Journal of Cell and Animal Biology Vol. 2 (11), pp. 187-194, November, 2008
Available online at http://www.academicjournals.org/JCAB
ISSN 1996-0867 © 2008 Academic Journals

Full Length Research Paper

Growth performance and carcass characteristics of Arsi-Bale goats castrated at different ages

Tesfaye Kebede[1*], Tesfaye Lemma[1], Hunduma Dinka[1], Mieso Guru[1] and Amsalu Sisay[2]

[1]Adami Tulu Agricultural Research Center, P. O. Box 35, Zeway, Ethiopia.
[2]Hawassa University, Department of Animal and Range Science; P. O. Box 05, Hawassa, Ethiopia

Accepted 29 October,2008

The study was conducted on thirty six male Arsi-Bale kids of 10.56 ± 0.39 kg initial body weight for 15 months to investigate the effects of age at castration on growth performance and carcass characteristics. The treatments were entire/intact (T1), castration at three (T2), at six (T3) and at nine months of age (T4). All castrated and entire goats were browsed during day time and supplemented with concentrate at 2.5% of body weight in DM per day. Five goats from each treatment were randomly selected and slaughtered for carcass evaluation. Age at castration had no significant effect on body weight, total weight gain (TG), over all average daily gain (ADG) and linear body measurements. T1 and T4 had significantly (P < 0.05) higher ADG (g) (113.73 ± 3.53 and 108.50 ± 5.23, respectively) than T2 (92.16 ± 6.20) and T3 (92.16 ± 5.72) at 9 - 12 months of age. There were no significant differences among treatments on most carcass or non-carcasses measurements except for fat deposition, which were significantly (P < 0.05) lower and heavier for entire as compared to castrated groups, respectively. Therefore, castration is important for better fat deposition in carcass than for body weight gain improvement. If castration desired, early castration is recommendable as goats castrated at three months of age had better rib eye area and fat thickness than other castrated groups and intact goats.

Key words: Arsi-Bale goats, carcass characteristics, castration, growth.

INTRODUCTION

Small ruminant animal husbandry is the most important and usually the only living source for people inhabiting in forest regions or regions not suitable for crop cultivation and cattle production (Daskiran et al., 2006). Castration of food animals is a common management practice that imposes unnecessary pain and stress and may reduce performance (Hopkins-Shoemaker et al., 2004). Intact male have relatively greater muscle in the neck and forequarter than females or castrates. The presence of testicular hormones is related to greater muscle growth capacity in intact males (Arnold et al., 1997 as cited by Brandstetter et al., 2000).

Arsi-Bale goats are distributed throughout the Arsi and Bale regions in Ethiopia, up to an altitude of 4000 m in the higher altitude area of Sidamo and Western Hararghae; also occupies all the agro-pastoral low lands within the Rift Valley from Lake Abaya in the South to Zeway in the North. They are medium to large in body size (FARM-Africa, 1996). This breed type is predominantly existing in the mid rift valley of Ethiopia and well adapted to the harsh environment and serving the community as source of income, milk and meat. There is high demand for goat meat both inland (mainly looking for meat with high fat content) and abroad (preferring lean meat from intact goats). However, little has been done to improve their productivity and management practices that might resulted in better quality and quantity meat production.

Castration is one of the management activities practiced in different parts of the country as castration in goats has an advantage of eliminating the strong male odor present in bucks. Un-castrated and sexually mature goats are difficult to sell or they may have low market price because of their strong male taint. Castrations also affect growth and carcass composition (Solomon et al., 1991). Castrating yearling male sheep can reduce their growth capability and higher dressing percentages in castrated males than intact rams were reported (Demisse et al., 1988).

*Corresponding author e-mail: tekebede@yahoo.com; Telephone: 251(0)911953947; Fax: 2510464419108

Some Ethiopian farmers usually castrate their goats after maturity and fatten them for sale at premium holiday markets or butchers or restaurants. However, castration at a younger age is rarely practiced, which may become necessary when superior bucks are being used for breed improvement programs since it may be more convenient for smallholders to castrate young bucks not required for breeding than to keep them from the does until they are sold. Early castration has much greater effect on carcass quality especially on marbling degree than has latter castration and male kids not required for breeding should preferably castrated at early ages, both to get good quality carcass and to prevent unwanted mating. However, since the action and level of androgen differ at different ages, castration at different ages may produce different outcome. Therefore, the present study was aimed to study effect of castration at different ages on growth and carcass characteristics of Arsi-Bale goats.

MATERIALS AND METHODS

Description of study area

The experiment was conducted at Adami Tulu Agricultural Research Center (ATARC), which is located 167 km south of Addis Ababa at an altitude of 1650 m above sea level in mid rift valley. The agro-ecological zone of the area is semi arid and sub humid with acacia woodland vegetation type. The mean annual rain falls is 760 mm. The mean minimum and maximum temperature are 12.6 and 27°C, respectively. The soil type is fine, sandy loam with sand: silt: clay in the ratio of 34: 38: 18, respectively. The pH is 7.88 (ATARC, 1998).

Experimental animals, their management and treatments

Thirty-six male Arsi-Bale kids with an average age of three months and 10.56 ± 0.39 kg body weight were purchased from local market. They were maintained in quarantine for few weeks and the kids were treated for external and internal parasites with accarcide and albendazole, respectively. One week after they have been treated, they were assigned to one of the following treatments of 9 kids each. T1 = un-castrated (control), T2 = castrated at an average age of 3 months, T3 = castrated at an average age of 6 months and T4 = castrated at an average age of 9 months. A preliminary period of 14 days was given to allow adjustment of goats to diets and facilities and followed by 15 months experimental period (from 4/3/2005 to 3/6/2006). Similar management practices such as feeding, housing, health care etc were given for all treatments and what varied among treatments was only age at castration. All kids were castrated by burdizzo.

Goats were managed in a semi-intensive management system in which they were allowed to browse on natural vegetation during the day time for 6 h and supplemented with concentrate feed daily on average 2.5% of their body weight on dry matter basis up on their return from browsing. Average daily supplement were adjusted according to fortnight body weight changes of the animals. The concentrate feed was a mixture of 49% noug cake, 50% wheat middling and 1% salt. The supplement was given on group bases. Water was offered over night and they were also allowed to drink water from river during the day time while browsing. The goats provided with shelter during the night. The shelter has concrete floor, corrugated iron roofing and open wall in which half of it (bottom part) is made simply to prevent animals from moving out while the rest half (top part) is left open to allow movement of air through the house. Separation wall within house is made to prevent mixing of animals among treatments. The house/barn is cleaned one time a day and bedding was not used on the floor.

During the experimental period, kids that showed abnormal symptoms such as diarrhea, loss of appetite, hair erections etc were treated after their problems were identified. The experiment commenced during the dry season when goats could not get alternative browses as a result kids were not in a good condition while taking initial weight. Weight was taken weekly while body condition score and linear measurements were measured fortnightly. The sensitivity of the scale used is 100 g.

Carcass evaluation

Five animals from each treatment group were randomly selected and slaughtered for carcass evaluation at the end of experimental period. The animals were slaughtered following the standard procedures of USDA (1982). The bodies were skinned; the heads and feet were removed. The carcasses were eviscerated and the internal organs and tissues were weighed. All body components such as head, feet with hooves, skin, blood, kidneys, bladder, liver with bile, heart, lungs, spleen, pancreas, penis, testicles, full and empty gut were weighed and their percentages with respect to the empty live weight of the animals were determined. Kidneys fat, heart fat, pelvic fat, scrotal fat, omental and mesenteric fat were also weighed using sensitive balance. Full live weight, empty live weight, hot carcass weight, and hot dressing percentage were determined. Carcass was dissected in order to separate muscle, fat and bone tissues after 24 h chilling at -2°C. The carcass was cut between 12^{th} and 13^{th} ribs to measure rib eye area (REA) with calibrated water proof paper. The thickness of fat along the surface of rib eye area was measured using ruler. Dressing percentage was calculated according to hot carcass weight and pre-slaughter live weight. One half of the carcass was separated in to different primal cuts (leg, loin, rack, breast and shank and shoulder and neck). From each primal cut muscle and fat were trimmed from bone by knife and weighed separately. Finally, the amount of each tissue from each primal cut was added together with their respective to determine the proportion of muscle, bone and fat in the carcass.

Statistical analysis

Data were analyzed in two ways: 1.) analysis of variance (ANOVA) procedures for a completely randomized design experiment using the General Linear Model (GLM) procedures of SAS (1999 - 2000) was implemented on body weight, body measurements, body condition score, carcass and non-carcass components data and Duncan's Multiple Range Test (DMRT) was used to compare treatment means and 2.) based on the analysis of variance result, analysis of covariance (ANCOVA) was used to correct the significant ($P \leq 0.05$) variation among treatments in initial body weight and body measurement as indicated on the analysis of variance out put. However, variations in initial body weight and body measurements were not resulted in significant difference on the parameters measured at any time of the experimental periods by both methods of analysis. Hence, results obtained from ANOVA were used to present the current finding.

RESULTS AND DISCUSSION

Body weight changes

Mean body weight at respective ages, over all total weight gain (TG) and average daily gains (ADG) of Arsi-

Table 1. LSM ± SE for changes in body weight by Arsi-Bale male kids castrated at different ages.

Weight by months of age	Entire	Castration at 3 month	Castration at 6 month	Castration at 9 month
Body weight (kg)				
3	10.28±0.49[a]	11.28±0.29[a]	9.83±0.57[b]	10.50±0.19[a]
6	16.17±0.98[a]	16.89±0.83[a]	16.39±1.31[a]	16.28±0.66[a]
9	24.94±1.14[a]	24.44±0.98[a]	22.72±1,44[a]	24.44±0.81[a]
12	34.56±1.21[a]	32.50±0.98[a]	31.00±1.66[a]	31.89±0.95[a]
15	35.44±0.94[a]	35.11±1.03[a]	34.39±1.71[a]	34.28±0.80[a]
18	40.89±1.32[a]	40.06±1.27[a]	39.50±1.78[a]	38.94±0.76[a]
Over all total gain (kg)	30.61±0.96[a]	28.78±1.23[a]	29.67±1.55[a]	28.44±0.65[a]
Daily weight gain (g)				
3 - 6	69.28±8.13[a]	66.01±7.90[a]	77.12±9.78[a]	67.97±6.51[a]
6 - 9	95.24±3.71[a]	86.64±7.23[a]	80.03±5.07[a]	94.54±3.05[a]
9 - 12	113.73±3.53[a]	92.16±6.20[b]	92.16±5.72[b]	108.50±5.23[a]
12 - 15	7.19±4.13[b]	18.95±6.85[ab]	31.37±5.00[a]	24.18±4.43[a]
15 - 18	69.30±7.19[a]	63.32±4.18[a]	63.32±4.18[a]	61.53±2.30[a]
Over all ADG	67.48±2.12[a]	63.67±2.71[a]	65.63±3.42[a]	62.93±1.45[a]
n	9	9	9	9

Means in the same row with different letters are statistical different ($p < 0.05$)

Bale male goats castrated at different ages are presented in Table 1. Castration or age at castration had no significant effect on body weight, total gain or overall ADG in Arsi-Bale goats. In line with our finding, Solomon et al. (1991) reported that castration had no significant effect on body weight or ADG in Adal goats. Even thoughADG was not statistically significant among treatments, entire goats had better over all average daily gain than castrated ones implying that castration resulted in growth rate reduction (Table 1). In support of this, Mahgoub and Lodge (1998) reported that among species/sex/slaughter weight groups, castrated male and female goats had the lowest growth rate. Hopkins-Shoemaker et al. (2004) also indicated that castration of young market goats reduced growth and also Murray et al. (2001) reported that the growth rate of entire Boer and feral backs were significantly higher than their respective castrate. In other species of animal, Demissie et al. (1989) stated that castration may depress the growth of young rams if they are fattened for sale immediately after castration which might be similar with current finding as intact group were better in live weight gain than the castrated once. Lee (1986) also indicated that the growth rate of wither lambs was less than that of rams. Similarly, Yibrha et al. (1991) reported that age at castration had no significant effect on body weight or average daily gain of Black-Head Somali rams.

In large ruminant, castration at either birth or weaning did not alter all growth, feedlot performance, or carcass characteristics of Angus and Charolais-sired steers (Looper et al., 2005). In contrary to current finding, Nsoso et al. (2004b) reported significantly higher average weight in castrates (22.37 ± 0.67 and 34.38 ± 0.55 kg) than the entire males (14.37 ± 0.76 and 31.22 ± 1.27 kg) at 0 - 12 and 13 - 24 months respectively. This might be due to difference in breed type, feeding management, slaughter age/weight and methods of castration. Intact goats and those castrated at nine months of age had significantly ($P < 0.05$) higher ADG than other groups at 9 - 12 months of ages. However, intact goats had significantly lower ADG than other treatments at 12 - 15 months of ages. Goats in all treatments performed better at 9 - 12 months of age, but rate of weight gain was reduced dramatically at 12 - 15 months of ages which might be partly due to shortage of feed (browses) as those three months (January, February and March) are critical dry periods where there is no green feeds available in the area. This is similar with the report of Velez et al. (1993) who stated that animal losses weight during the dry season where both the quantity and quality of forage available are limited. Growth rate of goats in all treatments was high up to 12 months of age, but declined then after.

Linear body measurements

Mean heart girth (HG), height at wither (HW) and body lengths (BL) measurements for Arsi Bale male goats castrated at different ages are presented in Table 2. Castration or age at castration had no significant effect on linear body measurements for Arsi-Bale goats. Inline with this report, Nsoso et al. (2004a) indicated absence of significant difference in linear body measurements among castrate and entire male goats at 14 months of

Table 2. LSM ± SE for linear body measurements by Arsi-Bale goats castrated at different ages.

Body measurements by months of age	Entire	Castration at 3 month	Castration at 6 month	Castration at 9 month
Heart girth (cm)				
Initial	52.78±1.02^{ab}	54.00±0.67^{a}	51.22±0.91^{b}	52.56±0.38^{ab}
3-6	56.17±1.14^{a}	57.59±0.78^{a}	56.10±1.32^{a}	56.71±0.60^{a}
6-9	63.57±1.34^{a}	63.96±1.02^{a}	62.87±1.56^{a}	64.13±0.78^{a}
9-12	70.89±1.00^{a}	70.34±0.94^{a}	69.74±1.54^{a}	70.11±0.84^{a}
12-15	76.41±0.72^{a}	75.93±0.81^{a}	74.94±1.46^{a}	75.46±0.70^{a}
15-18	77.83±0.58^{a}	77.46±0.66^{a}	76.90±1.46^{a}	76.54±0.71^{a}
Final	79.67±0.82^{a}	79.78±0.95^{a}	78.89±1.40^{a}	78.78±0.78^{a}
Height at wither (cm)				
Initial	49.22±0.95^{b}	51.89±0.81^{a}	51.56 ±0.60^{a}	50.78±0.46^{ab}
3-6	54.24±0.91^{a}	55.33±0.54^{a}	54.37±0.87^{a}	53.97±0.72^{a}
6-9	62.17±1.84^{a}	62.98±0.62^{a}	60.69±1.25^{a}	61.63±1.02^{a}
9-12	68.44±0.93^{a}	68.83±0.52^{a}	67.57±1.12^{a}	68.30±0.73^{a}
12-15	73.41±0.60^{a}	73.63±0.65^{a}	72.54±1.01^{a}	72.33±0.72^{a}
15-18	75.40±0.62^{a}	75.94±0.87^{a}	74.59±0.87^{a}	74.16±0.64^{a}
Final	76.56±0.87^{a}	77.33±0.91^{a}	76.44 ±0.93^{a}	74.78±0.91^{a}
Body length (cm)				
Initial	46.56±1.28^{a}	48.56±0.53^{a}	47.56±1.09^{a}	47.67±0.91^{a}
3-6	51.90±1.19^{a}	53.30±0.43^{a}	51.24±1.37^{a}	51.83±0.64^{a}
6-9	61.09±1.22^{a}	61.44±0.60^{a}	59.61±1.80^{a}	61.48±0.63^{a}
9-12	67.67±0.97^{a}	67.51±0.64^{a}	65.52±1.51^{a}	67.24±0.70^{a}
12-15	73.48±0.68^{a}	73.19±0.56^{a}	71.93±1.11^{a}	72.37±0.53^{a}
15-18	75.86±0.74^{a}	75.43±0.63^{a}	74.32±1.12^{a}	74.57±0.69^{a}
Final	77.67±0.87^{a}	77.89±0.77^{a}	77.00±1.30^{a}	77.67±1.11^{a}

Means in the same row with different letters are statistically different ($p < 0.05$)

age; but at 22 months of age height at withers was significantly higher for castrates than entire goats. However, Nsoso et al. (2004b) reported that there were significantly higher height at withers in castrates (56.54 ± 0.88 and 65.32 ± 0.72 cm) than the entire males (49.15 ± 1.00 and 62.26 ± 1.66 cm) at 0 - 12 and 13 - 24 months respectively. They also stated that diagonal body length was significantly higher in castrates (51.83 ± 0.61 and 60.2 ± 0.49 cm) than the entire males (43.03 ± 0.69 and 54.84 ± 1.15 cm) at 0 - 12 and 13 - 24 months respectively. The same authors reported that castrates develop longer and deeper bodies and body length differed significantly among burdizzo castrated and entire goats. This might be attributed to difference in accuracy of taking linear body measurements, breed type and methodology followed. In all treatments, among body measurements, heart girth was highest followed by height at wither and lowest for body length. This indicates that Arsi-Bale goats castrated at different age had wider chest and shorter body length. However, Thiruvenkadan (2005) reported that in all age groups among the body measurements, height at withers was highest followed by chest girth and body length.

There were no significant differences among treatments in body condition score except at 12 - 15 months of age when goats castrated at three months of age had significantly ($P < 0.05$) better body condition score than the intact one (Table 3). Castrated groups had good physical appearance and attractive shine hair coats whereas intact goats were not physically attractive and had erected hair coat which gave them an appearance of malnutrition animals. As a result, castrated groups have got preference on market as compared to the intact once. Behaviorally, castrated groups were very docile and friendly to persons managing them while the intact one were disturbing by fighting and mating each other. Similarly, Devendra and McLeroy (1988) reported that castrates are easier to manage than entire males.

Carcass measurements

Mean carcass measurements in Arsi-Bale goats castra-

Table 3. LSM ± SE for body condition score (BCS) by Arsi-Bale goats castrated at different ages.

Body condition score by months of age	Entire	Castration at 3 month	Castration at 6 month	Castration at 9 month
Initial	2.78±0.09[a]	2.33±0.08[a]	2.22±0.09[a]	2.78±0.08[a]
3 - 6	2.71±0.10[a]	2.91±0.09[a]	2.75±0.16[a]	2.71±0.08[a]
6 - 9	3.01±0.11[a]	3.28±0.14[a]	3.12±0.21[a]	3.24±0.11[a]
9 - 12	3.34±0.10[a]	3.45±0.11[a]	3.33±0.18[a]	3.31±0.10[a]
12 - 15	3.42±0.08[b]	3.76±0.08[a]	3.63±0.17[ab]	3.53±0.08[ab]
15 - 18	3.75±0.07[a]	3.90±0.07[a]	3.73±0.12[a]	3.67±0.08[a]
Final	3.89±0.11[a]	3.89±0.11[a]	3.83±0.17[a]	3.72±0.09[a]

Means in the same row with different letters are statistically different ($p < 0.05$)

Table 4. LSM ± SE for carcass traits by Arsi-Bale goats castrated at different ages.

Carcass traits	Entire	Castration at 3 month	Castration at 6 month	Castration at 9 month
n	5	5	5	5
Full live weight (kg)	41.5±2.00[a]	40.30±1.51[a]	42.0±1.76[a]	39.7±0.96[a]
Empty live weight (kg)	40.0±1.78[a]	38.80±1.34[a]	40.7±1.90[a]	37.4±0.80[a]
Hot carcass weight (kg)	19.44±0.91[a]	18.82±0.86[a]	19.32±0.89[a]	18.16±0.49[a]
Dressing percentage (%)	48.60[a]	48.51[a]	47.47[a]	48.56[a]
Fat thickness (mm)	0.98±0.05[c]	9.20±0.37[a]	8.80±1.02[a]	6.60±0.93[b]
REA (mm2)	59.20±4.07[a]	61.00±6.24[a]	55.60±3.82[a]	51.60±5.31[a]
Heart fat (kg)	0.039±0.01[a]	0.118±0.05[a]	0.101±0.01[a]	0.089±0.02[a]
Kidney fat (kg)	0.077±0.02[c]	0.610±0.08[a]	0.771±0.12[a]	0.509±0.05[b]
Pelvic fat (kg)	0.057±0.03[b]	0.115±0.04[b]	0.210±0.04[a]	0.077±0.01[b]
Scrotal fat (kg)	0.062±0.02[b]	0.206±0.01[a]	0.248±0.02[a]	0.219±0.03[a]
O + M fat (kg)	0.288±0.04[b]	1.560±0.37[a]	1.520±0.22[a]	1.300±0.11[a]

Means in the same row with different letters are statistically different ($p < 0.05$)

at different ages are presented in Table 4. There was no significant difference among treatments in mean full live weight, empty live weight, hot carcass weight (HCW), hot dressing percentages (HDP) and rib eye area (REA) which was in agreement with the report of Yibrha et al. (1991) on Black-head Somali rams. Inline with this report, Hopkins-Shoemaker et al. (2004) stated that absence of significant differences in hot carcass weight and dressing percentages between intact and castrated Boer x Spanish goats. However, Solomon et al. (1991) reported that castrated Adal goats had significantly higher dressing percentage than entire goats (41.6% vs. 39.5%) which were lower than current findings. This might be due to short duration of exposure to concentrate feed in previous study, slaughter weight and breed differences. Similarly, Lee (1986) indicated that dressed carcass of castrated lambs were approximately 2 percentage units heavier than those of the rams.

Dressing percentage for this study varies from 47.47 to 48.6%. Mesfin (2007) determined the dressing percentage of 35.6 to 40.4%, 42.3 to 44.2% and 42.1 to 44.3% for Arsi-Bale goats kept under different feeding regimens at an age of 6, 12 and 24 months, respectively. For the same breed of goats fed different level of sweet potato vines and concentrate, the dressing percentage varies from 42.13 to 43.78% (Tesfaye et al., 2008). Legesse et al. (2006) determined hot carcass dressing percentage of 42.6, 43.3 and 38.8% for Arsi-Bale goats kept under intensive, semi-intensive and extensive feeding system, respectively. The dressing percentages in this study is some what greater than the reports of fore mentioned authors on the same breed which might be due to heavier live weight at slaughter, castration and longer duration on supplemental feed than the previous works. Acharya (1988) determined the dressing percentage between 42.7 and 55.4% depending on the slaughter age, nutrition and the race of the kids. Hailu et al. (2005) determined the dressing percentage of 54.11 to 55.82% and 49.41 to 53.87% for Borana and Arsi-Bale goats kept under different durations of feedlot management, respectively. Bhattacharyya and Khan (1988) stated that empty body weight or the amount of rumen and intestine contents

indicated that dressing percentages might be affected by organs to be included in dressed carcass as inclusion or removal of some visceral organs in hot carcass measurement might be resulted in different dressing percentages. Therefore, the lower dressing percentage in current study as compared with some of the literature might be due to exclusion of some visceral organs in its determination, unlike other researchers (Daskiran et al., 2006) who included kidneys, pelvic fat and testicles in hot carcass measurements which in turn affected dressing percentages, in addition to what were mentioned. Further more, methods of calculation affected dressing percentages e.g. Hailu et al. (2005) calculated dressing percentages based on fasting body weight and empty body weight (live weight minus digesta in that case) which is completely different from the way dressing percentages was calculated in the current report (HDP = HCW/per slaughter live weight times 100).

Castration at three and six months of age had significantly ($P < 0.05$) higher fat thickness than castration at nine months of age and entire goats while castration at nine months had significantly ($P < 0.05$) higher fat thickness than entire goats. In line with our finding, Arnold and Meyer (1988) reported that castration improved carcass marbling. However, Hopkins-Shoemaker et al. (2004) did not observe significant difference in fat thickness between intact and castrated Boer x Spanish goats. Age at castration had no significant effect on rib eye area (REA). In support of this finding, Hopkins-Shoemaker et al. (2004) did not observe significant difference between intact and castrate in rib eye area.

Castration or age at castration had significant effect on visceral/internal fat contents except on heart fat. Castration at three and six months of age resulted in significantly ($P < 0.05$) heavier kidneys fat deposition than castration at nine months of age and intact group whereas those goats castrated at nine months of age had significantly ($P < 0.05$) heavier kidneys fat deposition than the intact group. Goats castrated at six months of age]had significantly ($P < 0.05$) higher pelvic fat content than other treatments. Similarly, Hopkins-Shoemaker et al. (2004) observed higher kidneys and pelvic fat in castrated than intact Boer x Spanish male goats. All castrated groups had significantly ($P < 0.05$) higher scrotal and omental + mesenteric (O + M) fat than intact group whereas no significant differences were observed among castrated groups in scrotal and O + M fat deposition. Solomon et al. (1991) reported that castrated Adal goats had significantly heavier kidney and omental fat deposit than entire Adal goats, but Yibrha et al. (1991) did not get difference in the indicated traits between castrated and entire Black-head Somali rams. In general, intact/entire goats had lower fat content than castrated groups.

Means and percentages of non-carcasses components in Arsi-Bale goats castrated at different ages are presented in Table 5. Entire/intact group had significantly ($p < 0.05$) heavier free draining blood, head, skin and testis (0.96, 1.42, 2.99, 0.63 percentage points, respectively) than castrated groups while castration at six month of age resulted in heavier blood (0.63 percentage points) in carcass when compared to castration at three months of age. There were no significant differences among treatments in feet, lung and trachea, liver with bile, kidney, spleen, penis and empty gut mass in carcass of goats. Those goats castrated at nine months of age had significantly ($p < 0.05$) heavier (0.02 percentage points) bladder in their carcass when compared to other treatments. Intact group had significantly ($p < 0.05$) heavier (5.77 percentage points) full gut in their carcass than castration at nine months of age whereas there were no significant differences among castrated groups in full gut content. Goats castrated at six months of age had significantly ($p < 0.05$) lighter (0.03 percentage points) heart in their carcass than the rest treatments. Riley et al. (1989) as cited by Moron-Fuenmayor and Clavero (1999) indicated that different growth of lungs, gallbladder, head, feet, heart and skin is influenced by the animal's age, breed and sex. The current finding revealed that castration influenced head, skin, heart and bladder growth on top of what is mentioned by other authors (Riley et al., 1989). However, Yibrha et al. (1991) did not observe significant difference in the skin weight between castrated and entire black-head Somali rams. So far, there is no report on non-carcass components for Arsi-Bale goats except the current finding.

Primal cut measurements

Mean carcass composition for different primal cuts in Arsi-Bale goats under different age of castration are presented in Table 6. Castration or age at castration had no significant effect on bone and muscle tissue composition of leg, loin and rack primal cuts. Intact and those castrate at three months of age had significantly ($P < 0.05$) higher muscle content in shoulder and neck primal cut than other treatments. Castration at nine months of age had significantly ($P < 0.05$) lower bone mass in breast and shank primal cut than the rest treatments. The fat content in all primal cuts except for shoulder and neck was significantly ($P < 0.05$) lower in intact goats than castrated groups while there were no significant differences among castrated groups in their fat deposit across all primal cuts. Muscle weight was highest followed by bone and lowest for fat in each primal cut for all treatments. These were all in agreement with the result of other researchers (Daskiran et al., 2006).

Mean carcass composition proportion (relative to hot carcass weight) in Arsi-Bale goats under different age of castration are presented in Table 7. There were no significant differences in bone proportion among treatments whereas intact group had significantly ($p <$

0.05) higher muscle and lower fat proportion than castrated groups. This implies that castration affected carcass composition in addition to other factors such as breed, sex and stages of maturity (El Karim and Owen, 1987; Snowder et al., 1994; Taylor et al., 1989). In general, carcass composition in Arsi-Bale male goats castrated at different age with slaughter weight from 37.4 - 40.7 kg, range from 65.69 - 75.97% lean (muscle), 3.67 - 14.8% fat and 16.75 - 20.57% bone. Colomer-Rocher et al. (1992) have reported that the mean muscle content of male New Zealand Saanen goats to be about 60% and stated that this was higher than that normally found in sheep and Ruvuna et al. (1992) have reported a lean: fat: bone ratio of 73:9:18 for 14½ month old goats which were in line with our findings. In support of current finding, Lee (1986) indicated that carcass of rams tends to be leaner than those of withers and fat score distributions, based on export standard, were such that withers scored higher (fatter) than rams.

Conclusions and Recommendation

Age at castration had no significant effect on body weight or over all average daily gain and linear body measurements except at an age of 9 - 15 months when significant differences observed among treatments in average daily gain. 9 - 12 months of age was considered as appropriate age at which optimum growth obtained from Arsi-Bale goats castrated at different ages as goats in all treatments attained better daily weight gain within this age group, but rate of weight gain was reduced dramatically from 12 - 15 months of ages. Castration or age at castration had no significant effect on most carcass parameters except on fat depositions and on non-carcass components. Intact/entire goats had lower fat deposition than castrated groups. Goats castrated at three months of age had higher fat thickness than other groups and followed by castration at six and nine months of age. Castration had significant effect on carcass composition proportion. Therefore, castration is important for better fat deposition in carcass than for body weight gain improvement as time of castration did not result in better weight gain in this study. If castration desired, early castration is recommendable as goats castrated at three months of age had better rib eye area and fat thickness than other castrated groups and intact group.

ACKNOWLEDGMENTS

The authors would like to acknowledge Mr. Kassahun Kitila, Mr. Abe Barko, and Mr. Osho Tibeso for their contribution in data collection. We would also like to thank Ethiopian Institute of Agricultural Research for funding the project. Our sincere gratitude goes to Adami Tulu Agricultural Research Center for facilitating logistic and other required materials during the project implementation.

REFERENCES

Acharya RM (1988). Goat breeding and meat production. In: Goat meat production in Asia, Proceeding of Workshop, Tandojam-Pakistan, pp. 14-30.

Arnold AM, Meyer HH (1988). Effects of gender, time of castration, genotype and feeding regimen on lamb growth and carcass fatness. J. Anim Sci. 66: 2468-2475.

Arnold AM, Peralta JM, Thonney ML (1997). Effect of testosterone on differential muscle growth and on protein and nucleic acid concentration in muscles of growing lambs. J. Anim. Sci. 75: 1495-1503.

ATARC (Adami Tulu Agricultural Research Center) (1998). Thirty years of research experience. Oromia Agricultural Research Coordination service. Bulletin no 1.

Bhattacharyya NK, Khan BU (1988). Goat meat production in India. In: Goat meat production in Asia, Proceeding of Workshop, Tandojam-Pakistan, pp. 31-45.

Brandstetter AM, Pfaffl MW, Hocquette JF, Gerrard DE, Picard B, Geay Y, Sauerwein H (2000). Effects of muscle type, castration, age and composatory growth rate on androgen receptor mRNA expression in bovine skeletal muscle. J.Anim.Sci. 78:629-637.

Colomer-Rocher F, Kirton AH, Merer GJK, Duganzich DM (1992). Carcass composition of New Zealand Saanen goats slaughtered at different weights. Small Rumin. Res. 7: 161-173.

Daskiran I, Askin K, Mehmet B (2006). Slaughter and carcass characteristics of Norduz male kids raised in either intensive or pasture conditions. Pakistan J. of Nutrition 5(3): 274-277.

Demissie T, Kassahun A, Yohannes G (1989). Comparison of castrated and entire Horro male lambs for growth and fattening ability and various feeding regimes. In: IAR Proceedings of the Second National Livestock Improvement Conference, Addis Ababa, Ethiopia. pp.74-77.

Devendra C, McLeroy GB (1988). Goat and Sheep production in the Tropics. Longman Scientific and Technical Singapore. pp. 271.

El Karim AIA, Owen JB (1987). Post-weaning growth performance, carcass characteristics and preliminary heritability estimate for some carcass traits of two types of Sudan Desert sheep on intensive feeding. J. agric. Sci. (Camb.). 109: 531-538.

Hopkins-Shoemaker C, Solaiman S, Kerth C, Jones W, Bransby D (2004). Growth and carcass characteristics of castrated or intact male Boer x Spanish goats grazing marshall annual ryegrass. J. Anim. Sci. (82) suppl. 1.

Lee GJ (1986). Growth and carcass characteristics of ram, cryptorchid and weather Border Leicester x Merino lambs: effects of increasing carcass weight. Australian. J. of Expe Agric 26(2): 153-157.

Looper ML, Burke JM, Mcbeth LJ, Krehbiel CR, Flores R, Rosenkrans JrCF, Alken GE (2005). Effects of time constriction on growth, feed lot performance, and carcass characteristics of Angus and Charolais-sired calves. American Society of Animal Science Southern Section meeting. J. Anim. Sci. 83: (suppl.2), 32.

Mahgoub O, Lodge GA (1998). A Comparative study on growth, body composition and carcass tissue distribution in Omani Sheep and Goats. The .J. of Agric.Sci. 131: 329-339.

Moron-Fuenmayor OE, Clavero T (1999). The effect of feeding system on carcass characteristics, non-carcass components and retail cut percentages of lams. Small Rumin. Res. 34:57-64.

Murray PJ, Sumarmono Pratiwi NMW, Taylor DG (2001). Growth of goats for meat production: effect of breed and castration. Asia Pacific .J. of Clinical Nutr. 10 (suupl.).

Nsoso SJ, Mannathoko GG, Tadubana TT, Malela L (2004a). The effect of methods of castration on live weight, dressed percentage and linear body measurements on indigenous Tswana goats raised under semi-intensive management in Southeast Botswana. Livestock Research for Rural Development 16 (2): (http://www.cipav.org.co/lrrd/lrrd16/2/nsos1602.htm).

Nsoso SJ, Podisi B, Otsogile E, Mokhutshwane BS, Ahmadu B (2004b).

Phenotypic characterization of indigenous Tswana goats and sheep breeds in Botswana: Continuous Traits. Tropical Animal Health and Production 36 (8): 789-800.
Riley RR, Savell JW, Johnson DD, Smith GC, Shelton M (1989). Carcass grades, rack composition on tenderness sheep and goats as influenced by market class and breed. Small Rumin.Res. 2: 278-280.
Ruvuna F, Taylor JF, Okeyo M, Wanyoike M, Ahuya C (1992). Effects of breed and castration on slaughter weight and carcass composition of goats. Small Rumin. Res. 7: 175-183.
SAS (1999-2000). Statistical Analysis System. Institute Inc., Cary, NC, USA.
Snowder GD, Glimp HA, Field RA (1994). Carcass characteristics and optimal slaughter weights in four breeds of sheep. J. Anim. Sci. 72: 932-937.
Solomon G, Fletcner I, Gizaw K, Yibrah Y (1991). Effects of castration and supplementary feeding on growth, carcass characteristics, and market value of Adal goats'. In: IAR Proceedings of the Fourth National Livestock Improvement Conference, Addis Ababa, Ethiopia. pp.159-164.
Taylor St. CS, Murray JI, Thonney ML (1989). Breed and sex differences among equally mature sheep and goats. 4. Carcass muscle, fat and bone. Animal Production. 49: 385-409.
Tesfaye K, Tesfaye L, Estifanos T, Mieso G (2008). Effect of level of substitution of sweet potato (*Ipomoea Batatas. L*) Vines for concentrate on body weight gain and carcass characteristics of browsing Arsi-Bale goats. J. Cell Anim. Biol. 2(2): 036-042.
Thiruvenkadan AK (2005)**.** Determination of best-fitted regression model for estimation of body weight in Kanni Adu kids under farmer's management system. Livestock Research for Rural Development 17 (7): (http://www.cipav.org.co/lrrd17/7/thir17085.htm).
USDA (1982). Official united state standards for grades of lamb, yearling mutton and mutton carcass. Agricultural marketing service USDA, Washington, DC, 1.
Vélez M, Raudales J, Esnaola MA, Murillo B (1993). Growth and carcass characteristics of lambs fed ammoniated corn straw and Gliricidia sepium or cotton-seed meal. Small Rumin. Res. 10: 209-217.
Yibrah Y, Fletcher I, Gizaw, Solomon G (1991). Effect of castration on growth, fattening and market value of Black-Head Somali rams. In: IAR Proceedings of Fourth National Livestock Improvement Conference, Addis Ababa, Ethiopia. pp.133-140.