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Full Length Research Paper

Supplementing rice bran, Sesbania (*Sesbania sesban)* leaf and their mixtures on digestibility and performance of Kaffa sheep fed native grass hay

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This study was carried out with the objective of determining dry matter (DM) intake, digestibility, body weight (BW) change and carcass parameters in Kaffa sheep breed fed native grass hay and supplemented with *Sesbania sesban* leaf (SS), rice bran (RB) and their mixtures in different proportions. Twenty-five intact male sheep with initial body weight of 17.08 ± 0.68 kg (mean±SD) were used in both the 90 days of feeding and 7 days of digestibility trials. The experimental animals were arranged into five blocks of five animals based on the initial body weight. The five treatments were assigned to each animal in a block. The dietary treatments used in the experiment were grass hay fed *ad libitum* alone (T1), or with 300 g RB (T2), 200 g RB+100 g SS (T3), 100 g RB+200 g SS (T4), and 300 g SS (T5). The crude protein (CP) content of hay, RB and SS were 6.1, 8.3 and 27.5%, respectively. Hay DM intake was highest for T1 (526 g/day) than the supplemented groups that ranged from 437-447 g/day. Total DM intake was 526, 699, 708, 707 and 712 and was in the order of T1<T2<T3=T4=T5. Digestibility of CP was lower for T1 (58%), but similar among the supplemented group (range of 75-86%); DM digestibility was greater ($p<0.05$) for T4 than T2 and T3, and values were similar ($p>0.05$) for T4 and T5, however digestibility of NDF was greater ($p<0.05$) for T2 than for other treatments. Daily BW gain (ADG) was -5, 52, 54, 67 and 86 g/day and was in the order of T1<T2=T3<T4<T5. Hot carcass weight was in the order of T1<T2<T3=T4<T5 (5.6, 8.2, 10.6, 11.2 and 12.4 kg, respectively). Dressing percentage both on slaughter weight and empty body weight basis were in the order of T3=T4=T5>T2>T1. Net return and marginal rate of return increased with increasing supplemental level of SS. Therefore, T5 was best in terms of both biological and economic performance of animals from the feeding regime employed in this study, suggesting the better feeding value of SS than RB. However, RB can be a potential supplement to low quality forages to prevent BW loss, and for better results RB need to be supplemented with protein rich feeds.

Key words: Crude protein, dressing percentage, hot carcass weight, Kaffa sheep, rice bran, Sesbania sesban.

INTRODUCTION

According to the 2011 sheep inventory, there are 25.5 million sheep population in Ethiopia (FAO, 2011). Sheep production is an integral component of the mixed crop-livestock production system in Ethiopia. Sheep contribute as a source of cash income, food, manure and wool for smallholder farmers. Sheep production in the mixed crop-livestock production system is based on communal grazing land which is shrinking due to crop encroachment and gully erosion (Benin et al., 2002; Mengistie, 2008). There is therefore, a need for an alternative feeding strategy which could alleviate livestock feed problem. The use of cut and carry system is a key principle for the

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successful integration of livestock into cropping systems to control and to preserve uplands, catchments and recharge areas essential for sustainable water supplies (Alemayehu, 2003).

One potential option to improve the nutritive value of low quality feed is the use of agro industrial by-products such as rice bran or browse plants like *Sesbania sesban*. Most browse plants have high CP content, ranging from 10 to more than 25% on dry matter (DM) basis and are reliable feed resource of high quality to develop sustainable feeding systems and in increasing livestock productivity (Okoli et al., 2003).

S. sesban is a potential source of protein having 24.0 - 31.9% CP (Mekoya, 2008; Kanyama et al., 1995). Research results indicate that *S. sesban* has superior nutritive value compared to other species of fodder trees. Its value when used as a protein supplement for sheep fed cereal crop residues can be equivalent to alfalfa hay, vetch hay, and several oil seed meals (Khalili and Varvikko, 1992; Siaw et al., 1993; Karachi et al., 1997; Woodward and Reed, 1997). *S. sesban* can be used as supplementary protein to roughage based diets or to concentrate mixture of sheep and goats.

Rice is a major food grain for millions of people in the tropics particularly in Asia (Cheeke, 1991). In Ethiopia, it is produced in Amhara (86% of annual production), Benshangul, Oromiya and Gambela regions (Bimerew, 2008). FAO reported the annual rice production of Ethiopia in 2010 was 25,200 tons from 13,300 ha of land. Bench Maji Zone Agriculture and Rural Development Office reported the annual rice production of the area in 2006 and 2007 was 4622.1 and 35,656.9 tons from 2311 and 9673 ha of land, respectively (Getachew, 2011). The national rice production of the country during the same year (2007) was 11,244 tons from 6100 ha of land (FAO, 2007).

Tessema and Baars (2004) recommended the inclusion of *Sesbania* leaves at 250 g/kg diet DM with grass-based hay feeding that improved digestibility of DM, OM and CP. However, Melaku et al. (2004) reported that increasing supplementation of tree fodder levels reduced nutrient digestibility due to increased passage rate and recommended low levels of tree leaves supplementation. On the other hand, Abebaw (2007) and Bimerew (2008) reported that supplementing rice bran with noug seed cake improve OM, CP, NDF, and ADF intake and digestibility of Farta sheep. Currently, rice production is expanding. However, no emphasis is being paid to the use of the by-products of rice processing to compensate for the continuously decreasing feed resources available for livestock from the communal grazing areas in the study area.

Objective

This study aims to assess feed intake, digestibility, live weight change, and carcass parameters of Kaffa sheep fed native grass hay supplemented with rice bran, *S. sesban* leaf and their mixtures at different proportions.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Mizan Agricultural Technical Vocational and Educational Training College (MATVET), Mizan Teferi. Mizan Teferi is the largest town and the administrative centre of the Bench Maji zone of the Southern Nation, Nationalities, and Peoples Region, and located about 261 km southwest of Jimma and 565 km from the capital, Addis Ababa. According to the metrology branch office of Mizan Teferi (2011), the town has latitude and longitude of 7°0′N and 35°35′E, coordinates, respectively and an elevation of 1451 m above sea level. The town has an average annual rainfall of 1800 mm and average minimum and maximum temperatures are 22 and 27°C, respectively.

Feeds and feeding management

The basal diet, mixed sward hay, was purchased from the farmers around the study area and stored under a shade to maintain its quality. The hay was chopped manually to the size of 1-3 cm so as to improve intake by experimental sheep, weighed, and offered as basal feed. The supplement, that is, rice bran was purchased from rice processing plants in Mizan town. The rice bran was collected in sacks, and stored on cemented floor and dark room to avoid rancidity. The *S. sesban* leaf was collected from Mizan ATVET College and Bebeka coffee plantation farm and dried under shade. The hay was offered *ad lib* along with free access of water and salt licks to experimental sheep. The concentrate supplements, that is, *S. sesban* and rice bran and their mixture were offered at 300 g DM daily at 0800 and 1600 hours in two equal portions.

Experimental animals and management

Twenty five yearling intact male Kaffa sheep breed with the mean body weight of 17.08 ± 0.68 kg (mean ± *SD*) were purchased from Wacha Maji market. The age of the sheep was determined by dentition and information from the owners. The animals were quarantined for 21 days at the site of the experiment in order to let the animals get accustomed to the specific environment and to observe their health conditions. The animals were vaccinated against ovine pasteurellosis, and sheep pox, with 1 ml ovine pasteurellosis vaccine and 1 ml sheep pox vaccine per sheep. Animals were de-wormed with Tetramizole tablet against internal parasites like flat worms and round worms and sprayed with accaricide against external parasites like tick and mange during the quarantine period. Animals were continuously observed for incidence

Table 1. Experimental treatments.

Treatment	Level of feeding (gram per animal per day)		
	Hay	RB	*Sesbania sesban*
T1	*ad libitum*	-	-
T2	*ad libitum*	300	0
T3	*ad libitum*	200	100
T4	*ad libitum*	100	200
T5	*ad libitum*	0	300

RB = rice bran.

of any ill health and disorders during the experimental period.

The experimental animals were housed in individual pens in a ventilated shade that was built for this purpose. The pens were equipped with feeding trough for hay and plastic buckets for concentrates and separate watering trough. The experimental sheep were identified with neck collars. Experimental animals were allowed to adapt for 15 days to experimental diets before the commencement of actual data collection. Samples of feed offer from all diets and refusals from hay and supplements were collected, weighed and bulked throughout the experimental period.

Experimental design and treatment

For the experiment, a randomized complete block design with five treatments was employed. Experimental sheep were blocked based on their initial body weight into five blocks of five animals each. The initial body weight was determined as a mean of two consecutive body weight measurements after overnight fasting. The treatments (Table 1) were then randomly assigned to the sheep in a block.

Statistical analysis

The analysis of variance (ANOVA) of data on feed intake, body weight change, digestibility and carcass parameters were run using the general linear model procedure of SAS (2008). Differences between treatments means were tested using least significance difference test. The statistical model for the analysis of data was:

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

where:

Y_{ij} = observation in the j^{th} block and i^{th} treatment;
μ = the overall mean;
T_i = the i^{th} treatment effect;
B_j = the j^{th} block effect;
E_{ij} = the random error.

RESULTS AND DISCUSSION

Chemical composition of treatment feeds

The results of the chemical composition analysis of the experimental and basal diet feeds are shown in Table 2. The CP content of the hay in the present study appeared to be low. However, lower (Ewnetu, 1990; Getachew, 2005) and higher values (Bimerew, 2008; Abebaw, 2007) as compared to the current value have been noted before. The lower CP content of hay in this study as well as difference among studies may be related to various factors such as species composition of the hay, stage of maturity at harvest and other environmental factors in which the hay was grown. It has been stated that CP value ranging from 7-7.5% is required to satisfy maintenance requirement of ruminant animals (Van Soest, 1982). Hence, the observed 6.08% CP content of grass hay in the current study was lower than the demand for maintenance requirements of sheep.

The NDF and ADF content of hay in the current study are high. Pond et al. (1995) noted that NDF portion of feed is only partially digestible by any species of animals, but can be used to greater extent by such animals as ruminants which depend on microbial digestion for utilization of most fibrous plant components. Feeds that contain high proportion of ADF have low availability of nutrients due to ADF being negatively correlated with feed digestibility (McDonald et al., 2002). The high level of fiber in the hay used in this study might limit its digestibility and feeding value.

The CP content of RB used in this experiment was higher than 7.8% CP reported by Bimrew (2008) but lower than the 10-14% reported by other authors (Abebaw, 2007; AFRIS, 2006; Zhao et al., 1996). McDonald et al. (2002) indicated that lower CP values of feeds like RB used in the current study might be attributed to different environmental condition in which the crops were grown and methods employed to process the grain, additives and amount of fat extracted. The authors noted that the lower values of CP observed may be due to the quality of the RB used in the experiment caused by the low de-hulling ability of rice processing mills. The same source described that if there is higher amount of hull in the RB, there will be higher mineral elements including silica which may in turn dilute the CP content of the RB. The bran may be good quality, but it is apt to be variable because of inclusion of hulls (Pond et al., 1995). The NDF and ADF contents of RB in the current study were higher than 40.75 and 18.67% reported by Abebaw (2007), 40.4 and 22.6% reported by Zhao et al. (1996) and 56.4 and 44.0% noted by Bimerew (2008). The differences in the results of chemical analysis might be attributed to varietal differences and grain processing techniques employed.

The OM content of *S. sesban* in the present study (91.53% DM) was slightly comparable with the

Table 2. Chemical composition of experimental feeds and refusals.

Feed offers (g/kg)	DM	OM	CP	NDF	ADF	ADL	Ash
	------------------- (g/kg DM) ---------------------						
Hay	912.5	935.6	60.8	781.9	453.6	81.6	64.4
Sesbania sesban	886.3	915.3	275.3	287.8	236.5	75.6	84.7
Rice bran	874.3	871.6	83.4	640.7	529.1	72.85	128.4
SS × RB (66.7%+33.3%)	882.3	900.75	211.4	404.16	334.02	74.66	99.25
SS × RB (33.3%+66.7%)	878.3	886.15	129.3	524.34	431.5	873.7	913.85
Feed refusals							
Hay (T1)	908.2	939.2	58.7	800.3	495.2	100.2	60.8
Hay (T2)	937.9	920	56.2	693.8	400	52	80
Hay (T3)	935	920	54.8	681.6	400.3	51.1	80
Hay (T4)	916.7	922	56	705.8	394.5	54.4	78
Hay (T5)	927.2	922	57.5	719.5	393.6	55.5	78
Sesbania sesban	880	919.1	254.5	481.1	371.9	206.5	80.9
Rice bran	889.8	861.8	81.1	679.8	530.8	70.4	138.2
SS × RB (66.7%+33.3%)	884.4	878.3	170.7	535.9	456.2	92.5	121.7
SS × RB (33.3%+66.7%)	883.5	863.7	93.5	695.1	601.7	106.3	136.3

ADF = acid detergent fiber; ADL = acid detergent lignin; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; SS = *Sesbania sesban*; OM = organic matter; RB = Rice bran; T1 = hay; T2 = hay *ad libitum* + 300 g RB DM/day; T3 = hay *ad libitum* + 100 g SS+200 g RB DM/day; T4 = hay *ad libitum* + 200 g SS+100 g RB DM/day; T5 = hay *ad libitum* + 300 g SS leaf DM/day.

observations of Kaitho et al. (1998b) (88.9% DM) and El Hassan et al. (2000) (89.3% DM), while the CP content (27.53% DM) was higher than the findings of Kaitho et al. (1998a) (26.1% DM), El Hassan et al. (2000) (24.9% DM), Bonsi and Osuji (1997) (24.0% DM) and lower than the findings of Kaitho et al. (1998b) (30.4% DM). The fiber fraction (NDF, ADF and ADL) of *S. sesban* in the present study was lower than that reported by Tibebu (2005) who noted 39.9%, 29.9% and 8.0% DM, respectively. This might be because of the inclusion of thin and delicate branches which had probably had higher fiber content in Tibebu's findings contrary to the offering of sole *S. sesban* leaf in the current study. However, NDF levels of 55% was reported by Kaitho and Kariuki (1998) which is by far higher than the NDF content in the present study. The variation in the chemical composition of *S. sesban* leaf used in the present study from CP content used in the other studies might be due to the environmental conditions in which the plant grows.

Feed intake of experimental animals

Feed intake by the sheep depend on a number of factors including the breed, forage to concentrate ratio, level of digestible energy, initial body weight, body condition, and environmental temperature (Do Thi, 2001). Table 3 shows the mean daily DM and nutrient intake of experimental sheep during the feeding trial. The mean daily DM intake of hay for T1 was higher ($P<0.001$) than that of the supplemented groups. Among the supplemented sheep, DM intake of hay was significantly lower ($P<0.05$) in T2 as compared to T3, T4 and T5, and values for T3, T4 and T5 were similar ($P>0.05$). Greater intake of the hay by sheep in T1 is expectedly due to an effort of the animal to extract more nutrients by consuming more hay in the absence of a supplement. Similarly, greater intake of hay in un-supplemented animals has been reported previously (Mulu, 2005; Abebaw, 2007; Bimerew, 2008). On the other hand, less hay DM intake for T2 than other supplemented animals may be due to the high fiber content of the RB that might have limited intake of the hay.

Total DM intake was in the order of T5=T4=T3>T2>T1($P<0.05$). Variations in hay and/or slight variation in supplemental diets appeared to induce such result. Overall supplementation in this study resulted to greater DM intake as compared to the non-supplemented sheep. This is consistent with previous reports (Emebet, 2008; Wegene, 2008). The high fiber content as well as low CP content of RB resulted in lower total DM intake in animals supplemented with RB as compared to the sole *S. sesban* supplement.

Intake of DM as % BW was lowest for T5, intermediate for T4 and greater for the other three treatments that were similar among each other. This appears to be a result of differences in daily body weight (Table 8). Values for the total DM intake expressed by metabolic body weight ranged from 63-70 g DM $Kg^{-1}BW^{0.75}$. These values were within the ranges of 55-82 g $DMkg^{-1} BW^{0.75}$

Table 3. Daily dry matter and nutrient intake in Kaffa sheep fed native grass hay and supplemented with *Sesbania sesban* leaf, rice bran and their mixture.

Intake (g/day)	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Hay DM intake	526.23[a]	437.66[c]	445.01[b]	444.58[b]	447.29[b]	4.85	***
Supplement DM intake	-	261.42[b]	263.17[a]	263.27[a]	264.32[a]	0.83	***
Total DM intake	526.23[d]	699.08[c]	708.18[b]	707.86[b]	711.62[a]	4.91	***
DM intake (% BW)	3.25[a]	3.23[a]	3.24[a]	3.02[b]	2.83[c]	0.17	***
DM intake (g/ kg $W^{0.75}$)	65.21[bc]	69.76[a]	70[a]	66.51[b]	63.36[c]	3.95	***
Total OM intake	539.36[d]	710.2[c]	722.27[b]	724.88[b]	731.85[a]	4.83	***
Total CP intake	35.11[e]	54.23[d]	68.49[c]	92.83[b]	111.98[a]	0.03	***
Total NDF intake	450.39[e]	568.74[a]	539.81[b]	502.35[c]	469.48[d]	2.94	***
Total ADF intake	260.56[e]	377.08[a]	351.25[b]	321.26[c]	293.29[d]	1.04	***
Substitution rate	-	0.34[b]	0.30[b]	0.31[b]	0.29[a]	0.00	***

[a, b, c, d, e] means within a row having different superscripts are significantly different at *** = (p<0.001); ADF = acid detergent fiber; BW = body weight; CP = crude protein; NDF = neutral detergent fiber; OM = organic matter; SEM = standard error mean; SL = significant level, SS = *Sesbania sesban*; RB = rice bran; T1 = hay; T2 = hay *ad libitum* + 300 g RB DM/day; T3 = hay *ad libitum* + 100 g SS+200 g RB DM/day; T4 = hay *ad libitum* + 200 g SS+100 g RB DM/day; T5 = hay *ad libitum* + 300 g SS DM/day.

Table 4. Apparent digestibility coefficients of nutrients in Kaffa sheep fed native grass hay and supplemented with *Sesbania sesban* leaf, rice bran and their mixture.

Digestibility	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
DM	60d	66.6bc	65.8c	68.6a	67.8ab	2.10	***
OM	63.4c	69b	69.2b	72a	71.2a	1.14	***
CP	58.4b	80.2a	75.2a	86.2a	85.8a	1.56	***
NDF	64.4cd	69a	65.8bc	66.8b	63.8d	1.98	***
ADF	61.2	69.8	65.8	68	64	4.33	ns

[a, b, c] Means within a row not bearing a common superscript letter are significantly different; *** = (P <0.001), * = (P<0.05); ns = not significant; ADF = acid detergent fiber; CP = crude protein; DM = dry matter; NDF = neutral detergent fiber; OM = organic matter; SEM = standard error of mean; SL = significant level. T1 = hay; T2 = hay *ad libitum* + 300 g DM rice bran/d; T3 = hay *ad libitum* + 200 g rice bran+100 g DM *Sesbania sesban*/d; T4 = hay *ad libitum* + 100 g rice bran+200 g *Sesbania sesban* DM/d; T5 = hay *ad libitum* + 300 g DM *Sesbania sesban*/day.

reported by other studies (Bonsi et al., 1996; Mulat, 2006; Bimerew, 2008).

The CP intakes were significantly higher (P<0.05) in the order of T5>T4>T3>T2>T1, which could be attributed to variations in CP content of the supplements especially *S. sesban* as well as differences between treatments in DM intake. As the level of *S. sesban* increased, crude protein intake increased from 35 to 112 g/day. Contrary to the CP intake, total NDF and ADF intakes decreased with increasing *S. sesban* supplementation for the supplemented animals and was in the order of T2>T3>T4>T5>T1. This is obviously related to the high fiber content of RB in the supplemented treatments.

Apparent digestibility of DM and nutrients

The digestibility of a food is most accurately defined as the DM proportion not excreted in the feces, and therefore to be assumed absorbed by the body. Digestibility is influenced by breed, type and individuality of an animal, type of ration and level of feeding (Do Thi, 2001). Therefore, the digestibility coefficient can show different values. The DM and nutrient digestibility of Kaffa sheep fed hay and supplemented with *S. sesban* leaf, rice bran and their mixtures is shown in Table 4. The DM and OM digestibility was greater (p<0.05) for the supplemented than the non-supplemented sheep. Among

Table 5. Body weight parameters and feed conversion efficiency of Kaffa sheep fed native grass hay and supplemented with *Sesbania sesban*, rice bran and their mixture.

BW Parameters	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Initial BW (kg)	16.70	16.90	17	17.36	17.42	0.47	ns
Final BW (kg)	16.28^{d}	21.62^{c}	21.88^{c}	23.44^{b}	25.17^{a}	0.51	***
BW change (kg)	-0.42^{d}	4.72^{c}	4.88^{c}	6.08^{b}	7.75^{a}	0.02	***
ADG (g/d)	-4.67^{d}	52.44^{c}	54.22^{c}	67.56^{b}	86.11^{a}	2.73	***
FCE	-0.01^{d}	0.067^{c}	0.069^{c}	0.086^{b}	0.175^{a}	0.00	***

$^{a, b, c, d}$ letters in the same row having different superscripts are significantly different; ADG = average daily body weight gain; *** (P<0.001); SEM = standard error of mean; SL = significance level; T1 = hay; T2 = hay *ad libitum* + 300 g DM rice bran/d; T3 = hay *ad libitum* + 200 g rice bran+100 g DM *Sesbania sesban*/d; T4 = hay *ad libitum* + 100 g rice bran+200 g *Sesbania sesban* DM/d; T5 = hay *ad libitum* + 300 g DM Sesbania sesban leaf/day; FCE = Feed conversion efficiency (g ADG/g DM intake); BW = body weight.

the supplemented groups, DM digestibility was greater (p<0.05) for T4 than T2 and T3, and the values were similar (p>0.05) for T4 and T5. Digestibility of OM among the supplemented group was in the order of T5=T4>T3=T2. Nutritive value of certain feedstuffs or poor quality roughages can be enhanced by supplementation with protein and energy rich concentrate which is usually due to the alleviation of a nutrient deficiency (Ellis et al., 1988), which appeared to be the case in this study.

Digestibility of CP was in the order of T5 = T4 = T3 = T2>T1 (P < 0.05). This appeared to be not consistent with CP intake in this study (Table 6). Generally, supplementation enhances the CP digestibility of the total ration, which is in agreement with previous reports (Simret, 2005; Matiwos, 2007; Wondwosen, 2008) that noted increased CP digestibility with supplemental CP source as compared to non-supplemented animals. Digestibility of NDF was greater (p<0.05) for T2 than other treatments; the reason of which appears not to be apparent. On the other hand, digestibility of ADF was not affected by (p>0.05) treatment. Generally, the increase in dry matter and nutrient digestibility due to supplementation was apparent in this study similar to what has been reported previously (Getachew, 2005; Abebaw, 2007; Fente, 2007; Bimerew, 2008). This may be due to the creation of favorable environment for the proliferation of ruminal microbes that in turn would enhance ruminal digestion of nutrients (Ranjan, 1997; Macdonald et al., 2002).

Body weight change and feed conversion efficiency

The effect of supplementation of Kaffa sheep fed native grass hay with *S. sesban*, RB, and their mixtures on body weight change and average body weight gain data are presented in Table 4. Final BW, BW change, ADG and FCE were significantly affected (P<0.05) by treatment and had similar trend across treatments. Accordingly, all the mentioned parameters were in the order of T5>T4>T3 = T2>T1. As expected, animals in T1 had negative ADG, because of the low CP content of hay whereas there was a positive ADG for supplemented animals. As supplementation of *S. sesban* increased, it appeared that there was an increasing trend for ADG and FCE (Table 5).

The difference in ADG and/or FCE among treatments in this study is consistent with differences in intake and/or digestibility of DM and nutrients observed in this study. Based on DM and CP intake data (Table 3), percentages of CP for the consumed diet were 6.7, 7.7, 9.8, 13.8 and 15.7% for T1, T2, T3, T4 and T5. This suggests that the CP level for T1 was lower than the minimum requirement to satisfy the maintenance requirement of the animals (VanSoest, 1982), which justifies loss of body weight of animals in T1. On the other hand, RB used in this study appeared to be low in CP content and high in fiber. Consequently, the CP content of the consumed diet was only 7.7% for animals supplemented with sole RB. Despite the low CP and relatively high fiber of RB, animals in T2 had a good ADG and FCE even similar to that of T3 animals. The reason for this is difficult to explain but may be due to the efficient utilization of the CP and fiber in the rice bran, probably greater digestibility of the feed nutrients in the rice bran as compared to the hay.

The overall trends of body weight changes across the feeding trial period are presented in Figure 1. In the current study, there was no change in weight gain for the first 10 days. Then after a gradual increment of body weight was observed for the supplemented group of sheep, while the control group had shown a slight body weight loss which continued at a constant trend until the end of the feeding period.

Table 6. Carcass characteristics of Kaffa sheep fed native grass hay and supplemented with *Sesbania sesban*, rice bran and their mixtures.

Parameter	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
SW (kg)	16.74^{d}	21.55^{c}	21.85^{c}	23.3^{b}	25.11^{a}	0.36	***
Empty BW (Kg)	11.23^{d}	16^{c}	15.99^{c}	18.02^{b}	20.84^{a}	0.81	***
Hot CW(Kg)	5.55^{d}	8.17^{c}	10.6^{b}	11.17 ^{b}	12.4 ^{a}	0.26	***
Dressing percentage							
On SW basis	0.33^{c}	0.38^{b}	0.485^{a}	0.48^{a}	0.49^{a}	0.001	***
On empty BW basis	0.52^{b}	0.51^{b}	0.67^{a}	0.63^{a}	0.62^{a}	0.003	***
Rib eye area (cm^{2})	2.43^{d}	3.57^{c}	3.67^{c}	4.6^{b}	5.23^{a}	0.03	***

^{a,b,c,d} Means in the same row with different superscripts differ significantly; *** P < 0.001; SEM: standard error of mean; SL: significance level; T1 = hay *ad libitum*; T2 = hay *ad libitum* + 300 g DM rice bran; T3 = hay *ad libitum* + 100 g DM *Sesbania sesban* + 200 g DM rice bran; T4 = hay *ad libitum* + 100 g DM rice bran + 200 g DM *Sesbania sesban*; T5 = hay *ad libitum* + 300 g DM *Sesbania sesban* leaf, BW = body weight; SW=slaughter weight.

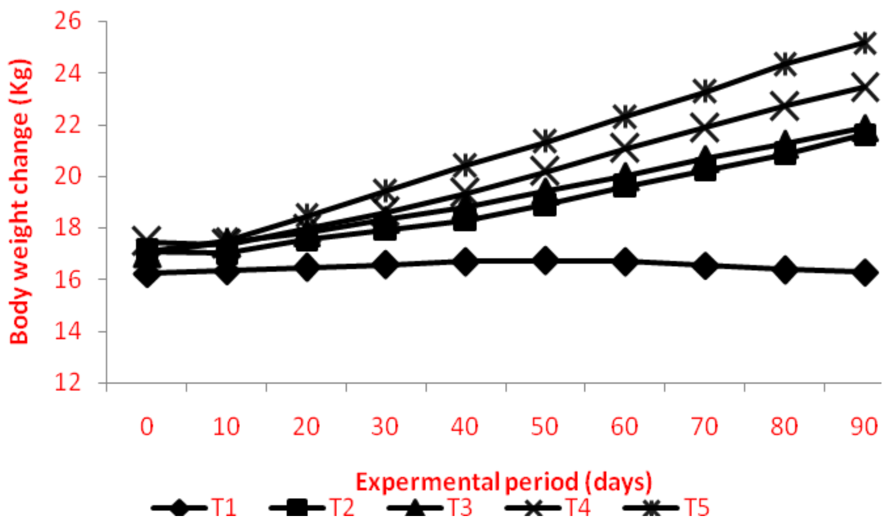

Figure 1. Trends in body weight changes across the experimental period for Kaffa sheep fed native grass hay and supplemented with *Sesbania sesban* leaf, rice bran and their mixture.
T1 = hay; T2 = hay *ad libitum* + 300 g DM rice bran/d; T3 = hay *ad libitum* + 200 g rice bran + 100 g DM *Sesbania sesban*; T4 = hay *ad libitum* + 100 g rice bran + 200 g *Sesbania sesban* DM; T5 = hay *ad libitum* + 300 g DM Sesbania sesban.

Supplementation in this study improved FCE consistent to previous supplementation study reports (Mulat, 2006; Abebaw, 2007). The improved feed conversion efficiency of the current result may presumably be due to higher nutrient concentration of the supplements and the consequent increase in body weight gain. Also, the current result is consistent with the work of Fluharty and McClure (1996) who indicated that lambs fed high protein ration had greater DM intakes, ADG, feed conversion efficiency and needed fewer days on feed to achieve high final weight than those fed diets with normal protein concentrates.

Carcass components

The results of carcass components of experimental sheep are given in Table 6. In the current study, all the main carcass parameters were better for the supplemented sheep than the control one. Similar trends in slaughter body weight, empty body weight, hot carcass weight, dressing percentage as a proportion of slaughter body weight and rib-eye muscle area with supplementation has been noted before (Ermias, 2008; Abebe, 2006). Among the supplemented sheep, slaughter and empty body weights were in the order of

Table 7. Edible offal components of Kaffa sheep fed native grass hay and supplemented with *Sesbania sesban* leaf, rice bran and their mixture.

ECO (g)	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Blood	605.42^{d}	658.33^{c}	749.53^{b}	750.95^{b}	895.63$^{\mathbf{a}}$	7.13	***
Kidney	47.17^{d}	68.83$^{\mathbf{a}}$	53.25^{c}	64.95^{b}	61.87^{b}	5.36	***
Heart	66.8e	91.95^{c}	79.13^{d}	106.45$^{\mathbf{a}}$	103.87^{b}	2.59	***
Liver+gall bladder	206.42^{d}	270^{c}	305.67^{b}	315.95$^{\mathbf{a}}$	315.63$^{\mathbf{a}}$	7.21	***
Small and large Intestine	463.05^{d}	539.08^{b}	518.38^{c}	599.45$^{\mathbf{a}}$	599.95$^{\mathbf{a}}$	2.91	***
Empty gut	1015.43^{d}	1198.86^{c}	1198.03^{c}	1455.95^{b}	1555.63$^{\mathbf{a}}$	6.16	***
Tongue	46.05^{c}	52.5^{b}	48.25^{c}	74.45$^{\mathbf{a}}$	75$^{\mathbf{a}}$	4.55	***
Tail	93.42^{d}	147.08^{b}	129.13^{c}	267.2$^{\mathbf{a}}$	267$^{\mathbf{a}}$	2.36	***
Testicles	126.42^{d}	268.33^{b}	241.51^{c}	265.95^{b}	315.62$^{\mathbf{a}}$	6.07	***
Intestinal fat	38.42^{d}	169.25^{c}	173.3^{b}	173.95^{b}	217$^{\mathbf{a}}$	5.83	***
Kidney fat	17.17^{d}	52.08^{c}	59.88^{b}	75.95$^{\mathbf{a}}$	76.75$^{\mathbf{a}}$	4.23	***
TECO (g)	2725.8^{d}	3527.98^{c}	3527.75^{c}	4151.2^{b}	4483.95$^{\mathbf{a}}$	74.13	***

^{a,b,c,d} Means in the same row with different superscripts differ significantly at P< 0.05; * P< 0.01; ** P< 0.001; *** ns: not significant; S.L: significant level; SEM: standard error of mean; TEOC: total edible offal component; T1 = hay *ad lib*; T2 = hay *ad lib* + 300 g DM rice bran; T3 = hay *adlib* + 200 g DM rice bran + 100 g DM *S. sesban*; T4 = hay *ad lib* + 100 g DM rice bran + 200 g DM *S. sesban*; T5 = hay *ad lib* + 300 g DM *S. sesban* leaf.

T5>T4>T3=T2, while hot carcass weight was in the order of T5>T4=T3>T2. Generally, *S. sesban* appeared to have greater effect on carcass weight than rice bran which is consistent to the ADG and FCE noted in this study.

Carcass offal components of Kaffa sheep fed hay basal diet and supplemented with *S. sesban*, rice bran and their mixture are given in Tables 7 and 8. In Ethiopia, carcass offal components are categorized into edible and non-edible based on tradition and culture of the people in the area (Abebe, 2006). In the present finding, all carcass offal components were higher (P<0.001) for supplemented sheep than the control except for gut contents which was greater for T1 than T2, T4 and T5. Kidney and intestinal fat were significantly (P<0.001) higher for supplemented sheep than control. This may be due to the supplement feed with more energy content promoting higher internal fat deposition, whereas animals fed on hay alone did not get adequate energy even to satisfy their maintenance requirements.

Non-edible offal components of Kaffa sheep fed a basal diet of grass hay and supplemented with *S. sesban*, rice bran and their mixtures are given in Table 8. Skin and feet weight of the control treatment was lower (P<0.001) than the supplemented treatments. Head without tongue, lung with trachea, spleen, and TNEOC of the T1 were also lower (P<0.001) than the supplemented treatments. However, the gut fill in the present findings was higher in the control sheep than the supplemented ones. Sendros et al. (1998) also reported higher gut content in non-supplemented lambs than in the supplemented ones, similar to the result in this study. Animals fed hay alone consumed more roughage in order to maintain their energy requirement, which increased the amount of digesta in the gut. According to the views of Van Soest (1994) and Pond et al. (1995), non-supplemented animals fill their gut with less digestible roughage which would be retained in the gut for a long time to be degraded by rumen microorganisms.

SUMMARY AND CONCLUSIONS

Inadequate nutrition is one of the major constraints limiting livestock production in Ethiopia. Especially in the current study area, the land available for natural grazing and forage production decreased due to the high demand of cash crop and cropland to produce food for humans. Thus, the use of other alternative and relatively cheap feed sources such as agro-industrial by-products and other browse plants should be investigated to alleviate livestock feed shortage. Among potential agro-industrial by-products available for livestock in the present study area is rice bran. Browse plant such as *S. sesban* is intensively cultivated for its best use as a shade for coffee plantation. Rice production is currently booming in the study area. While the rice grain is a helping hand for food security, the by-product of rice milling, rice bran, is also expected to make better the feed shortage as long as investigations are done on its feeding value with animal performance under local conditions.

This study was conducted at Mizan Agricultural Technical Vocational Education and Training College, Mizan Teferi, with the objective of investigating the effect of supplementation of *S. sesban*, rice bran and their mixtures on feed intake, digestibility, body weight performance and carcass parameters of kaffa sheep fed native grass hay basal diet. The study comprised twenty-

Table 8. Non-edible offal components of Kaffa sheep fed native grass hay and supplemented with *Sesbania sesban* leaf, rice bran and their mixture.

NEOC (g)	Treatments						
	T1	T2	T3	T4	T5	SEM	SL
Head without tongue	1005.5d	1344.13a	1279.05c	1315.63b	1318.63b	13.85	***
Skin	1168.37d	1771.75c	2014.25b	2251.75a	2245.87a	39.49	***
Feet	98.12d	153.13b	166.55a	168a	127.57c	9.39	***
Penis	35.73	36.57	35.87	36.75	34.52	2.85	ns
Lung with trachea	262.62c	308.87b	309.38b	411.25a	416.37a	19.33	***
Spleen	33.13c	63.37b	76.2a	78.37a	82.5a	20.66	***
Gut fill	5006.25a	4516.25b	4991.25a	4270c	4288.75c	201.67	***
TNEOC	7609.73d	8194.08c	8872.55a	8531.75b	8514.22b	110.57	***

[a,b,c,d] Means in the same row with different superscripts differ significantly at P< 0.05; * P< 0.01; ** P< 0.001; *** ns: not significant; S.L: significant level; SEM: standard error of mean; TNEOC: total non edible offal component; T1 = hay *ad lib*; T2 = hay *ad lib* + 300 g DM rice bran; T3 = hay *adlib* + 200 g DM rice bran + 100 g DM *Sesbania sesban*; T4 = hay *ad lib* + 100 g DM rice bran + 200 g DM *Sesbania sesban*; T5 = hay *ad lib* + 300 g DM *Sesbania sesban*.

five intact male sheep with average body weight of 17.08 ± 0.68 (mean ± SD) kg for both the 90 days of feeding and 7 days of digestibility trials. Experimental sheep were arranged in a randomized complete block design based on their initial body weights. The supplement was *S. sesban* and rice bran (RB). The five treatment diets consisting of grass hay alone *ad libitum* (T1), grass hay *ad libitum* + 300 g RB (T2), grass hay *ad libitum* + 200 g RB + 100 g *S. sesban* (T3), grass hay *ad libitum* + 100 g RB + 200 g *S. sesban* (T4), and grass hay *ad libitum* + 300 g *S. sesban* (T5) on DM basis were randomly assigned to each sheep within a block. Daily feed offer, feed refusals, and feces voided were recorded and the required samples were collected, while body weight change of sheep during the feeding trial was recorded at ten days interval. Chemical composition of feeds offer, refusal and fecal samples were analyzed for DM, OM, CP, NDF, ash, and ADL at Holeta Agricultural Research Center Animal Nutrition Laboratory to determine the nutritive value and digestibility of feeds, and in turn its impact on body weight change.

The results of chemical analysis of feed showed that basal diet (grass hay) used in the current study had relatively low amount of CP (6.08%) indicating that the grass had relatively low capability to supply CP requirements for body maintenance of growing sheep, as a result body weight loss was observed in the control sheep. Rice bran, one of the concentrate mixture supplement used in the current study had a relatively low CP (8.3%) and higher NDF (64.07%) and ADF (52.91%). The *S. sesban* used in the current study had 91.53% OM, 27.53% CP, 28.78% NDF, and 23.65% ADF.

Hay DM intake was highest for T1 (526 g/day) than the supplemented treatments that ranged from 437-447 g/day. Total DM intake followed the reverse trend and was in the order of T1<T2<T3=T4=T5 (526, 699, 708, 708, and 712 g/day, respectively). Total CP intake was 35, 54, 69, 98 and 112 g/day and was lowest for T1 and increased with increasing supplemental level of *S. sesban*. Supplementation improved the digestibility of organic matter and CP of the total ration. Digestibility of CP was 58, 80, 76, 87 and 86% for T1, T2, T3, T4, and T5, respectively and was lower for T1 but similar among the supplemented treatments.

Average daily body weight gain (ADG) was -5, 52, 54, 68 and 86 g/day and was in the order of T1<T2=T3<T4<T5 (P<0.05). Feed conversion efficiency also followed a similar trend like that of ADG. Hot carcass weight was in the order of T1<T2<T3=T4<T5 (5.6, 8.2, 10.6, 11.2 and 12.4 kg, respectively). Dressing percentage was generally lower for the non-supplemented than the supplemented sheep. The total edible and non-edible offal components were also greater for the supplemented sheep than the non-supplemented ones.

SCOPE FOR FUTURE WORK

In order to guarantee the importance of the supplementation at producers' level, undertaking on-farm trials using the treatment used in this study is worthwhile.

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