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Performance, Carcass Characteristics and Meat Quality of Intact and Castrated Ardhi Goat Kids Fed High Energy Diet

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Abstract: An experiment was conducted to evaluate the effects of castration on growth performance, carcass characteristics and meat quality of Ardhi goat kids. Twenty-four weaner male kids with an average age of 3 months and 14.1±0.91 kg body weight were assigned randomly to one of two equal groups and the kids in one group were castratoed using elastrator rings while the other group was left intact. All kids were fed *ad libitum* on high energy commercial pellets for 82 days and slaughtered. Castration had no significant effect on slaughter weight, feed intake, gain, feed: gain ratio, carcass weight and dressing percentage. Castrated goat kids had significantly ($p<0.05$) heavier liver weight, more body fat thickness and lighter head weight than comparable intact. There were no differences ($p>0.05$) between castrated and intact kids on all studied internal fat depot weights, chemical composition of the 9-11th rib joint and meat quality of the longissimus muscle except for the separable fat percentage from 9-11th rib joint which was higher ($p<0.05$) for castrated as compared to intact kids.

Key words: Ardhi goat, growth performance, carcass characteristics, meat quality, kids, thickness

INTRODUCTION

Goats occupy a special niche in Saudi Arabian agribusiness economy; it accounts for 14.4% of total red meat production. When compared to other ruminants, goat meat is lowest in fat and cholesterol content. While low fat content makes goat meat a healthy source for human nutrition, its low fat content is a disadvantage in terms of juiciness, flavor and tenderness (Ciftci and Kor, 2010). Castration is one of those important management activities used to produce carcasses with higher percentages of fat tissues than intact kids (Kebede *et al*., 2008; Solaiman *et al*., 2011). Louca *et al*. (1977) have shown that flavor and tenderness of castrated kid meat can improved by increasing the amount of intermuscular fat content. Also, castration of male goat is widely used to maintain control of breeding program and to reduce the unwanted strong odors present in goat meat (Kebede *et al*., 2008). Previous studies have been shown that intact animals grow faster and utilize feed better than castrated males (Louca *et al*., 1977; Solomon *et al*., 1991). In contrast with this view, Mackenzie (1970) and Kyomo (1978) concluded that castrated male goats grow faster and are heavier than intact goats.

There is scarce information on the effect of castration on growth rate, feed utilization and carcass and meat quality characteristics of indigenous goat breeds. Ardhi goat is considered one of the most predominant breed in the central province of Saudi Arabia. Therefore, this study was conducted to study the impact of castration on body growth, feed utilization and carcass characteristics in Ardhi male kids.

MATERIALS AND METHODS

Animals: Twenty-four weaner male Ardhi kids with an average age of 3 months and 14.1±0.91 kg body weight were purchased from local market. All kids were kept in quarantine for 3 weeks; concurrently with this, kids were ear tagged, vaccinated and received the anthelminthes treatments. After 1 week, they have been quarantined, kids were assigned randomly to one of two equal groups and the kids in one group were castrated using elastrator rings while the other group was left intact. Kids in each group were allotted randomly into four replicates of equal numbers each replicate was housed in a separate pen. Pen was used as the experimental unit for feed performance data; pens were 1.7×3.0 m and constructed of metal separators and concrete floors and were located under a roof in an open-sided barn.

Feeding: All kids were fed *ad libitum* on commercial pellets at 09:00 h after discarding the refusals from the previous day. Refusals were removed, weighed, sampled

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for DM determination and then discarded. The feeding period lasted for 82 days during which DM consumption and kid weight data were recorded weekly; kid weight was recorded after 12 h fasting and before feeding in the morning. Fresh drinking water was available at all times. Feeding and management practices were applied equally to castrated and intact kids. The commercial pellets was formed as a pelleted total-mixed ration with a ratio of 75% concentrate: 25% alfalfa hay; the chemical composition (DM basis) was 14.53% CP, 1.16% EE, 24.91% NDF, 14.22% ADF, 7.46% ash and 2.78 Mcal ME kg^{-1} DM.

Carcass data: At the end of the feeding period, all kids were slaughtered after 12 h without feed. Hot carcass, head, liver and internal fat namely; omental fat, mesenteric fat, perirenal fat and channel fat weights were recorded immediately after dressing. The gastro-intestinal content was weighed and empty body weight was calculated by deducting the weight of digesta from the fasted live weight at slaughter. Carcasses were then refrigerated at 4°C for 24 h and the cold carcass weights were recorded thereafter, the carcasses were carefully divided into two equal halves along the midline and the right side was ribbed between the 12 and 13th ribs. After ribbing, longissimus dorsi muscle area was measured by direct grid reading. Fat thickness over the center of the longissimus dorsi muscle and body wall thickness 11 cm lateral to the dorsal process between the 12 and 13th ribs were also determined. Then, the 9-11th rib joint was separated from the right side of each carcass and physically dissected into bone, fat and lean. The lean tissue was ground through a 4 mm plate, mixed and reground again. During the second grinding, 5 subsamples (10-12 g) were taken from each carcass to obtain a 50-60 g sample that was placed in a plastic bag, frozen and stored at -20°C pending chemical analysis.

Samples from the longissimus dorsi muscle between the 5-8th ribs after 24 h of the slaughter were removed, sliced into roughly equal proportions, weighed, cooked to a final internal temperature of 71°C in electric oven and then weighed again to determine percentage of cooking loss. The muscles were also used to analyze the color with the Minolta ChromaMeter CR-300, the values of pH were measured with MP-220 integrated electrode pH-meter and shear force values were determined using Warner-Bratzler shear device (Pena *et al*., 2009).

Chemical and statistical analysis: Samples of diet and ground lean tissues were analyzed for DM, ash, EE and CP according to AOAC (1995). NDF and ADF in diet were determined according to Van Soest *et al*. (1991). Data for growth performance, chemical composition and carcass characteristics were statistically conducted by one-way ANOVA using GLM procedures of SAS (2002).

RESULTS AND DISCUSSION

The effect of castration on feeding performance and carcass traits of growing kids are shown in Table 1. Despite there were no significant ($p>0.01$) differences existed in slaughter weight, feed intake, weight gain and feed: gain weight ratio between intact and castrated kids, intact kids numerically tended to have 5.7% heavier slaughter weight, 14.2% faster growth rate and 4% better feed conversion ratio than comparable castrated kids. Various studies have been conducted testing the effect of castration on feeding performance. The results to this point have been contradictory. In line with the findings, Solomon *et al*. (1991), Abdullah *et al*. (2008) and Kebede *et al*. (2008) reported that castration had no significant effect on body weight or average daily gain in Adal, Black and Arsi-Bale goats, respectively. Similarly, indicated that castration of young market Boer x Spanish goats slightly reduced growth and did not provide any distinct advantage in performance. In other species of animal, Looper *et al*. (2005) stated that castration at either birth or weaning did not alter all growth and feedlot performance of Angus and Charolais-sired steers. On the other hand, Ciftci and Kor (2010) and Solaiman *et al*. (2011) reported that the growth rate of entire Boer, Norduz and Boer-cross male kids, respectively were significantly higher than those of castrated, respective. The overall daily DM intake in intact and castrates were 4.1 and 4.2% of body weight, respectively. These values were higher than those values reported by El-Hag *et al*. (2007) who stated that intact and castrated Sudan desert goats consumed 3.1 and 3.9% of their body weight, respectively. This might be due to differences in breed, feeding management and slaughter age or weight. Zemmelink *et al*. (1985) reported that DM intake of goats can be >3% of body weight if a high quality feed is

Table 1: Effect of castration on feeding performance and carcass traits in Ardhi kids

Character	Intact	Castrated
Feeding performance		
Initial weight (kg)	14.0±0.960	14.3±0.850
Slaughter weight (kg)	27.9±1.270	26.4±0.910
Feed intake (g)	858.0±70.00	852.0±70.00
Average daily gain (kg^{-1})	169.0±6.000	148.0±9.300
Feed: gain ratio (kg kg^{-1})	5.6±0.670	5.8±0.430
Carcass traits		
Empty body weight (kg)	25.4±0.890	24.0±0.780
Carcass weight (kg)	12.7±0.640	12.7±0.540
Dressing (%)	45.5±1.230	47.7±0.640
Head weight (kg)	1.6±0.090[a]	1.3±0.050[b]
Liver weight (kg)	0.6±0.050[b]	0.7±0.030[a]
Longissimus dorsi area (cm^2)	11.6±0.420	11.2±0.430
Fat thickness (mm)	16.0±0.610[b]	26.0±0.220[a]
Body wall thickness (mm)	134.0±9.000	147.0±11.00

[a,b]Means in the same row bearing different superscripts differ (0.01)

offered and this was achieved in the present experiment. The overall daily weight gain was 148-169 g day^{-1} which was >63-133 g day^{-1} reported by El-Hag *et al.* (2007), Abdullah *et al.* (2008) and Kebede *et al.* (2008) but <400 g day^{-1} observed by Akinsoyinu *et al.* (1975) in West African Dwarf goats. The overall feed conversion ratio of 5.6/5.8:1 indicated lower weight-gain efficiency than those 4.5: 1 reported by El-Hag *et al.* (2007) but was in the range of 5.05:1-6.56:1 reported by Babiker *et al.* (1985) this difference may be attributable to differences in the ages of the goats or feeding regimens between studies.

Results showed that no significant differences ($p>0.01$) were found in the empty body and carcass weight, dressing percentage, Longissimus dorsi area and body wall thickness of intact kids and castrates which were in agreement with the report of Kebede *et al.* (2008). In line with the finding, El-Hag *et al.* (2007) and Ciftci and Kor (2010) reported that castration had no effect on carcass weight or dressing percentage in goats. This contradicts the finding of Solomon *et al.* (1991), Ruvuna *et al.* (1992) and Solaiman *et al.* (2011) who found that castration significantly improved dressing percentage. Dressing percentages for this study varies from 45.5-47.7% however, these values are in close agreement with that 46-49% reported for different breeds of goat kids (Koyuncu *et al.*, 2007; Kebede *et al.*, 2008; Johnson *et al.*, 2010).

Significant differences ($p<0.01$) were detected in head and liver weight and body fat thickness; intact kids had heavier head weight and less body fat thickness and lighter liver weight than comparable castrated kids. The difference in head weight is attributable to the presence of long developed horns in male kids than those of castrates. Similarly, Kebede *et al.* (2008) observed heavier head weight and thinner body fat thickness in intact Arsi-Bale males than castrated kids. Also, El-Hag *et al.* (2007) found that liver weight of castrated kids was significantly heavier in weight than those of intact. Forrest *et al.* (1975) attributed such differences to hormonal changes associated with castration; these kids were slaughtered approximately 1 month past at the age of their sexual puberty.

The effect of castration on internal fat depot weights, tissue distribution in the 9-11th rib joint and chemical composition of the separable lean from Aradhi kids are shown in Table 2. Although, intact kids had slightly lower ($p>0.01$) fat weights in omental, mesenteric and perirenal depots than castrates, results showed that castration had no significant ($p>0.01$) effects on all studied internal fat depot weights. In support of this finding, Ciftci and Kor (2010) did not get significant difference in omental and mesenteric fat weight between castrated and intact Norduz males. On the other hand, Solomon *et al.* (1991), Kebede *et al.* (2008) and Solaiman *et al.* (2011) reported that castrated goats had significantly heavier internal fat deposit than entire goats. The discrepancies in results might be due to breed differences in growth and stage of maturity at slaughter, fattening period, dietary energy, physiological condition and physical activities. In general, internal fat weights in this study were higher than those of some previous studies (Aydin and Arik, 1999; Ciftci and Kor, 2010) but lower than those of others (Kor and Ertugrul, 2000).

Table 2: Effect of castration on various fat depots and carcass composition in Ardhi kids

Character	Intact	Castrated
Fat depot		
Omental fat (g)	420.0±70.0	470.0±50.00
Mesenteric fat (g)	370.0±40.0	390.0±30.00
Perirenal fat (g)	310.0±30.0	340.0±20.00
Channel fat (g)	50.0± 1.0	40.0±4.000
9-11th rib joint composition		
Separable lean (%)	54.9±1.63	52.1±1.420
Separable fat (%)	21.3±1.49[b]	25.0±1.640[a]
Bone (%)	23.8±1.29	22.9±0.960
Lean: Fat ratio	2.6±0.03	2.1±0.030
Chemical composition[c]		
Moisture (%)	71.5±0.81	71.7±0.600
CP (%)	18.4±0.55	18.6±0.340
EE (%)	9.0±0.72	8.6±0.680
Ash (%)	1.1±0.05	1.1±0.030

[a, b]Means in the same row bearing different superscripts differ (0.01); [c]Chemical analyses of separable lean from 9-11th rib joint

Whole tissue analysis requires a significant amount of time and effort that reduces meat quality and results in economic loss. Al-Saiady *et al.* (2010) found that tissue analysis of the 9-11th rib joint can provide satisfactory results with less time and effort than whole or half-carcass tissue analysis. However, this study conducted tissue dissection on the 9-11th rib joints and found that castration resulted in significantly ($p<0.01$) higher separable fat percentage in castrates than the intact kids. This implies that castration affected carcass composition in addition to other factors such as breed, sex, dietary energy, fattening period and stages of maturity. Similar results were reported by Koyuncu *et al.* (2007), Abdullah *et al.* (2008) and Ciftci and Kor (2010) who found that castrated kids had lower carcass muscle percentage but higher subcutaneous fat percentage than intacts. Also, Kebede *et al.* (2008) found that fat content in all primal cuts except for shoulder and neck was lower in intact goats than castrated males. Lean: fat ratios for intact males and castrates were 2.6:1 and 2.1:1, respectively but the difference was not significant. Chemical composition of separable lean from 9-11th rib joint were not significantly different ($p>0.01$) between castrated and intact Ardhi kids; moisture, protein and ash

content averaged 71.6, 18.5 and 1.1%, respectively were in agreement with those found by other researchers (Arguello *et al*., 2005; Wattanachant *et al*., 2008) whereas ether extract content ranged between 8.6 and 9%. However, the often quoted standard composition of normal adult mammalian muscle is 75% moisture, 19% protein, 2.5% fat and 0.65% minerals (Lawrie, 1998). These values may vary considerably with factores such as breed, age, sex/castration, weight and nutritional history.

Table 3 shows quality chracteristics of meat obtained from intact and castrated Ardhi goat. Muscle pH values from longissimus dorsi measured 24 h postmortem were not significantly ($p>0.05$) affected by castration. Similar results were reported by Simela *et al.* (2004) and Solaiman *et al.* (2011) in indigenous South African and Boer-cross catrated and intact goats, respectively whereas Abdullah and Musallam (2007) noted a lower pH value in castrated than intact kids. The ultimate pH is important to the chilled meat because it affects its shelf life, color and quality. However, the ultimate pH of longissimus dorsi muscle in this trial with an average value of 5.85 was slightly high but in the acceptable range recorded (5.5-5.9) in earlier studies and considered optimal for high-quality goat meat (Herold *et al*., 2007; Pieniak-Lendzion *et al*., 2009). There was no difference in Warner Bratzler shear force (3.70 kg cm^{-2}) due to castration. This result was in concomitant with the findings of Simela *et al.* (2004) and Abdullah and Musallam (2007). On the other hand, Johnson *et al.* (1995) found that castrated goat carcasses had lower shear force values than those muscles from intact male carcasses. In general, the shear force values obtained in this study were similar to those observed by Babiker *et al.* (1990) using desert goats and Wattanachant *et al.* (2008) using Anglonubian x Thai native goats but were lower as compared to the studies of Sheridan *et al.* (2003) in Boer goat and Simela *et al.* (2004) in South African indigenous goats. The evaluation of factors affecting meat tenderness is particularly important in goat meat because of its lower tenderness than sheep and beef (Johnson *et al*., 1995). The acceptable limit for goat meat tenderness was not found in literatures. Shear force values around 3.0 kg cm^{-2} is noted for the acceptable limit of lamb tenderness (Bickerstaffe, 1996). Therefore, the values obtained in this study suggested that the meat from either castrated or intact kids were acceptable in term of tenderness. Cooking loss ranged from 26.8-27.5% which was within the normal range for goat meat (Pena *et al*., 2009) and showed no significant difference between intact and castrated kids. There was no difference ($p>0.05$) in all meat color components; castrated kids having non-significantly 1.07 units higher a* value associated with more red color of lean than intacts. Similar to findings in the present study, a non-significant effect of castration on goat meat color has been reported in Boer cross kids by Solaiman *et al.* (2011). Also, Simela *et al.* (2004) found that meat from castrates and intact indigenous South African goats were not significantly differed in L* and b* color components but a* value of average mean for female and castrates was 1.86 units higher than intact males. Abdullah and Musallam (2007) found that muscle of castrated kids had significantly higher L* compared to intact kids whereas a* and b* color components were not affected by castration. The present findings could be related to the similarity in pre and post-slaughter conditions since, the ultimate pH values were similar from meat of castrated and intact kids. This is in line with the fact that tenderness and color of meat were affected by both the rate and extent of glycolysis (Simela *et al*., 2004).

Table 3: Effect of castration on instrumental meat quality of longissimus muscle from Ardhi kids

Character	Intact	Castrated
pH	5.86±0.04	5.84±0.05
Shear force (kg cm^{-2})	3.59±0.30	3.84±0.33
Cooking loss (%)	26.78±1.15	27.52±1.08
Color profile		
L*	49.74±1.16	49.41±1.08
a*	15.58±0.44	16.65±0.71
b*	11.11±0.49	11.78±0.65

L* = Lightness; a*= redness; b*= yellowness

CONCLUSION

In the current study, the findings indicated that early castration and fattening of Ardhi goat kids on high energy diet up to 6 months of age had little influence on growth performance and carcass characteristics. However, carcasses from castrated goat kids had higher separable fat percentage and more body fat thickness in comparison to intacts.

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