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Effects of feeding different varieties of faba bean (*Vicia faba* L.) straws with concentrate supplement on feed intake, digestibility, body weight gain and carcass characteristics of Arsi-Bale sheep

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Objective: A study was conducted to evaluate the varietal differences among faba bean straws and also to assess the potentials of faba bean straws supplemented with concentrate fed at the rate 70% straws and 30% concentrate mixture on feed intake, digestibility, body weight gain and carcass characteristics of the animals.
Methods: Forty yearling Arsi-Bale sheep with initial body weight of 19.85±0.29 kg (mean± standard deviation) were grouped in a randomized complete block design into eight blocks of five animals each based on their initial body weight. Straws included in the study were from Mosisa (T1M), Walki (T2W), Degaga (T3D), Shallo (T4S), and local (T5L) varieties of faba bean and concentrate (2:1 ratio of wheat bran to "noug" seed cake). The experiment consisted of seven days of digestibility and 90 days of feeding trials followed by evaluation of carcass parameters at the end.
Results: Local variety had lower ($p<0.05$) in grain and straw yield compared to improved varieties but higher in crude protein, metabolizable energy contents and *in vitro* organic matter digestibility. The apparent digestibility of dry matter and crude protein of sheep fed Walki and Mosisa straws were higher than ($p<0.05$) straws from Shallo varieties. Sheep fed Walki straw had greater ($p<0.05$) dry matter intake, average daily gain and feed conversion efficiency than sheep fed local and Shallo straws. Slaughter body weight and empty body weight were higher ($p<0.05$) for sheep fed Mosisa and Walki straws as compared to sheep fed Shallo straws. Apart from this, the other carcass components were not affected ($p>0.05$) by variety of the faba bean straws.
Conclusion: There is significant varietal differences between faba bean straws both in quality and quantity. Similarly, significant variation was observed in feed intake, digestibility, body weight gain and feed conversion efficiency among sheep fed different straws of faba bean varieties with concentrate supplement. Based on these results, Walki and Mosisa varieties could be recommended as pulse crop rotation with cereals in the study area.

Keywords: Arsi Bale Sheep; Body Weight Gain; Digestibility; Faba Bean; Intake; Straw

INTRODUCTION

More than 80% of the Ethiopian population are dependent on agriculture for their livelihoods [1] and usually keep livestock as pastoralists or in mixed crop livestock systems. The average holding of sheep per household in Ethiopia ranges between 3.7 [2] to 31.6 [3]. Despite their number, the productivity of sheep per head is low mainly because of inadequate year round nutrition both in terms of quantity and quality, unimproved genetic potential and prevalence of diseases and parasites [4]. In farming systems where crop residues, such as cereal and pulse straws are major feed resources for sheep production, agro-industrial by-products such as oil seed cakes and wheat bran could be used as supplements in sheep diet.

Ethiopia is one of the largest faba bean producing countries in the world second to China [5]. The country is considered as the secondary center of diversity and also one of the nine major agro-geographical production regions of faba bean [6]. Cropping systems involving monoculture of cereals in the highland areas can cause reduction of cereal yield and depletion of soil nutrient. Legumes used in soil fertility improvement through biological nitrogen fixation and also improve physical characteristics of the soil by reducing incidence of pests and diseases and weed related problems. Farmers in the highlands of Ethiopia practices crop rotation especially rotation of cereals and faba bean to alleviate the mono cropping problems and the use of faba bean straws as animal feed becomes important because of the conversion of many former grazing areas into croplands needed for increased food production.

Crop residues vary greatly in chemical composition and digestibility depending on species and variety of the crops [7], time of harvest, handling and storage conditions and other factors [8]. Chemical composition of a feed is highly variable not only between straw types but also within each class of straw [9]. Research conducted at Haramaya University showed that from five varieties of faba bean evaluated, straw dry matter (DM) varied from 3.4 to 7.1 t/ha, straw to grain ratio and plant cell wall contents were significantly different among the varieties [10]. This shows great varietal variations among faba bean varieties which enable us to select faba bean varieties with high straw yield and quality without sacrificing grain yield. There is also a need to identify faba bean varieties with good straw qualities as animal feed together with concentrate supplements that can significantly improve productivity and profitability of farmers practice crop rotation. Thus, the objective of this study were to evaluate the varietal differences among faba bean straws and to assess the potentials of faba bean straws and concentrate supplement on feed intake, digestibility, body weight gain and carcass characteristics of Arsi-Bale sheep.

MATERIALS AND METHODS

Animal care

Animal care, handling and maintenance throughout the experiment were in accordance with the animal welfare regulations of Haramaya University where the proposal of this manuscript approved.

Study area and yield parameters of faba bean varieties

The experiment was conducted at Sinana Agricultural Research Center (SARC) from August 2014 to July 2015 (varieties platting plus animal experimentation) which is located in Bale zone of Oromia Regional State, Ethiopia. The center is located at 463 km South East of Addis Ababa, a capital city of Ethiopia at 07° 07′ N latitude and 40° 10′ E longitudes and at an altitude of 2,400 m above sea level. The average annual maximum and minimum temperatures are 21°C and 9°C, respectively. The rainfall pattern is bimodal with annual precipitation ranging 750 to 1,000 mm. The experimental faba bean varieties, one local and four improved (Mosisa, Walki, Deaga, Shallo) were planted at the center and managed uniformly. Initially, thirty representative plots (1 m^2 each) for each variety were taken for yield parameter determination. Harvesting of the plots was done after proper drying of the grain (at ca. 10% moisture content in the grain). Grain and straw yield were taken after threshing and harvest index was calculated as the percent proportion of grain yield to total above ground DM yield multiplied by 100.

Animals, experimental design and diet

Forty yearling male Arsi-Bale sheep with mean body weight of 19.85±0.29 kg (mean±standard deviation) were used for the experiment. The sheep were held in quarantine for 21 days and dewormed and vaccinated for ovine pasteurellosis and sheep pox. Animals were blocked on the basis of their initial body weight into eight blocks of five animals each in a randomized complete block design and placed in individual pen equipped with a bucket and a feeding trough in a well-ventilated experimental barn. Animals from each block were randomly allocated to the five treatment groups (T1M, Mosisa; T2W, Walki; T3D, Degaga; T4S, Shallo; T5L, local straws 70% each plus 30% concentrate mixed at 2:1 ratio of wheat bran and “noug” seed cake each) giving eight replications per treatment. The ratio of wheat bran to “noug” cake was based on the fact that faba bean haulms are richer in protein contents than cereal straws [8] and since sheep in the current study fed faba bean straws *ad libitum*, energy was more deficit than protein. Additional adaptation period of 15 days before actual data collection were given to acclimatize the animals to the feed, pens and experimental procedures. Water was provided to all animals’ free choice.

Straws of each variety were chopped to minimize wastage and selection by sheep. Wheat bran (the course outer covering of the wheat kernel as separated from cleaned and scoured wheat in a usual process of commercial milling) and “noug” (*Guizotia abyssinica*) seed cake (the by-products of oil processing from “*noug*” seed that can be used as a protein supplement in animal feeding) were used as a supplement. A local mineral soil known as “*Bole*” from Lake Abjata was supplemented at 12 grams/head/d to satisfy mineral requirements of the animal as recommended elsewhere [11] and 1% salt was included during diet formulation. Diet formulation was done based on DM basis, according to the ingredients chemical composition (Table 2), and a complete ration composed of 70% of straws of each variety and 30% of concentrate mixture were mixed uniformly. Sheep were offered uniformly mixed ration *ad libitum* at 20% refusal rate and the amount of feed offered was adjusted every five days based on the average feed consumed during the previous period. The diet was divided in to two equal portions and offered at 08:00 and at 16:00 h.

Digestibility trial

Digestibility trial was conducted before the commencement of the feeding trial and lasted for 10 days with a three days adaptation period to accustom the sheep to carrying the fecal bags, which was followed by a total collection of feces for seven consecutive days. Daily feed offered and refusal per animals was collected. The total fecal output was collected by emptying the bag per day per animal each morning prior to offering feeds and water. The feces were weighed fresh, thoroughly mixed and 20% of the feces were sampled for each sheep and stored in a deep freezer at −18°C. The samples were pooled per animal over the collection period and 20% of the composite sample was taken, weighed and partially dried at 60°C for 72 hours. Apparent digestibility of DM and other nutrients was determined as a percentage of the nutrient intake not recovered in the feces.

Feed intake and body weight change

The 90 days of feeding and growth experiment was conducted after the completion of the digestibility trial with 40 sheep after 10 days rest period. The sheep were re-randomized based on their body weight at the beginning of the feeding trial and adapted to experimental diets. The daily feed offered and refusals were weighed and recorded for each sheep. Daily feed and nutrient intake were calculated as the difference between the feed offered and refused based on DM basis. Samples of feed offered were collected per batch while samples of refusal were taken from each sheep daily and stored in plastic bags. Sub-samples of feed offered and refusal were taken after thorough mixing for nutrient composition determination. Body weight of the animals was taken at the beginning of the feeding trial after overnight fasting and every 10 days during the 90 days of feeding trial. All animals were weighed in the morning hours after overnight fasting before feed provision using weighing balance with a sensitivity of 100 grams. Daily body weight gain was calculated as the difference between final live weight and initial live weight divided by the number of feeding days. Feed conversion efficiency was calculated as the ratio of average daily gain to DM intake.

Carcass evaluation

At the end of 90th day of feeding experiment, half of the sheep in each trial (four sheep per treatment) were slaughtered after 24 hours fasting to determine the effects of treatment feeds on carcass characteristics. Slaughter body weight was taken immediately before slaughter. The animals were killed by severing the jugular vein and the carotid artery with a knife. Blood was collected, weighed and recorded. Skin was properly flayed and weighed. Empty body weight was calculated as the difference between slaughter weight and gut content. 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. The edible offal components and non-edible offal components were weighed and recorded individually. The dressing percentage was calculated as the proportion of hot carcass weight to slaughter and empty body weight basis.

The carcass was split down at the vertebral column having the two sides as symmetrically as possible and stored in a deep freeze at −4°C overnight. The frozen carcass (right part) was divided in to five main primal cuts carcass components namely: leg, loin, rack, breast and shank and shoulder and neck. The carcass was cut perpendicular to the back bone between the 12th and 13th ribs to measure the cross-sectional area of the rib-eye (*longissimus dorsi*) muscle area [12]. The five main primal cut carcass components were partitioned to muscle, bone and fat and each part was weighted and recorded.

Chemical analysis

The chemical analysis of the experimental feeds, refusals and feces were carried out after taking the representative samples and taken to International Livestock Research Institute (ILRI) nutrition lab, Ethiopia. Samples of feed offered, refusals and feces were ground to pass a 1 mm sieve mesh. Standard methods of AOAC [13] were followed for determining DM, ash and crude protein (CP, which was calculated as N×6.25) contents. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin were determined by using the procedures of Van Soest and Robertson [14]. The *in vitro* organic matter digestibility (IVOMD) and metabolizable energy (ME) content of the experimental feeds were calculated from gas produced, CP and ash [15]). Animals were managed in ILRI Debra Zeit, Ethiopia and rumen fluid were taken from three fistulated cross animals (oxen) and mixed and the donor animas fed hay and supplemented with oil cakes.

Statistical analysis

Data on feed intake, digestibility, body weight change and carcass characteristics were subjected to analysis of variance using the General Linear Model Procedure of SAS [16]. When significant, least significant difference was used to locate differences between the treatment means. Significance was declared at $p<0.05$. Data were analyzed using the following model for complete randomized block design.

$$Y_{ij} = \mu+T_i+B_i+E_{ij}$$

Where, Y_{ij} = response variable, μ = overall mean, T_i = treatment effect, B_i = block effect and E_{ij} = random error.

RESULTS

Yield parameters of faba bean varieties

Improved varieties (Mosisa, Walki, Degaga, Shallo) had greater ($p<0.001$) grain and straw yield than local variety (Table 1). Among improved varieties, straw yield from Mosisa had greater ($p<0.001$) than all other varieties and that obtained from Shallo was higher ($p<0.001$) than Walki and Degaga varieties. Mosisa, Shallo and local varieties had higher ($p<0.001$) straws to grain ratio than Walki and Degaga varieties. Harvest index for Walki and Degaga varieties had greater ($p<0.001$) than Mosisa, Shallo, and local varieties.

Digestibility trial

Apparent digestibility of DM for sheep fed Mosisa, Walki, and Degaga straws were higher ($p<0.05$) than sheep fed Shallo straw but no significant difference ($p>0.05$) were observed between sheep fed local and improved varieties (Table 3). The organic matter (OM) digestibility was higher ($p<0.05$) in sheep fed Walki straw than Shallo straw. The CP digestibility of sheep fed local straw was greater ($p<0.001$) than sheep fed Degaga and Shallo straws but did not differ ($p>0.05$) from sheep fed Mosisa and Walki straws. The current result revealed that there were no difference ($p>0.05$) in the digestibility of neutral and ADF components among treatments.

Feed intake and body weight change

Total DM and OM intake of sheep fed Walki straw was higher ($p<0.001$) than sheep fed Mosisa, Shallo, and local straws and also sheep fed Degaga straw was greater ($p<0.001$) than sheep fed Mosisa and Shallo straws (Table 4). Crude protein intake for sheep fed local straw was higher ($p<0.001$) than sheep fed

Table 1. Grain and straw yield, straws to grain ratio and harvest index of faba bean varieties extrapolated from 30 quadrants (1 m×1 m) each

Parameters	Varieties					CV (%)	LSD	LS
	Mosisa	Walki	Degaga	Shallo	Local			
Grain yield (t/ha)	4.4^{a}	4.2^{a}	4.2^{a}	4.1^{a}	2.9^{b}	23.7	0.48	***
Straw yield (t/ha)	5.1^{a}	4.0^{c}	3.9^{c}	4.5^{b}	3.3^{d}	21.5	0.45	***
Straw yield to grain ratio	1.2^{a}	0.96^{b}	0.95^{b}	1.2^{a}	1.2^{a}	26.4	0.15	***
Harvest index (%)	46.6^{b}	51.3^{a}	51.8^{a}	46.8^{b}	45.8^{b}	10.8	2.67	***

CV, coefficient of variation; LSD, least significant difference; LS, level of significance.
[a-d] Means with different superscripts in a row are significantly different. *** $p<0.001$.

Table 2. Chemical composition, in vitro digestibility and energetic value of main ingredients of the experimental diet

Item	Faba bean straws					WB	NSC
	Mosisa	Walki	Degaga	Shallo	Local		
Dry matter (%)	89.8	89.2	89.8	90.9	89.6	86.3	88.6
Crude protein (% DM)	4.9	5.1	5.2	4.3	6.2	13	26.8
Neutral detergent fiber (% DM)	78.8	75.9	79.7	82.2	79.6	44.7	44.6
Acid detergent fiber (% DM)	69.1	63.4	67	69.9	65.6	10.9	32.9
Acid detergent lignin (% DM)	13.3	12.8	13.3	13.9	13.7	2.1	12.9
Ash (% DM)	5.5	7.1	6.2	5.6	8.5	3.4	11.6
In vitro organic matter digestibility (%)	48.1	49.4	51.6	45.1	62.6	84.5	69.4
Metabolizable energy (MJ/kg DM)	6.9	7.1	7.5	6.5	9.2	11.9	8.1

DM, dry matter; WB, wheat bran; NSC, noug seed cake.

Table 3. Apparent nutrient digestibility of diets containing different varieties of faba bean straws (70%) and concentrate (30%) fed to Arsi-Bale sheep

Digestibility (%)	Treatments[1)]					SEM	SL
	T1M	T2W	T3D	T4S	T5L		
Dry matter	54.9^{a}	56.6^{a}	55.5^{a}	49.5^{b}	54.0^{ab}	0.86	*
Organic matter	52.1^{ab}	54.7^{a}	50.5^{ab}	46.0^{b}	47.8^{ab}	1.27	*
Crude protein	60.3^{ab}	55.4^{ab}	54.3^{bc}	47.5^{c}	61.9^{a}	1.32	***
Neutral detergent fiber	51.9	53.3	53.7	51.9	54.7	0.59	ns
Acid detergent fiber	50.7	52.3	49.8	50.0	50.0	1.26	ns

SEM, standard error of the mean; SL, significant level; ns, non-significant.
[1)] T1M, Mosisa; T2W, Walki; T3D, Degaga; T4S, Shallo; T5L, local straws 70% each plus 30% concentrate mixed at 2:1 ratio of wheat bran and "noug" seed cake each.
[a-c] Means with different superscripts in a row are significantly different. *** $p<0.001$; * $p<0.05$.

Table 4. Feed intake and fattening performance of Arsi-Bale sheep fed diet containing different varieties of faba bean straw (70%) and concentrate (30%)

Feed intake	Treatments[1)]					SEM	SL
	T1M	T2W	T3D	T4S	T5L		
Dry matter intake (g/d)	672[c]	754[a]	718[ab]	660[c]	696[bc]	8.2	***
Organic matter intake (g/d)	633[c]	704[a]	674[ab]	622[c]	644[bc]	7.4	***
Crude protein intake (g/d)	71[c]	76[ab]	74[b]	68[d]	77[a]	0.6	***
Neutral detergent fiber intake (g/d)	426[b]	478[a]	466[a]	431[b]	448[ab]	5.9	*
Acid detergent fiber intake (g/d)	309[b]	341[a]	333[ab]	305[b]	312[ab]	4.7	*
Acid detergent lignin intake (g/d)	66[c]	75[a]	72[ab]	67b[c]	71[ab]	0.9	*
Metabolizable energy intake (MJ/d)	5.4[c]	6.1[b]	5.9[b]	5.2[c]	6.4[a]	0.09	***
Growth performance							
Initial body weight (kg)	19.6	19.9	19.9	19.9	19.9	0.19	ns
Average daily gain (g/d)	52[ab]	65[a]	43[bc]	38[c]	48[bc]	2.6	**
Feed conversion efficiency	0.077[ab]	0.085[a]	0.059[bc]	0.056[c]	0.069[abc]	0.003	*

SEM, standard error of the mean; SL, significance level; ns, non-significant.
[1)] T1M, Mosisa; T2W, Walki; T3D, Degaga; T4S, Shallo; T5L, local straws 70% each plus 30% concentrate mixed at 2:1 ratio of wheat bran and "noug" seed cake each.
[a-d] Means with different superscripts in a row are significantly different. *** p < 0.001), ** p < 0.01; * p < 0.05.

Degaga, Mosisa, and Shallo straws whereas no significant difference was observed with sheep fed Walki straws. For other treatments, it was varied (p<0.001) in the order of sheep fed Walki and Degaga>Mosisa>Shallo straws. The ME intake of sheep fed local straw was highest (p<0.001) than all sheep fed straws from improved varieties and sheep fed Walki and Degaga straws also had higher (p<0.001) ME intake than sheep fed Mosisa and Shallo straws.

Sheep fed Walki straw had higher (p<0.01) average daily gain than sheep fed Degaga, local and Shallo straws but similar (p>0.05) with sheep fed Mosisa straws. Feed conversion efficiency was greater (p<0.05) in sheep fed Walki straw than sheep fed Degaga and Shallo straws whereas statistically similar (p>0.05) with values obtained for sheep fed Mosisa and local straws.

Carcass characteristics

Main carcass components and five primal carcass cuts (right part): Slaughter and empty body weight were higher (p<0.05) for sheep fed Mosisa and Walki straws as compared to sheep fed Shallo straw and there were no variation (p>0.05) among sheep fed Mosisa, Walki, Degaga, and local straws (Table 5). Hot carcass weight, chilled carcass weight and dressing percentage on both slaughter and empty body weight basis and rib-eye area did not differ (p>0.05) among treatments. Sheep fed local straw had greater (p<0.05) fat thickness than sheep fed Mosisa straw (p>0.05). The mean tissue weight and proportions of all five primal cut carcass components such as bone, muscle, fat and their total were not affected (p>0.05) for all treatments (Table 6). Muscle followed by bone and fat had the highest amount in each primal cut for all treatment groups.

Non carcass components: Carcass offal components are categorized into edible and non-edible based on tradition, beliefs, culture and differences in preference of the people from one locality to the other and is so more or less subjective [17]. The majority of the edible offal components including total edible offal components in this study were not affected (p>0.05) by the variety of faba bean straws used (Table 7). Sheep

Table 5. Carcass characteristics of Arsi-Bale sheep fed diets containing different varieties of faba bean straw (70%) and concentrate (30%)

Parameters	Treatments[1)]					SEM	SL
	T1M	T2W	T3D	T4S	T5L		
Slaughter body weight (kg)	24[a]	23.8[a]	22.8[ab]	21.7[b]	23.4[ab]	0.3	*
Hot carcass weight (kg)	8.5	8.4	8.4	8.1	8.7	0.11	ns
Chilled carcass weight (kg)	8.3	8.1	8.3	7.7	8.2	0.11	ns
Empty body weight (kg)	19.5[a]	19.7[a]	18.6[ab]	17.5[b]	18.8[ab]	0.32	*
Dressing percentage on							
SBW basis	31.5	35.3	36.9	37.3	37.1	0.44	ns
EBW basis	43.2	42.6	45.5	46.5	46.1	0.61	ns
Fat thickness (mm)	0.18[b]	0.23[ab]	0.33[ab]	0.2[ab]	0.35[a]	0.03	*
Rib eye area (cm^2)	7.3	7.3	8.3	8	8	0.24	ns

SEM, standard error of the mean; SL, significance level; ns, non-significant; SBW, slaughter body weight; EBW, empty body weight; CCW, chilled carcass weight.
[1)] T1M, Mosisa; T2W, Walki; T3D, Degaga; T4S, Shallo; T5L, local straws 70% each plus 30% concentrate mixed at 2:1 ratio of wheat bran and "noug" seed cake each.
[a,b] Means with different superscripts in a row are significantly different. * p < 0.5.

Table 6. Mean tissue weight and proportions from five primal carcass cuts (right half) of carcass from Arsi-Bale sheep fed diets containing different varieties of faba bean straw (70%) and concentrate (30%)

Mean tissue weight and proportions	Treatments[1)]					SEM	SL
	T1M	T2W	T3D	T4S	T5L		
Muscle (kg)	2.66	2.68	2.61	2.55	2.69	0.04	ns
(%)	62.2	58.8	61	61.8	60.8	0.9	ns
Bone (kg)	1.19	1.18	1.1	1.15	1.18	0.03	ns
(%)	29.3	30.9	27.9	29.6	28	0.73	ns
Fat (kg)	0.32	0.36	0.38	0.28	0.39	0.02	ns
(%)	8.4	10.3	11	8.6	11.2	0.61	ns

SEM, standard error of the mean; SL, significance level; ns, non-significant.
1) T1M, Mosisa; T2W, Walki; T3D, Degaga; T4S, Shallo; T5L, local straws 70% each plus 30% concentrate mixed at 2:1 ratio of wheat bran and "noug" seed cake each.

fed Mosisa straw had higher ($p<0.05$) kidney and testicles weight than sheep fed Shallo straw but similar with other treatments, on the other hand, sheep fed Mosisa straw had the lowest empty gut weight than other treatments might be related to lower total DM intake (Table 4) of sheep fed Mosisa straw as compared to the others.

Except lung with trachea and spleen, all non-edible offal components together with total non-edible offal components were similar ($p>0.05$) among treatments (Table 8). Sheep fed Mosisa straw had higher ($p<0.05$) lung with trachea as compared to sheep fed Shallo straw. In the same manner, sheep fed Mosisa and local straws had greater ($p<0.05$) spleen than the remaining groups.

DISCUSSION

Yield parameters of the faba bean varieties

Grain yield obtained from improved varieties of faba bean in the current study were higher than 1.97 to 3.98 t/ha for four improved varieties (Tesfa, Bulga-70, CS-20-Dk, Mesay, all released from Holeta Agricultural Research Center, Holeta, Ethiopia) of faba bean evaluated by Yetimwork [10]. The variations in grain yield among the current and earlier results might be due to variation in the nature of the varieties, location and environmental conditions of the study area. The same author revealed that straw yields ranged from 3.4 to 7.1 t/ha for five varieties of faba bean evaluated and the current straw yield were within the range of the earlier reports and this show great variability in straw yield among the varieties. The harvest index obtained from the present study was greater than 23.9% to 49.6% harvest index for five varieties of faba bean evaluated by Yetimwork [10].

Digestibility trial

The lower apparent DM and OM digestibility of sheep fed Shallo straw might be attributed to its higher neutral and ADF content and lower IVOMD compared to straws from other varieties. The NDF is the primary chemical component of feeds that determines the rate of digestion; thus there is a negative relationship between the NDF content of feeds and the

Table 7. Edible offal components of Arsi-Bale sheep fed diets containing different varieties of faba bean straw (70%) and concentrate (30%)

Edible offal	Treatments[1)]					SEM	SL
	T1M	T2W	T3D	T4S	T5L		
Blood (g)	943.6	829.8	915.8	835.5	876.0	21.4	ns
Liver (g)	287.3	284.8	264.3	272.8	260.8	4.67	ns
Kidney (g)	69.0^{a}	63.8^{ab}	65.5^{ab}	58.3^{b}	62.8^{ab}	1.39	*
Heart (g)	104.6	97.5	99.3	99.3	99.0	1.29	ns
Tongue (g)	75.5	70.0	82.5	71.5	72.0	2.09	ns
Reticulo-rumen (g)	3,933.7	3,525.8	3,716.5	3,648.8	3,989.0	107.05	ns
Omasum-abomasum (g)	558.1	536.8	537.3	612.0	623.8	22.14	ns
Empty gut (g)	624.3^{b}	797.8^{a}	780.8^{a}	780.0^{a}	771.3^{a}	18.33	**
Small intestine (g)	1,325.5	1,399.3	1,282.5	1,286.0	1,462.0	39.2	ns
Large intestine (g)	536.7^{b}	754.0^{a}	634.0^{ab}	617.3^{ab}	617.8^{ab}	29.02	*
Testicles (g)	385.4^{a}	342.5^{ab}	333.0^{ab}	245.3^{b}	328.5a^{b}	18.75	*
Tail (g)	466.4	579.0	462.0	540.7	493.7	29.18	ns
Kidney fat (g)	71.5	70.8	83.3	67.3	75.3	6.4	ns
Heart fat (g)	53.7	42.5	40.0	49.8	48.5	3.05	ns
Omental fat(g)	62.1	62.0	69.3	53.5	56.0	5.18	ns
Scrotal fat (g)	30.3	35.5	39.3	32.5	39.5	2.09	ns
Pelvic fat (g)	32.5	38.0	39.0	27.8	30.5	1.73	ns
TEOC (kg)	9.6	9.5	9.4	9.3	9.9	0.14	ns

SEM, standard error of the mean; SL, significance level; ns, non-significant; TEOC, total edible offal component.
1) T1M, Mosisa; T2W, Walki; T3D, Degaga; T4S, Shallo; T5L, local straws 70% each plus 30% concentrate mixed at 2:1 ratio of wheat bran and "noug" seed cake each.
a,b Means with different superscripts in a row are significantly different. ** $p<0.01$; * $p<0.05$.

Table 8. Non edible offal components of Arsi-Bale sheep fed diets containing different varieties of faba bean straw (70%) and concentrate (30%)

Non-edible offal	Treatments[1)]					SEM	SL
	T1M	T2W	T3D	T4S	T5L		
Head without tongue (g)	1,573.9	1,582	1,493.3	1,523.3	1,561.3	36.87	ns
Skin (g)	2,127.9	1,867.3	1,758.3	2,031.8	1,934	55.73	ns
Lung with trachea (g)	320.8[a]	284.5[ab]	285[ab]	206.3[b]	260.5[ab]	14.67	*
Pancreas (g)	36.29	32.5	33.3	33.0	22.5	0.87	ns
Spleen (g)	44.59[a]	34.75[bc]	36.0[bc]	28.25[c]	38.5[ab]	2.03	**
Bladder (g)	13.53	15.25	16.0	13.0	12.5	1.23	ns
Gall bladder (g)	3.6	5.3	5.0	7.5	6.3	1.35	ns
Full gut (g)	4,491.8	4,062.5	4,254.0	4,260.8	4,612.8	120.9	ns
Penis (g)	60.7	56.5	59.0	50.5	58.5	1.8	ns
Feet with hooves (g)	461.6	411.8	421.3	413.0	445.5	8.86	ns
TNEOC (kg)	9.1	8.4	8.4	8.6	8.9	0.16	ns

SEM, standard error of the mean; SL, significance level; ns, non-significant; TNEOC, total non-edible offal component.
[1)] T1M, Mosisa; T2W, Walki; T3D, Degaga; T4S, Shallo; T5L, local straws 70% each plus 30% concentrate mixed at 2:1 ratio of wheat bran and "noug" seed cake each.
[a-c] Means with different superscripts in a row are significantly different. ** $p<0.01$; * $p<0.05$.

rate at which they are digested [18]. Moreover, digestibility of a feed is influenced not only by its composition, but also by the composition of other feeds consumed with it. In line with the current results, other reports [19-21] no observed variation in digestibility in NDF and ADF for different breeds of small ruminants and different feed types.

Feed intake and body weight change

The straw obtained from Walki variety was consumed more than straws from other varieties (Mosisa, Shallo, and Local) and the variation might be related to less fiber contents of Walki straw compared to the other varieties. Feed that is low in protein and high in fiber content results in low digestibility and voluntary feed intake [22]. The differences in CP intake among treatments were as expected since straw obtained from local variety had higher CP than straws obtained from improved varieties. The ME intake indicated that the energy intake in all treatments was in the range of 5.1 to 6.2 MJ/d energy necessary for a 20 kg sheep gain 50 to 100 g/d [23].

The deviations in average daily gain and feed conversation efficiency among the treatments tested stemmed from variations in nutrient contents, cell wall constituents, digestibility and better DM intake within different faba bean straws. This indicates that there is a possibility for selecting faba bean crops for planting based on their straws qualities in addition to grain yield and quality attributes for enhanced use of the whole plant value. The current study showed that when sheep supplemented with 30% concentrate from their daily feed offered, higher mean daily body weight gain was observed depending on the faba bean varieties used. The present results agree with the previous findings [24-26] which reported higher weight gain when different pulse crops residues were supplemented with 300 g/d concentrate mixtures.

Carcass characteristic

Main carcass components and mean tissue weight and proportions of five primal carcass cuts: The greater slaughter body weight might be due to higher feed conversation efficiency and body weight gain of those groups fed on Walki and Mosisa straws as compared to the others since slaughter body weight depends on these parameters [27]. According to Gatenby [28] dressing percentage of sheep generally range between 40% to 50% (in empty body weight bases), but it depends very much on what parts of the carcass is sold as meat and the current results of 31.5% to 37.3% and 42.6% to 46.5% on slaughter and empty body weight basis, respectively were within this range. Large amounts of muscle found on the leg followed by shoulder and neck parts of primal carcass cuts was in line with earlier report by Daskiran et al [29].

Non carcass components: Riley et al [30] indicated that differences in internal organs are more influenced by age, breed and sex of the animals rather than plane of nutrition which is in line with the current results. Lack of significant difference in gut fill between different treatments of sheep in the current study might be due to the time elapsed (24 hour fasting time prior to slaughter) until slaughtering that made to shrink their gut fill equally. In agreement with the present study, Ermias [25] reported gut fill weight of 17.6% to 20.4% on slaughter body weight basis for the same breed of sheep fed faba bean haulms supplemented with linseed meal, barley bran and their mixture and weighed 18.5 to 27.6 kg at slaughter.

CONCLUSION

The present findings indicate that there is great varietal difference among straws obtained from faba bean varieties related to seed and straw yield, straw to grain ratio and harvest index parameters. Similarly, there are also huge variations between sheep fed different faba bean straws supplemented with concentrate mixture on feed intake, digestibility, feed conversion efficiency and body weight change. The majority of carcass parameters were not affected by using different straws of faba bean varieties. Based on these results, Walki and Mosisa varieties were found to be the most promising ones in terms of feeding value of the straws and hence could be recommended as more suitable candidates for pulse crop rotation with cereals in the study area because of their potential for providing better quality straws that can help in enhancing livestock production and productivity in addition to grain yield for human consumption.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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