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Carcass Characteristics and Meat Composition of Yearling Tswana Goats Fed *Teminalia sericea*, *Boscia albitrunca* Browses or Lurcene as Supplements

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Abstarct: Twenty five Tswana goats of 7 months of age were obtained from Botswana College of Agriculture farm. The goats were balanced out for weight (average weight; 20.1±0.1 kg) and sex (3 females and 2 males per set) and were randomly allocated to the treatments. They were individually housed and fed browses (Teminalia sericea and Boscia albitrunca) for 63 days, at two levels; high (800 g) and low (400 g), resulting in the following treatments; TS 800, TS 400, BA 800 and BA 400. The control group (C 800) was instead supplemented with lurcene at 800g daily. Grass hay (Cenchrus celiaris) and wheat bran were offered as a basal diet and as an energy source, respectively, to all the treatments. On day 63, feed was withdrawn overnight and the goats were transported to the Botswana Meat Commission (BMC) on the 64th day. Goats were processed according to the standard abattoir procedures and their carcasses were cut up into 5 primal cuts (rib, chuckblade, flank, leg and neck), which were thereafter weighed. Lean tissue, free from visible fat, was obtained from the right thigh part of the leg for chemical analyses. Dry Matter (DM), moisture, ash, Organic Matter (OM), Crude Protein (CP) and crude fat was done on the lean tissue. The data were subjected to Analysis of Variance (ANOVA) and Duncan's multiple range tests were used to separate means. Final live weights ranged from 24.2 to 27.8kg, with C800 having significantly higher weights compared to all treatment groups. Dressing percentage ranged from 45.9 to 51.2% and TS400 had higher value ($p<0.05$) compared to BA400. There were no significant differences ($p>0.05$) in primal cuts weights between the treatments. Meat moisture content showed a significant difference ($p<0.05$) between BA400 goats and other treatments. However when BA400 was compared with C800, no difference ($p>0.05$) was observed (77.94 vs 76.04%, respectively). Meat ash content for BA800 was found to be higher ($p<0.05$) than that of other treatments but similar ($p>0.05$) to that of C800. Meat dry matter, organic matter, crude protein and crude fat averaged 24.00, 97.77, 71.06 and 6.90%, respectively, without any significant differences ($p>0.05$) observed between the groups. Meat mineral contents averaged 0.058, 0.133, 1.037, 0.833 and 0.224% for calcium, phosphorus, potassium, sodium and magnesium, respectively and again no without significant differences ($p>0.05$) were observed between the groups. Goats supplemented on browses performed relatively like the lurcene supplemented goats though the browses are known to contain tannins. B. albitrunca and T. sericea can be successfully used by farmers as supplements during the dry seasons to raise goats for good quality meat.

Key words: Tswana goats, carcass characteristics, meat composition, browses, supplements

INTRODUCTION

Small ruminant husbandry is the most important and usually the only living source of proteins for people inhabiting forest regions or regions not suitable for crop cultivation and cattle production[1]. Several adaptations evolved in native goats that made them thrive in the dry areas during critical periods of the year and still produce products valued by farmers[2]. Tswana goat is a native breed which is well adapted to climatic regions of Botswana[3]. These animals are an integral part of the smallholder farming systems. Goats are an important source of protein for developing regions, mainly situated in the tropics[4,5] and they play a significant role in the food chain and overall livelihoods of the poor rural households where they are mostly raised by poor women and their children[6]. Meat is the p rimary reason for goat keeping, resulting in meat goats constituting the major proportion of the world goat population[4], with Sub-Saharan Africa accounting for 60% of the total goat population in Africa[6]. Animal production in Botswana is constrained by poor feed quality and quantity, mainly due

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to low annual rainfall[7]. There is need to feed or provide supplements to goats when pastures are poor to help meet their nutritional needs, for good quality meat production. Aganga and Nsinamwa[3] noted that goats spend a lot of their time browsing and up to 80% of total feed intake may be accounted to browses. Goats have the ability to select plants to meet their nutritional needs and thus make them survive drought better than cattle[3]. In Botswana, most research on goats is related to production parameters and their phenotypic characterization[8-13] and reproduction[14], but research on the carcass and meat composition of these animals, more especially as affected by feeding regimes is limited.

Among browse plants usually browsed by goats in Botswana include *Boscia albitrunca, Teminalia sericea and other acacia species*. These browse plants are well adapted to the climatic condition of Botswana and provide medium to high quality forage for goats, mainly during dry seasons when grazing conditions are low. However, no information is available as to how these browse species affect the meat quality of the animals. *B. albitrunca* and *T. sericea* contain 0.7 and 0.9% tannins, respectively. Tannins are phenolic compounds known to precipitate proteins[15]. Tannins are naturally occurring water soluble polyphenolics that precipitate proteins and other polymers such as cellulose, hemicellulose and pectin to form stable complexes[15,16]. These substances have either detrimental or beneficial effects to livestock consuming browses containing them, more especially the condensed type of tannins[16]. At high levels, tannins cause over protection of proteins resulting in low utilisation of nitrogen, while at quantities of less than 50 g kg^{-1} on dry matter basis, condensed tannins may increase supply of proteins to the small intestines[17,18].

Knowledge of quantity and distribution of tissues such as fat and lean on the carcass is important, not only to assess the quality of meat in meat producing animals, but also to market the meat more efficiently[8,5]. According to Maghoub and Lu[5], lean and to a lesser extent fat, are the major edible tissues of the carcass. In countries where meat is sold in cuts, lean content of each cut is an important factor for determining the value of the cut[5]. Goat meat or chevon is one of the most widely consumed meats worldwide, especially in the tropics and developing countries[19]. Specific consumption patterns and preferences for goat meat are dictated by cultural and traditional backgrounds and the socio-economic status of the community. According to Casey[4], there are virtually no religious or cultural taboos on the eating of goat meat, with the result that goat is readily available to societies in which eating beef, pork or other meat types are prohibited. In many parts of the world, goat meat is preferred to mutton and commands a better price[4]. It has less fat compared to conventional meats; beef, pork and lamb[19]. The nature, yield and composition of a carcass at slaughter is affected by the production system under which the animal was reared[20]. Therefore, this study was designed mainly to investigate the effects of the browse supplements on carcass and meat characteristics of Tswana goats.

MATERIALS AND METHODS

Animals: Twenty five Tswana goats of 7 months of age were obtained from Botswana College of Agriculture farm. At the beginning of the trial, 0.5 mL of ecomectin was administered to the goats to get rid of both ecto-and endo-parasites. The goats were balanced out for weight (20.1±0.1 kg) and sex (3 females and 2 males per group) and blocked into five groups of five animals each. Then each group was randomly allocated to the treatments. The treatment were as follows; *Boscia albitrunca* supplementation at 400g level (BA400; n = 5, 20.2±0.1 kg), *Boscia albitrunca* supplementation at 800g level (BA800, n = 5, 20.0±0.1 kg), *Teminalia sericea* supplentation at 400 g level (TS 400; n=5, 20.0±0.1 kg), *Teminalia sericea* supplentation at 800 g level (TS 800, n = 5, 20.0±0.1 kg) and Lurcene fed Control at 800g (C800, n = 5, 20.2±0.1 kg). Water was made available at all times. The animals were individually housed in goat units with a common roof made of corrugated iron sheets with a dwarf wall to allow free ventilation on concrete floor.

Feeding: The animals were fed *Teminalia sericea* and *Boscia albitrunca* each at two levls daily (400 and 800 g). The browses were fed together with grass hay (*Cenchrus celiaris*) offered as a basal diet and wheat bran at 250 g/day/animal was offered as an energy source. The browse leaves and twigs were cut, wilted overnight and fed to the goats the following day. The control group was supplemented on lurcene (*Medicago sativa*) at 800g per day. Cleaning of the pens and removal of the leftovers from the previous day was done every morning prior to feeding.

Animal slaughter: At the end of the trial after 2 months ie. at 9 months of age, on day 63, the animals were starved overnight and weighed to obtain Final Live Weights (FLW) and transported the following day (64th day) to the Botswana Meat Commission (BMC) abattoir, where they were processed according to the standard abattoir procedures. After dressing and evisceration procedures, carcasses were weighed to obtain Hot Carcass Weights

(HCW) and cut up into 5 primal cuts (rib, chuckblade, flank, leg and neck), which were thereafter individually weighed. The final live weights and hot carcass weights were used to determine Dressing Out Percentage (DOP), calculated as; DOP = (HCW/FLW)*100. Lean tissue, free from visible fat was obtained from the right thigh part of the leg, packaged and kept frozen at -70°C until analysis. After thawing overnight at 5°C, samples were then dried. Proximate analyses were carried using the procedures of AOAC[21] on meat and meat products. Proximate results were recorded as percent crude fat, Organic Matter (OM), moisture, Crude Protein (CP), Dry Matter (DM) and ash.

Statistical analyses: The study was structured as a Complete Randomized Design (CRD), where goat cuts and meat chemical composition parameters were variables. Data were subjected to Analysis of Variance (ANOVA) and Duncan's multiple range tests were used to separate means[22].

RESULTS AND DISCUSSION

Carcass characteristics: The final live weights of the animals ranged from 24.2 to 27.8 kg Table 1. The evident trend is that the two groups of goats fed *Boscia albitrunca* (BA400 and BA800) had the lowest final live weights followed by the *Terminilia sericea* groups at 24.2 and 24.7 kg, respectively. The control group had the highest final live weights which were significantly higher than those of the treatment groups ($p<0.05$). Hot carcass weights ranged between 11.1 and 13.3kg, the lowest being from the *B. albitrunca* (400g) and the highest from the control group. However, there were no significant differences ($p>0.05$) between the groups. *T. sericea* (400 g) group had a significantly high ($p<0.05$) dressing out percentage compared to the *B. albitrunca* (400 g) group at (51.2 vs 45.9%, respectively). According to Warriss[23], dressing out percentage varies widely between breeds, at different levels of fatness, between sexes and in animals reared in different husbandry systems. Warriss[23] reported dressing out percentage of about 50, 53, 75 and 72% for sheep, cattle, pigs and broiler chickens, respectively. Ruminants have bigger guts compared to monogastrics and thus ruminants dressing out percentage is usually lower than that of monogastrics and in some cases carcass composition varies due to components and consequently affecting the dressing out percentage, for instance pig carcasses may contain the skin, feet or head and these result in high dressing out percentages for such carcasses[23] Hatendi *et al.*[20] reported a range of 11.1 - 18.1kg for hot carcass weight and 40.2-53.3% dressing out percentage for indigenous Matebele goats (18-24 months) fed different levels of grass hay. Unlike the present study Hatendi *et al.*[20] reported high hot carcass weights probably because more mature goats were used in their study, however, the dressing out percentage range was similar to that of the present study (45.9-51.2%) and to that reported by Warriss[23] for sheep (50%) another small ruminant closely related to goats in terms of body size. Daskiran *et al.*[1] reported relatively lower dressing out percentages, 41.5-42.9% for Norduz native goats of about 2.5 months of age compared to the present study, probably due to their hairy coat, yielding smaller carcass compared to their final live weights. Dressing out percentage may also vary due to age, breed and feeding habit of the animal[23].

Although there were no significant differences ($p>0.05$) between respective primal cuts means are presented in Table 2. Rib weights ranged from 0.53 to 0.72 kg with animals fed *B. albitrunca* at 400g level having the lowest rib weights and the control and the *T. sericea* (400 g) having rib weights of 0.72 kg each. The chuckblade weights ranged between 1.83 to 2.15 kg for the *B. albitrunca* (400 g) and the control group, respectively. The flank of the *T. sericea* (800 g) was relatively higher at 1.00 kg, with the *T. sericea* (400 g) being the lowest at 0.88 kg. Leg weights for all the groups, control included were not that different with a range of 1.41-1.59 kg. The *B. sericea* (800 g) had relatively high neck weight at 1.07 kg compared to those of the *B. sericea* (400 g) group at 0.73 kg. It can be deduced from this study that goats supplemented on *B. albitrunca* and *T. sericea* performed just like the control group fed lurcene, probably indicating the good potential of these browses as supplements. These browses contain low levels of tannins, 0.7 and 0.9% for *B. albitrunca* and *T. sericea,* respectively[3]. According to Silanikove *et al.*[18], at low levels tannins protect the protein from being degraded in the rumen, thus it is delivered to the small intestines intact and subjected to acidic digestion.

Meat chemical composition: Thigh cut proximate analyses results are presented in Table 3. Moisture content showed a significant difference ($p<0.05$) between the *B. albitrunca* (400 g) at 77.94% and the other treatments, though it was similar ($p>0.05$) to that of the control group (77.94 vs 76.04%, respectively). Moisture content values in the present study are comparable to those of donkey meat (71.05-74.72%) obtained by Aganga *et al.*[24] and 75.23-79.24% reported by Srinivasan *et al.*[25] for different meat portions of the beef steers under two different feeding regimes. In Srinivasan *et al.*[25] study, the steers were either fed grass or grain and they were implanted with zeranol. Martinez-Cerezo *et al.*[16] also reported similar

Table 1: Final live and hot carcass weights and dressing out percentage of Tswana goats

Parameter	C800	BA400	BA800	TS400	TS800	[1]SE
[2]FLW (Kg)	27.8[a]	24.2[b]	24.2[b]	24.4[b]	24.9[b]	0.2
[3]HCW (Kg)	13.3	11.1	12.1	12.5	12.1	1.9
[4]DOP (%)	47.8[ab]	45.9[b]	50.0[ab]	51.2[a]	48.6[ab]	1.1

Note: Means in the same row with different superscripts differ significantly ($p<0.05$), [1]SE = standard error, [2]FLW = Final Live Weight, [3]HCW = Hot Carcass Weight, [4]DOP = Dressing Out Percentage

Table 2: Average weights of primal cuts of Tswana goat carcasses (Kg) fed either browses or Lucerne as supplements

Treatment	Rib	Chuckblade	Flank	Leg	Neck
C800	0.72	2.15	0.96	1.46	0.80
BA400	0.53	1.83	0.75	1.41	0.73
BA800	0.68	2.09	0.89	1.51	1.07
TA400	0.72	1.94	0.88	1.55	0.78
TA800	0.68	1.95	1.00	1.59	0.86
Means	0.67	1.99	0.88	1.5	0.85
Standard error	0.067	0.171	0.092	0.111	0.111

Note: means in the same column with different letters differ significantly ($p<0.05$)

Table 3: Average chemical composition of Tswana goat thigh cut (% DM) fed browses or Lucerne as supplements

Treatment	DM	Moisture	Ash	OM	CP	Crude fat
C800	23.97	76.04[ab]	2.43[ab]	97.58	75.39	6.12
BA400	22.07	77.94[a]	1.78[b]	98.22	74.12	6.57
BA800	25.05	74.93[b]	3.01[a]	96.99	69.81	6.68
TS400	24.32	75.49[b]	1.89[b]	97.93	67.83	7.29
TS800	24.60	75.40[b]	1.87[b]	98.13	68.16	7.80
Means	24.00	75.96	2.20	97.77	71.06	6.90
Standard error	0.595	0.592	0.338	0.339	2.19	0.914

Note: means in the same column with different letters differ significantly ($p<0.05$), DM = Dry Matter, OM = Organic Matter, CP = Crude Protein

Table 4: Average mineral composition of Tswana goat cuts (% DM) fed on browses or Lucerne as supplements

Treatment	Ca	P	K	Na	Mg
C800	0.040	0.106	1.036	0.823	0.224
BA400	0.029	0.136	1.085	0.851	0.213
BA800	0.026	0.117	1.085	0.832	0.232
TS400	0.138	0.103	0.932	0.850	0.217
TS800	0.055	0.200	1.049	0.810	0.232
Means	0.058	0.133	1.037	0.833	0.224
Standard error	0.035	0.049	0.055	0.032	0.007

Note: means in the same column with different letters differ significantly ($p<0.05$), Ca = Calcium, P = Phosphorus, K = Potassium, Na = Sodium, Mg = Magnesium

values for moisture content in the range of 75.23-76.74% for three Spanish lamb breeds. Ash content was high ($p<0.05$) for *B. albitrunca* (800 g) compared to other groups, except the control which were similar ($p>0.05$) (3.01 vs 2.43%, respectively). Ash content in the present study ranged between 1.78-3.01%, a range higher than 0.93-1.46%, 1.04-1.11% and 0.81-1.78% reported by Hoffman *et al.* (2000) for commercial broiler strains in South Africa, Srinivasan *et al.*[25] for beef steers and Hatendi *et al.*[20] for fattened indigenous Matebele goats, respectively. The control group in the present study had a relatively higher crude protein at 75.39% followed by *B. albitrunca* (400 g) at 74.12%. Crude fat content was relatively high for the *T. sericea* (800 g) at 7.80%, with the control having the lowest at 6.12%. Goat meat at times referred to as chevon is acclaimed for its low fat content (2.5 g 100 g^{-1}), compared to beef, pork and lamb at 6.8, 7.7, 7.9 g 100 g^{-1}, respectively[19]. The total average crude fat for chevon in the present study averaged 6.90%, an amount far much less than amounts reported by Holland *et al.*[26] for other meat sources. Holland *et al.* (1997) reported 13.7, 17.7, 18.7 and 25% for beef, chicken, lamb and pork, respectively. Crude fat reported in the present study is comparable to that reported by Hatendi *et al.*[20] for indigenous Matebele goats fattened with different levels of veld hay at 5.42-6.54%. Nonetheless, Hatendi *et al.*[20] once noted that the nature, yield and composition of a carcass at slaughter is affected by the production system under which the animal was reared. The small amounts of fat in chevon can be accounted to the fact that goats tend to deposit more fat along their internal organs (viscera) before they deposit it externally and it is also easily trimmable[26]. Goat fat also has an excellent ratio of polyunsaturated to saturated fats, making it a very healthy choice of meat[19]. Madruga *et al.*[19], reported unsaturated/saturated fatty acids ratios of 1.15 and 1.01 for castrated and intact, respectively for Mestiço goats slaughtered at different ages. According

to Marinova *et al.*[27], goat meat is a good source of lean meat due to its very little intramuscular fat content and a good source of desirable fatty acids, since goats deposit relatively higher amounts of polyunsaturated fatty acids (PUFA) than other ruminants. Dry matter and organic matter contents were very similar for all the groups, ranging from 22.07-25.05% and 96.99-98.22%, respectively. Casey[4] also reported a similar range of 16.98-25.14% of dry matter for different tissues of crossbred goats, whereas Aganga *et al.*[24] reported a range of 23.68-30.68% for donkey meat. Minor differences were recorded between the treatments and the control group supplemented on lurcene in the present study. These results may be yet another indicator that the browses are also highly nutritious just like lurcene and may be that is why goats prefer them. *T. sericea* and *B. albitrunca* contain tannins, 0.7% and 0.9%, respectively, compared to lurcene which does not contain any[3]. Although tannins are known for decreasing digestibility of forages[3,15], here is a likelihood that *T. sericea* and *B. albitrunca* may fall in that category of browses with low quantities of tannins, contributing to increased proteins availability to the small intestines[14,17] and resulting in a protein efficiency equivalent to that of lurcene in the gastro-intestinal tract of goats.

The thigh cut showed no significant differences ($p>0.05$) for minerals in all treatments Table 4. The calcium content was in the range 0.026-0.138%, with the lowest being from the *B. albitrunca* (800 g) and the highest content from *T. sericea* (400 g). The *B. albitrunca* treatments had generally the lowest calcium content, with the *T. sericea* having the highest though the differences were not significant ($p>0.05$). Calcium content in this study is comparable to that reported by Casey[4] who reported a range of 0.01-0.047% for different tissues of crossbred goats and Aganga *et al.*[24] reported a range of 0.095-0.160% for donkey meat. Phosphorus contents ranged between 0.103-0.200%, with the lowest from *T. sericea* (400 g) group and the highest from *T. sericea* (800 g) group. The phosphorus content of chevon in this study also compare well with values reported by Aganga *et al.*[24] and Libby who reported ranges of 0.167-0.195% for donkey meat and 0.131-0.343% for average beef lean, respectively. Mineral contents for potassium, sodium and magnesium were relatively very similar across treatments including the control group. Potassium values were however higher than those reported in Aganga *et al.*[24] and Libby studies, who reported ranges of 0.287-0.417% for donkey meat and 0.184-0.415% for beef lean, respectively. Once more no significant differences in the mineral analyses of meat were observed between the highly digestible and nutritious lucerne supplemented group and those of the two browse supplemented groups, an indication that the two browses are probably well utilized by the goats.

CONCLUSION

The browse species can successfully be used by farmers to supplement their goats during seasons of poor feed quality. It is important to consider the significance of browse plants in Botswana as it is clear from the present study that some of them can be successfully fed as supplements to produce goats of good meat quality. These browses can be obtained cheaply in the range in Botswana and can be fed to goats either as supplements of a particular ration or as feed.

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REFERENCES

1. Daskiran, I., A. Kor and M. Bingol, 2006. Slaughter and carcass characteristics of Norduz male kids raised in either intensive or natural pasture. Pakistan J. Nutrition, 5: 274-277.
2. Iñiguez, L., 2004. Goats in resource-poor systems in the dry environments of West Asia, Central Asia and the Inter-Andean valleys. Small Ruminant Res., 51: 137-144.
3. Aganga, A.A. and M. Nsinamwa, 1997. Ruminant Feeds and Feeding In Botswana. Botswana Government Printers, Gaborone.
4. Casey, N.H., 1992. Compostion and Physico-Chemical Properties of Goat Meat. Goat Meat in Human Nutrition. In: R.R. Lokeshwar (Ed). Proceedings and papers presented at V International conference on goats, New Dehli, India, pp: 581-593.
5. Mahgoub, O. And C. Lu, 1998. Growth, body composition and carcass tissue distribution in goats of large and small sizes. Small Ruminant Res., 27: 267-278.
6. Lebbie S.H.B., 2004. Goats under household conditions. Small Ruminant Res., 51: 131-136.
7. Aganga, A.A. and S.O. Tshwenyane, 2003. Feeding values and Anti-nutritive factors of forage tree legumes. Pakistan J. Nutrition 2: 170-177.

8. Owen, J.E., G. Norman, I.L. Fisher and R.A. Frost, 1977. Studies on the meat production characteristics of the Botswana goats and sheep. Part I: Sampling methods and materials and measurements on the live animals. Meat Sci., 1: 63-85.
9. Katongole, J.B.D., B. Sebolai and M.J. Madimabe, 1996. Morphological Characteristics of the Tswana goat. In: S.H.B. Lebbie and E. Kagwini (Eds). Proceedings of the Third Biennial Conference on the African Small Ruminant Research Network UICC, Kampala, Uganda held 9 December, pp: 43-47.
10. Podisi, B., 1999. Morphological Characteristics of the Tswana Goats and Sheep. In: A.A. Aganga, R.G. Chabo, M. Kgosimore, M. Letso and U.J. Omphile (Eds). Proceedings of the sheep and goats workshop held 19-23rd April, Centre for In-service and Continuing Education, Botswana College of Agriculture, Gaborone, Botswana, pp: 100-113.
11. Adogla-Bessa, T. and A.A. Aganga, 2000. Responses of Tswana goats to various length of water deprivation. South African J. Anim. Sci., 30: 87-91.
12. Nsoso, S.J. and A.A. Aganga, 2004. A Review of Phenotypic Characteristics, Production Traits and Water Utilisation of Indigenous Tswana Goats. 8th International Conference on goats held on the 4-9th July, 2004, Pretoria, South Africa, pp: 22.
13. Nsoso, S.J., B. Podisi, E. Otsogile, B.S. Mokhutshwane and A. Ahmadu, 2006. Phenotypic characterisation of indigenous Tswana goats and sheep in Botswana: categorical traits. Botswana J. Agric. Applied Sci., 2: 4-12.
14. Phale, O. and O.R. Madibela, 2006. Concetration of soluble condensed tannins and neutral detergent fibre-bound tannins in fodder trees and forage crops in Botswana. J. Biolo. Sci., 6: 320-323.
15. Makkar, H.P.S., 1995. Qunatification of Tannin: A Laboratory Manual. 2nd (Edn.), International Centre for Agric. Res., in Dry Areas. Allepo, Syria.
16. Martinez-Cerezo, S., C. Sanudo, B. Pnea, I. Medel and R. Delfa, 1995. Isolation and characterization of an anaerobic ruminal bacterium capable of degrading hydrolysable tannins. Applied Environ. Microbiol., 61: 3293-3298.
17. Miller, S.M., J.D. Brooke and L.L. Blackall, 1995. Feral goat rumen fluid inoculation improves nitrogen retention in sheep consuming a mulga (Acacia aneura) diet. Australian J. Agric. Res., 46: 1545-1553.
18. Silanikove, N., N. Gilboa and Z. Ntsan, 1997. Interactions among tannins, supplementation and polyethylene glycol in goats given oak leaves: Effects on digestion and food intake. Anim. Sci., 64: 479-484.
19. Madruga, M.S., N. Narain, J.G. Souza and R.G. Costa, 2001. Castration and slaughter age effects on fat components of Mestço goat meat. Small Ruminant Res., 42: 77-82.
20. Hatendi, P.R., L.R. Ndlovu, T. Smith and A.N. Said, 1994. Composition of body and carcass gain of castrate Matebele goat fed complete cereal based diets differing in roughage inclusion level to slaughter after 10 Kg liveweight gain. Zimbabwe J. Agric. Res., 32: 117-129.
21. AOAC, 1996. Official Methods of Analysis (Association of Official Analytical Chemists), 15th Edition, Washington DC.
22. SAS, 2005. SAS/STAT User's Guide, Version 6, 4th Edition. Statistical Analysis System Institute, Inc. Cary NC, USA.
23. Warriss, P.D., 2000. Meat science-An Introductory Text. CABI Publishing International, Wallingford, UK.
24. Aganga, A.A., A.O. Aganga, T. Thema and K. Obocheleng, 2003. Carcass analysis and meat composition of the donkey. Pakistan J. Nutrition 2: 141-147.
25. Srinivasan, S., Y.L. Xiong, S.P. Blanchard and W.G. Woody, 1998. Proximate, mineral and fatty acid composition of semimembranosus and cardiac muscles from grass-and grain-fed and zeranol-implanted cattle. Food Chemistry, 63: 543-547.
26. Holland, B., A.A. Welch, I.D. Unwin, D.H. Buss, A.A. Paul and D.A.T. Southgate, 1997. MacCance and Widdowson´s The Composition of Foods. 5th Edition. The Royal Society of Chemistry, Redwood Books Ltd, Trowdridge, Wiltshire, UK.
27. Marinova, P., V. Banskalieva, S. Alexandrov, V. Tzvetkova and H. Stanchev, 2001. Carcass composition and meat quality of kids fed sunflower oil supplemnted diet. Small Ruminant Res., 42: 219-227.