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The Potential of Coarsely Ground, Gelatinized and Soaked Maize Grain as Energy Supplements to Arsi-Bale Sheep Fed a Basal Diet of Native Grass Hay

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Abstract

An experiment was conducted in Randomized Complete Block Design using eighteen yearling male Arsi-Bale sheep with initial body weight of 14.27±1.12 (mean ± SD) with the objective of determining effect of supplementing coarsely ground maize (CGM), gelatinized maize (GM), and soaked maize(SM) as energy supplement to native grass hay (GH) basal diet on feed intake, live weight change and carcass parameters of Arsi-Bale sheep. The growth experiment lasted for 90 days followed by evaluation of carcass parameters. The experimental sheep were blocked into six blocks of four animals each based on their initial live weight and animals from each block were randomly assigned to three treatments, giving a replication of six animals per treatments. At the end of the experimental period the sheep were deprived of feed and water for 14 hours to reduce gut content variation before slaughter for carcass evaluation. Native grass hay had high NDF (66.9%) and ADF (43.4%) contents and low CP (6.8%) content. The differently processed form of maize grain used in the experiment had low NDF, ADF and ADL contents. Maize grain supplemented sheep had similar ($P>0.05$) hay DM, total DM and total OM intake which is at the end also similar in feed conversion efficiency, final body weight, average daily gain and dressing percentage.

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In the same way no significant differences (P>0.05) were also observed among different forms of maize grain supplementation on rib-eye area, the total edible offal components and carcass parameters because of comparable nutritional profile of the different forms of the grain. Coarse grinding of maize grain was found to be equally effective as other forms of processing such as soaking and gelatinization in improving feed utilization, growth rate and carcass attributes of sheep at lower cost, which could lead to a better profit margin.

Keywords: Sheep; Gelatinization; Coarse Grinding; Soaking, Maize; Wheat Bran; Feed Intake; Carcass Character; weight gain.

1. Introduction

Ethiopia is endowed with diverse agro-ecological zones and suitable environmental conditions and is home for many livestock species and suitable for livestock production. It is believed to have the largest livestock population in Africa [1:2]. Livestock production *contributes about 17% to the national Gross* Domestic Product (GDP), 45% of the agricultural GDP and 15% of export earnings [3]. It supports 30% of agricultural employment and sustains the livelihoods of about 80% of the all rural population. The actual contribution of the livestock sector to the GDP has been estimated at 59 billion Birr [4]. In Ethiopia sheep population has shown an increment trend 23.6 million [5], 25.97 million [6], 28.5 million [7] and 29.33 million [8] But there is shrinkage of grazing land due to cultivation [9]). As explained by [10] feed represents the most significant cost of animal production. Reference [11] stated that the quantity and the quality of Feed resources available and the feeding systems employed (practiced) have great impact on livestock production and productivity. The major feed resources in Ethiopia for ruminants are natural pasture, hays and crop residues, which are categorized as poor quality roughage with low nutrient content, low digestibility and intake [12]. This implies that there is need to look for some supplementation options. Thus supplementation of crop residues, poor quality pastures or hay with agro-industrial by-products and/or cereal grains will alleviate energy deficiency in fibrous feeds [13]. [14] explained that goal of feeding concentrate feed as supplement to growing lambs is to achieve maximum growth rates, better feed conversion efficiency and best carcass characteristics, leading to optimum profit opportunities. In Ethiopia, maize crop ranks first in terms of productivity and second in area coverage after teff and currently produced by more farmers than any other crop. It is cultivated in all of the major agro-ecological zones up to 2400 m.a.s.l [8]. As reported by [15], most of the grains produced are used for human consumption, while a small portion goes to the livestock sector. With grain production expected to grow in the future, some of the surplus will likely be channeled to the livestock sector. In particular, the use of more maize and soya in the livestock diet is expected to boost livestock productivity in the country. Improvement in animal performance can be achieved via appropriate feed processing method that improves availability of nutritional value of feed [16]. In addition, [17], explained concentrations of nutrients and energy of maize grains can be altered by both genetics and the growing environment, while availability of nutrient is altered by processing. the primary objective of cereal grain processing is to improve starch availability, which result in enhanced digestion and feed efficiency [18]. Even though cereal grains mainly maize is still utilized by feed lotters (those who fatten animals for short period of time) and farms established in colleges and universities, no study has been conducted on appropriate method of grain processing prior to feeding to sheep in Ethiopia. So the objectives of this study are: -

- To compare the different forms of maize processing (coarse grinding, soaking and gelatinization) on utilization efficiency of the maize grain as a supplement
- To evaluate cost benefit analysis of supplementing gelatinized, soaked, and coarsely ground maize grain as energy source to sheep fed a basal diet of native grass hay.

2. Materials and Methods

2.1. Description of The Study Area

The experiment was conducted at Alage Agricultural Technical Vocational and Education Training College which is located 217 km south of Addis Ababa and 32 km west of Bulbula town in the vicinity of Abidjata and Shalla Lakes. It is situated at 07^0 42’ N latitude and 38^0 28’ E longitudes and an altitude of 1580-1600 meters above sea level in the agro ecology of dry plateau of the mid rift valley of Ethiopia. The area is characterized by bimodal rainfall pattern where short rainy season occurs during the months of March and April and the main rain starts in June and extends to September. High amount of rainfall is recorded during July and August. While the mean annual rainfall is 810 mm, the annual average minimum and maximum temperatures are 14.9 ^{0}C and 29.2 ^{0}C, respectively (source: Alage weather station, unpublished data).

2.2. Preparation of experimental feed

The experimental feeds consisted of native grass hay, coarsely ground maize, gelatinized maize (soaked in water over night and then gelatinized at 62^OC-77^OC for 45 minutes) and soaked maize (soaked in water over night). The native grass hay used in the experiment was harvested from a mixed natural grass stand of the College and stored under shade. Concentrate ingredients differently processed maize grain and common salt were purchased from Ziway and formulated and mixed in feed processing plant of the College. The maize grain was coarsely ground and divided into three portions. The first portion was used as a supplement as it is to animals in treatment one (T1). The second portion was gelatinized at a temperature of 62-77^0C by using direct heat source and fed to animals in treatment two (T2). The remaining coarsely ground maize grain was soaked in water for 12 h [19] and fed to animals in treatment three (T3). Soaking and gelatinizing were done daily. Before soaking in water maize grain required for individual sheep was measured and then soaked for 12h then supplemented on fresh weight bases. The gelatinization process was preceded by coarse grinding and soaking overnight. Variation in temperature was controlled by thermostatic thermometer. The concentrate mix was fed at 300 g/day on DM basis and was assumed to meet the energy and protein requirements for maintenance [20].

2.3. Experimental Animals and Management

The experiment was conducted on eighteen yearlings intact male Arsi-Bale sheep with average initial body weight of 14.27±1.12 kg (mean±SD) purchased from the local market. The age of the sheep was estimated based on dentition and information obtained from the owners. The experimental sheep were ear tagged and divided in to three treatments and randomly assigned to the experimental diets. Sheep were acclimatized for 15 days to new environment, pens and experimental feed. The sheep were injected Oxytetracycline (intra muscular) as soon as they arrived at experimental site to reduce stress related problems. They were also injected with ivermectine against internal and external parasites and vaccinated against ovine pasteurellosis, sheep pox, and anthrax (subcutaneous) during the acclimatization period. During this period the sheep were offered *ad libitum* native grass hay at 20% refusal rate which was adjusted every other week and the supplemental feed composed of both maize grain coarsely ground, gelatinized and soaked to allow them to gradually adapt to the experimental diets before the commencement of the experiment. They were housed in individual pens in a well ventilated concrete floor barn. The pens were equipped with feed trough for hay and plastic buckets for offering the concentrate supplements and water separately. They were closely observed for occurrence of any ill health and disorders during the experiential period.

2.4. Experimental Design and Treatments

Randomized complete block design (RCBD) with three treatments was used to conduct the feeding experiment. Experimental sheep were fed for consecutive 90 days after being acclimatized to treatment feeds and pen for 15 days. The sheep were blocked based on their initial body weight into six blocks of four animals each and animals from each block were randomly assigned to the three treatment groups giving six replicate animals per treatment. The three treatment groups are shown below.

T1 = Native grass hay *ad libitum* + 45gDM/d NSC+255gDM/d coarsely ground maize grain (CGM)

T2 = Native grass hay *ad libitum* + 45 g DM/d NSC+255gDM/d gelatinized maize grain (GM)

T3 = Native grass hay *ad libitum* + 45 g DM/d NSC+255gDM/d soaked maize grain (SM)

2.5. Measurements and observations

2.5.1. Feed intake

The experimental animals were offered native grass hay free choice for *ad libitum* intake (20% refusal rate) whereas the concentrate supplement was offered twice a day at 8.00 and 16.00 h after the amount of daily feed offered and refused was recorded to determine the daily feed intake. Clean drinking water was also offered free choice. Chemical composition of sub-samples of feed offered and refusal were analyzed and the results were used for calculation of the daily intake of dry matter and other nutrients.

2.5.2. Live Weight Gain and Feed Conversion Efficiency

Body weight (BW) measurements were taken every 10 days after overnight fasting. Starting from last day of acclimatization period using a suspended spring balance. Average daily body weight gain for each sheep was determined as a difference between the final and initial body weights divided by the total number of actual feeding days. The feed conversion efficiency was determined by dividing the daily average live weight gain by daily total DMI of sheep.

FCE = g ADG/d

g DMI/d

2.5.3. Carcass analysis

All sheep used in feeding trial were deprived of feed and water for 14 h to reduce variation in gut fill and were slaughtered to assess the carcass characteristics of the animals. Before slaughter, the animals were weighed and then slaughtered by cutting the jugular vein to drain blood. The esophagus was tied off close to the head and the animals were then suspended head down, over a container and blood was collected and weighed. The head was detached from the body and weighed with tongue after the flow of blood was ceased. The skin was flayed and weighed; the forelegs and the hind legs were trimmed off at the carpal and tarsal joints and weighed. The alimentary canal with its contents was removed. Entire gastrointestinal tract with contents (full stomach, small intestine and large intestines) were removed and weighed and then internal contents were emptied and the weight of the empty gut was recorded. Edible offal (EO) component was taken as the sum of, head without tongue, liver, reticulo-rumen, omasum, abomasum, large and small intestine, kidneys and kidney fat, omental fat, heart, tongue and tail. Non-edible offal component (NEO) was computed as the sum of blood, spleen, skin and feet, testis and penis, lung, trachea, esophagus and gut content. After dressing and evisceration, hot carcass weight was immediately recorded to assess dressing percentage on slaughter weight and empty body weight bases. Empty body weight was calculated as slaughter weight without gut contents. The hot carcass weight was estimated after removing weight of head, thoracic, abdominal and pelvic cavity contents as well as legs below the hook and knee joints. The rib-eye muscle area of each animal was determined by tracing the cross sectional area of the 12^{th} and 13^{th} ribs after cutting perpendicular to the back bone. The left and right rib-eye area was traced on a transparent waterproof paper and the area was calculated by counting the squares on graph paper and multiplying with their area after the rib eye area was transferred to graph paper. The mean of the right and left cross sectional area was taken as a rib-eye muscle area [21]

2.5.4. Partial budget analysis

The partial budget analysis was calculated to determine profitability of supplemental feed to sheep according to [22]. The partial budget analysis involves calculation of variable cost and benefits. The partial budget analysis was assessed based on prices at local markets in Zeway, Adami Tullu and Bulbulla before purchasing experimental animals. The selling price of experimental sheep was estimated by experienced sheep dealers invited from Alage ATVET College. The difference between selling price after the experiment and purchased price of the sheep before the experiment was considered as total return (TR) in the analysis. Partial budget measures profit or losses, which are the net benefit or differences between gains and losses for the proposed change. The net income (NI) was calculated by subtracting total variable cost (price of sheep, feed cost, labor cost, travel allowance and transport cost) (TVC) from the total return (TR).

$NI = TR\text{-}TVC$

2.6. Chemical Analysis of Feeds

Samples of feed offered per treatment and grass hay refusals per individual sheep were subjected to chemical analysis at Hawassa University Animal Nutrition Laboratory. The dry matter (DM) and ash contents were determined according to [23]. The dry matter content of the feed was determined by oven drying the samples at 105°C overnight. The ash content of the samples was determined by combusting the samples in muffle furnace at 550 °C for 5 h. Nitrogen (N) content was determined using the Keldjhal method and then the crude protein (CP) content was calculated as N% × 6.25 [23]. The neutral detergent fiber (NDF) was analyzed using the method of [24] whereas the acid detergent fiber (ADF) and acid detergent lignin (ADL) contents were determined according to [25] using the ANKOM® 200 Fiber Analyzer (ANKOM Technology Corp., Fairport, NY, USA).

2.7. Statistical Analysis

Variables measured in the feeding trial (feed intake, feed conversion efficiency, body weight gain and carcass parameters) were subjected to analysis of variance (ANOVA) using General Linear Model (GLM) procedure of Statistical Analysis System software version 9.2 [26] Treatment means that were significantly different were separated by least significant difference (LSD) using Duncan's multiple range test (DMRT)

The model used for data analysis was:

$Yij = \mu + ti + bj + eij$

Where: Yij = an observation in treatment i and block j

μ = overall mean

ti = treatment effect

bj = block effect

eij = Random error term

3. Results

3.1. Chemical composition of treatment feeds

Chemical composition of experimental feeds and refused native grass hay are presented in Table 2. The basal diet used in this study was high in NDF (66.9%) and ADF (43.4%) contents and low in CP (6.8%) content compared to the supplemental feeds. The DM and OM contents of the hay were 91.5% and 89.7%, respectively

CP content of gelatinized, soaked and coarsely ground maize were 7.1%, 8.1% and 8.3%, respectively. Grass hay refusal had generally higher DM, NDF, ADF and ADL contents but lower CP and ash contents than offered grass hay.

Table 1: Chemical composition of experimental feeds.

Feed ingredients	Chemical Composition						
	DM%	OM	CP	NDF	ADF	ADL	Ash
		% DM					
Natural grass hay	91.5	89.7	6.8	66.9	43.4	2.7	10.3
Coarsely ground maize	91.6	98.5	8.3	7.9	9.9	0.5	1.5
Soaked maize	90.8	98.9	8.1	10.9	8.7	0.6	1.1
Gelatinized maize	90.5	98.7	7.1	16.2	10.9	0.6	1.3
Native grass hay refusal							
T1	95.2	91.3	3.1	76.6	49.7	3.5	8.7
T2	94.6	91.7	3.7	71.7	53.12	3.9	8.3
T3	95.2	91.3	3.1	77.2	44.6	3.6	8.7

3.2. Feed intake of sheep

The DM intake of hay, total DM intake, total OM intake, total ADF intake and total ADL intake were similar (P>0.05) among sheep supplemented with different form of maize grain supplemented groups (T1, T2 and T3). The concentrate supplement intake was highest (P<0.0001) when coarsely ground maize was used as energy supplement followed by gelatinized maize and soaked maize in a decreasing order. The CP intake was highest (P<0.05) T3 (68.7 g/head/day) and T1 (68.6 g/head/day), followed by T2 (65.6 g/head/day). NDF intake was lower (P<0.05) in T1 than in T2.

Table 2: Nutrient intake of Arsi-Bale sheep fed basal diet native grass hay and supplemented with coarsely ground, gelatinized and soaked maize

Nutrient intake (g/d)	Treatments			SEM	P value
	CGM	GM	SM		
Hay DMI	419.7	421.4	426.9	7.73	ns
Concentrate DMI	275.1^{a}	272.4^{c}	273.2^{b}	0.0002	P<0.0001
Total DMI	694.8	693.8	695.6	7.73	ns
Total OMI	705.1	705.7	711.7	7.61	ns
Total CPI	68.6^{a}	65.6^{b}	68.7^{a}	0.52	P<0.001
Total NDFI	341.9^{b}	362.9^{a}	353.6^{ab}	5.67	P<0.05
Total ADFI	233.9	240.4	237.04	3.68	ns
Total ADLI	17.03	17.4	17.4	0.23	ns

^{a,b,c}, Means with the same letter within a row are not significantly different; ns= non-significant, TDMI= total dry matter intake, CPI=crude protein intake, NDFI= neutral detergent fiber intake, ADFI= acid detergent fiber intake, ADLI= acid detergent lignin intake, CGM= coarsely ground maize, GM= gelatinized maize, SM= soaked maize.

3.3. Body weight gain and feed conversion efficiency

No significant differences (P>0.05) were observed among the groups supplemented with maize grain processed using different processing methods (T1, T2 and T3) in final body weight, body weight change, average daily gain and feed conversion efficiency.

Table 3: Body weight and feed conversion efficiency of Arsi-Bale sheep fed basal diet native grass hay and supplemented with coarsely ground, gelatinized and soaked maize

Parameters	Treatments			SEM	P value
	CGM	GM	SM		
Initial Body Weight (kg)	14.2	14.3	14.2	0.09	ns
Final Body Weight(kg)	23.1	22.7	22.8	0.49	ns
Body Weight Change (kg)	8.9	8.4	8.7	0.46	ns
Average Daily Gain (g)	99.3	93.5	96.4	5.04	ns
FC E (g ADG/g TDMI)	0.2	0.14	0.14	0.003	ns

[a, b, c,]Means with the same letter within a row are not significantly different, ns=non-significant, FCR=feed conversion ratio, FCE=feed conversion efficiency, ADG=average daily gain, SEM= standard error of mean, T1= coarsely ground maize, T2= gelatinized maize, T3= soaked maize.

3.4. Carcass parameters

Carcass characteristics of sheep under different feeding treatments were assessed on the basis of parameters such as slaughter body weight, empty body weight, hot carcass weight, dressing percentage, rib-eye area (*Longissimus dorsi muscle*), internal fat deposits and edible and non-edible offals. The slaughter weight, hot carcass weight, empty body weight, dressing percentage on slaughter body weight and empty body weight bases, sternum, hind leg and REA of maize grain supplemented groups (T1, T2 and T3) were not significantly different (P>0.05). Foreleg of animals supplemented with coarsely ground maize grain (T1) was higher (P<0.05) than those supplemented with gelatinized (T2) and soaked maize (T3).

Table 4: Carcass parameters of Arsi-Bale sheep fed basal diet native grass hay and supplemented with coarsely ground, gelatinized and soaked maize.

Carcass Parameters	Treatments			SEM	P value
	CGM	GM	SM		
Slaughter Body Weight (kg/)	23.1	22.6	22.8	0.49	ns
Empty Body Weight (kg)	18.7	18.2	18.5	0.44	ns
Hot Carcass Weight (kg)	10.5	10.03	10.3	0.32	ns
Sternum (g)	523.1	514.4	520.6	7.3	ns
Fore leg (kg)	1.83^a	1.8^b	1.8^b	0.04	P<0.05
Hind leg (kg)	2.6	2.4	2.6	0.13	ns
Dressing percentage (%)					
Slaughter Body Weight base	45.2	44.4	45.1	0.55	ns
Empty Body Weight base	55.8	55.1	55.7	0.575	ns
REA (cm^2)	7.9	7.5	7.7	0.265	ns

[a, b,], Means with the same letter within a row are not significantly different (P>0.05), ns=non-significant, SEM=standard error of mean, CGM=coarsely ground maize, GM=gelatinized maize, SM=soaked maize, REA=rib eye area, cm^2= centimeter square, g=gram, kg=kilogram Edible offal components of Arsi-Bale sheep

are shown in Table 6. Head and testicle were not affected by treatments (P>0.05). Abdominal fat, kidney with fat, large and small intestine and total edible offal (TEO) were indicated as there is no significant difference (P>0.05) among the different forms of maize grain supplementation. Liver weight was lower in T2 than in T1 and T3. Heart and Omasum and Abomasums weight were highest (P<0.05) in T1 compared to T3. Similarly, the weights of reticulo-rumen and tail were highest (P<0.05) in T1 whereas T2 and T3 are similar.

Table 5: Total edible offal components of Arsi-Bale sheep fed basal diet native grass hay and supplemented with coarsely ground, gelatinized and soaked maize

Edible offal components	Treatments			SEM	P value
	CGM	GM	SM		
Head (kg)	1.14	1.13	1.17	0.052	ns
Liver (g)	310.8	297.1	302.1	9.38	ns
Heart (g)	99.9^{a}	96.7^{ab}	87.8^{b}	3.311	P<0.05
Kidney with fat (g)	132.8	133.6	132.5	4.631	ns
Reticulo-rumen (g)	514.6^{a}	493.4^{b}	489.4^{b}	6.89	P<0.05
Omasum-Abomasum (g)	261.3^{a}	255.5^{ab}	237.3^{b}	7.92	P<0.05
Large and Small Intestine (g)	597.4	584.9	593.7	8.33	ns
Tail (g)	574.2^{a}	492.9^{b}	472.3^{b}	15.49	P<0.05
Abdominal fat (g)	163.9	158.1	158.5	6.189	ns
Testicle (g)	330.6	322.5	331.9	9.39	ns
TEO (kg)	4.2	4.03	4.03	0.104	ns

a, b c, means with the same letter within a row are not significantly different (P>0.05), ns=non-significant, SEM=standard error of mean, TEO=total edible offal's, g=gram, kg=kilo gram, CGM=coarsely ground maize, GM=gelatinized maize, SM=soaked maize

3.5.2. Non edible offals.

No significant differences were observed (P>0.05) in skin with feet, bile and gall bladder weights among the different treatments (Table 7). The weights of lung, esophagus and trachea, spleen, penis, blood and TNEO were also similar (P>0.05) among the different forms of maize grain supplementation sheep.

Table 6: Total non-edible offal components of Arsi-Bale sheep fed basal diet native grass hay supplemented with coarsely ground, gelatinized and soaked maize grain.

Non Edible Offal's	Treatment			SEM	P value
	CGM	GM	SM		
Skin With Feet (g)	2.1	2.2	2.1	0.047	ns
Blood (g)	901.02	887.3	894.9	12.82	ns
Lung, Esophagus & Trachea (g)	408.7	399.7	408.8	8.704	ns
Spleen (g)	62.8	60.3	66.8	3.816	ns
Penis (g)	63.7	59.9	62.6	3.732	ns
Gut Content (kg)	4.41	4.34	4.35	0.077	ns
Gall Bladder (g)	41.8	40.3	40.8	3.019	ns
Bile (g)	21.1	20.1	21.4	2.12	ns
TNEO (kg)	7.99	7.96	7.98	0.105	ns

ns=non-significant, SEM= standard error of mean, TNEO=total non-edible offals, g=gram, kg=kilo gram, CGM= coarsely ground maize, GM= gelatinized maize, SM=soaked maize.

3.6. Partial budget analysis

Cost benefit analysis of sheep supplemented with coarsely ground maize, gelatinized maize and soaked maize is shown in Table 8. The purchase price of the experimental sheep ranged from 250-480 ETB/head and the selling price ranged from 550-900 ETB/head. The net return was higher in treatment groups supplemented with coarsely ground maize followed by soaked maize and gelatinized maize grain.

Table 7: Partial budget analysis of Arsi-Bale sheep fed basal diet native grass hay supplemented with coarsely ground, gelatinized and soaked maize

Cost benefit analysis	Treatments		
	CGM	GM	SM
Sheep Purchase Price ETB	355	361.7	358.3
Sheep selling price ETB	716.7	724.2	708.3
Hay Price ETB	59.3	59.3	60.07
Total hay offered kg	60.8	60.9	62.1
Concentrate price ETB	137.8	137.8	137.8
Total Concentrate consumed kg	31.5	31.5	31.5
Gross Return ETB	361.7	362.5	350
Total variable cost ETB	291.9	346.9	297.7
Net Return ETB	69.7	15.5	52.3

ETB= Ethiopian birr, CGM=coarsely ground maize, GM=gelatinized maize, SM= soaked maize.

4. Discussion

4.1. Chemical composition of treatment feeds

The grass hay used in this experiment had high fiber and low CP contents due to problems of delayed harvesting time and improper drying and storage [27] suggested that as plants mature, fiber structure increases and the percentages of the CP normally decreases. In the highlands of Ethiopia, the CP content of most natural pastures falls below 6-8%, the minimum level required for optimum microbial activity [28]. Minimum protein level required for maintenance is about 8% CP in the DM [29]. However, most productive animals such as rapidly growing lambs and lactating ewes need about 11% CP in the DM [29]. The lower NDF, ADF and ADL content of maize grain indicated the potential of this grain to supplement feeds that are poor in energy. The three forms of maize grain had similar CP content indicating physical processing had no effect on chemical composition of the grain. As explained by NRC [30], Physical processing usually does not alter the nutrient composition of grains, but processing often increases the digestibility of starch and can alter the site of starch digestion that in turn can alter the efficiency of carbohydrate utilization.

4.2. Feed intake

Similar feed intake among differently processed maize grain supplemented sheep (T1, T2 and T3) was due to similarity in hay DM, Total DM and Total OM intake. The other reason for similar in feed intake among treatments was due lower content in factors limiting feed intake and digestibility of processed maize grain. The NDF content is a major factor limiting feed intake because of its effect on rumen fill and its influence on rumination [31]. Reference [32] confirmed that the level of dry matter intake was negatively correlated to the NDF content. High NDF and ADL depress DM intake and DM digestibility [33]. The size of these animals were also increased through experimental period which is confirmed with [34,35], suggested that feed intake is also directly related to the size of the animal and gut capacity, and would increase with increasing animal size.

4.3. Body weight gain and feed conversion efficiency

The uniform increments observed in final body weight, body weight change, average daily gain and feed conversion efficiency in groups supplemented with different forms of maize could be due to almost comparable feed intake (DMI hay, TDMI, and TOMI). Similar in body weight performance and feed conversion efficiency among sheep offered with differently processed maize grain confirmed that farther processing of grain does not differently improve these characters of sheep. Similar to this study [10] also reported presence of non-significant difference in weight gain of sheep supplemented with whole and coarsely ground barley. Maize grain supplementation after processing uniformly enhanced FCE showing maize grain is energetically more efficient. This conforms with [36] who stated that enhanced FCE is related to higher nutrient concentration of the supplements and the consequent increase in live weight gain. Reference [37] also showed that supplements with higher nutrient availability result in more efficient and higher body weight gain. Reference [38] concluded that diets that promote a high rate of gain will usually result in a greater efficiency than diets that do not allow rapid gain.

4.4. Carcass parameters

While evaluating carcass traits considering factors affecting growth and carcass like nutrition, age, sex, genetics, season and other related factors should be important [39]. In this study, the different form of maize grain (coarsely ground, soaked and gelatinized) had similar effect on hot carcass weight, which was greater than 10kg. According to [6] the average hot carcass yield for Ethiopian sheep is around 10 kg per animal. The high in dressing percentage, both on slaughter body weight and empty body weight bases, was due to relatively higher carcass weight relative to the weight of the gut content in sheep offered with different forms of maize. This indicates that sheep consumed more DM and OM with lower fiber components attained higher final body weight and accumulate less digesta [40;41]. Reference [42] also indicated that dressing percentage was increased with an increase in feed intake increased. Similarly [43], indicated that an increase in dressing percentage was noted with an increase in slaughter weight of lambs. The weight of sternum, hind leg and higher rib-eye area (REA) in treatments 1, 2 and 3 was also improved in a similar manner which indicated maize grain supplementation of Arsi-Bale sheep had better feed utilization efficiency and accumulated more muscle and harvestable meat and have better fattening potential when properly fed and managed. This is consistent with findings of [44] who reported that muscle development and fat deposition depend on nutrient utilization. As the rib-eye muscle area increases, the amount of muscle in a carcass increases [45]. Similar in almost all edible offal weight even though sheep were supplemented with differently processed maize grain reflected less importance of grain processing for sheep. Because sheep chew their feedstuffs to a greater degree compared to other ruminants like cow and goat. Reference [46] also explained no differences in lamb performance when whole or pelleted barley diets were fed.

4.5. Non carcass parameters

4.5.1. Edible offal components

The characterization of edible and non-edible offal depends on the eating habit of the people (social taboos) of a given area [47]. High weight of kidney with fat and abdominal fat obtained from sheep in all treatments (T1=T2=T3) was attributed to better in nutritional availability of maize grain to be digested easily because of its low fiber contents which in turn resulted higher fat storage. The study of [48] showed that animals fed on better quality feed store more fat than animals fed low quality feed and that they use their body fat reserve in order to fulfill their nutrient requirement. High intestinal fat and tail weight was presumably associated with more energy intake from supplement [49].

4.5.2. Non edible offals

In the current study the lack of significant difference among treatments (coarsely ground, soaked and gelatinized) on blood, lung esophagus and trachea, spleen, penis, gut content and TNEO indicates processing has negligible effect on these nonedible organs. Reference [50] found only small differences in the feeding value of whole, rolled, or steam rolled barley on non-carcass parameters. Similar result of non-edible offals like skin with feet, bile and gull bladder showed that difference in feed processing does not affect the weight of these non-edible offals [51,52] indicated that differences in the weight of internal organs and other body parts such as head, lung, skin and feet could be due to the metabolic differences among different age groups, breed and sex. As [53], showed that the weight of the skin is dependent on the breed and coat type of sheep, the short coated being lighter than those with wool or hairs. The weight of skin with feet in T1, T2 and T3 in our study was comparable to while the weight of TNEO was lower than the values reported by [54].

4.6. Partial budget analysis

The higher profit obtained in T1 is due to the lower cost of processing (equipment, time and energy), better FCE and ADG of the sheep in this treatment, which resulted in selling price. On the other hand, lower in NR of T2 and T3 compared to T1 was because of higher TVC

5. Conclusion

Sheep supplemented with different forms (coarsely ground, gelatinized and soaked) of maize grain had similar ($P>0.05$) FBW, FCE, FCR, TEO, TNEO, ADG, dressing percentage (SWb and EBb) and nutrient intake (TDMI, TOMI, TADFI and TNDL). Processing of maize grain had also similar effect on most edible offals (liver, heart, kidney with fat, omasum and abomasums, large and small intestine and abdominal fat) and NEO (blood) contents of sheep. By virtue of its lower fiber (NDF, ADF and ADL) and higher energy contents, maize grain plays significant role in achieving fast growth rate of sheep by fulfilling requirements of animals for fattening in combination with protein source feed. Cost benefit analysis of the current study indicated that supplementation with coarsely ground maize supplemented sheep (T1) was more profitable compared to the others. Farther Grain processing has negligible effect on sheep performance because they are efficient feed utilizers.

6. Recommendations

Maize grain plays significant role in achieving fast growth rate of sheep by fulfilling energy requirements of animals if utilized for fattening in combination with protein source feed. The end result of this experimental research in line with previous study insures simple way of processing (coarsely grinding) of grain is enough to assist sheep to utilize nutrient from given feed. Farther processing of grain (maize) like soaking and gelatinization which comes after coarse grounding has similar effect on sheep performance. So Soaking and gelatinization takes time, energy and costly affects the farmer and generally no need of farther processing feed for sheep and small ruminant as well.

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