.5^{b}	16.9	15.3	12.3
1PPI	AMZ	28.7^{a}	63.2^{a}	58.8	68.8	41.8^{b}	16.2^{b}	16.2^{a}	18.4	16.7^{a}	12.8^{b}
(N = 58)	MA	27.0^{b}	55.1^{b}	60.2	66.9	47.3^{a}	17.3^{a}	14.4^{b}	18.5	14.5^{b}	14.0^{a}
2PPI	AMZ	30.0	62.3^{a}	61.4	70.5^{a}	41.8^{b}	15.5^{b}	16.8^{a}	18.6	16.0^{a}	12.7^{b}
(N = 115)	MA	28.4	57.8^{b}	59.8	63.9^{b}	46.4^{a}	17.5^{a}	15.5^{b}	19.0	13.9^{b}	13.9^{a}
3PPI	AMZ	31.8^{a}	69.1^{a}	61.9	72.7^{a}	43.7^{b}	16.6^{b}	17.2^{a}	19.4	16.1^{a}	12.4^{b}
(N = 206)	MA	29.5^{b}	60.8^{b}	60.7	66.1^{b}	47.4^{a}	17.6^{a}	15.0^{b}	19.2	13.4^{b}	14.4^{a}
4PPI	AMZ	31.9	66.4^{a}	61.3	73.9^{a}	40.0^{b}	14.7^{b}	16.4^{a}	18.8^{b}	14.8^{a}	12.7^{b}
(N = 198)	MA	31.1	61.1^{b}	61.9	69.2^{b}	46.6^{a}	17.8^{a}	15.3^{b}	19.3^{a}	13.1^{b}	14.8^{a}
S.E.M		0.813	1.657	0.743	1.196	0.933	0.315	0.299	0.250	0.395	0.284

^{a,b} Means between districts within age groups with different superscript letters are significant at $p<0.05$

1PPI = one pair of permanent incisor; 2PPI = two pairs of permanent incisor; 3PPI = three pairs of permanent incisor; 4PPI = four pairs of permanent incisor; AMZ = Arbaminch-Zuria; MA = Mirab-Abaya; S.E.M = standard error of the mean

Table 3. Phenotypic correlations of body weight with morphometric traits in does (above diagonal) and bucks (below diagonal)

	BW	BL	WH	CG	CD	RL	RW	HL	HW
BW	-	0.52**	0.47*	0.57**	-0.13	-0.13	0.55**	0.55**	0.39*
BL	0.79***	-	0.02	0.52**	-0.47*	-0.49*	0.45*	0.32*	0.43*
HW	0.83***	0.55**	-	0.31	0.27	0.43*	0.32	0.45*	0.12
CG	0.72***	0.40*	0.80***	-	-0.44*	-0.33	0.55**	0.34	0.44*
CD	0.12	0.28	-0.13	-0.25	-	0.83***	0.05	0.22	0.01
RL	0.06	0.18	0.13	-0.12	0.49*	-	0.17	0.32	0.08
RW	0.21	0.27	0.24	0.26	0.18	0.58**	-	0.72***	0.86***
HL	0.69***	0.60**	0.70***	0.18*	0.30	0.50**	0.25	-	0.37
HW	-0.02	-0.17	0.09	0.20	0.13	0.24	0.61**	-0.10	-

*P<0.05; **P<0.01; ***P<0.001; BW = body weight; BL = body length; WH = height at wither; CG = chest girth; CD = chest depth; RL = rump length; RW = rump width; HL = head length; HW = head width

Prediction of body weight from morphometric traits

The regression models used for the prediction of BW from different morphometric traits of age and sex of sampled goats are presented in Table 4. Stepwise multiple linear regression analysis was used to predict BW from morphometric traits, which had a positive and significant correlation with BW. All variables were fitted into the model and through stepwise elimination procedures, the optimum model was identified. The best fitted prediction models (explanatory variables) were further selected with smaller C (P) and higher R^2 values and simplicity of measurement under field condition were also considered.

At 1PPI and 2PPI, the results of the multiple regression analysis revealed that WH was the single important variable in the prediction of BW in does. At 3PPI, RW was identified as best predictor of BW (R^2 = 93.9; P<0.007) in does. However, when data were pooled, CG appeared to be the best predictor of BW in does although the prediction model was not so strong (R^2 = 35.5; P<0.002).

At the 2PPI, WH alone appeared to be the best predictor of BW in bucks (R^2 = 88.9; P<0.01). The prediction became more accurate (R^2 = 99.6; P<0.01) when WH is combined with CG in the regression model. At the 3PPI, CG was found as suitable single predictor of bucks' BW (R^2 = 94.8; P<0.001). The prediction power of CG slightly increased when RL was included in the regression model (R^2 = 99.2; P<0.001). The RL was identified as a single and suitable predictor of BW in bucks at 4PPI (R^2 = 85.0; P>0.084). When all data were pooled, WH appeared to be the best predictor of BW in bucks (R^2 = 68.6; P<0.0001). However, the prediction power of WH considerably improved when BL was included in the regression model (R^2 = 84.6; P<0.001). The prediction power of both variables (WH and BL) slightly increased when CG was included in the model.

Table 4. Linear regression equations for estimation of live weight from linear body measurements and their determination coefficient

Sex	Age	Prediction equations	R^2	P-value
Does	1PPI	17.2 + 0.731*HW	66.6	0.028
	2PPI	16.0 + 0.907*HW	47.0	0.080
	3PPI	13.5 + 1.016*RW	93.9	0.007
	All ages	4.60 + 0.358*CG	35.5	0.002
	(data pooled)	-8.49 + 0.278*CG + 0.988*HL	49.3	0.0006
Bucks	2PPI	-26.3 + 0.911*WH	88.9	0.005
		-15 + 0.812*WH - 0.261*RL	98.3	0.002
		-12.1 + 0.707*WH + 0.044CG	99.6	0.006
	3PPI	4.55 + 0.399*CG	94.8	0.001
		1.418 + 0.353*CG + 0.409*RL	99.2	0.0007
		-1.704 + 0.368*CG + 0.294*RW + 0.204*HL	99.9	0.0015
	4PPI	- 111 + 9.56*RL (due to small number)	85.0	0.084
	All ages	-25.0+0.905*WH	68.6	<0.0001
	(data pooled)	-42.7+0.619BL+0.614*WH	84.6	<0.0001
		-42.2+0.637BL + 0.419WH + 0.149CG	86.2	<0.0001

BW = body weight; BL = body length; WH = wither height; CG = chest girth; HL = head length; HW = head width; RL = rump length; RW = rump width

Table 5. Calculated structural and functional indices from morphometric traits of goat types reared in the studied districts

Body indices	Arbaminch-Zuria	Mirab-Abaya	Overall mean	SD	CV (%)
Cephalic index	86.6	75.0	80.7	8.20	10.2
Body index (corporal index)	87.5	87.9	87.7	0.28	0.32
Thoracic development index	1.17	1.10	1.14	0.05	4.36
Relative depth of thorax	68.9	79.0	73.9	7.14	9.66
Pelvic index	102	86.0	93.0	11.3	12.0
Transversal pelvic index	26.9	25.2	26.1	1.20	4.61
Longitudinal pelvic index	26.4	29.3	27.9	2.05	7.36
Proportionality	97.4	103	100	3.96	3.95
Relative body or length index	1.03	0.97	1.00	0.04	4.24
Area index	3757	3480	3618	196	5.41
Compact index	5.01	4.78	4.90	0.16	3.32
Conformation index	83.3	72.6	77.9	7.57	9.71
Fore leg index	18.8	12.6	15.7	4.38	27.9
Weight	44.7	35.9	40.2	6.22	15.4

SD = standard deviation; CV= coefficient of variation

DISCUSSION

Morphometric traits

Body weight of MA does (29.1 kg) was similar with that of South African goats reared in semi-arid agro-ecology reported by Selolo *et al*. (2015). The overall mean of BW observed in AMZ goats was also in line with that of Hassen *et al*. (2012) who reported an average value of 31.1 kg for six Ethiopian indigenous goat breeds. Consistent with the current findings, Gatew *et al*. (2015) further reported 30.6 kg of BW for short-eared Somali goats. The BW of goats from both districts in the current study was also comparable to that of Central Highland goat populations; but was lower than Woyto-Guji goats reported by Zergaw *et al*. (2016). On the other hand, Chiemela *et al*. (2015) and Tsegaye *et al*. (2013) reported lower BW for Central Highland in south Wollo and Hararghe highland local goat populations, respectively. Conversely, Gatew *et al*. (2015) reported 41.3 and 40.4 kg BW for Bati and Borena male goat populations, respectively which are considerably higher than observed in the current study. Similarly, higher BW of Horro-Guduru goats than recorded in AMZ and MA goats of the current study were also reported by Seid *et al*. (2016). These variations could be associated with genetic potential of the local goat types reared in various parts of the country, season when the measurements were taken, type of management provided by the owners, sex and age of animals. Proportion of male to female in the reported flocks could also contribute to such variations as body weight of goats is mainly affected by the sex of animals due to sexual dimorphism.

Consistent with the current results for AMZ goats, Hassen *et al*. (2012) reported similar CG for Bati and Abergelle goat populations. The CG reported by Tsegaye *et al*. (2013) and Chiemela *et al*. (2015) was in good agreement with that of MA goats. Gatew *et al*. (2015) also reported CG values for short-eared Somali goats that are comparable with those of MA. Moreover, the CG values reported for Indian Assam Hill goats by Khargharia *et al*. (2015) and those of Central Highland goats reported by Zergaw *et al*. (2016) were in line with that of AMZ bucks. Furthermore, the CG of Horro-Guduru goats reported by Seid *et al*. (2016) was similar with that of AMZ does while it was higher than recorded in MA goat populations. Similarly, the CG of MA bucks was consistent with the findings of Okpeku *et al*. (2011) for Nigerian Red Sokoto goats. On the other hand, Tsegaye *et al*. (2013) and Chiemela *et al*. (2015) reported lower CG for Hararghe highland and Central Highland goats in south Wollo, respectively while higher values were reported by Hassen *et al*. (2012) for Gumuz, Agew and Begiamedir goat populations than observed in AMZ goats. Moreover, Gatew *et al*. (2015) reported higher CG for Bati and Borena goats than observed in the current study. Chacón *et al*. (2011) reported much higher CG value (76.9 cm) for Cuban Creole goats than observed in the current study for goats of both districts. Such differences might be attributed to the genetic makeup, management (housing, feeding, exposure to parasite load, etc.) and production environments due to location of various goat breeds.

The BL of AMZ goats was consistent with the findings of Hassen *et al*. (2012) (for Bati and Abergelle goats) and Gatew *et al*. (2015) (for Bati and Borena goats). Body length values reported by Gatew *et al*. (2015) for small-eared Somali goats were also in good agreement with those of MA. Moreover, the BL values reported by Selolo *et al*. (2015) for does reared in South African semi-arid agro-ecology were comparable to that of MA (60.9 vs. 60.4 cm). Zergaw *et al*. (2016) also reported 57.4 cm BL for Woyto-Guji goats which is consistent with that of bucks reared in both districts. Conversely, Traore *et al*. (2008) reported lower BL for Sudan female goats than that of observed in the current study. Higher BL was also reported by Seid *et al*. (2016) for Horro-Guduru goats than observed in the bucks reared in both study districts. These variations in BL might be associated with differences in the genetic makeup of goats, type of management practiced by the smallholder farmers, season and environmental conditions in which goats have been raised.

In the current study, WH for AMZ and MA does was 58.5 and 61.0 cm, respectively, which was in line with the findings of Selolo *et al*. (2015) reported for South African female goats reared in semi-arid agro-ecological zones and Okpeku *et al*. (2011) for Nigerian Red Sokoto goats. The WH in MA does was found to be similar with that of Traore *et al*. (2008) for the Sudanese goats reared in the Sahel area and Okpeku *et al*. (2011) for Nigerian Red Sokoto goats and Chacón *et al*. (2011) for Cuban Creole goats. The WH reported by Chiemela *et al*. (2015) and Tsegaye *et al*. (2013) for Ethiopian local goat populations were also comparable with that of AMZ and MA goats. The WH of Woyto-Guji goats reported by Zergaw *et al*. (2016) were comparable to that of AMZ bucks and MA does. However, the same authors reported higher WH for Central Highland goats than any of the goats assessed in the current study. Similarly, the WH of Horro-Guduru goat reported by Seid *et al*. (2016) was higher than the current findings in both districts. Dekhili *et al*. (2013) also reported 66.9 cm WH for Algerian goats which was much higher than observed in the current study. The observed variations in WH among the current finding and in the literature for local goat populations might be attributed to the existence of goats with variable genetic potentials which could be considered as a viable resource in the genetic improvement program of the existing indigenous goat populations.

The EL of Cuban Creole goats reported by Chacón *et al*. (2011) was similar with that of AMZ goats while it was lower than those of MA. Similarly, the EL reported by Zergaw *et al*. (2016) for Woyto-Guji goats was in good agreement with that of AMZ while it was lower than recorded in MA goats. The EL of MA goats was found to be similar to that of Central Highland goats as reported by Zergaw *et al*. (2016). Conversely, Dekhili *et al*. (2013) reported 18.5 cm ear length for Algerian goats which was much higher than observed for local goats of both districts in the current study. Such variations could be explained due to differences in the genetic makeup and adaptation potentials of the goat breeds to specific environmental conditions such as desert areas that are characterized by extreme ambient temperatures.

The BW of Hararghe highland goats at 2PPI reported by Tsegaye *et al*. (2013) was consistent with that of MA goats while it was lower than observed in those of AMZ. Goats of AMZ at 3PPI had similar BW with those of Hararghe highland goats at similar age as reported by Tsegaye *et al*. (2013). Moreover, the BW of MA at 2PPI and AMZ goats at 3PPI was consistent with the findings of Seid *et al*. (2016) for Horro-Guduru goats at similar age ranges. Moreover, the WH of Horro-Guduru goats at 1PPI and 3PPI was in good agreement with that of AMZ goats at similar ages. The WH of goats recorded until 2PPI in both districts was also similar with that of Hararghe highland goats reported by Tsegaye *et al*. (2013) for similar age range. The CG reported by the same authors for Hararghe highland goats at 1PPI was also consistent with that of AMZ goats of the same age. Similarly, the CG of AMZ and MA goat populations at 1PPI was comparable with that of Horro-Guduru goats reported by Seid *et al*. (2016) for the same age range. The same authors also reported CG values at 2PPI, 3PPI and 4PPI, which are comparable to AMZ goats of the same age ranges. The CG and WH values in MA goat populations at all PPI age ranges were inferior to those of Horro-Guduru goats reported by the same authors. The size of CG is considered as indicator of carcass yield potential and thus it can be speculated that the AMZ and Horro-Guduru goats are more suitable for meat production while the MA goats may fit for milk production. Such speculations are further evidenced by the fact that goats in AMZ had higher BW, BL, CG, RW and HW than those of MA, which suggests that they might be more suitable for meat production rather than milk production. On the other hand, the observed higher values for CD, RL and EL in goats reared in MA may suggest their suitability as a dairy goat type.

Correlation of morphometric traits and prediction of body weight

From the current findings, a higher relationship between body weight and linear measurements was observed in bucks than in the females. The higher association of BW with WH was possibly due to a relatively larger contribution of the wither area to body weight which consists of bones, muscles and the viscera organs. The association of BW with WH for bucks in the current study is in good agreement with that of Gatew *et al*. (2015) for Borena and short-eared Somali bucks, while it was higher than reported for Bati male goats. Okpeku *et al*. (2011) reported a high and positive correlation of BW with WH for the Nigerian WAD goats which is in good agreement with the current findings for bucks. Khargharia *et al*. (2015) also reported correlation of BW with BL (r = 0.86), RL (r = 0.70) and CG (r = 0.79) for Indian Assam Hill goats which are comparable to those observed for both sexes in the current study. The correlation of BW with BL in bucks of the current study was comparable with that of Borena bucks; but was higher than reported by Gatew *et al*. (2015) for short-eared Somali and Bati bucks. The positive correlation of morphometric traits indicated which trait could be further used for selection criteria. Moreover, the high phenotypic correlations observed between BW and morphometric traits suggests that these traits are under the same genetic influence and thus, selection for linear body measurement traits will favor the selection for body weight.

The strong positive and significant correlation of BW with BL, CG and WH suggested that either or the combination of these morphometric traits could be used to estimate BW of goats in the fields in the absence of a weighing scale. The regression model could not assess the prediction of body weight from morphometric traits in goats of 0PPI age category which might be due to age factor that they are still growing and their body has not yet been fully developed. Rump width was identified as the single important variable in the prediction of BW in does at 3PPI, which accounts for about 94% of the variations. The size of rump width is essential for does to accommodate the fetus during pregnancy and for efficient delivery during parturition. In males at 2PPI, WH accounts for about 90% of the variations in predicting the BW. The Model F statistic was highly significant ($F = 228.92$, $p<0.0001$), indicating that the model accounts for a higher portion of variation in the data. Even though, the magnitude of improvement varied in age groups, the inclusion of their respective linear measurements with WH and CG for bucks improved the accuracy of the prediction model (R^2) in all cases.

The result of stepwise regression analysis revealed that WH and CG in bucks were more consistent in predicting BW than others at 2PPI and 3PPI. This is in good agreement with the reports of various scholars in different parts of Ethiopia (Lorato *et al*., 2015; Seid *et al*., 2016; Hagos *et al*., 2016). The result of the multiple regression analysis for bucks at 3PPI indicated that the addition of other morphometric traits to the CG did not result in a significant increase in R^2, but it considerably improved the accuracy of prediction by decreasing the error source even though the quantity of increment was too small. Consequently, at farmers' management level where weighing scales may not be available using more than one trait may be impractical to measure by making the applicability less reliable. Moreover, adding more variables under farmers' management level will not be possible due to lack of technical skills and might increase errors. Therefore, CG alone could be used to predict body weight in bucks of 3PPI age category. The WH was found to be important variable to predict body weight of bucks in all age categories by accounting 68.8% of the variations.

Zoometric indices

Morphology of an animal expresses a strong relationship with productive potential, since it contains the structure which supports the biological functionality of the animal (Alpak *et al*., 2009). To the authors' knowledge, there is limited information in the literature reporting on the morphometric indices of local goat populations in Ethiopia. Moreover, reports dealing with structural and functional indices of goats in tropical and sub-tropical production environments are still scanty. As a result, it was difficult to make proper and plausible comparisons of the current findings with those of previous published works.

The cephalic index (CpI) refers to the harmony of the head, classifying it as brachycephalic, mesocephalic, or dolichocephalic (Arredondo-Ruiz *et al*., 2013). In the current study, CpI of MA goats was much smaller than those of AMZ (75.0 ver. 86.6). This is due to the fact that the head length of MA goats was much larger than the width and they can be thus classified as dolichocephalous. However, AMZ goats could be classified as mesocephalous. Body index (BI) indicates the relative capacity of the animal format (Latorre *et al*., 2011). Based on the results of BI, goats in both districts could be classified as mediolineous (¤85 and ≤89). The BI values in the current study are much similar to those reported by Chacón *et al*. (2011), Khargharia *et al*. (2015) and Chiemela *et al* (2016) for various types of local goat populations. The respective weight index of goat populations in AMZ and MA was 44.7 and 35.9 kg, which correspondingly classify them as medium or eumetric type.

Thoracic development (TD) is important in terms of fitness, good respiratory system, particularly in those goats adapted to higher altitudes. In the current study, AMZ goats had higher TD value than those of MA indicating a better thoracic capacity enabling them to survive in relatively high altitude terrains. The observations are consistent with those of Chiemela *et al*. (2016), who reported a TD value of 1.08 for Central Highland female goats in south Wollo; but were slightly lower than that of Chacón *et al*. (2011) for Cuban Creole goats (1.17) and Khargharia *et al*. (2015) for India Assam Hill goats (1.32).

Relative depth of thorax index (DTI) indicates a relationship between chest depth and wither-height and serves as an indirect measure of leg length, whereby higher indices for this trait corresponds to animals with longer legs (Chacón *et al*., 2011). According to these authors, animals with higher DTI values have a higher moving capacity, being more adapted to plains and long treks with bodies further from the ground to avoid heat radiation. In the current study, MA goats had a higher DTI (79.0 ver. 68.9), which suggests that they are characterized by long legs and their body is far from the ground. This has been clearly reflected in female goats of MA which had a significantly higher wither height value than those of AMZ. Moreover, the higher DTI observed in MA goats could suggest classifying them towards dairy phenotype. Chiemela *et al*. (2016) and Chacón *et al*. (2011) reported DTI of 43.8 for Central Highland goats in south Wollo and 47.7 for adult Cuban Creole goats, respectively, which is far lower from the current findings. Because of the small value in DTI, the Cuban Creole goats were characterized as short-legged with their body being much closer to the ground (Chacón *et al*., 2011).

The pelvic index (PI) is a racial diagnostic index which is used to determine the proportionality of the hindquarters and thus, could be related to the reproductive capacity of female goats (Cerqueira *et al*., 2011). According to the current result of PI, the rump of the MA goats had a convex curve ($p \leq 100$), with a predominance of the rump length over the width. However, pelvic index of AMZ goats was 102 indicating a balance between rump length and its width. Khargharia *et al*. (2015) reported PI values that are lower than observed in AMZ but higher than MA goats. Chacón *et al*., (2011) reported much lower (76.0) PI for Cuban Creole goats while Chiemela *et al*. (2016) reported much higher (123) values for Central Highland goats in south Wollo than observed in the current findings. Such variations might be due to differences in age and sex of goats when the morphometric measurements were taken. There is also a possibility of making errors while taking such measurements in the field.

Transversal pelvic (TPI) and longitudinal pelvic (LPI) indices are commonly used to estimate the meat aptitude of a given animal populations by relating the width and length of the rump to the height at withers (Barragán, 2017). A TPI largely exceeding 33 and LPI not exceeding 37 are suitable indicators of meat type. In the current study, the LPI values for both AMZ and MA goats showed lower values and thus, tended toward the meat phenotype. The observed TPI and LPI values are also comparable with those reported by Chacón *et al*. (2011) for Cuban Creole goats. According to Chiemela *et al*. (2016), the LPI of Central Highland goat in south Wollo was 17.0, which was much lower than observed in the current study. Lower LPI values could also be correlated to animals with a high incidence of dystocia (Chacón *et al*., 2011 and Chiemela *et al*., 2016). The LPI values reported by Khargharia *et al*. (2015) were comparable to those of recorded in AM goats (24.9 vs. 26.4), while those reported by Chacón *et al*. (2011) were much similar with that of MA goats.

Proportionality index (PrI) relates the body height to the body length and denotes the shape of a given animal populations (Barragán, 2017). A PrI value less than 1.00 (predominance of body length over body height) indicates that the breed's body tends to be rectangular which is a characteristic of meat type, while a value greater than 1.00 denotes that the shape of the animal tends to be square, which is a characteristic of dairy type (Bravo and Sepúlveda, 2010; Barragán, 2017). In the current study, the AMZ goats showed smaller PrI (0.97), which is a characteristic of meat type while those of MA demonstrated higher value (1.03) with almost a square shape relating them to a dairy type. PrI value (0.93) reported by Chacón *et al*. (2011) for Cuban Creole goats were comparable to those of

AMZ goats; but was much lower than those of MA. The PrI of Central Highland goats in south Wollo (1.08) reported by Chiemela *et al*. (2016) was comparable to that of MA goats.

The relative body or length index (LI) in the current study was 1.03 and 0.97 for AMZ and MA goats, respectively, which is in good agreement with that of Salako (2006) who reported 1.01 and 0.93 values for WAD and Yankasa sheep, respectively. The LI in the current study was also comparable to the findings of Chacón *et al*. (2011) and Chiemela *et al*. (2016), while it was slightly lower than reported by Khargharia *et al*. (2015). The respective LI values of AMZ and MA goats were comparable to those of Boer and Central Highland goats in south Wollo reported by Chiemela *et al*. (2016). The LI in the current study has confirmed that, relative to height, the AMZ goats are longer bodied than those of MA, which suggest that the carcass yield of the former is expected to be higher than those of the latter.

The area index (AI) values indicated that AMZ goats have larger body surface than those of MA. Animals with larger body surface area relative to their body mass have a better ability to withstand heat stress effectively by dissipating the excess heat load from their body surface by means of sensible and insensible heat dissipation mechanisms. The AI of the Indian Assam Hill goat reported by Khargharia *et al*. (2015) was somehow closer to that of MA goats but was much lower than that of AMZ.

The compact index (CI) value of AMZ goat populations was 5.01 and thus they can be classified as meat type animals validating previous indices. Chiemela *et al*. (2016) reported lower CI values (3.91) for Central Highland goats in south Wollo, while slightly higher values (5.20) were reported for adult Cuban Creole goats by Chacón *et al*. (2011) than observed in AMZ goats but was much higher than those of MA. Khargharia *et al*. (2015) reported 5.63 CI for Indian Assam Hill goats, which is higher than observed in the current study.

The overall body shape of an animal is referred as a conformation. The greater the conformation (baron) index, the more vigorous the breed would be. Accordingly, the AMZ goats are expected to be much vigorous with healthier physical appearance than those of the MA. The observed baron index values for both AMZ and MA goats were lower than reported for other goat breeds (Chacón *et al*., 2011; Khargharia *et al*. (2015). Goats of AMZ had comparable conformation index with that of Boer goats (83.3 vs. 82.7) reared in Central Highland of Ethiopia, while those of MA showed similar values with local goats of Central Highland goats in South Wollo (70.0 vs. 72.6) as reported by Chiemela *et al*. (2016). It is indeed interesting to note that the AMZ goats demonstrated closer similarities in many structural and functional indices with that of Boer goats reared in Central Highland of Ethiopia, while those of MA showed comparable values with Central Highland goats in south Wollo.

CONCLUSIONS

Bucks of AMZ were better in WH, CG, RW and HW than those of MA, while they were inferior in CD, RL, HL and EL. Does reared in AMZ had higher BW, BL, CG, RW and HW than those of MA. In general, goats of AMZ were better in BW, BL, CG, RW and HW than those of MA, while the latter demonstrated higher CD, RL and EL values than the former. The BW of does in all age groups could be predicted by using CG while that of bucks with WH. The estimated morphometric indices suggested classification of AMZ goats as a medium-sized and long-shaped body frame, with a marked orientation for meat production along with signs of adaptation to its environment. Conversely, MA goats were oriented as medium-sized whose morphology corresponds to dairy type. The milk production of MA goats could be thus studied to identify their potential within the existing production system.

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REFERENCES

Agamy, R., Abdel-Moneim, A.Y., Abd-Alla, M.S., Abdel-Mageed, I.I. and Ashmawi G.M. 2015.Using linear body measurements to predict body weight and carcass characteristics of three Egyptian fat-tailed sheep breeds. Asian Journal of Animal and Veterinary Advances 10 (7): 335-344.

Alpak, H., Onar, V. and Mutus, R. 2009. The relationship between morphometric and long bone measurements of the Morkaraman sheep. Turkish Journal of Veterinary and Animal Science 33:199-207

Arredondo-Ruiz, V., Macedo-Barragán, R., Molina-Cárdenas, J., Magaña-Álvarez, J., Prado-Rebolledo, O., García-Márquez, L.J., Herrera-Corredor, A. and Lee-Rangel, H. 2013. Morphological characterization of Pelibuey sheep in Colima, México. Tropical Animal Health and Production 45(4): 895-900.

Barragán, R.M. 2017. Zoometry: a useful tool for determining the productive aptitude of domestic ruminants. Journal of Dairy, Veterinary and Animal Research 5(3):86–87.

Bravo, S. and Sepúlveda, N. 2010. Zoometric indices in Araucanas Creole ewes. International Journal of Morphology 28(2): 489-95.

Cerqueira, J.O.L., Feás, X., Iglesia, A., Pacheco, L.F. and Araújo, J.P.P. 2011. Morphological traits in Portuguese Bordaleira de Entre Douro e Minho sheep: divergence of the breed. Animal Production Science 51: 635-641.

Chacón, E., Fernando, M., Francisco, V., Samuel, R. P., Eliecer, P. and Concepta, M. 2011. Morphological measurements and body indices for Cuban Creole goats and their crossbreds. Revista Brasileira de Zootecnia 40 (8): 1671-1679.

Chiemela, P.N., Banerjee, S., Egbu, C.F, Akpolu, E.S. and Ugbo, E.H. 2015. Some morphometric traits of Boer, Central Highland and their F1 crossbred goats reared at Ataye farm, Ethiopia. International Journal of Advanced Academic Research 1 (3). https://www.ijaar.org/volume1-issue3/.

Chiemela, P.N., Banerjee, S., Taye, M., Egbu, C.F., Ugbo, E.H., Akpolu, E.S. and Umanah, I.J. 2016. Structural indices of Boer, Central highland and their F1 Crossbred goats reared at Ataye farm, Ethiopia. Journal of Agriculture and Research 2: 1-19.

CSA (Central Statistical Agency). 2018. Agricultural sample survey. Report on livestock and livestock characteristics. The Federal Democratic Republic of Ethiopia, Central Statistical Agency (CSA). Vol. II. Report on Livestock and livestock characteristics (private peasant holdings). Statistical Bulletin 587, Addis Ababa, Ethiopia.

DAGRIS (Domestic Animal Genetic Resources Information System). 2007. Domestic Animal Genetic Resources Information System. Eds. S. Kemp, Y. Mamo, B. Asrat, and T. Dessie. International Livestock Research Institute, Addis Ababa, Ethiopia. http://dagris.ilri.cgiar.org.

Dekhili, M., Bounechada, M. and Mannalah, I. 2013. Multivariate analyses of morphological traits in Algerian goats, Sétif, north-eastern Algeria. Animal Genetic Resources 52: 51-57.

FAO (The Food and Agricultural Organization). 2012. Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines No. 11. Rome.

FAOSTAT (The Food and Agriculture Organization Corporate Statistical Database). 2016. Food and agricultural organization of the United Nations, statistical division. http://faostat3.fao.org/browse/Q/QA/E.

Gatew, H., Hassen, H., Kebede, K., Haile, A., Lôbo, R.N.B., Yetayew, A. and Rischkowsky, B. 2015. Characterization of indigenous goat populations in selected areas of Ethiopia. American-Eurasian Journal of Scientific Research 10 (5): 287-298.

Hagos, G., Kebede, K., Banerjee, A.K. and Wolde, Z. 2016. On-farm phenotypic characterization of Begait goat and their production system in western zone of Tigray, Ethiopia. International Journal of Research and Innovations in Earth Science 3 (1):15-20.

Hassen, H., Baum, M., Rischkowsky, B. and Tibbo, M. 2012. Phenotypic characterization of Ethiopian indigenous goat populations. African Journal of Biotechnology 11(73): 13838-13846.

Khargharia, G., Kadirvel, G., Kumar, S., Doley, S., Bharti, P.K. and Mukut, D. 2015. Principal component analysis of morphological traits of Assam Hill goat in eastern Himalayan India. The Journal of Animal and Plant Sciences 25(5): 1251-1258.

Latorre, E., Uribe, H., Martínez, M.E., Calderón, C. and de la Barra R. 2011. Morphology differentiation and structural functionality of ewes due to incomplete crossbreeding. International Journal of Morphology 29(3):954-959.

Lorato, Y., Ahmed, K.M. and Belay, B. 2015. Morphological characterization of indigenous Woyto-Guji goat breeds in Loma district, Southern Ethiopia. American-Eurasian Journal of Scientific Research 10 (2): 58-67. DOI: 10.5829/idosi. aejsr.2015.10.2.1147.

Mekuriaw, G. 2016. Molecular characterization of Ethiopian indigenous goat populations: genetic diversity and structure, demographic dynamics and assessment of the kisspeptin gene polymorphism. Dissertation, Addis Ababa University.

Melesse, A., Banerjee, S., Lakew, A., Mersha, F., Hailemariam, F., Tsegaye, S. and Makebo, T. 2013. Morphological characterization of indigenous sheep in Southern Regional State, Ethiopia. Animal Genetic Resources 52: 39-50.

Okpeku, M., Yakubu, A., Peters, S., Ozoje, M., Ikeobi, C., Adebambo, O. and Imumorin I. 2011. Application of multivariate principal component analysis to morphological characterization of indigenous goats in southern Nigeria. Acta Agriculturea Slovenica 98 (2): 101-109.

Salako, A.E. 2006. Application of morphological indices in the assessment of type and function in sheep. International Journal of Morphology 24: 13-18.

SAS (Statistical Analysis System). 2012. SAS for Windows, Release 9.4. SAS Institute, Inc., Cary, NC, USA.

Seid, A., Kebede, K. and Effa, K. 2016. Morphological characterization of indigenous goats in Western Ethiopia: implication for community-based breeding programs. Animal Genetic Resources 58: 53-62.

Selolo, T.C., Mashiloane, M.L., Norris, D., Ng'ambi, J.W. and Brown D. 2015. Morphological differentiation of indigenous goats in different agro-ecological zones of Vhembe district, Limpopo province, South Africa. Indian Journal of Animal Research 49 (4): 527-531.

Traoré, A., Tamboura, H.H., Kabore, A., Royo, L.J., Fernández, I., Álvarez, I., Sangare, M., Bouchel, D., Poivey, J.P., Francois, D., Sawadogo, L. and Goyache, F. 2008. Multivariate analyses on morphological traits of goats in Burkina Faso. Archiv für Tierzücht 51 (6): 588-600.

Tsegaye, D., Belay, B. and Haile, A. 2013. Morphological characterization of indigenous Hararghe Highland goat breeds in their native environment, West Hararghe, Ethiopia. American-Eurasian Journal of Scientific Research 8 (2): 72-79.

Zergaw, N., Dessie, T. and Kebede, K. 2016. Description of production system and on-farm phenotypic characterization of Central Highland and Woyto-Guji goat breeds in Ethiopia. Animal Genetic Resources 58: 43-51.

The Effect of Partial Substitution of Maize with *Furfurame* on the Production Performance and Carcass Characteristics of Broilers

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ABSTARCT

The objective of this study was to evaluate the effect of substituting maize with furfurame, a by-product of kocho (Ensete ventricosum) processing, in a concentrate mix on feed intake, growth performance, nutrient retention and carcass parameters of Hubbard chickens. Four treatment diets namely T1, T2, T3 and T4 were formulated containing 0%, 33%, 66%, and 100% of furfurame as a substitute for maize, respectively, in concentrate mixture. After 3 weeks of brooding, 120 unsexed chicks were weighed and randomly allocated to the four dietary treatments with three replicates of 10 chicks per treatment in completely randomized design. The experiment lasted for 56 days. At the end of the experiment, a cockerel and a pullet were randomly selected from each replicate, and slaughtered to assess nutrient retention and carcass traits. The daily dry matter intake of the chicks fed on T3 and T4 diets were higher ($P<0.05$) than those reared on T1 and T2 diets. The average daily weight gain of chicks fed T1 diet were higher ($P<0.05$) than chicks fed T3 and T4 diets. Chicks receiving T1 diet had better ($P<0.05$) feed conversion efficiency while those receiving T4 were the least ($P<0.05$) efficient. Crude protein retention was the highest ($P<0.05$) for T1 diet while chicks in T4 retained the least. Chicks fed on T1 diet had the highest ($P<0.05$) metabolizable energy retention compared to other treatment diets. Chicks fed on T1 diet had higher ($p<0.05$) slaughter weight, commercial carcass weight and edible offal weight compared to those fed on T4 diet. The dressing percentage of the chickens did not vary across the treatments. Based on intake of nutrients and dressing percentage, it is concluded that furfurame can be used as energy source feedstuff in poultry ration replacing maize up to 33% for stallholder farmers in enset growing areas.

***Key words**: Broilers; carcass traits; Ensete ventricosum; furfurame, growth, nutrient retention*

INTRODUCTION

Chicken are the most important avian species commonly reared among the resource challenged members of the society while they are also reared in large numbers in commercial enterprises. They are sources of income, animal protein, have cultural values, and can be raised under wide range of climates and with limited resources, feed and housing (Kondombo, 2005). According to Tadelle and Ogle (2003), most of the rural families in Ethiopia own chicken. The current total chicken population in Ethiopia is estimated to be 56.53 million (CSA, 2016/17) which are mainly kept under scavenging system.

Despite the large population of chicken, their contribution is far below the expectation which can be attributed to various constraints among which the scarcity and consequently high prices of the conventional feed (protein and energy sources) predominate (Aberra et al., 2012). In the tropics, poultry keeping has always poses a problem for subsistent farmers since poultry competes with humans for the available scarce concentrate feed ingredients (Tadelle and Ogle, 2003). Being monogastric animal the bulk of poultry ration is composed of cereal grains which are generally used for human consumption resulting in high production cost of poultry (Ravindran and Blair, 1991). Conventionally maize is the most common ingredient used in formulation of poultry ration. Unfortunately, the market price of maize is increasing from year to year under Ethiopian condition. This situation warrants investigating into less expensive and locally available energy source that could safely and economically replace maize in poultry ration (Nurfeta et al., 2015). One of such feed is enset (*Ensete ventricosum*) also called false banana which is used for human and animal consumption in southern region of Ethiopia. It is estimated that about 35% of the total population of Ethiopia live in areas where enset is an important staple food (CSA, 2014).

The major food products obtained from the enset plant are *kocho, bulla* and *amicho.* There are by-products not used for human consumption generated during the production and processing of enset plant into human foods that could be included into poultry feeding system of the region. One of such by-product is called *furfurame*. *Furfuram*e is a by-product obtained during *kocho* preparation. During preparations of kocho for human consumption, the processors remove the fiber and allied components from the raw *kocho* using a mesh like material. This by-product is traditionally called *furfurame* in the native Sidama language of Ethiopia. Few studies were aimed at determining the chemical composition (Nurfeta et al., 2008a) digestibility, nitrogen utilization and intake of unprocessed enset varieties (Nurfeta et al., 2008b; Nurfeta et al., 2009). However, there is no research work which evaluated the use of *furfurame* as livestock feed. Therefore, this study was planned to assess feed intake, growth performance and carcass traits of Hubbard chickens fed different levels of *furfurame* in concentrate mixture.

MATERIALS AND METHODS

Experimental Feed

The feeding experiment was done at Hawassa University, College of Agriculture, School of Animal and Range Science poultry research farm. *Furfurame* is the by-product of *kocho*. In brief, after fermentation of crashed pseudostem and corm in the pit, the wet mass is taken out of the pit and homogenized through mixing and hand pressure and allowed to dry using nylon. The dried mass is put on a sieve to separate *kocho* and *furfurame* which is the fibrous part. Some *kocho* could be left attached with the fiber part which was separated as a source of feed in this experiment. *Furfurame* was collected from restaurants in Hawassa town who are involved in preparation of traditional Sidama food such as *Chukame* and *Burssame*. It was collected using plastic sacks. The collected *furfurame* were evenly spread on plastic sheets to facilitate drying and separation from the fibers. Then the fiber was separated by hand. The sun dried *furfurame* was then hand ground by mortar and pestle for ease of mixing. Other feed ingredients, maize soybean and nouge cake were purchased from the local market. Vitamin premix and limiting amino acids (methionine and lysine) were also procured from the suppliers. Soybean was roasted before grinding to inactivate the trypsin inhibitor. The different feed ingredients used in the ration were ground and mixed for each treatment.

Experimental Animals

A total of two hundred day-old unsexed Hubbard chicken breed that had an average body weight of 34.6 g were purchased from Debre Zeit Poultry Multiplication and Distribution Centre, Ethiopia. After 18 days of brooding, the chicks were adapted to the experimental diet for 7 days. The chicks were leg tagged and weighed individually to determine their initial body weight. Thereafter, the chicks were randomly assigned to each of the 12 pens. The 12 pens were randomly assigned to the 4 treatment diets following the completely randomized design with three replications per treatment.

Experimental ration formulation and treatments

The treatment diets (Table 1) were formulated by taking into account the nutrient composition of each ingredients and balancing them with the nutrient requirements of the broilers.

Table 1. Proportions of ingredient feeds used to formulate treatment diets

Ingredients and nutrient content	Treatments			
	T1	T2	T3	T4
Maize	51	33	16	0
Furfurame	0	16	33	50
Soybean	30	30	30	30
Nouge cake	16	18	18	17
Limestone	1.2	1.2	1.2	1.2
Salt	0.5	0.5	0.5	0.5
Methionine	0.75	0.75	0.75	0.75
Lysine	1	1	1	1

T1 = control (100% maize); T2= 66.67 maize + 33.33% of *furfurame*; T3= 33.33% of maize + 66.67% *furfurame*; T4= 0% maize + 100% *furfurame* in the concentrate mixture.

The control treatment (T1) contained maize as the major source of energy. *Furfurame* was included in treatment 2, 3 and 4 to replace 33.33%, 66.67%, and 100% of maize, respectively. The experimental diets were formulated using win feed software to contain 21% CP and 13.2 MJ/kg DM metabolizable energy capable of meeting the recommended (Eekeren et al., 1997) nutrient requirements of broilers by. Adequate amounts of vitamin premixes along with lysine and methionine were added to the diets based on the recommendation of NRC (1994). The diets were formulated to be iso-nitrogenous and iso-caloric.

Management of chickens

The chicks were vaccinated against Gumburo, Lasota, HB1 and fowl pox on day 7, 21, 28, and 60 as per the recommended vaccination schedule. Chicks were reared in deep litter housing with sawdust at a depth of 5 cm. Each wire mesh partitioning pens had an area of 1.25 m*1.25 m. The pens were cleaned and fumigated using standard protocols prior to transferring the chicks.

Feed intake and body weight determination

During the experimental period, chickens were feed *ad-libitum* (with at least 20% refusal at the end of the day). The feed was provided twice a day at 8:00 am and 14:00 pm. The duration of the feeding trial was 56 days. The refusal was collected the next morning prior to offering the feed. Body weights of chicks were assessed weekly on an individual basis. Body weight gain was calculated as the difference between the final and initial body weight. The daily feed intake was measured as the difference between feed offered and feed refused. Samples of offered and refusals were collected throughout the experimental period for further chemical analysis.

Carcass evaluation

At the beginning of the experiment, 8 chicks representing the 4 treatment groups were randomly selected and killed by dislocation of neck after starving for 12 hours. Similarly, at the end of the feeding trial, two chickens (one rooster and one pullet) which are similar to the average body weight of the treatment were randomly selected from each pen. A total of 24 chicks were, therefore, selected for assessment of carcass traits. The chicks were starved overnight and weighed immediately prior to slaughtering. Chicks were slaughtered by severing the jugular veins and carotid arteries. After slaughtering, the chicks were allowed to bleed completely, defeathered manually and weighed to assess the blood and feather weight. Pre-slaughter live weight, eviscerated weight, weight of shank and claws, skin, neck, head, breast, drumsticks, thighs, gastro-intestinal and reproductive organs, the visceral organs which included heart, kidney, spleen, lung and liver were assessed. The carcass weight was calculated by subtracting the non-edible offal (blood, shank, spleen, feather, pancreas, head, respiratory and reproductive organs and digestive tracts) from the slaughter body weight. Dressing percentage was obtained by dividing carcass weight by slaughter weight and multiplied by 100.

Determination of nutrient retention

The nutrient retention was assessed according to the methods suggested by Nurfeta et al. (2015). The absolute dry matter of the carcass was determined by drying the carcass overnight at 105^0C. The amount of each nutrient deposited in the tissue was obtained by multiplying the nutrient being obtained during carcass analysis by the slaughter weight. The percent of nutrients retained by the chicks and the crude protein intake were assessed according to the methods suggested by Sevier et al. (2000).

Chemical analysis

The feed samples were analyzed for dry matter (DM), ash, ether extract (EE) and crude fiber (CF) according to AOAC (1995). Total nitrogen content of the feed was determined by micro-kjeldahl method and the crude protein (CP) was then calculated as nitrogen (N)* 6.25. Calcium was determined by atomic absorption spectrophotometer methods as described by AOAC (1995). All the samples were analyzed in duplicates. The metabolizable energy (ME) of the feed was estimated according to the equation proposed by Wiseman (1987): ME (kcal/kg DM) =3951+54.4EE-88.7CF-40.8ash.

Statistical analysis

The data were analyzed using one way ANOVA using SAS software (SAS, 2002) The means were compared according to Duncan's Multiple range test and the values were considered significant at P<0.05.

RESULTS

Chemical composition

The results of chemical composition of feed ingredients used in formulation of the ration are shown in Table 2. *Furfurame* had comparable metabolizable energy content with maize. There was a slight decrease in CP content with increasing levels of *furfurame* while metabolozable energy content of the treatment diets were comparable (Table 3).

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

Nutrients	Feed ingredients			
	Furfurame	Maize	Soybean	Noug cake
Dry matter (%)	92	93	94	95
Ash	5.3	18	9	13
Crude protein	3.2	9.4	31	26
Crude fiber	10	3.4	13	19
Ether extract	4.1	7.3	12	8.5
Calcium	0.5	0.8	1.7	0.8
ME (MJ/kg DM)	13	14	13	9.2

Table 3. Chemical composition (% DM, unless specified) of treatment diets

Nutrients	Treatments			
	T1	T2	T3	T4
Dry matter (%)	91.5	92.6	93.4	94
Ash	13.8	11.9	10.1	9.3
Crude protein	17.7	17.2	16.2	15.2
Crude fiber	8.7	9.6	11.2	12.4
Ether extract	8.7	9.6	11.2	12.4
Calcium	11	10	10	9.4
ME (MJ/kg DM)	12.9	12.8	12.4	12.1

T1 = control (100% maize); T2= 66.67 maize + 33.33% of *furfurame*; T3= 33.33% of maize + 66.67% *furfurame*; T4= 0% maize + 100% *furfurame* in the concentrate mixture.

Daily DM and nutrient intake

The mean DM and nutrient intake of chicks are presented in Table 4. The chicks fed T3 and T4 diet had higher ($p<0.05$) daily DM intake compared with those fed T1 and T2 diet. The DM intake of chicks fed T1 and T2 diet were comparable ($p>0.05$).

Chicks fed T4 diet had the highest ($p<0.05$) daily OM and CF intake while those fed T1 diet had the lowest ($p<0.05$) intake of OM and CF. There were an increasing trend in daily OM and CF intake with increasing level of *furfurame* in the diet. There were no significant differences in the daily CP and ME intake among treatment diets. Chicks fed T3 and T4 diets had significantly lower Ca intake compared to chicks fed T1 diet. The EE intake of the chicks fed T1 diet was higher ($P<0.05$) than that of T4.

Table 4. Average daily DM and nutrient intake of chicks fed different levels of *furfurame* (g/chick/day or MJ/kg feed) in the diet.

Treatment	DM	OM	CF	CP	EE	ME (MJ)	Ca
T1	137^{b}	105^{d}	12^{d}	28	12.93^{a}	1.8	1.1^{a}
T2	143^{b}	115^{c}	14^{c}	27	12.85^{ab}	1.8	0.83^{ab}
T3	152^{a}	126^{b}	17^{b}	26	12.42^{ab}	1.9	0.75^{b}
T4	158^{a}	134^{a}	20^{a}	25	12.1^{b}	1.9	0.73^{b}
SEM	3.0	2.1	0.32	0.57	0.27	0.04	0.13

^{abc}: Means in the same column with different superscript are significantly different ($p<0.05$).DM: dry natter, OM; organic matter; CP: crude protein, EE: ether extract, ME: Metabolizable energy, SEM: standard error mean,T1 = control (100% maize); T2= 66.67 maize + 33.33% of *furfurame*; T3= 33.33% of maize + 66.67% *furfurame*; T4= 0% maize + 100% *furfurame* in the concentrate mixture.

Mean daily DM and nutrient conversion efficiency ratio

The daily nutrient conversion efficiency of chicks is shown in Table 5. The chicks fed T1, T2 and T3 diets had higher (P<0.05) daily protein and EE efficiency ratio compared to T4 diet. The ME efficiency ratio of the chicks fed T1 and T2 diet was higher (p<0.05) than those chicks fed T4 diet. Chicks fed the control diet had the highest (p<0.05) daily efficiency ratio while those chicks fed T4 diet had the lowest daily OM, CF and NFE efficiency ratio.

Table 5. Mean daily nutrient conversion efficiency ratio

.Nutrients	Treatments			
	T1	T2	T3	T4
Dry matter	0.3±0.01[a]	0.3±0.01[b]	0.3±0.01[c]	0.2±0.01[d]
Ash	0.85±0.05[b]	0.7±0.07[ab]	0.6±0.05[ab]	0.4±0.07[a]
Crude protein	1.8±0.04[a]	1.7±0.05[a]	1.6±0.04[a]	1.5±0.05[b]
Crude protein	3.9±0.05[a]	3.1±0.07[b]	2.4±0.05[c]	1.8±0.07[d]
Ether extract	3.7±0.05[a]	3.4±0.07[a]	3.3±0.05[a]	3.0±0.07[b]
NFE	60±0.81[a]	54±1.1[b]	54±0.8[c]	50±1.1[d]
Calcium	1.5±0.5[c]	2±0.7[ab]	3.5±0.5[a]	4±0.7[b]
ME (kcal)	26±0.37[a]	23±0.52[a]	21±0.37[b]	18±0.52[c]
DMCER	0.34[a]	0.31[b]	0.26[c]	0.23[d]

[abc]: Means in the same column with different superscript are significantly (p<0.05) different.
NFE: nitrogen free extract, ME: Metabolizable energy, SEM: standard error mean, T_1: 0% *furfurame* and 100% maize, T_2: 33.33% *furfurame* and 66.66% maize, T_3: 66.66% *furfurame* and 33.33% maize and T_4: 100% *furfurame* and 0% maize in concentrate mixture

Daily nutrient retention of chicks

The daily nutrient retention of the chicks fed different diet is presented in Table 6. The retained CP of the chicks fed T1 and T2 diets were higher (P<0.05) than that of T4 diet. The retained ME and EE of the chicks fed T1 diet were higher (p<0.05) compared to the other treatments. Chicks fed on T1 diet had the highest (p<0.05) ash retention while those fed T4 diet had the lowest.

Table 6. Daily nutrient retention (g/chick/day or MJ/chick/day) of the chicks fed different levels of *furfurame* in the diet

Treatment	Crude protein	Ether extract	ME (MJ)	Ash
T1	13.3[a]	4.3[a]	17.5[a]	0.4[a]
T2	12.6[ab]	2.5[b]	17[b]	0.2[b]
T3	11.7[b]	2.3[b]	17[b]	0.2[b]
T4	10[c]	2[b]	17[b]	0.1[c]
SEM	0.5	0.23	0.11	0.01

[a bc]: Means in the same column with different superscript are significantly different (p<0.05), ME: Metabolizable energy, SEM: standard error of the mean, T1 = control (100% maize); T2= 66.67 maize + 33.33% of *furfurame*; T3= 33.33% of maize + 66.67% *furfurame*; T4= 0% maize + 100% *furfurame* in the concentrate mixture.

Average daily weight gain

The mean daily weight gain of the experimental chicks is presented in Table 7. The weight gain of chicks fed T1 and T2 diets were higher (P<0.05) than those fed T4 diet.

Table 7. Average daily body weight gain (g) of chicks fed different levels of *furfurame* in the diet

Treatment diets	Initial body weight	Final body weight	Total gain	Average daily gain/ day
T1	429±14	2811±74^{a}	2393±72^{a}	43±1.3^{a}
T2	426±14	2719±76^{ab}	2299±74^{ab}	41±1.3^{ab}
T3	422±14	2554±71^{b}	2111±70^{b}	38±1.3^{b}
T4	423±14	2284±71^{c}	1854±70^{c}	33±1.3^{c}

^{abc}Means in the same column with different superscript are significantly different (p<0.05). T1 = control (100% maize); T2= 66.67 maize + 33.33% of *furfurame*; T3= 33.33% of maize + 66.67% *furfurame*; T4= 0% maize + 100% *furfurame* in the concentrate mixture.

Carcass characteristics of chicks

The carcass components of chicks (neck, wing, skin, back, breast, thigh and drumstick) are presented in Table 8. Chicks fed T1 diet had the highest (P<0.05) slaughter weight while the lowest (P<0.05) was forT4. However, there was no significant difference in slaughter weight between chicks fed T2 and T3 diets but chicks fed T4 diet had the lowest slaughter weight.

Table 8. Effect of different levels of *furfurame* on edible carcass parts

Carcass component (g)	Treatments				SEM
	T1	T2	T3	T4	
Slaughter weight	3216^{a}	2785^{b}	2770^{b}	2266^{c}	92
Commercial carcass parts:					
Neck	105.7^{a}	95^{b}	95^{b}	83^{c}	3.2
Wing	146^{a}	128^{b}	127^{b}	95^{c}	4.1
Back	188^{a}	167^{b}	169^{b}	137^{c}	4.8
Breast	715^{a}	655^{b}	655^{b}	590^{c}	14
Thigh	397^{a}	334^{b}	332^{b}	262^{c}	14
Drumstick	369^{a}	315^{b}	314^{b}	248^{c}	12
Skin	194^{a}	153^{b}	151^{b}	102^{c}	10
Edible offal:					
Gizzard	90^{a}	76^{b}	75^{b}	55^{c}	3.9
Liver	107^{a}	90^{b}	88^{b}	67^{c}	4.3
TEO weight	198^{a}	165^{b}	163^{b}	121^{c}	13
Carcass weight	2114^{a}	1847^{b}	1842^{b}	1553^{c}	52
Total edible weight	2311^{a}	2013^{b}	2005^{b}	1674^{c}	69
Dressing percentage	71.8	72.2	72.7	72.7	0.3

$^{a\ b\ c}$ Means within rows with different superscript letters are significantly(p<0.05) different. SEM: standard error of means *TEO: Total Edible Offal-it is the summation of gizzard and liver; Carcass weight: it is the summation of all commercial carcass parts; *Total edible: the summation of carcass parts and edible offal. T1 = control (100% maize); T2= 66.67 maize + 33.33% of *furfurame*; T3= 33.33% of maize + 66.67% *furfurame*; T4= 0% maize + 100% *furfurame* in the concentrate mixture.

The highest (P<0.05) commercial carcass weight of the chicks was obtained for T1 diet whereas the lowest (P<0.05) was obtained from the chicks fed T4 diet. Under Ethiopian context, total edible includes edible offal such as gizzard and liver and commercial carcass parts such as skin, neck, wing, back, breast, thigh and drumstick. Total edible offal was the highest (P<0.05) for those chicks fed T1 diet and the lowest (P<0.05) was for those chicks fed T4 diet. There was no significant difference on dressing percentage among the chicks fed different treatment diets.

DISCUSSION

Nutrient and Energy Contents of the Experimental Diets

There is no information available on the chemical composition of *furfurame*. The CP content of T1, T2 and T3 diets (16.2–17.7%) is comparable with the minimum CP requirement (16%) suggested by NRC (1994) but the CP content of T4 diets (15.2 %) was lower than the minimum NRC requirement which could be due to low CP content of *furfurame*. The ME content of treatment diets (12 to 12.9/ kg DM) is more than the minimum ME requirement (11.72 MJ/kg DM) suggested by NRC (1994) for broiler breeds. The fat content of treatment diets (0.73 to 0.87%) was below the fat requirement (1%) of broiler breeds as suggested by NRC (1994). However, Ca content of the treatment diets (0.94 to 1%) in the current experiment is within the range recommended (0.8 to1%) for broiler breeds by NRC (1994). *Furfurame* had low ash, CP, EE, ME and Ca compared to maize but it had higher CF content. *Furfurame* had lower EE and ME but higher CF and similar CP content compared with *kocho* as reported by Nurfeta et al. (2015). Due to its high ME and EE content (13.2 MJ/kg DM and 36 g/kg DM, respectively) *furfurame* could be considered as good source energy.

Feed Intake, Weight Gain and DM and Nutrient Efficiency Ratio

The increase in DM intake with increasing levels of *furfurame* in the diet could be due to relatively low energy concentration of *furfurame*. This result agrees with that of Plavnik et al. (1997) who reported that poultry increases DM intake for compensating the low content of energy in their diet. On the other hand, the relatively low DM intake for T1 compared to T4 diets could be attributed to the relatively higher energy concentration of T1 diet which is attributable to maize (14.3 MJ/kg DM). Similar findings have been reported by other workers (Nahashon et al., 2005; Veldkamp et al., 2005) who reported that birds consume feed to primarily meet their energy requirement. The present findings also agrees with the findings of Plavnik et al. (1997) and Nahashon et al. (2006) who reported that as dietary energy increases birds satisfy their energy needs by decreasing feed intake. Decrease in feed intake with high energy diets was reported by Veldkamp et al. (2005) who showed that feed intake decreases linearly as dietary energy increases. The inclusion of high level of *furfurame* in the ration may have affected feed consumption and the bioavailability of other nutrients which agrees with Odensi et al. (1996) who suggested that increasing inclusion level of unconventional feed ingredients may alter the bioavailability of nutrients, texture, color, taste and odor of diets.

The higher daily body weight gain observed for T1 diet could be due to relatively better conversion efficiency. A decrease in body weight gain was observed with increasing levels of *furfurame* which is contrary to the result reported by Nurfeta et al. (2015) who observed similarity in ADG in broilers fed different levels of *kocho* as a substitute to maize. The reason for decreased weight gain with increasing level of *furfurame* in the current study may be due to the fibrous nature of *furfurame* compared with *kocho*. It has been reported that high crude fiber content of leaf meals at high level of inclusion resulted in lower weight gain (Ekenyem and Madubuike, 2006) which could be due to the limited absorption of amino acids and peptide and prevention of their absorption in the intestine (Nworgu et al., 2000). Moreover, Onifade and Babatunde (1997) reported that high fiber content in a diet of broiler interferes with nutrient availability at the tissue level and deprives nutrients availability for growth and maintenance. Dry matter conversion efficiency ratio (DMCER) is a measure of how well a flock converts feed intake into weight gain. It is also the ability of the livestock to turn feed mass to body mass. Birds that have high feed efficiency ratio are considered efficient users of feed. The results of the current study showed that birds fed T1 and T2 diet had better feed conversion efficiency compared to T4. In addition to this, the lower growth rate and the higher DM intake resulted in low *DMCER among the chicks that fed on T3 and T4 diet.*

Nutrient Retention

The CP, ME and EE in the current experiment is not consistent with the findings by Nurfeta et al. (2015) who observed better ME and EE retention in chicks supplemented with maize. Several factors are known to affect body composition such as strain, sex, age, quantity and quality of the dietary CP and ME, slaughter and sampling methods and environmental conditions. According to the results of the current study the higher nutrient retention observed for chicks under T1 and T2 diets might be attributed to the improved feed and nutrient conversion efficiency compared with the other treatments. Chicks fed T1 and T2 diets had higher retained CP than the chicks fed T4 diet because they had the highest feed conversion efficiency and protein efficiency ratio although CP intake was similar among treatments. To the contrary chicks fed T3 and T4 diet had higher DM intakes but lower nutrient retention which may be due to high fiber content of these diets which has had a dilution effect of other nutrient.

Carcass Characteristics

Chicks fed T4 diet had the lowest carcass yield which might be attributed to slightly low energy and CP concentration and poor bioavailability of nutrients. The important commercial parts like drumstick, thigh and breast meat weight were low for the chicks fed T4 diets which could be due to the poor nutrient utilization. However, there were similarities in dressing percentage between the treatments which agrees with the result reported by Scanes et al. (2007) on broiler breeds regardless of diet. To the contrary Nurfeta et al. (2015) observed higher dressing percentage in broilers fed on 100% *kocho* compared with that of 100 % maize. Dana (1999) also observed comparable dressing percentage (63%) for RIR hens kept on choice feeding of energy or protein feeds under intensive and semi-intensive management conditions in the central highlands of Ethiopia. From the result of the current study it can be concluded that *furfurame* diets have no any negative effect on the dressing percentage.

CONCLUSIONS

The availability and utilization of unconventional feed ingredients such as *furfurame* in chicken diets may provide opportunity to reduce cost of production. Better intake of nutrients was observed in T4 when *furfurame* totally (100%) replaced maize. Although important parameters like weight gain, commercial carcass parts are low when maize was replaced by *furfurame*, its availability and low cost may provide an opportunity for smallholder farmers in enset growing areas. *Furfurame* could be included in broilers ration up to 33% for stallholder farmers in enset growing areas.

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REFERENCES

Aberra, M., Workenesh, T., Tegene, N. 2012. Nutrient composition and effects of feeding different levels of Moringa stenopetala leaf meal on carcass traits of Rhode Island Red Dual-purpose grower chickens. *Ethiopian Journal of Animal Production* 12(1): 37-50

AOAC, 1995. Association of Analytical Chemist. Official Methods of analysis. 15th Edition. Washigton D.C.

CSA (Central Statistical Agency). 2014. Agricultural sample survey Volume II. Statistical Bulletin No. 505. CSA, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). 2016/17. Agricultural sample survey Vol. II. Statistical Bulletin No. 585. CSA, Addis Ababa, Ethiopia.

Dana, N., 1999. Choice feeding of energy or protein feeds of RIR chickens under intensive and semi-intensive management conditions in the central high land of Ethiopia. *Poultry Science* 65: 1857–1864.

Eekeren, N.V., Mass, A.; Saatkamp; H.W., Verschuur, M. 1997. Small production in the tropics. (Agrodok 4, Agromissa. (CTA). pp 70.

Ekenyem, B.U., Madubuike, F.N. 2006. An assessment of Ipomoea asarifolia meal as feed ingredient in broiler chick production. *Pakistan Journal of Nutrition* 5:46-50

Kondombo, S. R. 2005. Improvement of village chicken production in a mixed (chicken–ram) farming system in Burkina Faso. PhD Thesis. Wageningen Institute of Animal Sciences, Animal Nutrition Group, Wageningen University, The Netherlands. Pp 208.

Nahashon, S. N., Adefope, N., Amenyenu, A., Wright, D. 2005. Effect of dietary metabolizable energy and crude protein concentrations on growth performance and carcass characteristics of French guinea broilers. *Poultry Science* 85: 1847 – 1854.

Nahashon, S. N., Adefope, N., Amenyehu, A., Wright, D. 2006. Effect of dietary metabolizable energy and crude protein concentrations in diets of pear gray guinea fowl pullets growth performance. *Poultry Science* 85: 1847 – 1854.

NRC. 1994. Nutrition requirements of poultry. National Research Council. National Academy Press. Washington D.C., 33-34.

Nurfeta.,A., Kifle, A., Abebe, A. 2015. Evaluation of replacement value of maize with Kocho on the growth performance and carcass characteristics of Broiler Hubbard chickens. *Journal of Science and Development* 3 (1):35-43.

Nurfeta, A., Tsegaye, M., Abebe,A., 2012. Effects of substituting maize with kocho on intake, digestibility, nitrogen utilization and body weight gain in sheep fed a basal diet of Rhodes grass hay. *Ethiopian Journal of Applied Science and Technology 3* (2): 13-24.

Nurfeta, A. Eik, L.O., Tolera, A., Sundstøl, F. 2008a. Chemical composition and in sacco dry matter degradability of different morphological fractions of 10 enset (Ensete ventricosum) varieties. *Animal Feed Science and Technology* 146: 55-73.

Nurfeta, A. Eik, L.O., Tolera, A., Sundstøl, F. 2008b. The supplementary value of different parts of enset (Ensete ventricosum) to sheep fed wheat straw and Desmodium intortum hay. *Livestock Science*

119: 22-30.

Nurfeta, A. Tolera, A. Eik, L.O., Sundstøl, F., 2009. Feeding value of enset **(**Ensete ventricosum**),** Desmodium intortum hay and untreated or urea and calcium oxide treated wheat straw for sheep**.** *Journal of Animal Physiology and Animal Nutrition* 93: 94-104.

Nworgu, F. C., Egbunke, G. N., Ogundola F .I. 2000. Performance and nitrogen utilization of broiler chicks fed full fat extruded Soya bean meal and full fat Soya bean. *Tropical Animal Production and Investment* 3: 47-54.

Odensi, A.A., Farinu, G.O., Akinola, J.O. 1996. Influence of dietary wild sun flower (Tithonia diversefolia Helms A Gray) leaf meal on layers performance and egg quality. *Nigerian Journal of Animal Production* 23: 28-32.

Onifade A. A., Babatunde G. M. 1997. Comparative utilization of the tropical by-products feed resources supplemented with or without molasses by broiler chicks. *Archives of Zootechnology* 46:137-145.

Plavnik, I., Wax, E., Sklan, D. Bartov, I., Hurrwitz, S. 1997. The response of broiler chickens and turkey poults to dietary energy supplies either by fat or carbohydrates. *Poultry Science* 76:1000 – 1005.

Ravindran, V. ,Blair, R., 1991. Feed resources for poultry production in Asia and the Pacific Region. Energy sources. *World's Poultry Science Journal* 47: 214-231.

SAS , 2002. SAS/STAT guide to personal computers-Version 7. Statistical Analysis System Institute Inc. Cary, NC.

Scanes, C. G., 2007. Contribution of poultry quality of life and economic development in the developing world. *Poultry Science* 86 (11): 2289-2290.

Sevier, H, Raae, A.J., Lied, E. 2000. Growth and Protein turn over in- Atlantic Salmon (Salmo saler L.): the effect of dietary protein level and protein size. *Aquaculture* 185: 10-20.

Tadelle, D., Ogle, B., 2003. Village poultry production system in the central highlands of Ethiopia. *Tropical Animal Health and Production* 33:521-537.

Veldkamp, T., Kwakkel, R P., Ferket, P R.,Verstegen, M W A. 2005. Growth response to dietary energy and lysine at high and low ambient temperature in male turkeys. *Poultry Science* 84: 273–282.

Wiseman, J. 1987. Meeting nutritional requirements from available resources. In: Wiseman (Ed). Feeding of non-ruminant animals. Butterworth. London. pp. 132

Microbial Quality and Safety of Raw Cow Milk in Girar Jarso District of Oromia Regional State, Ethiopia

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ABSTRACT

The study aimed to evaluate the quality and safety of raw cow milk collected from dairy producers and collection centers in urban and peri urban areas of Girar Jarso district. A total of 60 milk samples (40 from milk producers and 20 from milk collectors) were collected for physico-chemical, and microbial quality and safety analysis. The analyses were made at Dairy Technology and Microbiology Laboratory of Holetta Agricultural Research Center. There were significant differences (P<0.05) in temperature (29.75±0.52 and 22.35±0.52°C), pH (6.69±0.02 and 6.55±0.02), specific gravity (1.026±0.002 and 1.023±0.002) and fat content (4.02±0.10 and 3.75±0.14%) between producers and collection centers milk samples, respectively. The mean total aerobic mesophilic bacterial count (TAMBC), coliform count (CC) and spore forming bacterial count (SFBC) for milk samples collected from producers were 6.42±0.07, 4.49±0.09 and 2.59±0.05 log10 cfu/ml, respectively. However, significantly higher (P<0.05) bacterial counts were observed for milk samples taken from milk collectors (7.49 log10 cfu/ml) than that of producer milk samples (6.42 log10 cfu/ml). Out of a total milk samples collected from producers, 57, 7.5 and 15% were positive for Staphylococcus aureus, Salmonella spp. and Listeria monocytogenes, respectively. The microbial quality of milk produced and marketed in the study areas was found to be substandard and could cause public health risks for raw milk consumers. This calls for establishment and enforcement of quality and safety control systems for both milk producers and collectors in order to improve the quality and safety of milk.

Keyword: raw milk, microbial quality, physico-chemical, safety.

INTRODUCTION

Milk and milk products are ideal media for multiplication of various microorganisms if it is not properly handled (Soomro *et al*., 2002). Most of the bacteria in fresh milk from a healthy animal are either harmless or beneficial. The health statuses of an animal or the milk handler, or contaminants from polluted water, dirt, manure vermin, cuts and wound can make raw milk potentially dangerous (Zelalem Yilma, 2012). The major determinant that influences the quality and safety of dairy products is the quality of raw milk. Therefore, milk should have normal composition, be free from adulteration and must be produced under hygienic conditions (Chamberlain, 1990).

The microbial contamination of milk not only reduces its nutritional quality but also may threaten the health of the consumers. Microorganisms may contaminate milk at various stages including production, procurement, processing and distribution. It is assumed that differences in feeding and housing strategies of cows may influence the microbial quality of milk (Coorevits *et al*., 2008). In addition to health of animal, cleanness of animal, milking practices, milk handling, and equipments used may affect quality and safety of milk. Bacteria in raw milk can affect the quality, safety, and consumer acceptance of dairy products. Several human microbial pathogens could contaminate milk and render it unsafe for public consumption. These include pathogenic *Escherichia coli, Staphylococcus aureus,* *Salmonella* spp., *Listeria monocytogenes, Brucella abortus, Mycobacterium* spp., *Campylobacter* spp., *Leptospira* spp., *Clostridium* spp., *Pseudomonas aeruginosa* and *Proteus* spp. (Jayarao *et al*., 2006).

There is a steady challenge to those involved in milk production to prevent or minimize the entry and subsequent growth of microorganisms in milk (O'Connor, 1995). Therefore, an understanding of the microbial load of raw milk is needed to measure its hygienic quality. High microbial load and presence of harmful pathogenic microorganisms in the milk samples are evidences of unhygienic milk production conditions (Abrahamsen *et al*., 2007).

Although milk and milk products represent an important place in the nutrition of consumers as well as nutrition and income of producers, there is limited work so far undertaken regarding physico-chemical and microbiological quality of raw milk in Girar Jarso district. Moreover, there is no formal quality control system in place to monitor and control the quality and safety of milk produced and sold in the district. Therefore, studying the quality and safety of cow milk in the study area has paramount importance. The results generated will be used to design appropriate intervention strategies for the policy makers to improve the production, quality and safety of cow milk. This is mainly important for producing milk of good hygienic quality, which is necessary to produce milk products with superior quality and prolonged shelf-life and thereby provide safe and wholesome food for the consumers. Therefore, the objective of this study was to evaluate the physico-chemical properties, microbiological quality and safety of raw cow milk produced and marketed in Girar Jarso District.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in urban and peri urban areas of Girar Jarso District that is found in North Shewa Zone of Oromia Regional State. The district is located at a distance of 112 km from Addis Ababa. Geographically it lies at 09°45’121’’N latitude and 038°46’728’’E longitude and at an altitude of 2677 meters above sea level. The area receives mean maximum and minimum temperature of 22.13°C and 10.26°C, respectively and average long-term annual rainfall of 1000 mm (WFEDO, 2010). The livestock sub-sector is an integral component in the farming practice of the study area. This sub-sector contributes to the livelihood of the population in terms of milk and milk products. High proportion of households in the district (80%) is selling raw milk (WFEDO, 2010).

Milk Sampling Techniques

Milk samples were collected from milk producers and collectors. One of the lots was placed in a separate sterile container for microbiological analysis while the second one was used for determination of the physico-chemical properties. All laboratory analyses were conducted in duplicates.

A total of 60 samples of morning raw cow milk (250mL) were randomly collected from dairy farmers milk containers at farm gate and milk collection centers from bulk milk. Milk samples were collected aseptically using sterile bottles and immediately kept in an ice box and transported to Holetta Agricultural Research Center, Dairy Technology and Microbiology Laboratory for analysis. The milk samples were kept in refrigerator at 4°C upon arrival.

Physico-Chemical Analysis of Raw Milk

Physicochemical parameters such as Temperature, pH, Titratable acidity, Total solids (TS), Ash, Solids not fat (SNF) and protein contents were determined following the procedures described by O'Connor (1995). Temperature of the milk sample was determined by a thermometer and pH was measured by digital pH meter after calibration using buffer solutions (4 and 7). While titratable acidity of the milk samples was determined by measuring the amount of lactic acid produced per ml of NaOH. Ten ml of milk sample was pipetted into a beaker and 3 to 5 drops of 0.5% phenolphthalein indicator was added. Then milk sample was titrated by 0.1N NaOH until a pink color persisted. The titratable acidity of the milk was expressed as percent of lactic acid (O'Connor, 1995).

$$\%lactic\ acid = \frac{ml\ NaOH(0.009)}{ml\ milk\ sample\ used} x100$$

For determination of specific gravity, fresh milk sample was filled sufficiently into a glass cylinder (100ml capacity) then a Lactometer was gently inserted into the milk. The lactometer was allowed to freely float until it reached equilibrium. Then the readings were recorded at the lower meniscus. The following formula was used to calculate the specific gravity of the milk.

$$Specific gravity = \frac{L}{1000} + 1$$

Where: L = corrected lactometer reading at a given temperature.
If the temperature of the milk is between 17 and 24°C, the following correction factors were used to determine L:

Temperature °C	17	18	19	20	21	22	23	24
Correction	–0.7	–0.5	–0.3	0	+0.3	+0.5	+0.8	+1.1

To determine total solid (TS) of milk three grams of milk sample was placed into pre–dried and weighed crucible. The sample was dried at 100 $\pm$ 2°C in a hot air oven (PBSO42, England) for two hours. Finally, the dried milk samples were taken out from the oven and placed in desiccators to cool at ambient temperature. Then it was weighed again and TS content was expressed as a percentage (O'Connor, 1995).

$$Total\ solids\ (\%) = \frac{weight\ of\ dried\ sample}{weight\ of\ sample} X\,100$$

The ash content of the cow milk sample was determined gravimetrically. The dried milk sample used for the determination of total solids content was ignited in a muffle furnace at 540 -550°C for five hours. The milk sample was burnt until black color disappeared or the ash residue become white. Finally, the ash content was calculated. The Gerber method was used to determine milk fat content. Ten ml of sulfuric acid was dispensed into a Gerber butyrometer. Then, 11ml of milk sample and one ml of amyl alcohol were added into the butyrometer having sulfuric acid, respectively. Then the content was shaken and the butyrometer was placed in a water bath at 65ºC for five minutes. The sample was centrifuged for five minutes at 1100rpm. Finally, the sample was placed in water bath with a temperature of about 65ºC for 5 minutes and fat percentage was recorded from the butyrometer reading (O' Connor, 1995). Solids-not-fat (SNF %) content were determined by subtracting the percentage of fat from the total solids (O' Connor, 1995).

% SNF = % TS – % Fat

Total protein content of the milk samples was determined by the formaldehyde (formal) titration (O' Connor, 1995). Saturated aqueous potassium oxalate (0.4ml) was dispensed and 0.5ml of 0.5% phenolphthalein solution was added to 10ml of milk sample. The sample was allowed to stand for two minutes and titrated with N/9 NaOH until a pink color was obtained. Two ml of neutral 40% formalin which was discharge the pink color added and continue the titration with N/9 NaOH until a pink color was obtained. The number of ml of the NaOH used after the addition of the formalin multiplied by 1.74 gives the percentage protein in the milk.

Microbiological Analysis

The microbiological analysis was done through enumeration of total coliform count (TCC), total aerobic mesophilic bacterial count (TAMBC) and spore-forming bacterial count (SFBC) and isolation and identification of microbial pathogens such as *Salmonella spp., staphylococcus aureus* and *Listeria monocytogenes.*

For TAMBC determination, 1ml of milk sample was diluted in 9ml sterile peptone water (Oxoid, CM0009) and serial dilutions (tenfold) were made in sterile peptone water diluents until the expected level of count of 30-300 was obtained. One ml of the milk sample from a chosen dilution was placed on the sterile plate. Then, plate count agar media (Oxoid, CM0325) of 15-20ml was poured on to the plate and thoroughly mixed with the sample and allowed to solidify for 15 minutes. Then the plates were incubated for 48 $\pm$2hrs at 35°C in an inverted position. Finally, colonies were counted manually using colony counter (FDA, 2003).

Total colony count was determined using sterile violet red bile agar (VRBA) (Oxoid, CM0107). One mL of raw milk sample was added into a sterile test tube containing 9 mL of sterile peptone water (Oxoid, CM0009). After thoroughly mixing, the sample was serially diluted up to 10^{-9} and duplicate samples (each with 1mL) were pour plated using sterile 15-20mL VRBA. After gently mixing, the resulting plates were allowed to solidify and then incubated at 32±1^{o}C for 24hrs (Murphy, 1996). Following incubation, typical dark red or purplish red or pink colonies appearing on the plates, measuring 0.5mm or more in diameter on un-crowded plates and with bile precipitation around them were counted as coliforms (FDA, 2003). For SFBC determination, milk samples were first heat treated in a water bath (Chifton, UK) at 80^{o}C for 10 minutes. Appropriate dilutions of the milk samples (1ml) were plated on duplicate solid plate count agar (Oxoid, CM0325) media. Then, colonies were counted after 3 days of incubation at 30^{o}C (Roberts and Greenwood, 2003).

Isolation and identification of selected pathogenic bacteria

Three pathogenic bacterial species were isolated to measure safety of milk samples in the study area. Isolation and identification of *Salmonella* spp involved three steps based on ISO-6579, 2000. First, 25ml of milk sample was pre-enriched with 225ml of buffered peptone water (BPW) (Oxoid, CM509) and incubated for 24hrs at 37°C. A portion (0.1ml) of the pre-enriched cultured was transferred to10 ml of Rappaport Vassilidis (RVs) broth (Oxoid, CM0866) and incubated at 42°C for 24hrs. Finally, a loop full of a culture broth was streaked on the surface of a dry Xylose Lysine Deoxycholate (XLD) (HIMEDIA, M031) agar plate. Then the plates were incubated at 37°C for 24hrs and the incubation was prolonged to 48 hrs for those that did not show any growth during the 24hrs of incubation. Characteristic *Salmonella* spp. colonies, having a slightly transparent zone of reddish color and a black center, were sub-cultured on nutrient agar (Oxoid, CM0003). To confirm the presence of

Salmonella spp. further tests were made including gram staining and biochemical tests such as Triple Sugar Iron (TSI), Voges-Proskauer (VP), Methyl red, glucose fermentation and Citrate utilization tests (ISO, 2003).

For isolation and characterization of *Staphylococcus aureus,* 1ml of milk sample was transferred to a test tube containing 9ml of normal peptone water. This was again serially diluted until an appropriate dilution was obtained. After properly shaken the homogenate, 0.1 ml of the appropriate dilution was spread-plated on the surface of a dry Baird Parker Agar (Oxoid, CM0275) plate using a sterile bent glass rod and incubated at 37°C for 24 - 36hrs. White yellow colonies surrounded by clear haloes were considered as colonies belonging to *Staphylococcus aureus*. Further confirmation of *Staphylococcus aureus* colonies was made using gram staining and biochemical tests such as methyl red test, catalase test, coagulase test, mannitol fermentation, oxidase test and VP tests (FDA, 2003).

For isolation and characterization of *Listeria monocytogenes*, a portion of 25ml of milk sample was pre-enriched in 225ml of the BPW (Oxoid, CM 0509) at 32°C for 24hrs. Then, 0.1ml of pre-enriched sample was inoculated into 10ml Listeria enrichment broth part A (HIMEDIA, M569) and Listeria enrichment broth part B (HIMEDIA, M569) and incubated at 37°C for 24hrs. A loop full of the enriched culture broth was taken and streaked on PALCAM agar. (HIMEDIA, M1064) and incubated for 48hrs at 37°C. Colonies that were gray-green with black precipitate were considered as *Listeria monocytogenes*. Further confirmation of the identity of suspected colonies of *Listeria monocytogenes* was made using gram staining and biochemical tests such as TSI, VP, Methyl red and Citrate tests (FDA, 2003).

Data Analysis

Physicochemical and microbial analyses data were analyzed using analysis of variance (ANOVA), SAS procedure, version 9.0 (SAS, 2009). Tukey's Studentized Range (HSD) test was employed to detect mean differences between sample sources. The numbers of microorganisms (colony forming units) per milliliter of milk samples were expressed using the following mathematical formula (FDA, 2003):

$$N= \frac{\Sigma C}{(n1*2)+(0.1*n2)} *d$$

Where,

N = Number of colony-forming units per ml of milk

∑C = Sum of all colonies counted on plates

n_1 = Number of plates in the first dilution counted

n_2 = Number of plates in the second dilution counted

d = Dilution factor of lowest dilution used

Microbial count data were first transformed into logarithmic values ($\log_{10}$) before statistical analysis. The $\log_{10}$ transformed values were analyzed using the General Linear Model (GLM) of SAS software.

$Y_{ij} = \mu + L_i + C_j + e_{ij}$

Where

Y_{ij} = the dependent variables

μ =overall mean,

L_i = location effect (peri-urban and urban) and

C_j= collection site effect (producers and collection center)

e_{ij} = random error

RESULTS

Physicochemical Properties of Raw Milk

The temperature of milk samples collected from urban producers (29.5^{0}C ± 0.61) was significantly (P<0.0001) higher than urban collectors (19.9^{0}C ± 0.86) (Table 1). The temperature of milk from peri urban producers (30^{0}C ± 0.86) were also significantly higher (P<0.0001) than peri urban collectors (24.8 ±0.6^{0}C). The mean value of temperature for milk sampled from producers and collectors of the study area were also significantly different.

The overall mean pH value of milk collected from the producer and collector in the study areas was 6.69±0.02 and 6.55±0.02, respectively (Table 1). The pH of milk from peri-urban producer was significantly (P<0.01) higher than that of the urban milk producer. Similarly, the pH of milk sample collected from urban collector was significantly (P< 0.05) lower than the milk sample collected from urban producer. The titratable acidity of milk samples in the current study was found to be significantly (P<0.05) lower for milk samples collected from peri urban producers (Table 1). The average titratable acidity/percent of lactic acid of milk from producer and collector falls almost in the range of fresh milk pH that is 0.14 to 0.16%. The specific gravity of milk samples in the current study were significantly (P<0.001) different among the two locations (Table 1). The specific gravity of milk samples collected from the two sites did not lie within the normal range (1.027-1.035) of the specific gravity of milk.

Table 1: Physical properties (means ± SE) of raw cow milk produced and marketed in the study area

Parameters	Milk sources	Location		Overall mean
		Urban	Peri urban	
Temp (^{0}C)	Producers	29.50 ±0.61^a	30.00 ±0.86^a	30.00 ±0.86
	Collection center	19.90 ±0.86^c	24.80 ±0.61^b	22.35±0.52
pH	Producers	6.62±0.03 ^{b}	6.76±0.03 ^{a}	6.69±0.02
	Collection	6.49±0.04 ^{b}	6.62±0.04 ^{b}	6.55±0.02
Acidity	Producers	0.17±0.004^a	0.15±0.004^b	0.16±0.003
	Collection center	0.17±0.006 ^{a}	0.18±0.006^a	0.175±0.003
Specific gravity.	Producers	1.024±0.002 ^{b}	1.026±0.002 ^{a}	1.026±0.002
	Collection center	1.023±0.003^b	1.026±0.003^a	1.023±0.002

Means in all columns and rows bearing different superscripts for the same parameter are significantly different (P<0.05). Temp. = Temperature.

Chemical composition of raw cow milk in the study areas

The mean value of fat content of milk samples from the urban producer and urban collector 3.69±0.14 and 3.57±0.20%, respectively showed significant deference (P<0.001). The overall mean fat content of milk samples from urban producer was significantly (P<0.0001) higher than milk sample from peri urban producer of the study area (Table 2). The total solids (TS) content of milk samples obtained in the current study showed highly significant differences (P<0.001) among locations (Table 2). Likewise, the TS content of milk samples collected from peri-urban and urban producers were significantly different. The mean value of Protein, SNF and Ash content of milk samples obtained in the current study did not show significant differences (P<0.05) between locations and collection centers.

Table 2: Chemical composition (mean ± SE) of raw cow milk produced and sold in study area

Parameters (%)	Milk sources	Location		Overall mean
		Urban	Peri urban	
Fat	Producers	3.69 ±0.14[c]	4.34 ±0.14[a]	4.02±0.10
	Collection center	3.57 ±0.20[d]	3.94 ±0.20[b]	3.75±0.14
Protein	Producers	3.44±0.10	3.51±0.11	3.47±0.07
	Collection center	3.25±0.76	3.26 ±0.76	3.26±0.05
TS	Producers	11.73±0.39[b]	13.51±0.39[a]	12.62±0.28
	Collection center	10.96±0.56[b]	12.25±0.56[b]	11.60±0.39
SNF	Producers	8.04±0.33	9.16±0.33	8.60±0.23
	Collection center	7.49±0.48	8.31±0.48	7.90±0.33
Ash	Producers	0.66±0.02	0.67±0.02	0.66±0.01
	Collection center	0.72±0.03	0.67±0.03	0.69±0.02

Means in all columns and rows bearing with different superscripts for the same parameter are significantly different (P<0.05). TS= Total Solid SNF= Solid Not fat.

Microbial Quality of Raw Cow Milk in the Study area

The mean value of aerobic mesophilic bacterial count (AMBC) of raw milk samples collected at producers was significantly (P<0.05) lower than that of the milk collectors (Table 3). However, significantly (P<0.05) lower bacterial counts of raw milk in both sampling sources were observed in urban areas of the district. The difference in the overall mean AMBC observed in the study area might be associated with the difference in hygienic practices during milking, milk storage condition, and the cleanliness of milk utensils.

In the current study, the TCC of raw milk sampled from collection site (7.05±0.10) were significantly (P<0.001) higher than the TCC of milk sampled from producers. The spore forming bacteria count (SFBC) from milk samples of peri urban collector was significantly (P<0.0001) higher than that of urban collectors with the mean values of 4.13±0.10 log10cfu/ml and 3.27±0.10 log10cfu/ml, respectively (Table 3). Similarly, the SFBC in peri urban producer was significantly (P<0.05) higher than the urban producer with 2.77±0.10 log cfu/ml and 2.42±0.74 log10 cfu/ml, respectively.

Table 3: Total microbial counts (log cfu/ml) in raw cow milk produced and marketed in the study area

Parameters	Milk Sampling sources	Location		Overall mean
		Urban	Peri urban	
AMBC	Producers	6.22 ±0.10[c]	6.62 ±0.13[b]	6.42±0.07
	Collection center	6.99 ±0.15[b]	7.99 ±0.15[a]	7.49±0.10
TCC	Producers	3.87 ±0.13[d]	5.10±0.13[c]	4.49±0.09
	Collection center	6.96±0.18 [b]	7.13±0.18 [a]	7.05±0.10
SFBC	Producers	2.42±0.74[d]	2.77±0.10[c]	2.95±0.05
	Collection center	3.27±0.10[b]	4.13±0.10[a]	3.70±0.07

Means in all columns and rows bearing with different superscripts for the same parameter are significantly different at P<0.05. AMBC = Aerobic Mesophilic Bacteria Count; TCC= Total Coliform Count; SFBC = Spore Forming Bacteria Count.

Safety of raw cow milk in the study area

Staphylococcus aureus is one of the major pathogens that affect the quality and safety of raw milk in the study area. It is a major causative pathogen of clinical and subclinical mastitis. The results of the current study showed that 55 - 70% of the milk samples taken from producers and milk collectors were contaminated by *Staphylococcus aureus*. The mean *Staphylococcus aureus* count of the milk samples sampled from producers was 3.44±0.18 log10cfu/ml, while 5.64±0.26 log_{10} cfu/ml was found for milk collectors (Table 4).

Table 4.* Staphylococcus aureus *count (mean ± SE) (log CFU/ml) in raw cow milk produced and marketed in the study areas

Parameters	Location	Milk Sampling sources	
		Producers	Collection center
Staphylococcus aureus count	Urban	2.79 ±0.26[c]	5.48±0.36[b]
	Peri-urban	5.48±0.26[b]	5.79 ±0.36[a]
	Overall mean	3.44±0.18	5.64±0.26

Means in all columns and rows bearing with different superscripts for the same parameter are significantly different at P<0.05.

As observed in the present study, the proportion of positive *Salmonella* spp. was higher for collection centers than the producers, with the minimum value observed at urban producers (5%) and the maximum was recorded for peri urban milk collectors (50%). The higher prevalence of *Salmonella* spp. in the current study might be related to poor hygienic handling practices of raw milk (Table 4). Prevalence of *Listeria monocytogenes* was high in all milk sampling sites. Out of the total 60 milk samples considered from different sources, about 25% were found to be contaminated with *Listeria Monocytogenes*. The highest prevalence rate of about 50% was recorded for peri urban milk collection site of the study districts. In the present study the frequency of detection of *Salmonella* spp., *Listeria monocytogenes* and *staphylococcus aureus* were higher in milk collection centers.

Table 5: Prevalence of* Staphylococcus aureus, *Salmonella spp. and* Listeria monocytogenes *in raw cow milk produced and marketed in the study areas

Parameters	Sampling sources	Location		
		Urban	Peri urban	Overall means
Staphylococcus aureus (%)	Producers	55	60	57.5
	Collection center	60	70	65
Salmonella spp. (%)	Producers	5	10	7.5
	Collection center	30	40	35
Listeria monocytogenes (%)	Producers	10	20	15
	Collection center	40	50	45

DISCUSSION

Physicochemical Properties of Raw Milk

The mean value of temperature for milk sampled from producers and collectors of the study area were significantly different that might be because of temperature difference of the environment, equipment used and time elapsed since production. This result is in agreement with the finding of Almaz Kehase (2014) who reported milk temperature of 30.61±0.52 and 21.05± 0.42^{0}C from dairy farms and milk vendor, respectively in Mekelle.

The pH of milk from peri-urban producer and collectors was significantly different from that of the urban milk producer but were in the range of pH of cow's fresh milk which varies between 6.6 and 6.8 (Van den Berg 1988). This value is in agreement with the value recorded by Srairi *et al*. (2005) in Morocco (6.74 ± 0.14). However, Abebe Bereda *et al*. (2012) reported a lower pH value of 6.15 for milk in Ezha district of the Gurage zone. The low pH of milk in the collection site as compared to the pH values of milk from farms gate might be due to the proliferation of acid producing bacteria during transportation of milk samples.

The average titratable acidity of milk from producer and collector (0.16±0.003 and 0.17±0.003 %, respectively) were almost in the range of fresh milk acidity. Asaminew and Eyassu Seifu (2011) reported higher titratable acidity for milk samples collected from individual farmers with (0.23 ±0.01%) and dairy cooperatives (0.28±0.01% lactic acid) in Bahir Dar District. Normal fresh milk should have an apparent acidity of 0.14 to 0.16 % and the percentage of acid present in milk is a rough indication of its age or freshness and the manner in which it has been handled (O'Connor, 1995). The specific gravity of milk samples collected from the four sites was slightly below the normal range (1.027-1.035) of the specific gravity of milk suggesting that these milk samples might have been adulterated with water.

Chemical composition of raw cow milk in the study areas

The overall mean fat content of milk samples from urban producer was significantly higher than that of milk sample from peri urban producer of the study area which could be attributed to variation in breeds of animal, feeds, stage of lactation and health, physiological status of animal. The average TS content in this study is lower than the average result of 13.4% TS obtained from similar study conducted in Shashemene on milk from dairy cooperative collection centers, small scale milk producers, kiosks and hotels (Teshome Gemechu *et al.,* 2015).

Microbial Quality of Raw Cow Milk in the Study area

There were significantly ($P<0.05$) lower AMBC of raw milk in both urban and peri urban producers sampling sources. The difference in the overall mean AMBC observed in the study area might be associated with the difference in hygienic practices during milking, milk storage condition, and the cleanliness of milk utensils. According to Ethiopian standard (ES, 2009), the overall AMBC recorded in the present study was higher than 6 log10 cfu/ml and put the microbial quality of milk as bad microbial quality due to high bacterial load.

Earlier study by Alganesh Tola (2016), showed similar total AMBC of 6.97±0.35, 7.11±0.33 7.92±0.35log10 cfu/ml from Selale, Debre Birhan and Ejere milk producers, respectively. Similarly, Haile Welearegay et al. (2012) reported an average AMB count of 7.28 log10cfu/ml for milk samples collected from different farm sizes in Hawassa, southern Ethiopia. The result of the present study is not in agreement with the findings of Zelalem Yilma (2010), Haile Welearegay et al. (2012) and Teklemichael Tesfaye (2012) who reported a total bacterial count of 9.10 log10 cfu/ml for milk samples collected from different parts of Ethiopia; 10.28 log10 cfu/ml from distribution containers (at selling point) and 9.137 log10cfu/ml from vendors, respectively. According to ES (2009), good quality milk should not contain a total bacterial count of more than 5 log10 cfu/ml and the result of the current study revealed higher bacterial counts which call for measures to reduce bacterial load to meet standard set by Quality and Standards Authority of Ethiopia (QSAE).

The overall mean total coliform count (TCC) observed in this study at producers (4.49±0.09) was lower than the result of Teshome Gemechu *et al*. (2014) who reported an average TCC of 4.99±0.081log cfu/ml for milk marketed in Shashemene town. The current result is also lower than that of Amistu Kuma *et al* (2015) and Asaminew Tassew and Eyassu Seifu (2011) who reported TCC of 5.42±1.735 to 5.78±0.985 log10cfu/ml and 4.84 log10cfu/ml in milk samples of special zone of Oromia and Bahir Dar milk shed, respectively. However, the current study showed higher TCC than the finding of Abebe Bereda *et al.* (2012) who report 4.18 ± 0.01 log10 cfu/ml for raw milk samples in the Ezha districts of the Gurage Zone. In the current study, the TCC of raw milk sampled from collection site (7.05±0.10) were significantly (P<0.001) higher than the TCC of milk sampled from producers. According to Ethiopian standard (2009) the TCC of good quality raw milk should not exceed 3 log10 cfu/ml. The presence of high TCC in milk could be attributed to unsanitary conditions of milk production, processing and storage conditions in the study area. Moreover, their presence in large number in dairy products is also an indicator of potential hazard to the consumer's health due to possible presence of other enteric pathogens (Godefay Bekele and Molla Bayileyegn, 2000).

The spore forming bacteria count (SFBC) from milk samples of peri urban producers and collector was significantly higher than that of urban producers and collectors These results are higher than the finding of Mulugojjam Adugna *et al.* (2013) (2.1 log 10cfu/ml) for camel milk in Eastern Ethiopia and lower than the finding of Teshome Gemechu *et al.* (2014) who reported SFBC of 4.703 ± 0.069 log10 cfu/ml in milk samples collected from Shashemene town. The ubiquitous nature of aerobic spore-forming bacteria leads to numerous points of potential entry into raw milk. Soiling of the udder and teats is considered as one of the most important factors in the contamination of raw milk by spores. High levels of spores in feed may also lead to large quantities of spores in the feces, which in turn can contaminate the udder and teats of lactating cows (Almaz Kehase, 2014).

Safety of raw cow milk in the study area

Staphylococcus aureus is one of the major pathogens that affect the quality and safety of raw milk in the study area. It is a major causative pathogen of clinical and subclinical mastitis. The results of the current study showed that 55 - 70% of the milk samples taken from producers and milk collectors were contaminated by *Staphylococcus aureus*. The mean *Staphylococcus aureus* count of the milk samples collected from producers was 3.44±0.18 log10cfu/ml, while 5.64±0.26 $\log_{10}$ cfu/ml was found in milk samples taken from milk collectors (Table 4). Similarly, Almaz Kehase (2014) found about 46 - 60% *Staphylococcus aureu*s positive milk samples in Mekele dairy farms and vendors. The same author also stated that *Staphylococcus aureus* is often found in raw milk and dairy products due to contamination caused by poor hygienic conditions or from mastitic cows. *Staphylococcus aureus* is a common cause of mastitis in dairy cattle and can enter the milk supply from sores on the teats of cows or from the hands and nasal discharges of dairy farmers and workers (Aberra Aseffa, 2010).

As observed in the present study, the proportion of positive *Salmonella* spp. was higher for collection centers than the producers, with the minimum value observed in samples from urban producers (5%) and the maximum was recorded for peri urban milk collectors (50%). The higher prevalence of *Salmonella* spp. in the current study might be related to poor hygienic handling practices of raw milk.

The consumption of raw cow milk produced and marketed in the study areas may pose public health hazards unless strict control measures taken. Hailemariam Mekonnen *et al.* (2006) and Mulugojjam Adugna *et al.* (2013) reported the high prevalence of *Salmonella* (33 - 83%) in milk samples collected from small, medium and large-scale dairy farms in Ethiopia and 79.17% prevalence in camel milk samples from eastern Ethiopia. The water which was used for cleaning of milking equipment could be one possible source of pathogenic bacteria and responsible for the contamination of milk and its products. The difference in prevalence of *Salmonella* may be due to differences in hygienic practices employed by the producers and collectors (Almaz Kehase, 2014).

Listeria monocytogenes showed high prevalence in the current study areas with prevalence rate of 25% and the highest prevalence rate was about 50% for peri urban milk collectors. Eyasu Tigabu et al. (2015) found 18.9% prevalence rate of *L. monocytogenes* in raw milk and milk products produced in urban and peri-urban areas of central Ethiopia. The current high prevalence rate might be due to the feeding of *Listeria* contaminated feed during grazing which may have direct contact to the soil, due to contaminated udders, and milking equipment, and animals with listeria mastitis. Since these pathogenic bacteria are present in raw milk, it is a major public health concern, especially for those individuals who frequently drink raw milk (Lang Halter et al., 2013).

In the present study the frequency of detection of *Salmonella* spp., *Listeria monocytogenes* and *staphylococcus aureus* were higher in milk collection centers. This could be attributed to poor post-harvest hygienic handling practices of milk by the collectors. Matofari *et al*. (2007) suggested that contamination of camel milk by pathogen was influenced by post-harvest handling of the milk rather than camel infection by the pathogen.

CONCLUSIONS

The microbial quality of milk produced and marketed in the study area was found to be substandard which could be attributed to poor hygienic milk handling practices and absence of cooling system along the milk market chain. In addition, the presences of pathogenic microorganisms mainly *Staphylococcus aureus*, *Listeria monocytogenes* and Salmonella species are potential cause of public health hazards. Therefore, awareness needs to be created through trainings among dairy cow owners and workers on the importance of hygienic milking techniques, and use of clean dairy equipment, washing of utensils and milkers hands using properly treated water plus detergents to improve the milk hygienic quality. Moreover, milk collection centers should be equipped with cold chain and the necessary milk handling equipment to avoid/minimize milk contamination. It is also necessary to establish and enforce quality and safety control systems in order to produce and market wholesome milk and dairy products.

REFERENCES

Abebe Bereda, Zelalem Yilma and Ajebu Nurfeta. 2012. Hygienic and Microbial Quality of Raw Whole Cow's Milk Produced in Ezha district of the Gurage zone, Southern Ethiopia. Journal of Agricultural Biotechnology and Sustainable Development, 5(6): 91-98.

Aberra Aseffa. 2010. Microbiological Safety of Pasteurized and Raw Milk from Milk Processing Plants in and Around Addis Ababa. MSc Thesis, Addis Ababa University, Addis Ababa, Ethiopia.

Abrahamsen, R.K., Borg, G.I., Harstad, O.M., Haug A. and Wetlessen A. 2007. Milk Quality-Future Approach from a Researcher's Point of View. Journal Animal and Feed Science, 16(1): 209-226.

Alganesh Tola. 2016. Assessment of safety and quality of raw whole cow milk produced and marketed by smallholders in Central highlands of Ethiopia. Food Science and Quality, 49:63-71.

Almaz Kehase. 2014. The quality and safety of raw cow milk produced and marketed by three dairy farms in Mekelle, northern Ethiopia. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

Amistu Kuma, Degefa Tolossa and Melese Abdisa. 2015. Assessment of Raw Milk Microbial Quality at Different Critical Points of Oromia to Milk Retail Centers in Addis Ababa. Food Science and Quality Management. 38:1-9.

Asaminew Tassew and Eyassu Seifu. 2011. Microbial quality of raw cow's milk collected from farmers and dairy cooperatives in Bahir Dar Zuria and Mecha district, Ethiopia. Agriculture and Biology Journal of North America, 2(1):2933.

Chamberlain, A. 1990. An Introduction to Animal Husbandry in the Tropics. 4th ed. John Wiley and Sons INC. New York. pp. 758.

Coorevits, A., De Jonghe, V., Vandroemme, J., Reekmans, R., Heyrman,J., Messens, W., De Vos, P. and Heyndrickx, M. 2008. Comparative Analysis of the Diversity of Aerobic-Spore-Forming Bacteria in Raw Milk from Organic and Conventional Dairy Farms System, U.S. Department of Health and Human Services Applied Microbiology. System Applied Microbiology, 31(2):126-140.

ES (Ethiopian Standard). 2009. Unprocessed Whole/Raw Cow Milk Specification. 2nd ed., ES: 3460:2009.

Eyasu Tigabu Seyoum, Daniel Asrat Woldetsadik, Tesfu Kassa Mekonen, Haile Alemayehu Gezahegn and Wondwossen Abebe Gebreyes. 2015 Prevalence of Listeria monocytogenes in raw bovine milk and milk products from central highlands of Ethiopia. Journal of Infection in Developing Country, 9(11):1204-1209.

FDA (Food and Drug Administration). 2003. Bacteriological Analytical Manual on line, Center for Food Safety and Applied Nutrition. U.S.

Godefay Bekele and Molla Bayileyegn. 2000. Bacteriological quality of raw milk from four dairy farms and milk collection center in and around Addis Ababa. Berl. Münch. Tierärztl.Wschr. pp 113.

Haile Welearegay, Zelalem Yilma and Yosef Tekle. 2012. Hygienic Practices and Microbiological Quality of Raw milk Produced under Different Farm Size in Hawassa, Southern Ethiopia. Agricultural Research and Review, 1(4): 132- 142.

Hailemariam Mekonnen, Asmamaw Kassaye and Courreau, J.F. 2006. Husbandry practices and health in smallholder dairy farms near Addis Ababa, Ethiopia. Preventive Veterinary Medicine, 74:99-107.

ISO (International Standard organization). 2003. ISO expert committee on international organization for standardization, recommendation of the meeting of the ISO of milk and dairy products. ISO/TC-34/SC.6. Netherlands: 10-18. P.

Jayarao, B.M., Pillai, S.R., Sawant, A.A., Wolfgang, D.R. and Hegde, N.V. 2006. Guidelines for monitoring bulk tank milk somatic cell count and bacterial counts. Journal of Dairy Science, 87: 3561–3573.

Lang Halter E., Neuhaus, K. and Scherer, S. 2013. Listeria weihenstephanensis sp. nov., isolated from the water plant Lemna trisulca taken from a freshwater pond. International Journal of System Evolution Microbiology, 63:641–647.

Matofari, J.W., Shitandi, A., Shalo, P.L., Nanua, N.J. and Younan, M. 2007. A survey of Salmonella enteric Contamination of Camel Milk in Kenya. African Journal of Microbiological Research, 1(4): 46-50.

Mulugojjam Adugna, Eyassu Seifu, Ameha Kebede, and Reiner Doluschitze. 2013. Quality and Safety of Camel Milk along the Value Chain in Eastern Ethiopia. International Journal of Food Studies, 2:150-157.

Murphy, S.C. 1996. Sources and Causes of High Bacteria Count in Raw Milk: Cornell University, Ithaca, N.Y.

O'Connor, C.B. 1995. Rural Dairy Technology. ILRI Training Manual No.1. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia.

Roberts, D. and Greenwood, M. 2003. Practical Food Microbiology (3rd edi.). Blackwell Publishing Ltd, Oxford, UK.

SAS (Statistical Analysis System). 2009. Users Guide. Version 9.2 Institute, Inc. Carry, NC.

Soomro, A.H., Arain, M.A., Khaskheli, M. and Bhuto, B. 2002. Isolation of E. coliform Raw Milk and Milk Products in Relation to Public Health Sold Under Market Conditions at Tandonjam. Pakistan Journal Nutrition, 1 (3): 151-152.

Srairi, M.T., Alaoui, I.H., Hamama, A. Faye, B. 2005. Relationship between Rearing practices and Cow's Milk Global Quality in Suburban Dairy Farms in Morocco. Rev Med. Vet. 156: 155-162.

Teklemichael Tesfaye. 2012. Quality and safety of raw and pasteurized cow milk produced and marketed in Dire Dawa Town. MSc Thesis, Haramaya University.

Teshome Gemechu, Fekadu Beyene and Mitiku Eshetu. 2014. Handling practices and microbial quality of raw row's milk produced and marketed in Shashemene Town. MSc thesis, Haramaya University.

Teshome Gemechu, Fekadu Beyene and Mitiku Eshetu. 2015. Physical and chemical quality of raw cow's milk produced and marketed in Shashemene Town, Southern Ethiopia. Journal of Food and Agricultural Science, 5 (2):7-13.

Van den Berg, J.C.T. 1988. Dairy Technology in Tropics and Sub-tropics. Wageningen, the Thomas, S.B. 1974. The Microflora of Bulk Collected Milk-Part 1. Dairy Ind. Int. 39: 237 Netherlands, Pp 184-185.

WFEDO (Woreda Finance and Economic Development Office). 2010. Fitche, Ethiopia.

Zelalem Yilma. 2010. Quality Factors that Affect Ethiopian Milk Business: Experiences from Selected Dairy Potential Areas. Netherlands Development Organization, Addis Ababa, Ethiopia.

Zelalem.Yilma. 2012. Microbial Properties of Ethiopian Marketed Milk and Milk Products and Associated Critical Points of Contamination: An Epidemiological Perspective, Epidemiology Insights. Maria De Lourdes Ribeiro De Souza Da Cunha Ed., ISBN: 9

Milk Production Performance Indicators of *Begait* Cattle in Western Zone of Tigray, Ethiopia

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ABSTRACT

*The purpose of this study was to estimate some milk production performance indicators of Begait cattle kept in Kafta and Setit Humera Woredas of Tigray Region, Ethiopia. Purposive sampling of study villages (Kebeles) keeping Begait cattle and random sampling of Begait cattle owning households and animals were used for data collection. Primary data were collected from 368 Begait cattle sampled from six Kebeles and 180 households. Cattle herd sizes in the study area were about 97 and 27 heads in the large and small scale farms, respectively. Pure Begait cattle account for about 90% of the cattle herd, while the rest were classified as Arado, Begait*Arado crosses and other genotypes. The body frame of Begait cattle looks like that of the temperate dairy cattle. Begait cattle were observed to have relatively large udder size, wide hind quarter, long naval flap (8.6±0.28 cm), thin and long neck (45.5±0.35), and no (if any in females) or small humps (15.4%). Age at first mating was estimated to be 3.4 (±0.5) years for bulls and 3.1 (±0.6) for heifers. The reproductive lifetime was estimated to be 4.6 (±1.3) for bulls, and 10.3 (±1.3) for cows during which they produce an average of 7 (±1) calves. The average daily milk off-take of random Begait cows and old Begait cows were 2.8 (±0.3) and 2.6 (±0.4) liters during average lactation lengths of 6.4 (±0.9) and 6.1 (±1.0) months, respectively. However, daily milk off-take was as high as 6.68 liters at the Humera Agricultural Research center, indicating the highly considerable dairy potential of Begait cows with better management. The lactation length of Begait cows kept under on farm extensive management in both small scale and large scale farms ranged from 144-225 days indicating a wide scope for selection and genetic improvement. It is, therefore, recommended that appropriate community based breeding program should be developed for Begait cattle in order to improve their overall dairy performance in their potential niche area.*

Key words: *- Begait cattle, dairy performance, Ethiopia, herd size, milk production indicator*

INTRODUCTION

Characterization information is essential for planning farm animal genetic resources management at local, national, regional and global levels (FAO, 2011b). Ethiopia has massive livestock genetic diversity; however, breed level characterization is inadequate (Workneh *et al.,* 2004). DAGRIS (2009) also highlighted the need to report on current breed performance indicators as an input for planning conservation of existing genetic diversity. Almost all (98.2%) of the cattle populations in Ethiopia are indigenous types (CSA, 2016/17). Tigray Regional State has seven indigenous cattle breeds which consist of Raya-Azebo, Irrob, Abergele, Adwa, Arado, *Begait* and Medense. Arado cattle are the most populous cattle in the highland parts whereas *Begait* cattle are dominant in the lowland parts of the Regional State (Merha, 2006).

Cow milk constitutes most of the national milk production (FAO, 1993; CSA, 2008/09), even though average daily milk off-take remains as low as 1.5 to 2 liters (ILCA, 1991; CSA, 2012/13; 2015/16 and 2016/17). The Ethiopian Institute of Biodiversity Conservation (IBC, 2004) reported *Begait* cattle as one of the recognized indigenous cattle breeds of Ethiopia. *Begait* cattle are categorized under the breed group classification of Zebu; the breed population belongs to the North Sudan Zebu sub-group, maintained for milk and beef production mainly by the Beni-Amir tribes in the lowlands of Eritrea but also in the neighboring areas of the Sudan and Ethiopia (Zerabruk *et al*., 2007; DAGRIS, 2014). DARIS (2007) report also declares that *Begait* cattle are grouped under the large East African Zebu cattle breeds and are characterized by their active disposition.

Begait cattle have been known for adaptation to hot and dry environments (heat tolerant breed). They are used for both milk and meat production. They are known as relatively good milk producers, and some available information suggests that they have promising dairy type attributes. However, there exists very little farm level dairy performance information except the recent work of Ftiwi and Tamir (2015). Thus, this study was conducted to generate information on dairy performance indicators of the breed in its niche area in Western Zone of Tigray Region, North Western Ethiopia.

MATERIALS AND METHODS

The Study Area

The study was conducted in Kafta Humera and Setit Humera districts which are considered the niche areas of *Begait* cattle in the Western Zone of Tigray Regional State, Ethiopia. The area is located about 600 Kilometers (km) west of Mekelle city and 954 km north of Addis Ababa. Kafta Humera lies at $13^0$40'and $14^0$27'N of latitude, and $36^0$27'and $37^0$32'E of longitude with an altitude ranging from 515 to 1863 meter above sea level (masl). The annual rainfall ranges from 449 to 1,100 mm (Kafta Humera OoARD, 2015, unpublished), with annual temperatures of 33°C to 41.7°C in the lowlands and 17.5°C to 22.2°C in the highlands (Niguse and Aleme, 2015). Setit Humera is located at $14^0$16' N of latitude and $36^0$37'E of longitude and has an altitude of 611 masl.

Sampling Method and Data Collection

Both Kafta Humera and Setit Humera districts were purposively selected from the Western Zone of Tigray for being niche areas of *Begait* cattle population. All the six hot spot Kebeles for *Begait* cattle in Kafta Humera and Setit Humera and large scale farms were purposively sampled. Random sampling was employed to select small scale farms and the animals for characterization.

Types of data collected included dairy performances of selected cows as recalled by owners, livestock holdings of households, and some qualitative and quantitative traits of *Begait* cattle. The quantitative traits measured were body length, chest girth, height at withers, neck length, pelvic width, rump length, backline length, teat length, ear length, horn length, muzzle circumference, dewlap width, navel flap width, hock circumference, scrotal circumference, preputial sheath and tail length. Hump presence, hump size, face profile, udder and hind quarter sizes were the qualitative traits observed. The quantitative data were measured using measuring tape whereas the qualitative data were taken via thorough observation of the body parts. Body length was measured from the thurl bone to the point of shoulder.

Primary data were collected through household interviews of 63 large scale and 117 small scale farms, and via morphometric measurement and observation on some qualitative traits on a sample of 368 mature *Begait* cattle. Large scale farms are farms which are owned by individual investors but not by organizations and/or cooperatives. The 368 mature *Begait* cattle were sampled from animals kept by large and small scale farms, and Humera Ranch under extensive production system. Moreover, two years data on milk off-take and lactation length were taken from *Begait* cows (N=10) kept under moderate intensive production system at Humera Agricultural Research Center (HuARC). Mature animal morphometric and qualitative traits were taken following the global indicators and guideline presented in FAO (2012). Field data collection was carried out from October 2015 to February 2016.

Age of the sample cattle was estimated using the stage of eruption of permanent pair of incisors (Kikule, 1953) and the information from owners. On that basis, all the selected sample animals were four and above years old.

Data Analysis

SPSS version 20 (2012) was employed to analyze data on reproduction and milk off-take. SAS version 9.1 (SAS, 2003) was used to analyze morphometric data. The GLM procedure of SAS was used to analyze morphometric traits, using the following general model:

$$\mathbf{Y_{ijk} = \mu + m_i + a_j + (ma)_{ij} + e_{ijk}},$$

Where, Y_{ijk}= the observed value of trait of interest, μ is overall mean, m_i is the effect of i^{th} farm type (i=1, 2 and 3), a_j is the effect of the j^{th} age class (j=1,2 and 3), $(ma)_{ij}$ is interaction effect of farm type and age class of animals and e_{ijk} is the residual random error.

RESULTS

Animal Management

All animals in large and small scale farms, and Humera Ranch were kept under extensive management (mainly grazing on communal rangelands) whereas animals in HuARC were kept under moderate intensive management system. The animals in large and small scale farms were supplemented with crop residues while animals in Humera Ranch were supplemented with crop residues, hay and commercial concentrates during the dry seasons. Animals in HuARC were fed on sorghum stover and grass hay as year round basal feeds with the supplementation of sorghum grain, cowpea hay and commercial concentrates. However, no feed formulation is practiced due to lack of feed ingredients and lack of information on body weight of each animal in the farm.

Well water was the main source of drinking water for large scale farms (85.7%) and small scale farms (48.7% of the respondents). About 35% of the respondents from small scale farms also used pipe water as a source of drinking water for cattle. Cattle watering frequency was different among the farms. The result showed that 33.3% and 63.5% of the large scale farms water their cattle once and twice a day, respectively. On the other hand, 49.6% and 44.4% of the respondents from small scale farms water their cattle once and twice a day, respectively. These differences could be associated with differences in distances of watering points to the farms. The main source of water for animals at Humera Ranch was river water located less than one kilometer from the ranch.

Herd Size

Large scale farms are owned by individuals who were involved in both crop production and livestock production. Except donkeys, the other common livestock species were significantly ($P<0.05$) different between small scale and large scale farms. It was also noted that *Begait* cattle, *Arado* cattle and *Begait* Arado* crossbred cattle holding were significantly (P<0.05) different between small scale and large scale farms (Table 1). The average *Begait* cattle holding per farm in the large scale and small scale farms were 90±31 and 24±17 heads, respectively (Table 1). The aggregate livestock holding in Tropical Livestock Unit (TLU) of large scale farms was over four times bigger than in the small scale farms. In the large scale farms, 93.3% of the cattle were *Begait*, 2.7% Arado, and 4.4% were crosses of Begait and Arado cattle. In small scale farms, 89.8% were *Begait* cattle, 2.9% Arado, 0.2% Holstein Friesian, 0.4% crosses of Holstein Friesian and *Begait*, and 6.6% were crossbreds of *Begait* and Arado cattle. Large scale farms did not introduce Holstein Friesian cattle and their crossbreds to their herds. The reason why large scale farms did not breed Holstein Friesian cattle and their crossbreds was due to the fact that large scale farms aim has been generating income from the sale of *Begait* cattle kept under extensive management system, rather than milk. All *Begait* cattle kept under small and large scale farms were reared in mixed crop-livestock farming system.

Table 1. Livestock holding of sample respondents by farm size (TLU, Mean±SE)

Livestock type	Farm type		Total (N=180)	*P*-Value
	Large farm (N=63)	Small farms (N=117)		
Begait cattle (B)	90±31	24±17	47±39	0.000
Arado cattle (A)	28±21	7±4	14±15	0.003
Holstein Friesian (HF)	-	2±1	2±1	
HF x B crossbreds	-	2±2	2±2	
B x A crossbreds	27±10	12±9	18±12	0.001
Total cattle (number)	97±36	27±18	51±42	0.000
Sheep (number)	207±103	33±25	109±111	0.000
Goats (number)	108±64	23±19	66±63	0.000
Chickens (number)	38±20	11±11	22±20	0.000
Donkeys (number)	2±1	2±2	2±2	0.367
Total TLU	96±33	23±14	-	0.000

TLU= Tropical Livestock Units

Body Size

Most of the morphometric traits of *Begait* cows kept under small scale farms, large scale farms and Humera Ranch were significantly (P<0.05) different due to the differences in selection-mating process and overall animal management (Table 2). Traits more directly related to dairy characteristics, such as teat length, neck length, tail length, body length, chest girth and pelvic width significantly (*P*<0.05) varied among farm types, with larger size of morphometric traits in *Begait* cows kept by large scale farms (Table 2). The difference could be associated with the level of management and selection practices. Proximal traits like ear length and navel flap width were similar across farm types. *Begait* bulls kept by the large scale farms also had larger body size. Body length, chest girth, preputial sheath and hock circumference of bulls were significantly (*P*<0.05) different between farm types due to the differences in selection and overall animal management (Table 3).

Table 2. Morphometric traits of Begait cows by farm type (cm, Mean±SE)

Traits	Farm type			*P*-Value
	Small farms (N=117)	Large farms (N=120)	Ranch (N=107)	
Body length	115.5±0.48	118.4±0.48	114.1±0.5	0.000
Chest girth	153.2±0.56	155.6±0.56	152.1±0.59	0.000
Height at withers	129.1±0.46	131.4±0.45	130.8±0.48	0.389
Neck length	45.5±0.35	43.8±0.34	43.3±0.36	0.000
Pelvic width	38.1±0.19	38.4±0.19	38.3±0.21	0.048
Rump length	21.0±0.24	22.5±0.23	21.7±0.25	0.015
Backline length	88.6±0.42	89.2±0.42	89.3±0.44	0.001
Teat length	6.5±0.14	7.5±0.14	5.7±0.15	0.000
Ear length	22.8±0.16	22.3±0.16	23.2±0.17	0.942
Horn length	22.4±0.69	21.8±0.68	21.8±0.72	0.000
Muzzle circumference	38.8±0.17	38.2±0.16	38.2±0.17	0.001
Dewlap width	16.0±0.26	15.8±0.26	15.3±0.28	0.005
Navel flap width	8.6±0.28	9.1±0.27	7.8±0.29	0.453
Hock circumference	33.7±0.17	35.2±0.16	34.6±0.17	0.034
Tail length	96.9±0.72	97.8±0.71	95.8±0.76	0.000

SE=Standard errors

Table 3. Morphometric traits of Begait bulls by farm type (cm, Mean±SE)

Traits	Farm type		P-Value
	Small farms (N=14)	Large farms (N=10)	
Body length	125.6±1.21	131.3±1.43	0.009
Chest girth	167.9±1.58	174.7±1.87	0.005
Height at withers	143.4±1.24	147.6±1.46	0.074
Neck length	46.1±1.14	48.4±1.34	0.198
Rump length	20.9±0.62	21.8±0.73	0.364
Backline length	89.6±1.42	90.5±1.68	0.725
Scrotal circumference	32.1±0.46	33.2±0.54	0.278
Ear length	23.2±0.49	23.4±0.58	0.806
Horn length	26.8±2.28	23.2±2.69	0.334
Muzzle circumference	43.1±0.48	43.6±0.56	0.578
Dewlap width	20.36±0.96	19.3±1.14	0.430
Preputial sheath	14.1±0.63	18.7±0.75	0.007
Hock circumference	35.3±0.61	37.7±0.72	0.012
Tail length	106.9±1.49	110.0±1.77	0.212

SE=Standard errors

Qualitative Traits as Dairy Indicators

As shown in Table 4, most cows in all the farm types have no humps while all males were humped. Most females exhibit concave face profile. These together with the relatively large udder sizes, wide hind quarter, thin and long tail, long naval flap and thin and long necks indicate desirable dairy attributes of *Begait* cattle.

Table 4. Frequency of occurrence of qualitative traits of Begait cattle by farm type and sex

Major traits by sex	Trait categories	Farm types		
		Small farms	Large farms	Ranch
Females				
Hump presence	Absent	99 (84.6)	101 (84.2)	103 (96.3)
	Present	18 (15.4)	19 (15.8)	4 (3.7)
Hump size	No hump	99 (84.6)	101 (84.2)	103 (96.3)
	Small	18 (15.4)	19 (15.8)	4 (3.7)
Face profile	Straight	19 (16.2)	30 (25)	35 (32.7)
	Concave	92 (78.6)	85 (70.8)	71 (66.4)
	Convex	6 (5.1)	5 (4.2)	1 (0.9)
Males				
Hump presence	Absent	0	0	0
	Present	14 (100)	10 (100)	24 (100)
Hump size	Small	7 (50)	3 (30)	10 (41.7)
	Medium	4 (28.6)	4 (40)	8 (33.3)
	Large	3 (21.4)	3 (30)	6 (25)
Face profile	Straight	0	4 (40)	4 (16.7)
	Concave	12 (85.7)	4 (40)	16 (66.7)
	Convex	2 (14.3)	2 (20)	4 (16.7)

Temperament and Adaptive Traits

Aggressive temperament is a characteristic feature of *Begait* cattle in general. Although, aggressiveness is considered undesirable by many other global dairy farmers, *Begait* cattle keepers in the study area consider it important for against predator attack and theft by the cattle. As shown in Table 5, large scale farms maintain a greater frequency of aggressive animals in their herds. Majority of *Begait* cattle owners believe that *Begait* cattle exhibit excellent tolerance to environmental temperature (up to 41.7^{o}C) in their niche area.

Table 5. Reported temperament types of Begait cattle by farm type

Temperaments	**Farm type**					
	Large farms		Small farms		Total	
	N	%	N	%	N	%
Docile	3	4.8	28	23.9	31	17.2
Moderately tractable	0	0.0	5	4.3	5	2.8
Aggressive	22	34.9	16	13.7	38	21.1
Docile and moderately tractable	0	0.0	6	5.1	6	3.3
Docile and aggressive	8	12.7	30	25.6	38	21.1
Moderately tractable and aggressive	15	23.8	10	8.5	25	13.9
Docile, moderately tractable, and aggressive	15	23.8	22	18.8	37	20.6

Reproductive Performance

As presented in Table 6, the overall mean age at first mating is 3.4 years for bulls and 3.1 years for heifers, with the first calves expected at the age of 4.1 years. These values were significantly (P<0.05) different between large and small scale farms, with animals under small scale farms reaching age at first mating at about 3.6 months later. Breeding bulls were culled by about a year later in large scale farms than in small scale farms, whereas cows were culled about 22.8 months earlier in large scale farms than the small scale (Table 6). The main reason for the variation in age at first mating and age at first calving under small and large scale farms was attributed to differences in the level of management (mainly in calf rearing). The differences in productive lifetime of bulls and cows between the farms could be associated to purpose of breeding. However, the overall mean number of calves born in productive lifetime of cows is about 7.1 in both large and small scale farms. Days open is significantly (P<0.05) different between cows under small and large scale farms in which *Begait* cows kept under large scale farms conceive 47 days earlier than those kept under small scale farms due to the difference in selection and mating practices.

Table 6. Average reproductive performance of Begait cattle by farm type (Mean ± SD)

Reproductive traits (in years)	Farm type			P-value
	Large farms (N=63)	Small farms (N=117)	Total (N=180)	
Age at first mating (bulls)	3.2±0.5	3.5±0.5	3.4±0.5	0.000
Age at first mating (heifers)	2.9±0.7	3.2±0.6	3.1±0.6	0.004
Age at first calving	3.9±0.7	4.2±0.6	4.1±0.6	0.004
Reproductive lifetime of bulls	5.3±1.2	4.2±1.2	4.6±1.3	0.000
Reproductive lifetime of cows	9.1±0.9	11.0±0.8	10.3±1.3	0.000
Calves born per lifetime of cow	7±1	7±1	7±1	0.006
Days Open (days)	182±38	229±36	213±43	0.000
Culling age of bulls	8.2±1.7	7.5±1.9	7.8±1.9	0.022
Culling age of cows	12.0±0.9	14.2±0.8	13.4±1.3	0.000

Estimated Milk Off-take

Based on the calculated dairy performance indicators presented in Table 7, the overall mean milk off-take of a random mature *Begait* cow was 537.6 litres, with overall mean daily milk off-take of 2.8 (±0.3) liters and lactation length (LL) of 6.4 (±0.9) months at small scale and large scale farms. The overall estimated age of the random cow was about 6.5 (±1.5) whereas that of the old cow was 11 (±2.5) years. Overall LL was 6.4 (±0.9) for the randomly selected cows and 6.1 (±1.0) months for the old *Begait* cows, and significantly (P<0.05) differ between large and small scale farms. The primary purpose of large scale farms was income genertion from sale of live animals than milk, which may be the reason for shorter LL of the cows in large scale farms as compared to the small scale farms. Average lactation milk yield (LMY) of old *Begait* cows ranged from 349.8-657 liters under small scale farms and from 374.4-556.8 liters under large scale farms. Moreover, the lactation milk yield (LMY) of random *Begait* cows ranged from 410.4-675 liters under small scale farms and from 382.5-585.9 liters in large scale farms. Both small and large scale farms were not practicing complete milking and the cows were mainly milked once a day. Likewise, the average LL of *Begait* cows (N=10) kept under on station in Humera Agricultural Research Center (HuARC) was 7 months, which is numerically higher than that of *Begait* cows in large and small scale farms. Under the more or less zero grazing production system of the HuARC, average daily milk off-take was as high as 6.68 litres, indicating the highly considerable dairy performance potential of *Begait* cows under better management condition. The average lactation milk yield of Begait cows kept under HuARC was estimated to be 1402.8 liters. This large gap in average daily milk off-take could be mainly associated with differences in management levels between the research center and the farms. Moreover, the desire to save more milk for calf suckling in the large and small scale farms so as to maintain rapid calf growth and prevent cows from stresses associated with frequent milking in the harsh environment could be other reasons. In general, the difference in average dairy performance between small and large scale *Begait* cattle farms is a strong proxy indicator of high variability in dairy performance of the existing *Begait* cattle population.

About 50.8% of the large scale farms were not milking their cows, and all cows with new born calves were not milked for the first four weeks. About 30.2 and 78.6% of the sample respondents in large and small scale farms respectively reported to milk their cows only once a day. Hence, this practice might have contributed for the lower daily milk off take of *Begait* cows under both farms. Milk supply for sale was also very low, because 41.3% in the large scale farms and 48.7% of the respondents in the small scale farms did not supply milk to the local markets, instead more opting to feed the calves and/or meet needs for home consumption. About 14.5% of the respondents in small scale farms also reported lack of market and demand for milk as a constraint.

DISCUSSION

A study conducted at Haramaya University, Ethiopia on Ogaden cattle breed showed that female Ogaden cattle fed on pasture had chest girth (CG) of 150.1±8.20 cm and height at withers (HW) of 115.5 cm, while the males had a CG of 148.2±14.31 and HW of 115.5 cm (Getinet et al., 2009). Therefore, CG of Ogaden cows is similar to that of *Begait* cattle, nevertheless, HW of females and CG and HW of males of Ogaden cattle and *Begait* cattle are different; being higher in *Begait* cattle. A similar study on different traits of Arsi cattle showed the following scenarios: CG (female=139±7.0 cm and male=152±11.0 cm), HW (female=113±2.7 cm and male=115.0±3.0 cm), muzzle circumference (MC) (female=37±2.2 cm and male=40±3.2 cm), pelvic width of (PW) (female=29.±2.3 cm and male= 30±3.6 cm) and rump length (female=35±2.5 cm and males=37±3.5 cm) (Chali, 2014). Hence, CG, HW and PW of Begait cattle recorded in this study are higher than that of Arsi cattle while MC is similar whereas rump length of Arsi cattle is longer than that of *Begait* cattle.

Table 7. Average milk off-take (liters), lactation length (months) and age (years) of old and randomly selected Begait cows (Mean ± SD)

Dairy traits	**Farm types**			
	Large farms (N=63)	Small farms (N=117)	Total (N=180)	*P*-value
Age of old cow	10.8±2.5	11.2±2.5	11.1±2.5	0.480
Age of random cow	6.1±1.1	6.6±1.6	6.5±1.5	0.102
Lactation length (LL) of old cows	5.3±0.5	6.3±1.0	6.1±1.0	0.000
LL of random cows	5.7±0.6	6.6±0.9	6.4±0.9	0.000
Daily milk (DM) off-take of old cow	2.9±0.3	2.6±0.4	2.6±0.4	0.000
DM off-take of random cow	2.8±0.3	2.7±0.3	2.8±0.3	0.209
LL of cows in HuARC	-	-	7	-
DM off-take of cows in HuARC	-	-	6.68	-

Most recent study on *Begait* cattle showed the following: HW (female=131.48±0.25 and male=136.99±0.10), CG (female=159.55±0.24 and male=168.91±0.10), PW (female=39.96±0.31) and a preputial sheath (12.05±0.04 cm), which is similar with the present finding (Ftiwi and Tamir, 2015).

Begait cattle appear to reach sexual maturity earlier than Borana cattle maintained under similar agro-ecologies, where bulls and heifers reach first mating at the age of 4.6 and 3.9 years in the midlands and 4.2 and 3.7 years in the lowlands, respectively (Dejene, 2014). *Begait* cattle exhibited earlier age at first mating, age at first calving and more lifetime calf crop than the figures reported for Arado cattle: age at first mating (39.8 months), age at first calving (56.9 months) and lifetime calf crop (4.6) (Dessalegn *et al.,* 2012). This earliness could be attributed to genotypic difference as the environment/management in which the two breeds are raised is similar. Borana cows maintained under improved management in Abernosa Ranch exhibited were able to produce the first calf at the age of 36 to 45 months (Ababu et al., 2006); suggesting that reproductive performance of *Begait* cattle may also be improved under improved management. Similarly, Getinet *et al*. (2009) indicated that Ogaden cows kept on pasture at Haramaya University had age at first service of 34.4±2.28 months, which is earlier than the present figure for *Begait* cattle. The reproductive lifespan reported for *Begait* cattle was lower the 13.67±0.31 years reported for Horro cows (Agere *et al*., 2012), although they compare well with the Horro in terms of lifetime calf crop production (6.46±0.13 calves) and reproductive lifespan of bulls (3.72±0.10 years). Chali (2014) also reported an earlier age at first mating (36.3±0.6 months) for Arsi bulls, and longer reproductive lifetime (12.1±0.2 years) for Arsi cows but similar numbers of calves born per cow within reproductive lifetime (7.0±0.2 calves). Some reproductive traits reported by Ftiwi and Tamir (2015) on *Begait* cattle kept under small scale farms include: age at first mating for males (38.1±0.17 months), age at first mating for females (35.5±0.14), age at first calving (48.7±0.16) and lifetime productivity (8.2±0.07 years). In the current study, age at first mating for both sexes was late by 3-4 months, and age at first calving by one month. However, reproductive lifetime of *Begait* cattle was longer in the current study than the figure reported by Ftiwi and Tamir (2015). The variations might have arisen from differences in methods followed in data collection.

Estimated daily milk off-take and lactation length recorded for *Begait* cattle in this study are closer to the figures (2.52L, 6.38 months) reported by Ftiwi and Tamir (2015), and the milk off-take (2.56L) reported for Fogera cattle (Zewdu, 2004). The lactation length recorded for *begait* cattle in this study was similar to the overall average of six months recorded for indigenous cattle in the country (CSA, 2012/13; 2015/16 and 2016/17), but the daily milk off-take is much higher than the national average figures of 1.32 and 1.37 liters recorded for indigenous cattle in Ethiopia (CSA, 2012/13; 2015/16and2016/17). The dairy attributes of *Begait* cattle are apparent from the much higher daily milk off-take values compared to the values reported for other indigenous cattle breeds *viz.,* 1.65 liters for Horro cattle (Agere *et al*., 2012), 1.44±0.04 liters for Arsi cattle (Chali, 2014) and 1.85 liters for Boran cattle (Dejene, 2014). The main reason for the considerably higher daily milk off take in *Begait* cattle than the other indigenous cattle breeds in Ethiopia could be associated to the unique genetic makeup for milk production by *Begait* cattle. On the other hand, lactation length of *Begait* cows recorded in this study was is much shorter than the figures reported for the other breeds *viz.,* 10.5 months for Fogera cows (Damitie *et al*., 2015), 314±91 days for Horro cows (Laval and Assegid, 2002), 9.6 months for Horro cows (Agere *et al*., 2012), 9.6 months for Arsi cows (Chali, 2014) and 7.3 months for Arado cattle (Dessalegn *et al*., 2012). This could be attributed to the harsh environment and associated seasonal scarcity of feed in the niche areas of *Begait* cattle.

CONCLUSION

Begait cattle are grouped under the large East African Zebu cattle breeds that can be used as milk and beef animals. The existing population of *Begait* cattle under extensive management exhibit good dairy attributes in terms of daily milk off-take, age at first mating, age at first calving, days open and lifetime calf crop compared to some of the studied breeds such as Boran, Ogaden, Arsi and Horro cattle breeds. However, it should be noted that daily milk off take of *Begait* cows was significantly influenced by their daily milking frequency because 78.6% of the small scale farms and 30.2% of the large scale farms reported to milk their cows once a day. The higher dairy performance of *Begait* cows under moderately improved management condition at Humera Agricultural Research Centre indicated that the breed has a good dairy performance if managed well. The relatively short lactation length of *Begait* breed is attributed to the seasonal feed scarcity and the tendency of keepers to allow calves to suckle/consume more of the milk than milk off-take for sale or home consumption. Better access to reliable milk market may encourage higher milk off-take mainly during the lush season. Hence, interventions to improve dairy performance of the breed should also consider essential infrastructures for efficient milk collection and aggregation given the hot climate of the area. The promising dairy attributes of *Begait* cattle even under the largely extensive management merit consideration as a basis for promoting commercial dairy production in the niche areas and other similar warm and stressful production environments. Based on the morphometric traits of the cows kept under small scale farms, large scale farms and Humera Ranch, intensive selection particularly at Humera Ranch should be taken as an urgent assignment. Therefore, it is recommended to introduce continuous community capacity building and appropriate participatory community based breed improvement interventions. This should also need to be supported by possible reproductive technologies for sustainable improvement of the overall dairy performance of the breed in its niche area. Moreover, mechanisms should be devised to prevent introduction of other indigenous and exotic cattle genotypes in to the niche areas in order to maintain a distinct breed.

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REFRENCES

Ababu Dekeba, Workneh Ayalew, Hedge, P.B. and Zerihun Tadesse. 2006. Performance of the Abernosa Ranch in the production of Ethiopian Boran x Holstein crossbred dairy heifers in Ethiopia.

Agere Mekonnen, Aynalem Haile, Tadelle Dessie and Yosef Mekasha. 2012. On farm characterization of Horro cattle breed production systems in western Oromia, Ethiopia. Livestock Research for Rural Development 24 (6): 100.

Chali Yimamu. 2014. In-Situ Phenotypic Characterization and Production System Study of Arsi Cattle type in Arsi highland of Oromiya region, Ethiopia. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

CSA (Central Statistics Agency). 2008/9. Agricultural sample survey; Report on livestock and livestock characteristics. Statistical bulletin 446. Addis Ababa, Ethiopia.

CSA.2012/13. Agricultural sample survey. Report on livestock and livestock characteristics of Ethiopia. Private Peasant Holdings. Statistical Bulletin 570, April 2013, Addis Ababa, Ethiopia.

CSA.2015/2016. Key findings of the 2015/2016 (2008 E.C) Agricultural sample surveys: Report on livestock and livestock characteristics.Statistical bulletin 583, June 2016, Addis Ababa, Ethiopia.

CSA.2016/17. Agricultural sample survey of Ethiopia in 2016/17 [2009 E.C.], volume-2: Report on livestock and livestock characteristics (private peasant holdings). Statistical bulletin-585, April 2017, Addis Ababa, Ethiopia.

DAGRIS (Domestic Animals Genetic Resources Information System). 2007.(edsS.Kemp, Y.Mamo, B. Asrat and T. Dessie).International Livestock Research Institute, Addis Ababa, Ethiopia.

DAGRIS (Domestic Animals Genetic Resources Information System). 2009.http://dagris.ilri.cgiar.org/display.asp. (Cited in October 2016).

DAGRIS (Domestic Animals Genetic Resources Information System). 2014. www.cda-is.org.cn/DAGRIS/cattle/.(Retrived: April 2018).

Damitie Kebede, Kefyalew Alemayehu and Endalkachew Girma. 2015. Reproductive and Productive Performance of Fogera Cattle in Lake Tana Watershed, North Western Amhara, Ethiopia. Journal of Reproduction and Infertility 6(2): 56-62, ISSN 2079-2166.

Dejene Takele Gebissa. 2014. Assessment of Dairy Cattle Husbandry and Breeding Management Practices of Lowland and Mid-Highland Agro-Ecologies of Borana Zone. Animal and Veterinary Sciences, 2(3): 62-69. doi: 10.11648/j.avs.20140203.12.

Dessalegn Genzebu, Mekonnen Hailemariam and Kelay Belihu. 2012. Morphometric characteristics and livestock keeper perceptions of "Arado" cattle breed in Northern Tigray, Ethiopia. Livestock Research for Rural Development,24 (1) 2012.

FAO (Food and Agriculture Organization). 1993. Livestock and improvements of pasture, feed and forage. Committee on Agriculture, 12th Session, item 7, 26 April–4 May 1993. FAO, Rome, Italy.

FAO (Food and Agriculture Organization). 2011. Commission on genetic resources for food and agriculture: draft guidelines on phenotypic characterization of animal genetic resources, Rome.

FAO (Food and Agriculture Organization). 2012. Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines No. 11. Rome.

Ftiwi Mulugeta and Tamir Brhan. 2015. On-Farm Phenotypic Characterization of Indigenous Begait Cattle in Western Tigray, Northern Ethiopia. J Anim Pro Adv, 5(7): 718-732, DOI: 10.5455/japa.20150725122859.

Getinet Mekuriaw, Workneh Ayalew and Hedge, P. B. 2009.Growth and Reproductive performance of Ogaden cattle.MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

IBC (Institute of Biodiversity Conservation). 2004. The State of Ethiopia's Farm Animal Genetic Resources: Country Report. A Contribution to the First Report on the State of the World's Animal Genetic Resources, Addis Ababa, Ethiopia.

ILCA (International Livestock Center for Africa). 1991. Hand book of African livestock statistics Working document No.15, ILCA, Addis Ababa, Ethiopia.

Kikule S.B. 1953. Age changes in the teeth of zebu cattle. East African Agricultural Journal, 19(2):86-88.

Laval G. and Assegid Workalemahu.2002. Traditional Horro Cattle Production in Boji District, West Wellega, Ethiopia, Eth. J. Anim. Prod., 2(1): 97-114.

Merha Zerabruk. 2006. Genetic Diversity in Northern Ethiopian Cattle Breed: An on-Farm and Molecular Characterization. PhD dissertation, Agricultural University, Wageningen, The Netherlands.

Niguse, A. and Aleme, A. 2015.Modeling the Impact of Climate Change on Production of Sesame in Western Zone of Tigray, Northern Ethiopia. J Climatol Weather Forecasting 3: 150. doi:10.4172/2332-2594.1000150.

SAS (Statistical Analysis Software). 2003. SAS User's Guide: Statistics. Ver.9.1. Cary, NC: Statistical Analysis System Inc.

SPSS (Statistical Package for Social Science). 2012. SPSS user's guide, Version 20.0., (http://ibm-spss-statistics.soft32.com/).

Workneh Ayalew, Ephrem Getahun, Markos Tibbo, Yetnayet Mamo and J.E.O. Rege. 2004. Farm Animal Biodiversity in Ethiopia: Status and Prospects, Current State of Knowledge on Characterization of Farm Animal Genetic Resources in Ethiopia. Proceedings of the 11th Annual conference of the Ethiopian Society of Animal Production (ESAP), August 28-30, 2003, Addis Ababa, Ethiopia.Pp. 441.

Zerabruk Merha, Vangeo M and Haile M.2007. The status of cattle genetic resources in north Ethiopia: On-farm characterization of six major cattle breeds. Anim. Genet. Resource. Info. Bull., 40: 15-32.

Zewdu Wuletaw. 2004. Indigenous cattle genetic resources, their husbandry practices and breeding objectives in North Western Ethiopia. MSc Thesis, Alemaya University,Alemaya, Ethiopia.

Seed Yield and Quality of *Desmodium uncinatum (Jacq.) DC.* as Affected by Method and Time of Harvesting Seed at Wondo-Genet

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ABSTRACT

A three year experiment was conducted at Wondo-Genet Agricultural Research Center to determine the appropriate time and efficient method of seed harvesting to produce large quantity of better quality Desmodium uncinatum (Jacq.) DC seed. The experiment was laid out in factorial combinations of Randomized Complete Block Design with four replications. The first harvest was made when the early pods started to disintegrate; and the second, third and fourth harvests were made one week, two weeks and three weeks after the first harvest, respectively. The harvesting methods used include direct mowing of the whole sward by sickle, hand picking of matured seed pods and sweeping of shattered seed pods from the ground. The results revealed that seed yield of D. uncinatum (Jacq.) DC. was significantly (P<0.001) affected by harvesting methods. However, there was no significant (P>0.05) interaction effects between harvesting method and time on seed yield. On average, the highest seed yield (281.9±11.8 kg ha^{-1}) was obtained in the hand picking method, while the lowest (27.2±11.8 kg ha^{-1}) was obtained from the sweeping method. On the other hand, the sweeping method resulted in higher 1000-seed weight (8.2±0.4) than the hand picking method (6.3±0.4) (P<0.01). Harvesting method and time did not have significant effect on germination percentage, number of inflorescences per meter square, number of spikelet per raceme and plant height (P>0.05). Thus it can be concluded that harvesting by hand picking is promising for producing large quantity seed from D. uncinatum (Jacq.) DC. Moreover, D. uncinatum (Jacq.) DC. seeds should be harvested within one week time following the beginning of fragmentation of the early pods.

Key words: *Desmodium uncinatum, harvesting method, harvesting time, seed yield*

INTRODUCTION

The major feed resources for livestock in tropics are mainly native pasture and crop residues which are poor in nutrient supply to keep animals at productive stage (Alemayehu Mengistu and Sissay Amare, 2003; Alemu Yami, 2016). In crop-livestock mixed farming systems of such regions, feed is one of the major limitations for livestock productivity (Berhanu Gebremedhin, 2007; Getahun *et al.,* 2008). As a result, livestock perform below their potential and suffer feed shortage at all levels (Alemu Yami, 2016). Therefore, it is necessary to evaluate and incorporate alternative high yielding and better quality forage seeds which can mitigate the prevailing forage seed related problems which in turn help to unlock the potential of farm animals via supply of better quality feeds. Inadequate availability of planting material in terms of both amount and diversity, and low level of experience and support to forage seed production are the major barriers to the progress of improved forage development in the country (Alemu Yami, 2016). For example by 2020, the small and medium specialized dairy sectors of Ethiopia will require an estimated 2520 tons of forage seeds per year (Shapiro *et al.,* 2015).

The sticky nature and presence of large amounts of vegetative material of Desmodium seed pods, harvesting even using modern harvesters has been considered to be a problem (English, 1988).

The choice of an efficient harvesting method depends on species to be harvested, size of the area, and availability and relative costs of labor and machinery. Some forage crops have indeterminate growth habit which has a negative effect on seed quality unless the seeds are harvested at optimum harvesting stage (Getnet Assefa *et al.,* 2012). The choice of harvesting time is a complicated decision for tropical pasture seed crops due to presence of some immature seeds. Days after inflorescence emergence were the chosen parameter to determine optimum harvesting time of forage seeds. It indicates when harvesting is likely to occur after inflorescence emergence. Desmodium seed yield is the product of inflorescence density, the number of floral nodes differentiated on each raceme, the number of seeds formed and recovered from each node, and the weight of individual seed formed (Nicholls *et al.,* 1973).

Desmodium has an outstanding performance across a wide range of environments (Roder *et al.,* 2002). Push-pull strategy requires an adequate amount of Desmodium seed production and distribution system in order to avail the seed for smallholder farmers (Khan *et al.,* 2014). However, the seed could not be widely used as it is not produced in adequate quantities and hence unavailable in the market. Despite close to half a century old research on forage crops in Ethiopia, research endeavors have been generally scanty in the areas of forage seed. As a result, very limited information is available on the appropriate agronomic management practices to be followed by forage seed producers for producing high quantity and better quality forage seeds. Therefore, this study was conducted to determine the appropriate time and efficient method of seed harvesting for *Desmodium uncinatum (Jacq.) DC.* under Wondogenet condition, Southern Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at the experimental field of Wondogenet Agricultural Research Center, which is located at 07°19' North latitude, 38°38' East longitude, with an altitude of 1876 meter above sea level. The area receives mean annual rain fall of 1000 mm with minimum and maximum temperature of 12.02 and 26.72°c, respectively. The texture of the soil was sandy clay loam (Notisol) with pH of 6.4 (Beemnet Kassahun *et al.,* 2015).

Treatments and Design

The experiment was laid-out in Randomized Complete Block Design with factorial arrangement of treatments in four replications. Twelve treatment combinations were used (Table 1). The seed was sown during the beginning of the main rain using 30 cm row spacing and a recommended seeding rate of 5 kg per hectare (Skerman *et al.,* 1988; ILRI, 2013). Harvesting time and harvesting method were the first and second factors, respectively. Factor one had four levels of harvesting time (the first harvest was made when the early pods start to disintegrate; and the second, third and fourth harvests were made one, two and three weeks after the first harvest, respectively). Factor two included three levels of harvesting methods (1= direct mowing of the whole sward by sickle; 2= selective stripping or hand picking of matured seedpods and 3= sweeping shattered seed pods on the ground). Mowing is the method of seed harvesting by cutting the entire stem with sickle and threshing while hand picking refers to stripping the seed from the inflorescence by running a hand from the base of the inflorescence upwards. Sweeping is disposing of the seed pods to shatter and then collect the seed from the ground. The three harvesting methods were selected based on nature of hairy seed pods, which adhere to clothing and size of the seed. The treatment combinations were randomly and independently assigned to each block.

Table 1.Treatment combinations

Treatment No.	Harvesting Time (HT)	Harvesting Method (HM)	Treatment combinations
1	HT1	MW	HT1MW
2	HT1	PK	HT1PK
3	HT1	SW	HT1SW
4	HT2	MW	HT2MW
5	HT2	PK	HT2PK
6	HT2	SW	HT2SW
7	HT3	MW	HT3MW
8	HT3	PK	HT3PK
9	HT3	SW	HT3SW
10	HT4	MW	HT4MW
11	HT4	PK	HT4PK
12	HT4	SW	HT4SW

HT=Harvesting Time, MW=Mowing, PK=Hand Picking, SW=Sweeping shattered seed on the ground

Data Collection

The experiment was conducted for the period of three years. The collected data were number of inflorescences per meter square, number of racemes per inflorescence, number of spikelet per raceme, seed yield per hectare (SYPH), thousand seed weight, seed viability or germination percentage and plant height. Plot cover and vigor were also scored based on 1 to 10 scales, with the score 10 referring to 100% good plot cover or vigor. Plant height was determined by taking the average heights of five randomly selected plants from each plot. Germination test was carried out by taking 50 randomly selected pure sample seeds per plot in replica. The seeds were then put in labeled Petri-dishes with moistened paper on the bottom. The seeds were allowed to germinate and counting was conducted at regular intervals during the test period.

Germination percent = Number of germinated seeds x 100 divided by total number of seeds tested.

Data Analysis

Data was analyzed using general linear model procedure of statistical analysis system (SAS, 2002-version 9.0). Least significant difference (LSD) test was employed for variables whose F-values declared a significant difference ($P<0.05$). The statistical model for data analysis was $Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + \varepsilon_{ijk}$; $i = 1,\ldots, a; j = 1,\ldots,b; k = 1,\ldots,n$

Where: Y_{ijk}= observation k at i^{th} level of harvesting time and j^{th} level of harvesting method; μ= the overall mean; A_i= the i^{th} level effect of harvesting time; B_j= the j^{th} level effect of harvesting method;

$(AB)_{ij}$= the effect of the interaction of i^{th} level of harvesting time with j^{th} level of harvesting method; ε_{ijk}= random error; a= number of levels of harvesting time; b= number of levels of harvesting method; n= number of observations of each factor combinations.

RESULTS AND DISCUSSION

Analysis of variance for the variables measured in the study is shown in Table 2. Seed yield per hectare was significantly (P<0.001) affected by harvesting method. Thousand seed weight also differed significantly (P<0.01) among the harvesting methods. On the other hand, only number of raceme per inflorescence was significantly (P<0.01) affected by harvesting time.

Table 2.Summary of analysis of variance for the different variables measured during the study

Factors	NIPMS	NRPI	NSPR	TSW	SYPH	GP
HM	NS	NS	NS	**	***	NS
HT	NS	**	NS	NS	NS	NS
HM*HT	NS	NS	NS	NS	NS	NS

, *: Significant at the 0.01, 0.001 levels respectively; NS=Non significant; HM=Harvesting Method; HT=Harvesting Time; NIPMS=Number of Inflorescence Per Meter Square; NRPI=Number of Raceme per Inflorescence; NSPR=Number of Spikelet per Raceme; TSW=Thousand Seed Weight; SYPH=Seed Yield Per Hectare; GP=Germination Percentage.

Effect of Harvesting Time on Seed Yield and Quality of *Desmodium uncinatum*

Seed production parameters of *Desmodium uncinatum (Jacq.) DC.*as affected by harvesting time is presented in Table 3. The number of raceme per inflorescence was significantly (P<0.01) affected by harvesting time with the highest value (11.5±0.8) recorded at harvesting time one. According to Puzio-IdKowska (1993), the number of racemes per stem, number of pods per raceme and number of seeds per pod have positive correlation coefficients with seed yield per plant. Plants characterized by a high seed yield also have high number of seeds per raceme (Huyghe *et al.* 1998, 1999). A reduction in number of raceme per inflorescence across the harvesting times might be due to shattering of seed pods. Hacquet (1990) and Rosellini *et al.* (1990) reported positive relationships between seed yield and number of seeds per pod.

Parameters including number of inflorescences per meter square, number of spikelet per raceme, thousand seed weight, seed yield per hectare, germination percentage and plant height did not differ significantly (P>0.05) across the different harvesting time. Although not significant, the average seed yield over the different harvesting time ranged from 123.4±13.7kg ha^{-1} during the fourth harvest to 160.2±13.7 kg ha^{-1} during the first harvest (beginning of fragmentation of early pods). The reduction in seed yield across harvesting time (one to four) might be due to shattering nature of the seed pods. The yields obtained in this study were within the range (50 to 330kg ha^{-1}) reported for Desmodium (Muyekho, 1996).

Effect of Harvesting Method on Seed Yield and Quality of *Desmodium uncinatum*

Table 4 indicates seed production parameters of *Desmodium uncinatum (Jacq.) DC.* as affected by harvesting methods. Seed yield showed significant variation (P<0.001) among the different harvesting methods. The highest seed yield (281.9±11.8 kg ha^{-1}) was obtained by hand picking method, while the lowest (27.2±11.8 kg ha^{-1}) was recorded in the sweeping method of seed harvesting. The lowest yield obtained might be due to difficulty of collecting small sized *Desmodium uncinatum (Jacq.) DC* seed from the ground. Skerman *et al.* (1988) reported a seed yield of 220-330 kg ha^{-1} from *Desmodium uncinatum (Jacq.) DC* harvested by hand picking. However, Alemayehu *et al.* (2016) reported that *Desmodium uncinatum (Jacq.) DC* can produce up to 400 kg ha^{-1} seed in sub-humid areas of Ethiopia such as Bako.

According to Roder *et al. (*2002) *Desmodium uncinatum (Jacq.) DC* produces higher seed yield than Greenleaf desmodium and is less sensitive to unfavorable conditions. Even though, harvesting by sweeping method resulted in lower seed yield, it resulted in significantly ($P<0.01$) higher thousand seed weight (8.2±0.4) than hand picking (6.3±0.4). This might be attributed to the possibility of collecting large sized seeds from the ground in the sweeping method. In contrast to this finding, Yoshiaki (2012) showed that bigger seeds usually result in better yield, and the seed weight is also important for good seedling vigor upon planting.

Table 3. Effect of harvesting time on seed yield and quality of *Desmodium uncinatum (Jacq.) DC.*

Parameters	Harvesting time (Mean ±SEM)				Over all mean	CV %	Sig
	HT1	HT2	HT3	HT4			
NIPMS	93.4±4.3	85.1±4.3	90.3±4.3	88.1±4.3	89.2	16.8	ns
NRPI	11.5±0.8[a]	7.8±0.8[b]	7.2±0.8[b]	7.8±0.8[b]	8.6	31.3	**
NSPR	22.3±1.2	22.6±1.2	24.0±1.2	21.4±1.2	22.6	18.6	ns
TSW (gm)	7.1±0.5	7.7±0.5	7.6±0.5	6.5±0.5	7.2	23.2	ns
SYPH (kg)	160.2±13.7	152.9±13.7	132.0±13.7	123.4±13.7	142.15	33.3	ns
GP	75.88±6.6	73.95±6.6	79.54±6.6	70.68±6.6	75.01	31.96	ns
Height (cm)	158.9±4.3	157.1±4.3	158.6±4.3	145.6±4.3	155.1	9.6	ns

[ab]Means with different superscripts along the row differ significantly; **Significant at 0.01; ns=non-significant, CV=Coefficient of Variation, NIPMS=Number of Inflorescence Per Meter Square, NRPI=Number of Raceme per Inflorescence, NSPR=Number of Spikelet per Raceme, TSW=Thousand Seed Weight, SYPH: Seed Yield Per Hectare, GP=Germination Percentage, SEM=Standard Error of Means, HT1=Harvesting when the early pods started to fragment; HT2, HT3 and HT4 refer to the harvests made one, two and three weeks after the first harvest, respectively.

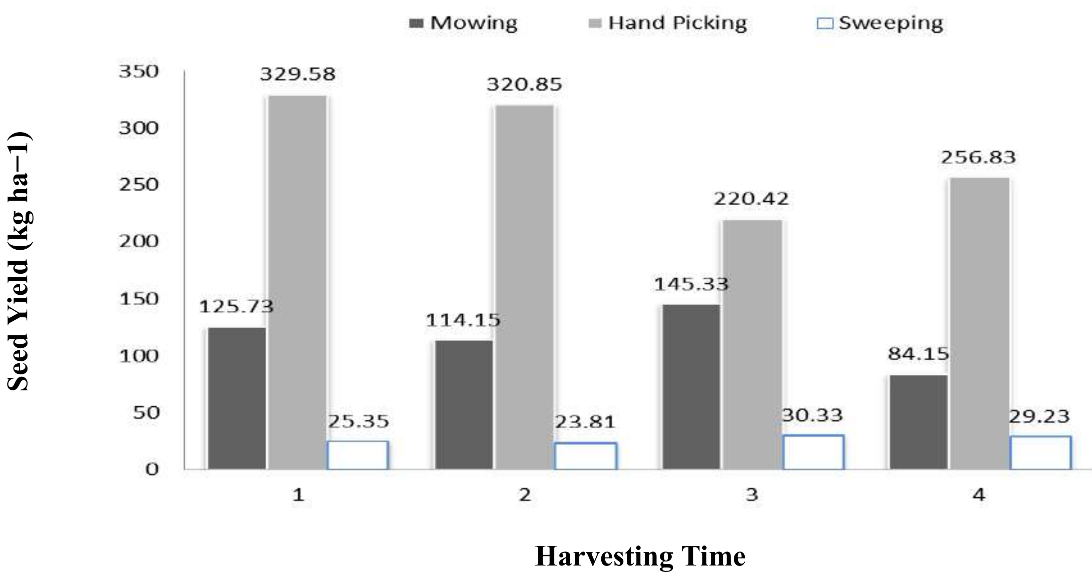
Table 4. Effect of harvesting method on seed yield and quality parameters of *Desmodium uncinatum (Jacq.) DC.*

Parameters	Harvesting methods (Mean±SEM)			Over all mean	CV %	Sig
	Mowing	Hand Picking	Sweeping			
NIPMS	90.4±3.7	94.8±3.7	82.5±3.7	89.2	16.8	ns
NRPI	8.2±0.7	8.6±0.7	8.9±0.7	8.6	31.3	ns
NSPR	21.1±1.1	23.7±1.1	22.9±1.1	22.6	18.6	ns
TSW (gm)	7.1±0.4[ab]	6.3±0.4[b]	8.2±0.4[a]	7.2	23.2	**
SYPH (kg)	117.3±11.8[b]	281.9±11.8[a]	27.2±11.8[c]	142.15	33.3	***
GP	72.49±5.7	74.28±5.7	78.28±5.7	75.01	31.96	ns

[abc]Means with different superscripts along the row differ significantly. **, ***: Significant at 0.01 and 0.001 levels, ns=non-significant, CV=Coefficient of Variation, NIPMS=Number of Inflorescence Per Meter Square, NRPI=Number of Raceme per Inflorescence, NSPR=Number of Spikelet per Raceme, TSW=Thousand Seed Weight, SYPH= Seed Yield Per Hectare, GP=Germination Percentage, SEM= Standard Error of Means.

Effects of Harvesting Method and Time on Seed Yield of *Desmodium uncinatum*

The average seed yield of *Desmodium uncinatum* (Jacq.) DC. at various harvesting methods over the different harvesting times is shown in Figure1. The highest seed yield was obtained during the first harvest (harvesting time1) followed by harvesting time 2 using the hand picking method. Bocsa and Buglos (1983) and Rosellini *et al.* (1990) reported a high correlation of seed yield with number of seeds per pod. The increased numbers of pods and seeds per pod can result in higher number of seeds per raceme. The number of inflorescences per plant is the most important component of seed yield (Taylor and Marble, 1996). Zambrana (1972) also reported that number of seeds per plant was the main component of seed yield and there were also high and positive relationships between seed yield and number of fertile stems, number of seeds per pod and number of inflorescences per plant.



Harvesting time: - 1=beginning of disintegration of early pods; 2, 3 and 4 – one, two and three weeks after the first harvest, respectively

Figure 1. Effects of harvesting method and time on seed yield of *Desmodium uncinatum (Jacq.) DC.*

Effects of Harvesting Method and Harvesting Time on Seed Viability of *Desmodium uncinatum*

The average viability of *Desmodium uncinatum (Jacq.)DC.*seed as affected by harvesting methods and harvesting times is shown in Table 5. The result showed that germination rate of *Desmodium uncinatum (Jacq.) DC* seed ranged from 62 to 86%. According to Ethiopian Standards (ES505:2000/2012), germination percentage of silver leaf desmodium (*Desmodium uncinatum (Jacq.) DC* seed should be at least 60% to qualify for seed certification. Therefore, the germination percentage recorded in this study can comply with requirements of the Ethiopian Standards.

AlemuYami. 2016. Forage production: Reference and Training Manual for Ethiopia. Addis Ababa, Ethiopia.

Beemnet Kassahun, Tigest German, Zewdinesh Damtew, Samuel Tilahun, Aynalem Gebere, Seferu Taddese, Desta Fikadu, Beriso Miesso. 2015. Performance of sage (Salvia officinalis L.) for morpho-agronomic and chemical traits in different agro-ecologies of Ethiopia. International Journal of Advanced Biological and Biomedical Research 3(4): 351-360.

Berhanu Gebremedhin. 2007. Forage seed inputs supply in Ethiopia. ILRI, Addis Ababa, Ethiopia.

Bocsa, I. and Buglos, J. 1983. Seed yield and some factors influencing seed setting at the variety level in lucerne. Z. Pflanzenzüchtg. 90: 172-176.

English, B.H. 1988. Greenleaf desmodium seed production. Queensland Agricultural Journal, May-June, 171-174.

Ethiopian Standards, ES 505. 2000/2012. Silver Leaf Desmodium Seed-Specification. Ethiopian Standard Agency ©ESA, Addis Ababa.

Getahun Legesse, Girma Abebe, Schultze, S.M., Zárate, A.V. 2008. Small ruminant production in two mixed-farming systems of southern Ethiopia: Status and prospects for improvement. Experimental Agriculture 44: 399-412.

Getnet Assefa, Gezahegn Kebede and Fekede Feyissa. 2012. Forage Seed Production and Quality in Ethiopia. In: Dawit Alemu, Shiratori, K., Abebe Kirub and Kibebew Assefa (ed): Empowering Farmers' Innovation, Series No. 3. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia. ISBN: 978-99944-53-63-4, pp. 41-48.

Hacquet, J. 1990. Genetic variability and climatic factors affecting lucerne seed production. Journal of Applied Seed Production 8: 59–67.

Huyghe, C., Bolazos, A.E.D., Ecalle, C., Julier, B. 1998. Distribution of the seed in an alfalfa canopy.Rep. 36th N. Amer. Alfalfa Impr. Conf. Bozeman: 57.

Huyghe, C., Bolazos, A.E.D., Ecalle, C., Hacquet, J., Julier, B. 1999. The seed weight per inflorescence as a selection criterion for seed yield in alfalfa. Proc.13th Eucarpia Meet. Medicago Working Group. Perugia, pp 107-116.

ILRI. 2013. Silver leaf (Desmodium uncinatum cultivar Silver leaf) for livestock feed on small-scale farms. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/2364

Khan, Z.R., Midega, C.A.O., Pittchar, J.O., Murage, A.W., Birkett, M.A., Bruce, T.J.A. and Pickett, J.A. 2014.Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020. Philosophical Transactions of Royal Society B 369: 20120284.

Muyekho, F.N. 1996. Forage legume seed production: Opportunities and challenges for research and on-farm production in Kenya. In: Focus on Agricultural research for sustainable development in a changing economic environment. Proceedings of the 5th KARI Scientific Conference, Nairobi, Kenya. Pp. 645-657.

Nicholls, D.F., Gibson, T.A., Humphreys, L.R., Hunter, G.D. and Bahnisch, L.M. 1973. Nitrogen and phosphorus response of *Desmodium uncinatum* on seed production at Mt. Cotton, South-Eastern Queensland. Tropical Grassland 7(2): 243-247

Puzio-Id, Kowska, M. 1993. Heritability of some traits determining seed yields of hybrid lucerne (*Medicago media L.*) cv. Warmiñska]. Zesz.Nauk.AR. Wroc³.Roln. LVIII 223: 317-323.

Roder, W., Tshering, S., Dorji, J., Samdup, C. and Wangchuk, P. 2002. Experiences with Greenleaf desmodium *(Desmodium intortum)* seed production in Bhutan. Tropical Grasslands, 36: 159-164.

Rosellini, D., Veronesi, F., Falcinelli, M., Lorenzetti, F. 1990. Seed yield components in alfalfa materials selected for seed yield, In: G. Bauchan (Ed.), Rep. 32nd North American Alfalfa Improvement Conf., Pasco, Washington, pp. 29.

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

Shapiro, B.I., Getachew Gebru, Solomon Desta, Asfaw Negassa, Kidus Negussie, Gezahegn Aboset and Henok Mechal. 2015. Ethiopia Livestock Master Plan. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Skerman, P.J., Cameron, D.G. and Rivero, S.F. 1988. Tropical forage legumes.FAO Plant production and protection series No. 2. (FAO: Rome).

Taylor, A.J. and Marble, V.L. 1996. Lucerne irrigation and soil water use during bloom and seed set on a red-brown earth in south-eastern Australia, Australian Journal of Experimental Agriculture 26: 577-581.

Yoshiaki, N. 2012. Good Quality Seeds and Linking Formal Seed System with Farmers' Own Perspectives and Initiatives: A Japanese Experience. In: Dawit Alemu, Shiratori, K., Abebe Kirub and Kibebew Assefa (ed): Empowering Farmers' Innovation, Series No. 3. Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia. ISBN: 978-99944-53-63-4, pp. 1-2.

Zambrana, T. 1972. Components of seed yield in different varieties of alfalfa, Revista Cubana de Ciencia Agricola 6: 289-299.

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Journal article:

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Crosse, S., Umunna, N.N., Osuji, P.O., Tegegne, A., Khalili, H. and Tedla, A.. 1998. Comparative yield and nutritive value of forages from two cereal-legume based cropping systems: 2. Milk production and reproductive performance of crossbred (Bos taurus x Bos indicus) cows. Tropical Agriculture 75 (4):415-421.

Article by DOI

Negewo, T., Melaku, S., Asmare, B. and Tolera, T. 2018. Performance of Arsi-Bale sheep fed urea treated maize cob as basal dietand supplemented with graded levels of concentrate mixture. *Tropical Animal Health and Production*. https://doi.org/10.1007/s11250-018-1544-4

Book

Steel, R.G.D. and Torrie, J.H. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., Inc., New York.

Chapter in a Book

Zerbini, E., Gemeda, T., Gebre Wold, A. and Tegegne, A. 1995. Effect of draught work on the metabolism and reproduction of dairy cows. In: Philips, C.J.C. (ed.), Progress in Dairy Science. Chapter 8. CAB International. pp. 145-168.

Paper in Proceedings

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).

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