Trop Anim Health Prod (2008) 40:553–560
DOI 10.1007/s11250-008-9133-6

ORIGINAL PAPER

Bodyweight and carcass characteristics of somali goats fed hay supplemented with graded levels of peanut cake and wheat bran mixture

Solomon Melaku · Simret Betsha

Accepted: 21 January 2008 / Published online: 7 February 2008
© Springer Science + Business Media B.V. 2008

Abstract The experiment was conducted for ninety days of feeding trial at Haramaya University, Ethiopia using twenty four yearling male Somali goats weighing 20.4±2.02 (mean±SD) with the objectives to evaluate the effect of supplementation of peanut cake and wheat bran mixture (3:1) on body weight (BW) gain and carcass characteristics of Somali goats. The experiment was arranged with six blocks and four treatments in a randomized complete block design. The treatments were *ad libitum* feeding of hay (T1, control) and supplementation with 200 g (T2), 300 g (T3) and 400 g (T4) peanut cake and wheat bran mixture on dry matter (DM) basis. Supplementation reduced ($P<0.001$) hay DM intake, but increased ($P<0.001$) total DM intake at 300 g DM (T3) and 400 g DM (T4) level of supplementation compared to the control treatment. Daily BW gain, final BW, empty BW, hot carcass weight and dressing percent were higher ($P<0.001$) in the supplemented treatments. Goats on the medium (T3) level of supplementation had significantly heavier ($P<0.001$) liver and more muscle deposition, whereas those on hay alone (T1) exhibited heavier bone, head as well as gut contents ($P<0.05$). It was concluded that supplementation of Somali goats with the different levels of peanut cake and wheat bran mixture promoted BW gain, dressing percentage and increased the proportion of edible offals. Similarity between the different levels of supplementation used in this study with regard to BW and carcass characteristics favours the use of the low (T2) or medium (T3) level than the high (T4) level of supplementation.

Keywords Carcass parameters · Body weight · Peanut cake · Somali goats · Supplementation · Wheat bran

Abbreviations

BW	body weight
DM	dry matter
TEOC	total edible offal component
TNEOC	total non-edible offal component
TUP	total usable product

Introduction

The potential of several tropical goat breeds for meat production has not been exhaustively explored. The major factor that compromises the meat production of tropical goats is poor nutrition due to the low nutrient content of commonly available animal feeds. One

S. Melaku (✉)
Haramaya University,
P.O. Box 138, Dire Dawa, Ethiopia
e-mail: solmelay@yahoo.com

S. Betsha
Hawassa University,
P.O. Box 5, Hawassa, Ethiopia

strategy to improving the poor nutritional status of goats is by supplementation with energy and/ or protein sources. In this regard, Ott et al. (2004) demonstrated that supplementation of lambs with high levels of peanut cake promoted higher daily body weight (BW) gain and final BW than supplementation at low levels. Supplementation of does with a mixture of peanut cake and wheat bran at a proportion of 3:1 resulted in higher daily BW gain of kids than supplementation with only wheat bran or a higher proportion of wheat bran in the mixture (Berhanu 1998). Moreover, higher inclusion of peanut cake at 3:1 ratio in the supplement improved most of the performance parameters of late pregnant and lactating goats (Berhanu 1998). Therefore, this study was conducted to assess the effects of supplementation with graded levels of peanut cake and wheat bran mixed at the ratio of 3:1 on BW gain, edible and non-edible carcass components of Somali goats.

Materials and methods

Study area

The experiment was conducted at Haramaya University, which is located at an altitude of 1980 meters above sea level, and at 9° 26′ N latitude and 42° 3′ E longitude. The mean annual rainfall is 780 mm, and the mean annual maximum and minimum temperatures are 23.4°C and 8.25°C, respectively (AUA 1998).

Management of animals and experimental design

Twenty four yearling male Somali goats with initial BW of 20.4±2.02 (mean±SD) and housed in individual pens were used in a randomized complete block design. The experimental goats were grouped into six blocks with similar BW and one from each block was assigned at random to a treatment group. The treatments consisted of *ad libitum* feeding of chopped grass hay (T1, control) or *ad libitum* feeding of chopped grass hay and daily supplementation with 200 (T2), 300 (T3) and 400 g (T4) peanut cake and wheat bran mixture at 3:1 ratio. The supplements were offered in two equal portions at 8:00 h and 16:00 h daily, and the experimental goats had free access to mineral blocks and water. Feed intake was recorded daily for the 90 days of feeding trial and BW was measured weekly after overnight fasting. The grass hay contained 89.4% organic matter (OM), 6.6% crude protein (CP), 74.3% neutral detergent fiber (NDF) and the peanut cake–wheat bran mixture contained 94.3% OM, 41.6% CP and 26.8% NDF.

Determination of carcass components

At the end of the 90 days feeding trial, the goats were fasted overnight, weighed and slaughtered. The different components of the carcass were separated, weighed and recorded for each goat. The carcass was split into two halves and weighed separately. The rib eye muscle area was traced between the tenth and eleventh rib of the left half carcass and the area was measured with planimeter. The left side of the carcass was dissected into lean, fat, bone and weighed. The empty BW was calculated as slaughter weight less gut content. Dressing percent was calculated as proportion of hot carcass weight to slaughter weight and/ or empty BW. Percent of total edible offal component (TEOC) was calculated as the sum of blood, lung, trachea, heart, liver, spleen, empty gut, kidney and internal fat (mesenteric, pelvic and kidney) weight to slaughter weight. Percent of total non-edible offal component (TNEOC) was calculated as the sum of head, skin, genital organs, gall bladder and gut fill weight to slaughter weight. Percent of total usable product (TUP) was estimated as the sum of dressing percentage and percent TEOC.

Data analysis

Experimental data were subjected to the analysis of variance using the computer software MSTAT-C. Treatment means were separated by least significant difference test. The correlation between lean meat and rib eye area were determined using SPSS computer software. The model for a randomized complete block design given below was used for assessing the experimental data.

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij},$$

where μ is the overall mean, α_i is the i^{th} treatment effect, β^j is the j^{th} block effect, and e_{ij} is the random error associated with Y_{ij}.

Table 1 Daily feed intake and live weight parameters of Somali goats fed hay supplemented with graded levels of peanut cake and wheat bran mixture (3:1)

Feed intake (g/kgW$^{.75}$)	T1 (Control)	T2	T3	T4	SL	SEM
Hay	56.34^{a}	41.31^{b}	40.71^{b}	40.46^{b}	***	0.95
Supplement DMI	–	17.33^{c}	25.95^{b}	31.70^{a}	***	0.69
Total DMI	56.34^{c}	58.65^{c}	66.66^{b}	72.16^{a}	***	1.25
CPI (hay)	3.94^{a}	3.15^{b}	3.15^{b}	3.18^{b}	***	0.11
CPI (supplement)	–	7.04^{c}	10.88^{b}	13.82^{a}	***	0.44
Total CPI	3.94^{d}	10.20^{c}	14.04^{b}	17.19^{a}	***	0.47
Initial BW (kg)	21.4	22.5	21.83	21.08	ns	0.50
Daily BW gain (g/day)	−30.18^{b}	39.90^{a}	36.29^{a}	44.72^{a}	***	9.03
Final BW (kg)	18.70^{b}	25.84^{a}	23.94^{a}	25.10^{a}	***	0.97

^{abc} Means in the same row with different superscripts differ significantly; ***=P<0.001; BW=body weight; CP=crude protein; CPI=crude protein intake; DMI=dry matter intake; ns=not significant; SEM=standard error of mean; SL=significance level; T1=hay alone; T2=hay+200 g PC and WB mix (3:1); T3=hay+300 g PC and WB mix (3:1); T4=hay+400 g PC and WB mix (3:1); PC=peanut cake; WB=wheat bran.

Results

Feed intake

Supplementation promoted significantly higher (P< 0.001) total dry matter intake (DMI) and crude protein intake (CPI) than the control diet, but significantly less (P<0.001) of the total DMI and CPI was derived from hay. Within the supplemented treatments, supplement and total DMI and CPI increased (P<0.001) with the level of supplement offered (Table 1).

Body weight change

Supplementation promoted heavier (P<0.001) daily BW gains and final BW, whereas the non-supplemented goats lost BW during the experimental period

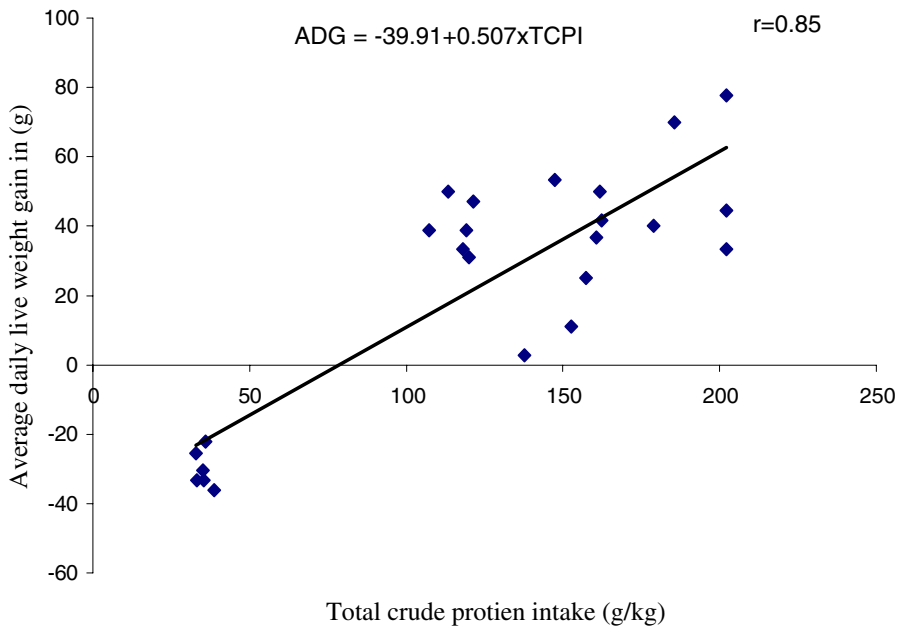

Fig. 1 Regression of crude protein intake on body weight gain of Somali goats fed hay supplemented with different levels of peanut cake and wheat bran mixture (3:1)

Table 2 Carcass characteristics and components of Somali goats fed hay supplemented with different levels of peanut cake and wheat bran mixture (3:1)

Variables	T1 (Control)	T2	T3	T4	SL	SEM
Slaughter weight (kg)	16.6[b]	24.7[a]	23.82[a]	24.0[a]	**	1.19
Empty body weight (kg)	12.8[b]	20.1[a]	20.24[a]	20.3[a]	***	0.95
Hot carcass weight (kg)	6.9[b]	11.5[a]	11.70[a]	11.9[a]	***	0.56
DP as proportion of SW	41.7[b]	46.8[ab]	48.49[a]	49.4[a]	**	1.42
DP as proportion of EBW	53.1	57.0	57.0	57.7	ns	1.18
Lean (g/kg cold carcass)	511.2[b]	599.2[a]	606.4[a]	588[a]	**	14.73
Fat (g/kg cold carcass)	47.4[b]	148.93[a]	145.84[a]	144.80[a]	***	13.99
Bone (g/kg cold carcass)	274.4[a]	183.0[b]	184.2[b]	179.6[b]	***	13.94
Lean meat+fat: bone ratio	2.24[b]	4.01[a]	4.13[a]	4.13[a]	***	0.25
Lean: bone ratio	1.89[b]	3.33[a]	3.33[a]	3.32[a]	***	0.20
Fat: bone ratio	0.34	0.81	1.04	1.05	ns	0.21
Lean: fat ratio	9.05	4.19	4.32	4.21	ns	1.66
Rib eye area (cm^2)	4.8	6.88	7.88	7.16	ns	0.81

[ab] Means in the same row different superscript differ significantly **=P<0.01; ***=P<0.001; DP=dressing percentage; EBW=empty body weight; ns=not significant; SEM: standard error of mean; SL=significance level; SW=slaughter weight; T1=hay alone; T2=hay+200 g PC and WB mix (3:1); T3=hay+300 g PC and WB mix (3:1); T4=hay+400 g PC and WB mix (3:1); PC=peanut cake; WB=wheat bran.

(Table 1). However, no differences were observed in daily BW gain or final BW among the supplemented goats. Positive correlation (P<0.001; r=0.85) between CP intake and mean daily BW gain (Fig. 1) was observed.

Carcass characteristics

Slaughter weight and dressing percentage as a proportion of slaughter weight (P<0.05), empty BW and hot carcass weight (P<0.001) were significantly higher for supplemented than non-supplemented goats (Table 2). Lean (P<0.01) and fat (P<0.001) tissue components were higher for the supplemented goats than for goats in the control treatment, however, the contrary was true with regard to the proportion of bone in the carcass (Table 2).

Proportion of muscle, bone and fat were similar between the different levels of supplementation. Lean meat+fat to bone ratio and lean to bone ratio was higher (P<0.001) in supplemented as compared to the non-supplemented goats. Positive correlation (P< 0.001; r=0.698) was observed between rib eye muscle area and carcass lean meat (Fig. 2).

Supplemented goats had heavier (P<0.01) liver, blood and internal fat as compared to those on the control (T1) treatment (Table 3). The high (T4) level of supplementation promoted heavier (P<0.05) TEOC compared to the control (T1) treatment. The percentage of TNEOC was higher (P<0.01) in non-supplemented goats.

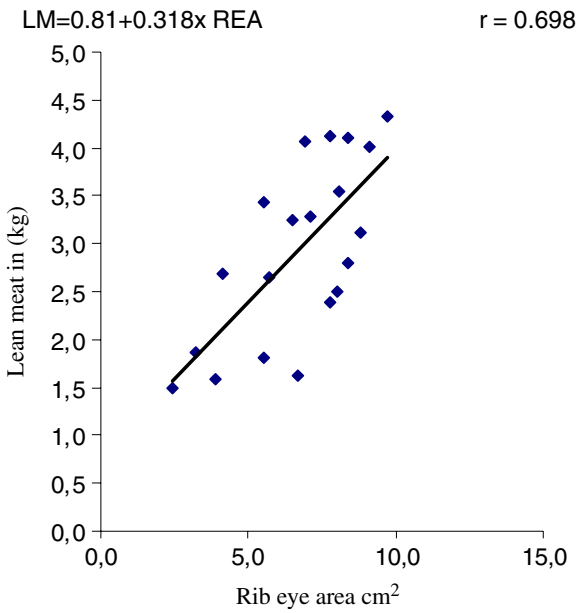

Fig. 2 Regression of rib eye area on lean meat of Somali goats fed hay supplemented with different levels of peanut cake and wheat bran mixture (3:1)

Table 3 Carcass offal of Somali goats fed hay supplemented with different levels of peanut cake and wheat bran mixture (3:1)

Carcass offal (% SW)	T1 (Control)	T2	T3	T4	SL	SEM
Blood	2.92[b]	3.75[a]	3.50[a]	3.81[a]	***	0.09
Lung, trachea and heart	1.53	1.648	1.35	1.49	ns	0.11
Liver	1.14[c]	1.54[b]	1.84[a]	1.73[ab]	***	0.07
Spleen and pancreas	0.27[b]	0.33[ab]	0.42[a]	0.35[a]	***	0.02
Empty gut	6.29	5.57	5.55	5.53	ns	0.36
Internal fat	1.64[b]	3.48[a]	3.39[a]	3.84[a]	*	0.50
Tail	0.11[b]	0.15[a]	0.15[a]	0.16[a]	**	0.009
Kidney	0.31	0.29	0.32	0.31	ns	0.01
TEOC	14.03[b]	16.12[ab]	16.39[ab]	17.08[a]	*	0.68
Head	7.49[a]	6.16[b]	6.35[b]	5.99[b]	**	0.24
Skin	6.81	6.36	7.87	6.98	ns	0.75
Testicle and penis	0.75	0.96	1.05	0.93	ns	0.09
Gut fill	23.58[a]	18.71[b]	14.95[c]	15.69[bc]	*	1.33
Gall bladder	0.05	0.04	0.04	0.08	ns	0.02
Feet	2.94	2.48	2.54	2.73	ns	0.001
TNEOC	41.65[a]	34.73[b]	33.17[b]	33.57[b]	***	1.29
TUP	56.23[b]	62.98[a]	65.45[a]	65.15[a]	*	1.98

[ab] Means in the same row with different superscripts differ significantly; *=P<0.05; **=P<0.01;***=P<0.001; ns=not significant; SEM=standard error of mean; SL=significance level; SW=slaughter weight; TEOC=total edible offal components; TNEOC=total non-edible offal components; TUP=total usable product; T1=hay alone; T2=hay+200 g PC and WB mix (3:1); T3=hay+300 g PC and WB mix (3:1); T4=hay+400 g PC and WB mix (3:1); PC=peanut cake; WB=wheat bran.

The gastro intestinal tract (GIT) content ranged from 14.9–23.6% of BW (Table 4). The total GIT content and its proportion to slaughter weight were higher (P<0.01) for the control (T1) as compared to the supplemented treatments (T2, T3 and T4). The low (T2) level of supplementation also resulted in higher (P<0.01) total GIT content and reticulo-rumen content as percentage of slaughter weight compared to the medium (T3) level of supplementation.

Discussion

Feed intake

Increased DMI by supplemented goats could be attributed to increased CPI that facilitated higher total DMI. The result is similar to the study of Yahaya et al. (1999) in which increased DMI was reported in bulls supplemented with cottonseed cake. Moreover,

Table 4 The gastro intestinal contents as percent of slaughter weight in Somali goats fed hay supplemented with different levels of peanut cake and wheat bran mixture (3:1)

Variables	T1 (Control)	T2	T3	T4	SL	SEM
Reticulo rumen content (% SW)	16.28[a]	13.30[b]	10.27[c]	11.63[bc]	**	0.98
Omaso-abomasum content (% SW)	2.22[a]	1.58[ab]	1.05[b]	1.24[b]	**	0.19
Intestinal content (% SW)	5.08[a]	3.82[b]	3.62[b]	3.32[b]	*	0.42
Total gut content (% SW)	23.58[a]	18.71[b]	14.95[c]	15.69[bc]	***	1.33
Reticulo rumen tissue (% SW)	2.22	2.15	2.05	2.16	ns	0.27
Omasum and abomasum (% SW)	0.95	0.69	0.91	0.72	ns	0.12
Intestines (% SW)	2.93	2.54	2.41	2.40	ns	0.23

[ab] Means in the same row with different superscripts differ significantly; ***=P<0.001; **=P<0.01; *=0.05; ns: not significant; SW: slaughter weight; SEM: standard error of mean; SL=significance level; T1=hay alone; T2=hay+200 g PC and WB mix (3:1); T3=hay+300 g PC and WB mix (3:1); T4=hay+400 g PC and WB mix (3:1); PC=peanut cake; WB=wheat bran.

the observation in this study confirmed the substitution of hay intake by increased intake of concentrate reported in sheep by Dixon et al. (2003).

Body weight change

Lack of significant effect on BW gain due to increased levels of supplement in the present investigation may be attributed to the similar amount of protein available from different protein levels at the small intestine, although there were great differences in CP intake between high (T4) and medium (T3) level of the supplement diets. The major proportion of the dietary protein in goats fed on the high (T4) level of supplement was probably degraded in the rumen, with the production of ammonia and may have resulted in greater urinary losses of nitrogen. This may be the reason for failure of observing differences in the mean daily BW gain in goats fed the high (T4) and low (T2) levels of peanut cake and wheat bran mixture, which is similar to the result reported by Shahjalal et al. (2000). Furthermore, Ash and Norton (1987a) reported that Australian Cashmere goats given high protein (209 g CP kg^{-1} DM) containing diet lost 28% of the dietary N in the stomach.

Goats fed hay alone lost BW which could be attributed to low DM and CP intake. Gihad (1976) reported similar result in sheep and goat fed hay alone. Body weight gain of the supplemented goats as observed in this study was similar to the daily BW gain of 36–53 g/ day in Somali goats fed on a basal diet of hay and supplemented with 200 g DM/ day of wheat bran and peanut cake mixture under varying watering regimen (Urge et al. 2004). Atti et al. (2004) also reported improved daily BW gain in browse consuming growing nanny kids supplemented with peanut cake. Similarly, Ebro et al. (1998) reported that goats supplemented with concentrates comprising 69% wheat bran, 30% noug cake and 1% salt during post weaning period gained more weight (71.89 g/ day) compared with non-supplemented ones (51.2 g/ day) in Ethiopia. Ash and Norton (1987b) also reported higher BW gain in Australian Cashmere goats fed increasing levels of protein in the diet.

Carcass characteristics

Dressing percentage is an important parameter for assessing meat production potential in animals, and it is influenced by age, sex and plane of nutrition (Devendra and Burns 1983). The dressing percentage observed in this study was 41.7–49.4, and similar to the value of 43.5±6.16 reported for Somali goats (Abera et al. 2002). The higher dressing percentage in this study for goats supplemented with the medium (T3) and high (T4) level of peanut cake–wheat bran mixture could be attributed to higher intake of CP leading to better tissue deposition. Moreover, the trend for dressing percentage to increase with level of supplementation agrees with similar studies (Baruasha and Saikia 1989; Adu and Brinckman 1981) that reported increased dressing percentage with increasing level of concentrate in the diet. Pralomkarn et al. (1995) also indicated that dressing percentage increased as feed intake increased, but there was no significant effect of either genotype or plane of nutrition on dressing percentage after adjustment for differences in the empty BW of the different breeds.

The lack of differences in bone weight between the supplemented goats is that bone is a tissue with early development in all animal species, and does not depend on nutrition and sex at older ages. On the other hand, muscle, and especially fat deposition depends on nutrient utilization (Atti et al. 2004). Muscle, fat and bone are usually used in the appraisal of carcass composition, and any change in the proportion of one of the components will influence the others (Hedrick et al. 1994). In the present study, the supplemented goats had comparable bone weight, expressed as a proportion of the carcass, which is inversely proportional to fat and muscle tissue.

Goats supplemented with the medium (T3) level of peanut cake and wheat bran mixture had relatively more muscle than those receiving the high (T4) level of supplementation, despite a lower CP intake (155.5 g) in the former compared to the higher CP intake (175.26 g) in those supplemented with the high (T4) level of peanut cake and wheat bran mixture. This may suggest that goats on the medium (T3) level of supplementation efficiently utilized dietary N. This result indirectly agreed with the report of Lathan et al. (1966) that showed non-significant correlation between carcass lean and mean daily BW gain since the goats supplemented with the medium (T3) level of peanut cake–wheat bran mixture in the present study had relatively lower daily BW gain than the low (T2) and high (T40 levels of supplementation. The results of this study is also similar to other studies

(Wellington et al. 2003) that reported higher proportion of lean in lighter lambs that resulted in a slightly higher percentage of retail cuts. Fat to bone ratio and lean to fat ratio was not affected by supplementation, although the actual values increased with increasing levels of supplementation. Pralomkarn et al. (1995) also reported increase in meat to bone ratio with increasing carcass weight and advance in maturity within a breed. In Australian Cashmere goats, this ratio increased from 2.4 (carcass weight 4.9 kg) to 5.0 at maturity (carcass weight 19.5 kg). In the present study, the meat to bone ratio was 3.3 at 23.82 kg of slaughter weight, which is within the range reported. The higher content of fat in supplemented animals in the current study is similar to that reported by Garrigus et al. (1969), whereby animals on concentrate feed had higher weight of fat than those fed hay based diets.

The lack of differences between treatment diets in rib eye muscle area is similar to the study of Chestnut (1994) that reported no effect of plane of nutrition on rib eye muscle area. Similarly, Kirton et al. (1995) reported lack of effect of breed and plane of nutrition on rib eye muscle area. In the present study, the rib eye muscle area ranged from 4.8–7.8 cm^2, which is comparable to those reported by Hussain et al. (2003) in Jamnapari×Black Bengal goats (8.05 cm^2) slaughtered at 17.71 kg. According to the report of Wolf et al. (1980), larger rib eye muscle area is associated with a higher production of lean in the carcass and higher lean to bone ratio. In the present study, goats fed the medium (T3) level of supplement had relatively larger rib eye muscle area, a reflection of an increase of lean tissue content which was also relatively higher in this treatment, though statistically non-significant. The rib eye muscle area is frequently used as a measure of carcass lean or an expression of carcass desirability. Ament et al. (1962) reported a correlation of 0.8 between rib eye muscle area and carcass lean in lamb carcasses. Field et al. (1963) and Smith and Galgan (1964) also considered the rib eye muscle area as a variable in prediction equations of carcass lean and the yield of retail salable meat. The positive correlation between rib eye muscle area and carcass lean meat content in the present study also confirmed the previous reports.

The results on the carcass offal in this study agrees with those reported by Rondon and Combellas (1980) that showed differences in the size of heart, liver and kidneys in relative terms between supplemented and non-supplemented treatments. Kirton et al. (1972) remarked that proportion of carcass offal can be affected by the nutritional status and BW of animals, and therefore, the differences observed between the control and supplemented treatments in proportion of carcass offal could be traced to dietary origins. Percentage of TUP was the highest for goats fed the high level of supplementation probably due to their relatively higher dressing percentage. The results on the GIT content observed in this study is similar to that of Fehr et al. (1976) who reported that gut fill varied from 12% of BW in milk fed kids (57 days old) to 25% of BW in weaned kids (133 days old). Similar result was also reported by Shahjalal et al. (2000) who found gut fill to be 20.1–22.3% of BW. The relatively higher weight of the GIT contents in goats fed hay is associated with their high intake of hay, which is bulky in nature.

Conclusions

It is concluded that supplementation of Somali goats with different levels of peanut cake–wheat bran mixture avoided BW loss and promoted BW gain, and thus may be a viable management tool to enhance growth during seasons of feed scarcity. Moreover, supplementation promoted dressing percentage and increased the proportion of edible offal. Similarity between the different levels of supplementation in BW and carcass parameters favours the supplementation of 200 or 300 g DM/ day peanut cake–wheat bran mixture at a ratio of 3:1. The data from this study suggested that feed evaluation for meat production should not only consider carcass weight and dressing percentage, but also take into account the yield of TUP in traditions where edible offal components are consumed.

References

Abera, A., Tegene, A. and Banerjee, A.K., 2002. Slaughtering component yield characteristics of some indigenous goat types in Ethiopia, Ethiopian Journal of Animal Production, 2, 87–95.

Adu, I.F. and Brinckman, W.L., 1981. Feed lot performance and carcass characteristics of sheep fed varying concentrate levels, Journal of Animal Science, 1, 1–12.

Ament, D.L., Galagan, M.W. and Rupnow, E. H., 1962. Carcass characteristics of Columbia market lambs, Journal of Animal Science (Abstr), 21, 997.

Ash, A.J. and Norton, W.B., 1987a. Studies with the Australian Cashmere goat. I. Effects of dietary protein concentration and feeding level on body composition of male and female goats, Australian Journal of Agricultural Research, 38, 971–982.

Ash, A.J. and Norton, W.B., 1987b. Studies with the Australian Cashmere goat. II. Growth and digestion in male and female goats given pelleted diets varying in protein content and energy level, Australian Journal of Agricultural Research, 38, 957–969.

Atti, N., Rouissi, H. and Mahouachi, M., 2004. The effect of dietary crude protein level on growth, carcass and meat composition of male goat kids in Tunisia. Small Ruminant Research, 54, 89–97.

AUA, 1998. Alemaya University of Agriculture. Proceeding of the 15th Annual Research and Extension Review Meeting, Alemaya.

Baruasha, D.K. and Saikia, S., 1989. Carcass characteristic of Assam local and half-bred kids under different feeding regimen. Indian Animal Production, 5, 121–123.

Berhanu, G., 1998. Performance of Somali goats supplemented with different proportion of groundnut cake and wheat bran. MSc Thesis, Alemaya University, Ethiopia.

Chestnut, D.M.B., 1994. Effect of lamb growth rate and growth pattern on carcass fat leaves. Animal Production, 58, 77–85.

Devendra, C. and Burns, M., 1983. Goat Production in the Tropics. Commonwealth Agricultural Bureaux, Farnham Royal, England.

Dixon, R.M., Hosking, B.J. and Egan, A.R., 2003. Effects of oilseed meal and grain-urea supplements fed infrequently on digestion in sheep. 1. Low quality grass hay diets. Animal Feed Science and Technology, 110, 75–94.

Ebro, A., Sisay, A. and Alemu, T., 1998. Effect of supplementation of lablab (*Dolichos lablab*) for concentrate on growth rate and efficency in post weaning goats. In: Proceeding of 6th Annual Conference of Ethiopian Society of Animal Production, Addis Ababa. pp. 264–268.

Fehr, P.M., Sauvant, D., Delage, J., Dumont, B.L. and Roy, G., 1976. Effect of feeding methods and age at slaughter on growth performance and carcass characteristics of entire young male goats, Livestock Production Science, 3, 183–194.

Field, R.A., Kemp, J.D. and Varney, W.Y., 1963. Indices for lamb carcass composition. Journal of Animal Science, 22, 218.

Garrigus, R.R., Johnson, R.H., Thomas, W.N., Firm, L.N., Harrington, B.R. and Judge, D.M., 1969. Dietary effects on beef composition. I. Quantities and qualitative traits. Journal of Agricultural Science, (Cambridge), 72, 289–295.

Gihad, E.A., 1976. Digestibility and nitrogen utilization of tropical natural grass hay by goats and sheep. Journal of Animal Science, 43, 879–883.

Hedrick, H.B., Aberle, D.E., Forrest, C.J., Judge, D.M. and Merkel, A.R., 1994. Principles of Meat Science. 3rd ed. Kendall and Hunt Publishing Co., Iowa.

Hussain, M.E., Shahjala, M., Khan, J.M. and Hasanat, S.M., 2003. Effect of dietary energy supplementation on feed intake growth and reproductive performance of goats under grazing condition. Pakistan Journal of Nutrition, 2, 159–163.

Kirton, A.H., Fourie, D.P. and Jury, E.K., 1972. Growth and development of sheep. III. Growth of the carcass and non-carcass component of the Southdown and Romney and their cross and some relationships with composition. Journal of Agricultural Research, 15, 214–227.

Kirton, A.H., Bennett, L.G., Dobbie, L.J., Mercer, K.G. and Duganzich, M.D., 1995. Effects of sire breed (Southdown, Suffolk) Sex and growth path on carcass composition of cross-bred lambs. Journal of Agricultural Research, 38, 105–114.

Lathan, S., Duane, G.W. and Kemp, J. D., 1966. Techniques for estimating lamb carcass composition. Journal of Animal Science, 22, 492.

Ott, J.P., Muir, J.P., Brown T.F. and Wittie, R.D., 2004. Peanut meal supplementation for growing doe kids on woodland range. Small Ruminant Research, 52, 63–74.

Pralomkarn, W., Kochapakdee, S., Saithanoo, S. and Norton, B.W., 1995. Energy and protein utilisation for maintenance and growth of Thai native and Anglo-Nubian × Thai native male weaner goats. Small Ruminant Research, 16, 13–20.

Rondon, Z. and Combellas, J., 1980. Evaluation of visceral organs in adult goats. Institution of Animal Production, UCV. Fac. Agronomia.

Shahjalal, M., Bishwas, A.M., Tareque, A. and Hoki, M. M., 2000. Growth and carcass characteristics of goats given diets varying in protein concentration and feeding level. Asian-Australian Journal of Animal Science, 13, 613–618.

Smith, G.C. and Galgan, M.W., 1964. Estimation of true retail value in lamb carcass. Journal of Animal Science (Abstr.)., 23, 863.

Urge, M., Dahlborn, K. and Olsson, K., 2004. Effect of intermittent watering on dry matter intake and body weight of male Ethiopian Somali goats. Journal of Animal Nutrition and Feed Sciences, 13, (Suppl. 1), 647–650.

Wellington, G.H., Hogue, D.E. and Foote, H.R., 2003. Growth, carcass characteristics and androgen concentrations of gonad-altered ram lambs. Small Ruminant Research, 48, 51–59.

Wolf, B.T., Smith C. and Sales, D.I., 1980. Growth and Carcass composition in the cross bred progeny of six terminal sire breeds of sheep. Animal Production, 31, 307–313.

Yahaya, M.S., Takahashi, J., Matsuoka, S. and Kibon, A. 1999. Effect of supplementary feeding of cotton seed cake on feed intake, water consumption and work output of work bulls in Borno state, Nigeria. Animal Feed Science and Technology, 79, 137–143.