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Effect of supplementing Tsara (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*) leaves and concentrate mixture on carcass characteristics of Begait sheep fed hay as a basal diet

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The study was conducted with the objective of determining the carcass characteristics of Begait sheep fed hay basal diet and supplemented with different levels of Tsara (*Pterocarpus lucens*) leaves, pigeon pea (*Cajanus cajan*) leaves and concentrate mixture on iso-nitrogenous basis to supply 66.60 g/day crude protein on dry matter (DM) basis. Twenty five yearling male Begait sheep with initial body weight (BW) of 24.2±1.1 kg (Mean±SD) were used in a Randomized Complete Block Design (RCBD) based on their initial BW. The hay was fed on *ad libitum* basis to all sheep. Treatments were hay alone (T1) or supplemented with 400 g DM Tsara leaf (T2), 320 g DM pigeon pea leaf (T3), 360 g DM mixtures of Tsara and pigeon pea leaves (T4) and 300 g DM concentrate mixture (75% rice bran and 25% sesame seed cake; T5). The study consisted of 90 days feeding trial and carcass evaluation at the end. The average final body weight was 32.2, 31.6, 27.76, 28 and 26.88 kg (standard error of mean, SEM = 0.38) in the order of T5 > T2 > T3 = T4 > T1. Hot carcass weight of 14.9, 14.3, 11.3, 11.2 and 9.5 (SEM = 0.33) followed almost a similar trend to that of the final body weight except that values for T2 and T5 were similar. In conclusion, based on the biological performance results supplementation of concentrate mixture (T5) and Tsara (T2) induced a comparable response and were better than the supplemental regimes that contained pigeon pea and are therefore recommended.

Key words: Begait sheep, dressing percentage, edible offal components, empty body weight hot carcass weight, non-edible offal components, rib eye muscle area, slaughter weight.

INTRODUCTION

Small ruminants occupy an important economic and ecological niche in agricultural systems throughout the developing countries (Devendra, 2005). According to FAO (2009), in Ethiopia, small ruminants (sheep and

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goats) are important components of the livestock sub-sector. Therefore, sheep and goats are among the major economically important livestock, playing an important role in the livelihood of resource poor farmers (Adane and Girma, 2008). They contribute a quarter of the domestic meat consumption, about half of the domestic wool requirements, about 40% of fresh skins and 92% of the value of semi processed skin and hide export trade (FAO, 2004). There is also a growing export market for sheep and goat meat in the Middle Eastern Gulf States and some African countries. At optimum offtake rates, Ethiopia can export 700,000 sheep and 2 million goats annually, and at the same time supply 1,078,000 sheep and 1,128,000 goats for the domestic market or consumption (Adane and Girma, 2008).

The current annual offtake rate of sheep and goats is however, only 33 and 35%, respectively (Adane and Girma, 2008; FAO, 2001). The average carcass weight of Ethiopian sheep and goats is 10 kg, which is the second lowest in sub Saharan Africa (FAO, 2001). On the other hand, the increased domestic and international demand for Ethiopian sheep and goats has established them as important sources of Inland Revenue as well as foreign currency. This increased demand also creates an opportunity to substantially improve food security of the population and alleviate poverty (EPA, 2002; Adane and Girma, 2008; FAO, 2009). However, currently the majority of indigenous sheep marketed have low live weight resulting in poor dressing percentage and carcass (Ameha et al., 2011). This is mostly associated with the deficiency of dietary energy and protein levels which can influence the quality and quantity of carcass (Bellof and Pallauf, 2004).

Inadequate nutrition is one of the complex factors that generally affect livestock productivity in the tropical countries. Total weight gained by ruminants during the rainy season is lost in the dry season due to feed scarcity; this feed fluctuation affects growth and carcass traits of small ruminants (Woods et al., 1994).

The available feed resources in Tigray region of Ethiopia are mainly crop residues, natural grazing and hay from natural pasture; these feed resources are characterized by their low crude protein content; which is below the critical requirement of ruminant production, 7% of crude protein and this level of crude protein reduces feed intake and dry matter digestibility of the animals (Devendra and McLeroy, 1982). On the other hand, the western and north western zones of Tigray region, northern Ethiopia, are endowed with a diversified livestock resources and wider rangelands with dominant browse species coverage (CSA, 2014). Among these resources, Begait sheep is one of the indigenous small ruminant breeds reared in the area; which is a sub type of north Sudan desert sheep and is characterized as tall, long tailed, consume large amounts of feed, muscular body size, dual purpose breeds (for milk and meat) and known for its good productive and reproductive performance (FAO, 1991; Amare et al., 2012). In addition, Tsara (*Pterocarpus lucens*), pigeon pea (*Cajuns cajan*) and concentrate feeds like rice bran, sesame seed cake are available and commonly used by the farmers to feed their animals but not on a scientific basis.

However, different authors revealed that supplementation of sheep with forage legumes and concentrate based diets shows great improvements on the carcass performance of different Ethiopian indigenous sheep breeds (Hirut, 2008; Gebretinsae, 2011; Gebreslasie, 2012).

In addition, Hunegnaw and Brehan (2016) reported that the significantly higher results of valuable carcass traits when Wollo sheep fed grass hay and supplemented with legume forage leaf meal (pigeon pea, cow pea and lablab) as compared to sheep that supplemented with concentrate feed. Therefore, the objective of this study was to determine the carcass characteristics of Begait sheep supplemented with different levels of Tsara (*P. lucens*) and pigeon pea (*C. cajan*) leaves and concentrate mixture.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Shire-Maitsebri Agricultural Research Center (SMARC), Tselemti Woreda, North Western zone of Tigray Regional State, Ethiopia. The Woreda is located 405 km far to the North West of Mekelle, the capital of the region, 85 km far to the South of Shire along the Gondar way and 1172 km far from Addis Ababa, capital of Ethiopia. Elevation ranges from 800 to 2870 m above sea level (masl). Its geographical location is 13° 05’ N latitude and 38° 08’ E longitude. The average annual rainfall in the area is 758 to 1100 mm, with mono modal pattern falling from June to September. The annual temperature ranges from 16 to 38°C.

Experimental animals and their management

Begait sheep breed was used for the experiment. Twenty five yearling intact local male sheep with average live body weight of 24.2±1.1 kg (mean±SD) were purchased from Shiraro local market. The age of the animals was determined by dentition and by asking information from the owners. The sheep were quarantined for 21 days in the experimental area. During this quarantine period, they were dewormed and sprayed against internal and external parasites, respectively, and vaccinated against ovine pasteruolosis and anthrax.

Experimental design and dietary treatments

Randomized Complete Block Design (RCBD) having five blocks and treatments (five sheep per treatment) was used for the study. The experimental sheep were blocked into five blocks of five animals each based on their initial body weight and placed in an individual pen. Sheep within a block were randomly assigned to one of the five dietary treatments which were hay alone (T1) and supplementation with 400 g DM Tsara leaves (T2), supplementation with 320 g DM pigeon pea leaves (T3), supplementation with 360 g DM mixtures of Tsara and pigeon pea leaves (T4) and supplementation with 300 g DM concentrate mixture (T5).

Table 1. Layout of the experimental treatment.

Treatment	Basal diet natural pasture hay	Supplement feeds (g/day)		
		Concentrate mixture	*Tsara* Leaf	Pigeon pea leaf
T_1	*Ad libitum*	0	0	0
T_2	*Ad libitum*	0	400	0
T_3	*Ad libitum*	0	0	320
T_4	*Ad libitum*	0	200	160
T_5	*Ad libitum*	300	0	0

Concentrate mixture = 75% rice bran: 25% sesame seed cake.

Consequently, supplements for the other treatments were arranged on iso-nitrogenous basis and samples of the feed supplements were analyzed for DM and CP content before the execution of the experiment and the results of analysis were used to make the supplemental diets on iso-nitrogenous basis.

The DM and CP contents obtained from laboratory analysis were 95 and 16.67% for Tsara; 95.5 and 20.74% for pigeon pea, 96 and 16.41% for rice bran and 95.5 and 39.55% for sesame seed cake on DM basis, respectively. According to the laboratory result, the 300 g DM concentrate mixture (75% rice bran and 25% sesame seed cake) supplied 66.60 g/day CP on dry matter basis. To supply the same amount of CP from the other feed treatments on iso-nitrogenous basis 400 g DM *Tsara*, 320 g DM pigeon pea and 360 g DM (200 g DM *Tsara* + 160 g DM pigeon pea) leaves were required for the experimental sheep in T2, T3 and T4, respectively (Table 1). Therefore, treatments were no supplentation to a hay diet fed *ad libitum* (T1) or hay supplementation with Tsara leaf (T2), pigeon pea leaf (T3), 50:50 combination of *Tsara* and pigeon pea (T4), and concentrate mixture (T5). Drinking water and common salt block were freely available to all experimental sheep throughout the experimental period.

Carcass parameters measurement

At the end of the digestibility trial, all sheep were allowed to fast overnight before slaughtering, weighed to determine slaughter weight (SW) and then slaughtered by severing the jugular vein and carotid arteries with a knife for carcass evaluation. On slaughtering, the blood was collected in a container, weighed and recorded. The skin was carefully flayed to avoid attachment of fat and muscle tissues to the skin and then weighed without feet and the feet below fetlock joints was weighed and recorded separately. The entire gastrointestinal tract (GIT) except esophagus was removed with its contents and weighed with and without its contents and the weight of the gut fill (content) was measured by difference.

The non-edible offal contents (NEOC), the head without tongue, skin, feet, spleen, pancreas, genital organ, lung and trachea, gall bladder, and the gut contents were weighed separately. Similarly, the edible offal components (EOC), namely, the liver, heart, kidney, stomach (reticulum, rumen, omasum, and abomasum), small and large intestine, blood, abdominal and kidney fat, testes, and tongue was recorded and weighed. The total non-edible offal contents (TNEOC) and total edible offal components (TEOC) were computed as the sum of all NEOC and EOC, respectively. An empty body weight (EBW) was determined by subtracting the weight of gut contents from slaughter weight. Hot carcass weight (HCW) was computed by excluding the contents of thoracic, abdominal and pelvic cavity, head, skin, and the limbs. Dressing percentage (DP) was calculated as a ratio of hot carcass weight to slaughter weight and hot carcass weight to empty body weight.

The rib-eye muscle area (REMA) which indicates the amount of valuable muscle in the carcass was allowed to chill for 12 h in a refrigerator for proper cutting. The cross sectional area of rib-eye muscle at the 11 and 12th ribs of each slaughtered sheep was traced from each side on transparency paper after cutting perpendicular to the backbone and measured by tracing the transparency paper on graph papers. The average measure of the left and right REMA was taken.

Statistical analysis

Data obtained from the study were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (SAS, 2008) version 9.2. The differences among treatment means was tested using Tukeys' studentized range (HSD) test.

The model used for data analysis was:

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

where Y_{ij} = response variable, μ = overall mean, Ti = treatment effect, B_j = block effect, and ε_{ij} = random error.

RESULTS AND DISCUSSION

Carcass characteristics of Begait sheep

Slaughter weight, empty body weight, hot carcass weight and dressing percentage on slaughter weight basis took a similar trend as presented in Table 2. Despite a similar slaughter weight of the non-supplemented sheep with T3 and T4 ($P>0.05$), empty body weight was the least for the non-supplemented sheep indicating for greater gut fill in T1 to account for part of the weight gain that make the control treatment to have similar final body weight with two of the supplemented treatments. Hot carcass weight and dressing percentage on slaughter weight basis took a similar trend like that of empty body weight and was in the order of T5 = T2 > T3 = T4 > T1. Therefore, Tsara leaf supplementation induced similar carcass yield and dressing percentage as compared to supplemental concentrate in the current study indicating the comparable feeding value of the fodder and concentrate mixture.

Table 2. Carcass characteristics of Begait sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Carcass characteristic	Treatment feeds					SEM	SL
	T_1	T_2	T_3	T_4	T_5		
Initial body weight (kg)	24.52	24.76	23.76	23.96	23.84	0.41	ns
Final body weight (kg)	27.28^{b}	32.44^{a}	28.4^{b}	28.8^{b}	33.44^{a}	0.38	***
SW (kg)	26.88^{b}	31.60^{a}	27.76^{b}	28.00^{b}	32.28^{a}	0.49	***
EBW (kg)	17.80^{c}	24.06^{a}	19.86^{b}	19.829^{b}	24.92^{a}	0.44	***
HCW (kg)	9.49^{c}	14.31^{a}	11.29^{b}	11.24^{b}	14.90^{a}	0.33	***
Dressing percentage							
SW basis (%)	35.28^{c}	45.468^{a}	40.856^{b}	40.138^{b}	46.26^{a}	0.97	***
EBW basis (%)	53.28^{b}	59.54^{a}	57.24^{ab}	56.65^{ab}	59.86^{a}	1.14	**
REMA (cm^2)	8.48^{d}	10.91^{b}	9.78^{c}	9.05^{cd}	13.38^{a}	0.25	***

$^{a-d}$Mean values in a row having different superscripts differ significantly; ns = not significant; ** = significant at $P < 0.01$; SW = slaughter weight; EBW = empty body weight; HCW = hot carcass weight; REMA = rib-eye muscle area; T_1 = Hay *ad libitum*; T_2 = T_1 + 400 g DM/day *Tsara*; T_3 = T_1 + 320 g DM/day pigeon pea; T_4 = T_1 + 360 g DM/day *Tsara* + pigeon pea; T_5 = T_1 + 300 g DM/day Concentrate mixture.

Conversely, Hunegnaw and berhan (2016) reported significantly higher carcass yield and dressing percentage of Wollo sheep when fed grass hay and supplemented with legume forage leaf meal as compared to those that supplemented with concentrate. This might be due to the fact that supplementation induced higher total dry matter intake and digestibility of nutrients, consequently, this leads to greater nutrient availability that promote weight gain and tissue development (Mushi et al., 2009). In addition, Pralomokarn et al. (1995) indicated that carcass characteristics of animals increased as total dry matter and nutrient intake increased.

Dressing percentage on slaughter weight basis ranges from 35 to 46% in this study, which was comparable with the results of 32 to 44% for *Farta* sheep, local sheep and *Horro* rams reported by different studies (Zemicael and Solomon, 2009; Aschalew and Getachew, 2013; Chala et al., 2014). On the other hand, lower results for Tigray Highland sheep (Micheale and Yaynshet, 2014) and higher values local sheep, African dwarf sheep and growing Najidi lambs of Saudi Arabia (AL-Saiday et al., 2010; Fasae et al., 2011; Hagos, 2014) for dressing percentage as compared to that obtained in the current study has been reported.

The rib eye muscle area was in the order of T5 > T2 > T3 > T1, while values for T4 was similar with T3 and T1. The values for REMA which is an indicator of muscling and lean meat production in the current study was in line with the findings of Gebreslassie (2012), higher than the findings reported by weldegebriel et al. (2014), Gebretnsae (2011), Hagos (2011), and Hagos (2014) and was lower than the findings reported by Mulu (2005) for different breeds of sheep.

Supplementation had a positive effect on the total edible offals as compared to the control diet, and value were in the order of T2 > T5 > T3 > T4 > T1 (Table 3). The average head, heart, testes, liver with bile, internal fat, reticulo-rumen and omaso-abomasum weight in the control diet in this study was significantly lower ($P<0.001$) than the supplemented groups. Increments in total edible offal associated with supplementation has also been reported before (Hirut, 2008; Gebretnsae, 2011; Gebreslassie, 2012) for Hararghe highland sheep, Tigray highland sheep and Tigray local sheep. Liver weight was higher in the supplemented than non-supplemented sheep, possibly due to glycogen deposition as an energy reserve. Similarly, the higher weights of reticulo-rumen, omaso-abomasum and large and small intestine in the supplemented Begait sheep in this study might be in agreement with the fact reported by Burrin et al. (1990) that the level of feed intake changes the relative proportion of visceral organs to body mass.

The non-edible offal components were all variable among treatments ($P < 0.05$), although there was lack of apparent trend (Table 4). One obvious trend is the high gut content in T1 which was statistically similar with T3 and T4. This observation is consistent with the greater hay intake in T1 which is less digestible in the non-supplemented sheep, and the relatively lower digestibility of the diet in T3 and T4 probably associated with the greater CT content of pigeon pea that might have deterred ruminal digestibility of nutrients and increased ruminal retention time (Bonsi et al., 1995). Total non-edible offal components were, however similar among treatments.

Conclusion

Based on the biological performance results, supplementation of concentrate mixture (T5) and Tsara (P. lucens) leaf (T2) induced a comparable response on

Table 3. Edible offal components of Begait sheep fed hay and supplemented with *Tsara* (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Edible offal	Treatments					SEM	SL
	T_1	T_2	T_3	T_4	T_5		
Head (g)	1019^{e}	1347^{a}	1223^{c}	1218^{c}	1250^{b}	1.47	***
Blood (g)	1122^{c}	1234^{b}	1040^{d}	1034^{d}	1281^{a}	2.17	***
Tongue (g)	94.90^{a}	77.80^{c}	71.30^{d}	87.70^{b}	84.65^{b}	0.90	***
Heart (g)	102.41^{e}	129.5^{b}	124.8^{c}	113.74^{d}	140.2^{a}	0.54	***
Kidney (g)	72.05^{c}	85.75^{a}	68.15^{d}	72.55^{c}	78.8^{b}	0.46	***
Testes (g)	197.1^{d}	302.46^{b}	258.90^{c}	298.70^{c}	421.70^{a}	1.16	***
Liver + Bile (g)	310^{e}	383.6^{a}	360.5^{c}	333.4^{d}	371.40^{b}	0.58	***
Internal fat (g)	173^{e}	376.40^{a}	229.60^{c}	185.30^{d}	358.66^{b}	0.75	***
Ret-Rum (g)	556.00^{e}	775.82^{a}	608.10^{d}	617.30^{c}	673.20^{b}	1.37	***
Oma-Abo (g)	214.90^{d}	240.20^{b}	221.00^{c}	215.80^{d}	262.20^{a}	0.98	***
SI and LI (g)	687.70^{d}	924.30^{a}	735.00^{c}	647.80^{e}	891.00^{b}	1.03	***
TEOs (kg)	4.55^{e}	5.88^{a}	4.94^{c}	4.83^{d}	5.82^{b}	0.005	***

$^{a-e}$Mean values in a row having different superscripts differ significantly; ** = significant at P < 0.01; *** = significant at P < 0.001; Ret-Rum = reticulo-rumen; Oma-Abo = Omasum and Abomasum; TEOs = total edible offals; SW = slaughter weight; T_1 = Hay *ad libitum*; T_2 = T_1 + 400 g DM/day *Tsara*; T_3 = T_1+320 g DM/day pigeon pea; T_4 = T_1+360 g DM/day *Tsara* + pigeon pea; T_5 = T_1+300 g DM/day Concentrate mixture.

Table 4. Non-edible offal components of Begait sheep fed hay and supplemented with Tsara (*Pterocarpus lucens*), pigeon pea (*Cajanes cajan*), mixture of *Tsara* and pigeon pea leaves, and concentrate mixture.

Non edible offal	Treatment feeds					SEM	SL
	T_1	T_2	T_3	T_4	T_5		
Skin (g)	2219^{e}	2522^{b}	2317^{d}	2406^{c}	2621^{a}	0.91	***
Penis and penis fat (g)	69^{d}	102.8^{a}	71.3^{c}	67.8^{d}	81.3^{b}	0.45	***
Feet (g)	673.2^{d}	762.9^{b}	638.9^{e}	702.4^{bc}	839.6^{a}	0.75	***
LTE (g)	420.6^{d}	469.2^{a}	393.7^{e}	440.4^{c}	451^{b}	1.11	***
Spleen (g)	71^{cd}	104.7^{b}	57.4^{d}	81.4^{c}	144.6^{a}	3.38	***
Pancreas(g)	62^{b}	70.6^{a}	67^{ab}	46.7^{c}	39.72^{d}	1.52	***
Bladder (g)	25.6^{b}	29.5^{a}	18.3^{c}	14.9^{c}	30.3^{a}	0.39	***
Gut content (kg)	9.3^{a}	7.35^{b}	7.97^{ab}	8.17^{ab}	7.36^{b}	0.40	**
TNEOs (kg)	12.84	11.41	11.53	11.93	11.56	0.40	ns

$^{a-d}$Mean values in a row having different superscripts differ significantly; ns = not significant; ** = significant at P < 0.01; *** = significant at P < 0.001; LTE = lung + trachea + esophagus; TNEOs = total non-edible offals; SW = slaughter weight; T_1 = Hay *ad libitum*; T_2 = T_1+ 400 g DM/day *Tsara*; T_3 = T_1+ 320 g DM/day pigeon pea; T_4 = T_1+ 360 g DM/day *Tsara* + pigeon pea; T_5 = T_1+ 300 gDM/day Concentrate mixture.

the valuable carcass parameters and were better than the supplemental regimes that contained pigeon pea and are therefore recommended for Begait sheep reared by small holder farmers and investors.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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