

Effects of Supplementation with Different Forms of Barley on Feed Intake, Digestibility, Live Weight Change and Carcass Characteristics of Hararghe Highland Sheep Fed Natural Pasture

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Abstract

This study was conducted using 24 yearling intact male Hararghe highland sheep with initial body weight (BW) of 15.7 ± 2.3 kg (Mean \pm SD), to determine effects of supplementing different forms of barley grain to natural pasture hay basal diet on feed intake, digestibility, average daily BW gain (ADG) and carcass parameters. Animals were grouped into 6 blocks of 4 animals based on initial BW and were randomly assigned to the four treatments. Treatments were feeding hay *ad libitum* alone (T_1) or supplemented with 300 g dry matter (DM) of raw barley (RB, T_2), malted barley (MB, T_3) or cracked barley (CB, T_4). All animals received 50 g DM supplemental noug seed cake (NSC) and had a free access to water and mineral block. The experiment consisted 90 days of feeding and 7 days digestibility trials and carcass evaluation at the end. The crude protein (CP) content of hay, NSC, RB, MB and CB were 6.6, 35.7, 11.7, 12.5 and 11.6%, respectively. Hay DM intake was higher for T_1 (523 g/day) than other treatments (360-425 g/day). Total DM intake (573, 710, 723 and 775 g/day (SEM = 29.5)) and CP intake (52, 77, 77 and 83 g/day (SEM = 2.0) for T_1 , T_2 , T_3 and T_4 , respectively) was lower for T_1 than supplemented groups, with no difference ($P > 0.05$) among the supplemented treatments. Digestibility of CP (55.8, 71.1, 69.0 and 70.0% for T_1 , T_2 , T_3 and T_4 , respectively (SEM = 1.93)) were higher ($P < 0.05$) in supplemented sheep than T_1 . ADG of 13, 73, 87 and 83 g/day for T_1 , T_2 , T_3 and T_4 , respectively (SEM = 6.0), was also greater ($P < 0.05$) for the supplemented groups than T_1 . Barley supplementation resulted in a higher ($P < 0.05$) hot carcass weight than T_1 (6.0, 10.0, 10.7 and 10.5 kg for T_1 , T_2 , T_3 and T_4 , respectively (SEM = 0.56)). The results of this study highlighted that treatment of barley as in malting and cracking do not alter the performance of sheep as compared to the untreated barley. Thus, supplementation with raw barley is recommended. In general, supplementing animals with energy dense diet has proven to improve animal performance and profitability.

Keywords: Barley processing; Digestibility; Intake; Live weight; Carcass parameter

Introduction

Barley (*Hordeum vulgare* L.) is one of the cereal founder crops, domesticated about 10,000 years ago in the Fertile Crescent [1]. In Ethiopia, the long history of cultivation and the diverse agro-ecological and cultural practices have resulted in a wide range of barley diversity. Barley is the predominant cereal in the high altitudes and cultivated in some regions in two distinct seasons: Belg that relies on the short rainfall period from March to April and Meher that relies on the long rainfall period from June to September [2]. In the highland areas, barley is the major source of food, homemade drinks, animal feed and cash [3].

Barley is a very important grain in the world today. It is very versatile, and has been well adapted through its evolution. Barley grain is one of the most common feed grains used in diets for ruminant livestock species [4]. It is very well suited for sheep and cattle as a source of energy [5]. Barley contains a large proportion of starch and can be a good source of energy supplement to ruminants [6]. Barley as feed has similar nutritive value as corn. It has been found to contain more protein and a better amino acid balance than corn, and as a result, barley-based diets require less protein supplementation [7]. Processing methods for barley were originally developed to improve starch and protein digestibility of the grain [8]. Nicholson et al., [9] found that organic matter digestibility was decreased when whole barley was fed. Dry rolled barley increased organic matter digestibility by 42% and starch digestibility by 100% [10]. Likewise, Morgan and Campling [11] reported a 49% decrease in starch digestibility with whole barley, and Mathison [12] found 37% average decrease in starch digestibility when whole barley was compared to rolled barley.

Different types of barley grain processing (namely cracking, dry rolling and to a lesser extent grinding) are recommended to farmers in order to improve their feeding values in ruminants. Malts are also supposed to have higher nutritive values than seeds. A number of workers have reported increased levels of nutrients from malt [13]. However, the benefit if any, from these processing methods over the grain fed intact for sheep is not well quantified. Therefore, the objectives of this study were to evaluate the effect of supplementation of different forms of barley grain on intake, digestibility, live weight gain, and carcass characteristics of Hararghe highland sheep fed natural pasture hay.

Materials and Methods

The experiment was carried out at Haramaya University goat farm, Ethiopia, which is located 515 km east of Addis Ababa. The site is located at an altitude of 1950 masl at latitude $9^{\circ}26'N$ and longitude $42^{\circ}3'E$. The mean annual rainfall and temperature of the study area is 790 mm and $16^{\circ}C$, respectively.

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Experimental animals and management

Twenty-four intact yearling male Hararghe highland lambs weighing 15.7 ± 2.3 kg (Mean \pm SD) were purchased from *Kulubi* and *Chelenko* markets and used for the experiment. The age of the animals was determined by their dentition and information obtained from the owner. The animals were quarantined for 21 days and during this period; they were drenched with albendazol against internal parasites and sprayed with acaricide against external parasites. All animals were vaccinated against common disease in the area and penned individually.

Feed preparation and feeding

Natural pasture hay was purchased from *Babile*, stored under shade, and used as basal diet throughout the experimental period. Barley grain sufficient for the study was purchased from *Weter* market. The purchased barley was then divided in to three equal portions. One part remains untreated, the second one was malted and the third portion was cracked. Malted barley was prepared by steeping barley in water for 24 hours and then water was drained out. After that, it was allowed to sprout/germinate under room temperature for 3-4 days. Finally, it was partially sun dried under shade and stored properly. Cracked barley was prepared by crashing the grain at the size normally used for soup making with hammer mill in locally available food grinder. Noug seed cake was purchased from Dire dawa oil factory and ground with hammer mill before provided to experimental animals.

Experimental design and treatments

To conduct the experiment a completely randomized block design with six blocks and four treatments was used. At the end of the quarantine period, the experimental animals were blocked in to six blocks of four animal based on their initial body weight (BW) and animals within a block were randomly assigned to one of the four treatment diets. The initial BW was determined as a mean of two consecutive weighing after withholding feed and water overnight. The four experimental treatments are as shown in Table 1. Hay was fed *ad libitum* to animals to allow 20% refusal. Noug seed cake 50 grams per day per animal was supplemented to all animals to prevent loss of body weight for animals not supplemented with barley. The noug seed cake was provided to all animals at 08:00 hour in a separate container, where as the supplemental barley was offered to the animals at 08:00 and 16:00 hours in two equal portions. All animals had free access to water and mineralized salt block. The mineralized salt block contain a mixture of 18.8% calcium, 2.8% phosphorus, 31.2% sodium chloride, 0.09% magnesium, 0.084% manganese, 0.17% zinc, 0.0068% iodine, 0.055% copper, 0.115% iron, 0.0009% cobalt and 0.0004% selenium.

Feeding trial

The feeding trial was conducted for 90 days following an acclimatization period of 15 days to make animals adapted to the experimental diets and pens. The amount of feed offered and that of refused was weighed and recorded daily. Daily feed intake was calculated

Treatment	Hay	Supplement (g DM/day/animal)			
		NSC	RB	MB	CB
T 1	<i>ad libitum</i>	50	-	-	-
T 2	<i>ad libitum</i>	50	300	-	-
T 3	<i>ad libitum</i>	50	-	300	-
T 4	<i>ad libitum</i>	50	-	-	300

NSC: Noug Seed Cake; RB: Raw Barley; MB: Malted Barley; CB: Cracked Barley

Table 1: Experimental treatments.

as the difference between quantity of feed offered and refused. Sample was taken from batches of feed offer, thoroughly mixed, and sub-sampled for chemical analysis. Feed refusal samples were daily taken per animal, pooled on treatment basis, mixed thoroughly and sub-sampled for chemical analysis. The body weight (BW) of the animals was measured initially at the beginning of the feeding trial and at ten days interval after overnight with holding of feed. Daily BW change was calculated as the difference between final BW and initial BW divided by the number of feeding days. The feed conversion efficiency was calculated as a proportion of daily BW gain to daily feed intake.

Digestibility trial

The digestibility trial was conducted after the feeding trial. The digestibility trial was undertaken for 7 days. Feed offered and refusal was recorded daily. Total fecal collection for the digestibility trial was done using fecal bags. Each animal was fitted with fecal collection bags (harness) for three days of adaptation period. This was followed by a 7 days fecal collection period. The fecal output per animal was collected and weighed each morning before offering the morning meal. After weighing the daily total feces voided by each animal, the feces were thoroughly mixed, and a sub sample of 20% was taken to form a single weekly composite fecal sample for each animal. Composite samples per animal were stored in airtight plastic bags in deep freezer at -20°C . The composite fecal samples were thawed and thoroughly mixed for each animal and a sub-sample was taken for chemical analysis. A grab of feed samples from each feed and refusal for each animal was taken daily to make a weekly composite sample. Refusal samples were then bulked per treatment.

$$\text{Apparent disgestibility coefficient} = \frac{\text{Nutrient intake} - \text{Nutrient in feces}}{\text{Nutrient intake}}$$

Carcass parameters

At the end of the digestibility trial, all experimental sheep were fasted for about 12 hours and slaughtered for carcass analysis. Animals were weighed immediately before slaughter. The sheep were killed by severing the jugular vein and the carotid artery with a knife. The blood was drained in to bucket and its weight was recorded. The esophagus was tied off close to the head to avoid leaking of gut contents. The animal was then suspended head down over a container to collect any remaining blood droppings. The head was detached from the body after blood flow ceases. The skin was flayed, fore and hind legs were trimmed off at the carpal and the tarsal joints and weighed. The entire alimentary tract (stomach, small and large intestines) with its contents was removed and weighed. Then the internal content of the gut was emptied and weight of the empty gut was recorded. Empty body weight was then determined following the procedure of Ashbrook [14] as slaughtered weight less gut content. The remaining internal organs were removed and weighed. After dressing and evisceration, hot carcass weight was recorded to assess dressing percentage on slaughter weight and empty body weight basis. The hot carcass weight was estimated after removing weight of the head, thorax, abdominal and pelvic cavity contents, as well as legs below the hock and knee joints. Rib eye muscle area was traced on transparency paper and measured by using square paper after cutting the vertebrae between the 12th and 13th ribs.

Chemical analysis

The feed, refusal and fecal samples were partially dried in an oven at 60°C for 72 hours and ground to pass 1 mm screen. The sample of feed offered, refused, and feces were analyzed for DM, ash and nitrogen (N) according to the procedures of AOAC. The CP content was estimated as $\text{N} \times 6.25$. Neutral detergent fiber (NDF), acid detergent fiber (ADF)

and acid detergent lignin (ADL) were analyzed by the method of Van Soest and Robertson [15]. The ADL was analyzed for feed samples only. Organic matter was calculated by subtracting the ash content from 100.

Statistical analysis

The data was subjected to analysis of variance (ANOVA) in a randomized complete block design using the general linear model procedure of SAS [16]. The treatment means were separated using list significant difference.

Result and Discussion

Chemical composition of feed

The chemical composition of the treatment feeds is given in Table 2. The CP (5.35%) content of hay used in this study was lower than the CP value of 8.9 reported by Yoseph. The low CP content of hay in this experiment may be due to the over maturity of the grass at the time of harvest. McDonald et al., [17] suggested that as plants mature the percentages of the CP normally decreases. The CP content of NSC in this study was slightly higher than the CP content of NSC as reported by Wondwosen [18] which was 28.9%. The difference in CP content of NSC used in this study and others might be due to the oil extraction method, laboratory procedures and the difference in variety of the noug seed used [19]. The ADF and NDF contents in NSC used in this study were comparable to the ADF content of 30.57% and NDF content of 36.27% for NSC reported by Abebaw [20], but lower than the ADF content of 33.12% and NDF content of 40.18% reported by Almaz [21]. The ADL content of NSC was lower than ADL content of 12 to 13% reported by others [20,21].

Barley grain used in this study had DM values comparable to the DM value of 90% reported by NRC [22]. The ADF and NDF content of barley grain in this study were higher than ADF value that ranges from 5.7 to 7.2% and NDF values that ranges from 22.3 to 25.6% reported by Fairbairn et al. [23]. The ADL content of barley used in this study was greater than the 2.3% reported by Hatfield et al. [24]. The variation in nutrient content is generally attributed to soil fertility and climatic conditions [8].

The CP content of barley grain used in this experiment was comparable to the value of 11.0% reported by NRC [22]. The malted barley contained 12.5% CP that was relatively comparable to the values of 13.0 reported by Peer and Leeson [25]. In agreement with this result, Morgan et al., [26] noted that changes in the protein contents for malted barley occur rapidly from day four corresponding with the extension of the root.

Dry matter and nutrient intake

The mean daily hay and total DM intake and nutrient intake of Hararghe highland sheep is presented in Table 3. The daily hay DM

intake of the non-supplemented sheep was higher ($P < 0.05$) than that of the supplemented group. Supplementation through substitution may cause reductions in forage intake by grazing and pen-fed ruminants. However, supplementation for energy and/or protein can be very desirable at times, based on factors of forage quantity and quality and production demands [27].

The animals consumed almost the entire offered supplement. Consequently, total DM intake of the supplemented groups were greater ($P < 0.05$) than the non-supplemented sheep. Nevertheless, supplemented animals had similar DM intake ($P > 0.05$). Lower total DM intake in T₁ may be due to the quality of the basal diet used in this study. The higher structural carbohydrate content of the hay compared to the supplements might have limited intake of the animals due to their effect on ruminal fill.

The positive effects of supplementation on feed intake could be a reflection of the increase in the intake of essential nutrients such as energy, vitamins, and minerals and in particular nitrogen [28]. Similarly, Inoue et al., [29] reported that concentrate supplementation to low quality feeds increase feed intake because the supplements stimulate the rumen microbial function and thereby reduce digesta retention time.

Digestibility of dry matter and nutrients

The apparent digestibility of DM and nutrients for Hararghe highland sheep fed hay as a basal diet and supplemented with different forms of barley grain are given in Table 4. The DM and OM digestibility in supplemented animals were significantly higher ($P < 0.05$) than in control treatment. An animal in T₃ also had higher ($P < 0.05$) DM digestibility relative to animals in T₄. Increases in DM and OM digestibility were likely a result of the supplement being more digestible than the grass hay [30]. In parallel to this result, Fonseca et al., [31] confirmed that supplementation with maize increased DM and OM digestibility of wheat straw.

The apparent digestibility of CP was higher ($P < 0.05$) in supplemented sheep than the control ones, with no difference ($P > 0.05$) among the supplemented groups. The lack of differences in the digestibility of DM and nutrients in the supplemented group in this study indicates similar level of nutrient supply from the different forms of barley grain. This is in agreement with the results of Rainey [32] who found similar nitrogen digestibility in rolled and whole barley. Similarly, Bengochea et al., [30] reported that digestibility of CP were not affected by degree of barley processing. In the present result, there was no significant ($P > 0.05$) difference in NDF and ADF digestibility. Feeding grain based commercial supplements may reduce ruminal pH and decrease fiber digestibility. Moore et al. [33], which may be the cause for similar fiber digestibility in the supplemented and non-supplemented treatments. The ability of the microbial population within the rumen to digest fiber decreases when the amount and proportion of readily fermentable carbohydrate digested in the rumen increases [34].

Body weight change and feed conversion efficiency

The supplemented sheep had significantly ($P < 0.05$) higher final weight and daily live weight gain (ADG) compared with the sheep on the control treatment (Table 5). This might be due to enhanced DM intake and nutrient supply for production through improved intake and digestibility of nutrients as the result of supplemental barley. Animals in the supplemented group had similar performance ($P > 0.05$) in body weight gain and final weight. The results indicated that

Variables	Hay offer	Hay refusal							
		T1	T2	T3	T4	NSC	RB	MB	CB
DM (%)	90.1	90	90.3	90.4	90	91.8	89.7	88.7	89.9
OM (% DM)	91.3	90.3	89.9	89.7	91.3	92.4	94.2	96	93.1
CP (% DM)	6.6	5.3	5.1	5.4	5.6	35.7	11.7	12.5	11.6
NDF (% DM)	80.1	81.9	82.8	80.1	80.9	36.5	30.6	33.7	31
ADF (% DM)	52.7	53.6	50.4	48.6	51.1	31.2	15.6	13.5	16
ADL (% DM)	11.2	-	-	-	-	7.9	4.9	4.1	4.1

DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; ADL: Acid Detergent Lignin; NSC: Noug Seed Cake; RB: Raw Barley; MB: Malted Barley; CR: Cracked Barley

Table 2: Chemical composition of treatment feeds and hay refusal.

Intake (g/day)	Treatment				SEM
	T ₁	T ₂	T ₃	T ₄	
Hay DM	522.5 ^a	360.2 ^b	375.2 ^b	424.6 ^b	28.8
Total DM	572.5 ^b	710.2 ^a	722.6 ^a	774.6 ^a	29.2
Total OM	523.1 ^b	657.4 ^a	674.0 ^a	713.1 ^a	26.7
Total CP	52.4 ^b	76.7 ^a	77.3 ^a	83.4 ^a	2
Total NDF	436.5 ^{ab}	398.4 ^c	418.9 ^{bc}	451.1 ^a	23.2
Total ADF	290.8 ^a	252.1 ^b	253.3 ^b	287.3 ^a	15.2

^{a-c}means within a row not bearing a common superscript are significantly different (P < 0.05); SEM: Standard Error of Mean; DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; ADF: Acid Detergent Fiber; NDF: Neutral Detergent Fiber; NSC: Noug Seed Cake; RB: Raw Barley; MB: Malted Barley; CR: Cracked Barley

Table 3: Dry matter and nutrient intake of Hararghe highland sheep fed a basal diet of natural pasture hay and supplemented with different forms of barley grain.

Digestibility (%)	Treatments				SEM
	T ₁	T ₂	T ₃	T ₄	
DM	70.0 ^c	71.3 ^{ab}	71.9 ^a	70.7 ^b	0.43
OM	61.4 ^b	73.4 ^a	73.8 ^a	70.6 ^a	1.70
CP	55.8 ^b	71.1 ^a	69.0 ^a	70.0 ^a	1.93
NDF	60.6	62.7	62.9	59.8	2.76
ADF	62.5	64.5	64.8	61.4	2.56

^{a-c}means within a row not bearing a similar superscript letter significantly differ (P < 0.05); DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; SEM: Standard Error of Means; NSC: Noug Seed Cake; RB: Raw Barley; MB: Malted Barley; CR: Cracked Barley

Table 4: Apparent dry matter and nutrient digestibility of Hararghe highland sheep fed a basal diet of natural pasture hay and supplemented with different forms of barley grain.

Parameter	Treatments				SEM
	T ₁	T ₂	T ₃	T ₄	
IBW (kg)	15.75 ^a	15.75 ^a	15.58 ^a	15.75 ^a	0.93
FBW (kg)	17.0 ^b	22.4 ^a	23.5 ^a	23.3 ^a	0.68
ADG (g/day)	13.3 ^b	73.2 ^a	87.3 ^a	83.1 ^a	6.02
FCE (g gain/ g feed)	0.025 ^c	0.105 ^b	0.123 ^a	0.110 ^{ab}	0.01

^{a-c}means within a row not bearing a similar superscript letter significantly differ (P < 0.05); IBW: Initial Body Weight; FBW: Final Body Weight; ADG: Average Daily Gain; FCE: Feed Conversion Efficiency; NSC: Noug Seed Cake; RB: Raw Barley; MB: Malted Barley; CR: Cracked Barley

Table 5: Body weight change of Hararghe highland sheep fed a basal diet of natural pasture hay and supplemented with different forms of barley grain.

the supplements were comparable in their potential to supply nutrients for improving the weight gains of sheep. L'estrangue [35] also reported presence of non-significant difference in sheep supplemented with whole and ground barley to hay and wheat straw based basal diet.

The level of ADG observed in this study for sheep was within the range of 69.04-104.11 g/day found by Abebe [36] from supplementation to low quality feed positively impact animal performance [37,38]. Similarly, study performed by Yagoub and Babiker [39] to determine effect of energy supplementation on performance of goats indicated that animals supplemented with high energy diets performed better than animals supplemented with low energy containing diets. This indicates that supplementation of animals with energy source improve their performance. Thus, energy appeared to be an important factor for growing sheep [40]. The synthesis of microbial protein in the rumen requires the presence of digestible carbohydrate to provide energy Rids [41] amount of feed nutrient converted in to a gram of body weight gain in supplemented sheep was higher than non-supplemented sheep. An animal in T3 also had higher (P < 0.05) feed conversion efficiency

Parameter	Treatments				SEM
	T ₁	T ₂	T ₃	T ₄	
Slaughter weight (kg)	16.0 ^b	21.7 ^a	22.33 ^a	21.7 ^a	1.23
Empty body weight (kg)	12.2 ^b	17.8 ^a	18.2 ^a	17.8 ^a	1.10
Hot carcass weight (kg)	6.0 ^b	10.0 ^a	10.7 ^a	10.5 ^a	0.56
Dressing percentage (%)					
Slaughter weight basis	37.5 ^c	46.1 ^a	48.0 ^a	48.49 ^a	3.33
Empty weight basis	49.5 ^b	56.2 ^a	58.8 ^a	59.0 ^a	4.90
REA (cm ²)	5.6 ^b	8.4 ^a	8.2 ^a	8.6 ^a	0.60

^{a-c}means within a row not bearing a similar superscript letter significantly differ (P < 0.05); REA: Rib-Eye Muscle Area; SEM: Standard Error of Mean; NSC: Noug Seed Cake; RB: Raw Barley; MB: Malted Barley; CR: Cracked Barley

Table 6: Carcass parameters of Hararghe highland sheep fed a basal diet of natural pasture hay and supplemented with different forms of barley grain.

relative to animals in T2. Diets that promote a high rate of gain will usually result in a greater efficiency than diets that do not allow rapid gain [42].

Carcass parameters

Effect of treatment on slaughter weight and empty body weight were significantly higher (P < 0.05; Table 6). Both slaughter weight and empty body weight were greater (P < 0.05) for the supplemented than non-supplemented sheep. Hot carcass weight, dressing percentage and rib eye muscle area were also higher (P < 0.05) for the supplemented than non-supplemented animals. In almost all carcass parameter values for the supplemented treatments were generally similar (P > 0.05). Dressing percentage is both yielding and value determining factor and is therefore, an important parameter in assessing performance of meat producing animals. According to Alexandre et al., [43], the carcass weight increased with the increasing live weight at slaughter. Thus, greater carcass yield for the supplemented animals is consistent with enhanced ADG presumably due to the supplemental barley. The lower dressing percentage in animals not supplemented with barley may be due to retarded muscle growth of animals possibly due to lack of sufficient and balanced nutrients [44]. Reduced dressing percentage in non-supplemented animals' shows reduced in carcass yield, and body fat and increase in gut fill due to more hay intake by the control group [39]. Similarly, Sayed [37] reported that dressing percentage increased with increase of fatness associated with feeding high dietary energy. Rib-eye muscle area is an indicator of the amount of lean muscle associated with a carcass since these two parameters are positively correlated [45,46]. Greater rib-eye muscle area for the supplemented sheep in this study suggests that supplementation with energy dense diets might induce the development of muscle in growing sheep. The rib-eye muscle area of 8.2 to 8.6 cm² was within the range of 7.10 to 10.7 cm² reported by Takele and Getachew when Horro sheep fed on vetch haulm basal diet was supplemented with wheat bran and/or Acacia albida leaf meal.

Conclusion

The above results indicate that barley processing for sheep was not given additional benefit over feeding intact barley. However, malted barley contains higher CP (12.5%) than intact barley. It can be concluded that processing barley for sheep is might not necessary to improve performance.

References

1. Lev-Yadun S, Gopher A, Abbo S (2000) Archaeology. The cradle of agriculture. *Science* 288: 1602-1603.

2. Grando S, Bekele B, Alemayehu F, Lakew B (2005) Food barley: Importance, uses and local knowledge. *H ICARDA Aleppo* 53- 82.
3. Eticha F, Woldeyesus S, Grausgruber H (2010) On-farm diversity and characterization of barley (*Hordeum vulgare* L.) landraces in the highlands of West Shewa. *Ethno-botany research and applications*: 25-34.
4. Taghizadeh A, Zabihollah N (2008) Degradability characteristics of treated and untreated barley grain using in situ technique. *Amer J Anim Vet Sci* 3: 53-56.
5. Paris RL (2000) Potential of hullless winter barley as an improved feed crop. Virginia Polytechnic Institute and State University Blacksburg Virginia.
6. Neuman CW, McGuire CF (1985) Barley. In: Rasmusson C (ed.) *Am Soc Agron Crop Sci Soc and Soil Sci Soc*, pp: 403-456.
7. Bhatti RS (1993) No malting uses of barley. In: MacGregor AW, Bhatti RS (eds.) *Barley: chemistry and technology*. American Association of Cereal Chemists Inc, St.Paul, MN, pp: 355-418.
8. Boyles SL, Anderson PL, Koch PL (2000) Feeding barley to cattle. The Beef InfoBase version 1.2 Jan. 2001/Feeding and Nutrition. ADDS Inc. USDA Coop State Res Ext Ed Ser NCBA.
9. Nicholson JWG, Gorrill ADL, Burgess PL (1971) Loss in digestible nutrients when ensiled barley is fed whole. *Can J Anim Sci* 51: 697-700.
10. Toland PC (1976) The digestibility of wheat barley or oat grain fed either whole or rolled at restricted levels with hay to steers. *Aust J Exp Agric Anim Husband* 16: 71-75.
11. Morgan CA, Campling RC (1978) Digestibility of whole barley and oat grains by cattle of different ages. *Anim Prod* 27: 323-329.
12. Mathison GW (1996) Effects of processing on the utilization of grain by cattle. *Anim Feed Sci and Tech* 58: 113-125.
13. Anderson VL, Bock EJ (2000) Malting barley co-products or wheat midds in corn based diets for growing yearling steers. Carrington research extension center beef production field day proceedings 23: 20-21.
14. Ashbrook FG (1955) Butchering processing and preservation of meat. D van Nostrand company Inc, London.
15. Van Soest PJ, Robertson BJ (1985) Analysis of forage and fibrous feeds. A laboratory manual for animal science. *J Dairy Sci* 74: 3583-3597.
16. SAS (1998) *SAS/STAT Guide to Personal Computers Version 9*. Prentice Hall, London.
17. McDonald P, Edwards RA, Greenhalgh JFD, Morgan CA (2002) *Animal nutrition*. Prentice Hall, London.
18. Alemu W (2008) Effect of supplementing hay from natural pasture with oil seed cakes on feed intake digestibility and live weight change of Sidama goats. School of Graduate Studies of Haramaya University, Ethiopia.
19. Mogus S (1992) The Effect of processing method of oilseed cakes in Ethiopia on their nutritive value: in vitro N-degradability in growing sheep fed a basal diet of maize stover. Bonn University Germany.
20. Abebaw Nega (2007) Effects of supplementation with rice bran, noug seed (*guizotia abyssinica*) cake and their mixtures on feed utilization and live weight change of Farta sheep. School of Graduate Studies of Haramaya University, Ethiopia.
21. Ayenew A (2008) Supplementation of dried atella noug seed (*guizotia abyssinica*) cake and their mixtures on feed intake digestibility and live weight change of local sheep fed finger millet (*eleusine coracana*) straw basal diet. School of Graduate Studies of Haramaya University, Ethiopia.
22. NRC (National Research Council) (1985) *Nutrient requirements of sheep* National Academic Press. Washigton DC.
23. Fairbairn SL, JF Patience, HL Classes, RT Zijlstra (1999) The energy content of barley fed to growing pigs: Characterizing the nature of its variability and developing prediction equations for its estimation. *J. Anim. Sci* 77: 1502-1512.
24. Hatfield PG, Walker JW, Glimp HA, Adams DC (1991) Effect of level of intake and supplemental barley on marker estimates of fecal output using an intraruminal continuous-release chromic oxide bolus. *J Anim Sci* 69: 1788-1794.
25. Peer DJ, S Lesson (1985) Feeding value of hydroponically sprouted barley for poultry and pigs. *Anim Feed Sci and Tech* 13: 183-190.
26. Morgan EK, Gibson ML, Nelson ML, Males JR (1991) Utilization of whole or steam rolled barley fed with forages to wethers and cattle. *Anim Feed Sci and Tech* 33: 59-78.
27. Caton JS, Dhuyvetter DV (1997) Influence of energy supplementation on grazing ruminants: requirements and responses. *J Anim Sci* 75: 533-542.
28. Sisay Z, Shenkoru T, Tegegne A, Woldeamanuel Y (2006) Feed intake water balance and water economy in highland sheep fed teff (*eragrostis teff*) straw and supplemented with graded levels of leucaena leucocephal. *Eth J Anim Prod* 6: 67-82.
29. Inoue T, IM Brookes, A John ES, Kolver, TN Barry (1994) Effects of leaf shear breaking load on the feeding value of perennial rye grass (*Lolium perenne*) for sheep 2 Effects on feed intake particle breakdown rumen digesta outflow and animal performance. *J Agri Sci* 123: 137-147.
30. Bengochea WL, GP Lardy, ML Bauer, Soto-Navarro SA (2005) Effect of grain processing degree on intake digestion ruminal fermentation and performance characteristics of steers fed medium-concentrate growing diets. *J Anim Sci* 83: 2815-2825.
31. Fonseca AJM, daSilva D, Lourenço ALG (2001) Effects of maize and citrus-pulp supplementation of urea-treated wheat straw on intake and productivity in female lambs. *Bra Soc Anim Sci* 73: 123-136.
32. Rainey BM (2004) Effect of beef cattle age, gender and barley grain processing method on rate and efficiency of gain and nutrient digestibilities. Montana State University Montana.
33. Moore JA, Poore MH, Luginbuhl JM (2002) By-product feeds for meat goats: effects on digestibility, ruminal environment, and carcass characteristics. *J Anim Sci* 80: 1752-1758.
34. Hoover WH (1986) Chemical factors involved in ruminal fiber digestion. *J Dairy Sci* 69: 2755-2766.
35. L'estrage JL (1977) The performance and carcass fat characteristics of lambs fattened indoors on concentrate diets. *Ir Agric Res* 16: 221-232.
36. Hailu A (2008) Supplementation of graded levels of concentrate mix on feed intake digestibility live weight change and carcass characteristics of Washera sheep fed urea treated rice straw. School of Graduate Studies of Haramaya University, Ethiopia.
37. Abdel-Baset NS (2009) Effect of different dietary energy levels on the performance and nutrient digestibility of lambs. *Vet. World* 2: 418-420.
38. Bowman JGP, Sanson DW (1996) Starch or fiber based energy supplements for grazing ruminants. In: proceedings grazing livestock. Nutrition Conf Rapid City USA, pp: 118-135.
39. Yagoub YM, Babiker SA (2008) Effect of dietary energy level on growth and carcass characteristics of female goats in Sudan. LRRD.
40. Abdias M, Geleti D, Gizachew L, Diriba T, Hirpa A (2001) The effect of improved forages and/or concentrate supplementation on live weight of horro lambs and growing bulls. Proceedings of the 9th annual conference of the Ethiopian society of animal production (ESAP), Bako Research Center Addis Ababa, Ethiopia.
41. Rids PM (1983) *The pools of tissue constituents and products*. Elsevier Science Publishers, Amsterdam, the Netherlands.
42. Matiws Solomon (2007) The effect of different levels of cottonseed meal supplementation on feed intake digestibility live weight changes and carcass parameters of Sidama goats. School of Graduate Studies of Haramaya University Ethiopia 119: 137-144.
43. Alexandre G, Coppry O, Bocage, Fleury J, Archimède H (2008) Effect of live weight at slaughter on the carcass characteristics of intensively fattened Martinik sheep fed sugar cane supplemented with pea flour. LRRD.
44. Woldemariam B (2008) Supplementation with dried foliages of selected indigenous browse: effects on feed intake body weight gain carcass characteristics of Abergalle goats offered hay. School of Graduate Studies of Haramaya University, Ethiopia.
45. Yirga H (2008) Supplementation of concentrate mix to Hararghe highland sheep fed a basal diet of urea-treated maize Stover: effect on feed utilization live weight change and carcass characteristics. School of Graduate Studies of Haramaya University, Ethiopia.
46. Mekasha Y, Urge M, Kurtu MY, Bayissa M (2001) Effect of strategic supplementation with different proportion of agro-industrial by-products and grass hay on body weight change and carcass characteristics of tropical Ogaden bulls (*Bos indicus*) grazing native pasture *Afri J Agri Res* 6: 825-833.