Influence of Sex, Age and Body Condition Score on Carcass Composition and Tissue Distribution in Marketed Small East African Goats

Mushi, D. E.*, Mtenga, L.A., Kifaro, G.C. and Chenyambuga, S.W.

Department of Animal Science and Production, Sokoine University of Agriculture, P.O.Box 3004, Morogoro, Tanzanian.

Abstract

Twenty-four half carcasses of Small East African goats (8 females, 8 entire males and 8 castrated males) were jointed into seven joints namely: hind leg, chump, loin, rib, breast, neck and fore leg. These joints were further dissected into the separable components: muscle, bone, and fat. The carcasses of these goats were composed of 7.8 – 16.5% fat, 55.6 – 62.7% muscle and 27.9 – 29.5% bone. The proportions of muscle in carcasses of females (56%) and castrates (58%) were significantly ($P<0.05$) lower than in entire males (63%). Fat content in the carcasses of females (16%) and castrates (12%) were significantly ($P<0.05$) higher than in entire males (9%). The neck of entire males had higher ($P<0.001$) percentage muscle weight (11%) than the neck of females (8%) and castrates (9%). The hind leg of females had higher ($P<0.05$) percentage muscle weight (28%) than hind leg of males (25%), but castrates had values in between the two (27%). The fore leg of females had the least ($P<0.001$) percentage of muscle (21%) compared with males (23%) and castrates (24%). The loin and fore legs of females had higher (17% vs. 12%) and lower (16% vs. 20%) percentage of fat than those of castrates and entire males. The fore leg of females had lower (10% vs. 12%) percentage of bone than that of entire males and castrates. The neck and fore leg of goats above 3 years old had higher (10% vs. 9%) and lower (22% vs. 23%) percentage of muscles, respectively than those of goats aged 2 to 3 years. The loin and hind legs of goats with body condition score of 4 had higher (12% vs. 11%) and lower (25% vs. 27%) muscle percentage, respectively than those of goats with five score. The rib joint of goats with body condition score of 4 had higher (13% vs. 11%) percentage of bone than those of goats with five score. It is concluded that sex of the animal affects both the proportion and distribution of carcass tissue to a greater extent than age and body condition score. This means that where carcass quality is a major goal, given the right market guidelines, farmers can make use of the sex differences in the proportion and distribution of carcass tissue to serve the consumer markets with meat goat of their preference.

Keywords: Carcass composition, tissue distribution, market goats

Introduction

The Small East African goats are raised mainly for meat production and hence their marketability depends on the expected amount and quality of the meat produced. Meat quality refers to its composition in terms of muscle (lean), fat and bones in the carcass. Carcass composition is therefore an important aspect for determination of the slaughter value of an animal. To determine the economic value of the carcass, it is important to know the proportions of saleable to

*Corresponding author

unsaleable and edible to inedible parts of the carcass. Muscle and to a lesser extent fat are the major edible tissues of the carcass. Although bone is not an edible tissue, its proportion in the carcass affects those of muscle and fat (Mahgoub and Lu, 1998). Though different markets have different meat preferences, leanness of meat is the major criterion by which consumers judge quality of meat over the shop counter (Bracken, 1992). According to Anous (1992) and Simm (1992), an ideal carcass should contain maximum lean, just enough bone to support the animal and optimum level of fatness depending on the fat requirements of the market.

The quality of meat is affected by factors such as breed, sex, age, nutritional status of the animal and slaughter weight (Owen *et al*., 1978; Naude and Hofmeyr, 1981; Dhanda et al., 2003, unpublished). Carcasses of the same weight produced from different goat breeds differ in proportions and distribution of muscle, fat and the bone (Dhanda *et al*., 1999). The most pronounced sex influence on carcass composition is achieved through the fattening process. Females tend to enter a fattening phase at lighter weights than castrates, and castrates at lighter weights than intact males (Berg and Butterfield, 1976; Naude and Hofmeyr, 1981; Hogg *et al*., 1992). Moreover, the fat distribution vary between sexes with females having more of their total fat in the loin areas of the carcass while castrates have more fat in their legs (Hogg *et al*., 1992). Studies have shown that fat deposition in goats varies with the age and plane of nutrition and hence body condition score (Owen *et al*., 1978). In Tanzania, on-station studies have shown that fat content in goats varies from 6.7 to 14.5% whereas lean content accounts for 65% of the total composition of the carcass depending on the plane of nutrition (Nyakyi, 1981; Kitalyi, 1982). There is however limited information on carcass composition of local goats marketed in traditional sector in Tanzania. In an attempt to generate more information, a study was carried out to assess the effects of body condition score, age and sex on carcass composition and tissue distribution of Small East African goats in livestock markets in Gairo division, Morogoro, Tanzania.

Materials and methods

This study was carried out in May 2003 in Gairo division in Kilosa district, Morogoro region, Tanzania. The division lies along the foots of Ukaguru Mountains within an altitude of 1076 to 1631 metres above sea level with semi – arid type of climate. Twenty-four goats were selected among the goats brought to the livestock markets in the division. Among the selected animals 8 were females, 8 were entire males and 8 were castrates. Arrangements were made with the goat meat traders to buy the half carcasses after slaughter at the market. Before slaughter, animals were weighed, their age determined and their body conditions scored. Estimation of age was done according to the procedure developed by Owen *et al*. (1978). The age of animals is estimated by looking at the front teeth (incisors) and assess how worn they are. Two age categories (that is, over three years, n = 12 and two to three years, n = 12) were slaughtered. A method developed by Steele (1999) was adopted in body condition scoring of goats. This method relies on physical appraisal of the quantity of the subcutaneous fat cover under the skin on the hipbone, tail head area, gluteal muscle, spinous process and the lower rib cage. A numerical score given is an indication of the body reserve and hence, nutritional status of the animal. The goats were grouped into two categories based on boy condition score (score of five points (5) - very fat, n = 12 and score of four points (4) – fat, n = 12). Goats were slaughtered as described by Ruvuna et al. (1992) and the carcasses were split into two halves longitudinally along the median plane of the *vertebrae* using a hand meat saw. The left carcass was jointed into seven joints (hind leg, chump, loin, rib, breast, neck and fore leg) as described by Kyomo (1978). The joints were weighed and separated into dissectible muscle, bone, and fat.

Total half-carcass muscle, fat and bone weights were obtained by adding weights of muscles, fat and bone from all the joints. The sum of these dissected tissue weights is referred to as "carcass tissue weight" (Ruvuna *et al*., 1992) and was used as the denominator for calculating percentages of carcass muscle, fat and bone. Carcass tissue distribution was obtained by expressing muscle, fat and bone weights in

each joint as a percent of total half carcass muscle, fat and bone, respectively.

Data analysis

The least squares procedure of the General Linear Model of SAS (2000) was used to test the effects of sex, age and body condition scores on carcass composition and tissue distribution. Since the animals at the market were highly variable in live weight, liveweight was used as a covariate in the model. Least square means and standard error of the mean (SEM) for all parameters used in the study were computed and tested for differences between factors.

Results and Discussion

Effects of sex, age and body condition score on carcass composition

The carcasses of goats slaughtered in Gairo markets had 55.6 – 62.72% muscle, 7.8 – 16.5% fat and 27.9 – 29.5% bone (Table 1). The higher proportion of muscle than other tissues in goats' carcasses found in the present study is in agreement with the findings by Colomer- Rocher *et al.* (1992) and Kirk *et al.* (1996) that normally, muscle occupies a greater proportion of the total composition of the carcass. However, the values of percentage muscle obtained in the present study are lower than 68 – 73% range reported by Kyomo (1978) and Malole (2002). This discrepancy might be due to difference in plane of nutrition, sex and age at slaughter of goats in Gairo, among many factors known to affect carcass composition (Owen *et al.*, 1978; Naude and Hofmeyr, 1981). Goats in Gairo solely depend on free grazing on natural pastures that are highly variable in their nutritive values. Moreover, goats are slaughtered when they are above 2 years old and weighing between 25 to 30 kg liveweight. However, Mavoa (1980) and Pralomkarn *et al.* (1995) reported similar values as those observed in the present study for carcass muscle content when goats were compared at the same body weight. The fat contents of 7.8 – 16.5% in the carcass of goats observed in the present study are within the range of 6 – 15.5% reported by Kyomo (1978), Kitalyi (1982) and Hogg *et al.* (1992). The observed bone content (27.9 – 29.53%) in goat carcasses were higher than 6 – 20.0% reported previously (Kyomo, 1978; Mavoa, 1980; Kitalyi, 1982). This discrepancy is probably due to the difference in stage of maturity of the slaughtered goats. Goats in Gairo are slaughtered mainly when they are at their late stage of maturity (above 2 years of age).

There were no significant sex, age and body condition score interactions noted for the parameters evaluated in the present study and therefore only main effects have been presented and discussed. The proportions of muscle, fat and bones in the carcasses were significantly ($P<0.01$) influenced by sex but not by age and body condition score (Table 1). The observed higher content of muscle in the carcasses of entire males than females and castrates has been also reported in other studies (Naude and Hofmeyr, 1981; Babiker *et al.*, 1985; Ruvuna *et al.*, 1992). Intact males have higher muscle content than females or castrates because they have higher impetus for muscle growth than other sexes (Berg and Butterfield, 1976). Females and castrates have low muscle impetus, as they do not come under the influence of androgen hormones, which are required to complete the full patterns of muscle growth both in amount and distribution. Moreover, the 5% higher content of carcass muscle in entire males compared to castrates found in the present study seems to be a manifestation of the entire males maintaining a more prolonged impetus for muscle growth (this is hormonally driven), whereas castrates slow down and fatten. The observed higher percentage muscle content in entire males than castrates partly agrees with Babiker *et al.* (1985) and Ruvuna *et al.* (1992) who reported that intact males have leaner carcass, averaging 7% more muscle content than the castrated males at two years of age. The 2% difference between the results of the two studies is probably due to the differences in age at slaughter, goats in Gairo being slaughtered when they are above 2 years of age.

The fat content in re males was significantly ($P < 0.05$) lower than that of females by about 50%. Moreover, the fat content in castrated males tended to be similar to that in females. Similar sex effect in carcass fat content has been observed by Owen et al. (1978), Hogg *et al.* (1992) and Ruvuna *et al.* (1992). Females are fatter than males since they enter fattening phase earlier and they tend to have higher rate of fattening (Colomer-Rocher *et al.*, 1992). This dif-

Table 1: Lsmeans (±SEM) for total tissue weights and percentages as influenced by sex, age and body scores

Factor	Tissue weight (kg)			Tissue percentage		
	Muscle	Fat	Bone	Muscle	Fat	Bone
Sex						
Castrate	4.57 ±0.17	0.98 ±0.11[a]	2.33 ±0.07	58.0 ±1.17[b]	12.4 ±1.5[a]	29.5 ±0.5
Female	4.27 ±0.17	1.28 ±0.11[a]	2.14 ±0.07	55.6 ±1.15[b]	16.5 ±1.48[a]	27.9 ±0.5
Male	4.90 ±0.17	0.60 ±0.11[b]	2.30 ±0.07	62.7 ±1.14[a]	7.8 ±1.47[b]	29.4 ±0.5
Sign.	ns	**	ns	**	**	ns
Age (yrs)						
2 to 3	4.55 ±0.13	0.92 ±0.09	2.22 ±0.06	59.1 ±0.92	12.0 ±1.19	28.8 ±0.4
Above 3	4.62 ±0.14	0.99 ±0.09	2.30 ±0.06	56.4 ±0.96	12.4 ±1.25	29.1 ±0.38
Sign.	ns	ns	ns	ns	ns	ns
Score						
5	4.45 ±0.14	1.07 ±0.09	2.19 ±0.06	57.8 ±0.99	13.7 ±1.28	28.5 ±0.4
4	4.71 ±0.13	0.84 ±0.08	2.32 ±0.06	59.8 ±0.89	10.7 ±1.15	29.4 ±0.4
Sign.	ns	ns	ns	ns	ns	ns

In this and subsequent tables;

[a,b,c] LS Means bearing different superent superscripts in a columns within factor are significantly ($P<0.05$) different.

*, **, *** =Significantly different at 5%, 1% and 0.1%, respectively.

NS=no significant difference

ference in fat content between entire males and females is brought about by hormonal difference between the two. The estrogen hormones in female have high potency for fattening while the androgen hormones in entire males have high potency for muscle growth. Castration influences accretion of fat (Babiker *et al.* 1985; Ruvuna *et al.* 1992) thus making castrated males to have about 8% more fat content than intact males. Castrated males are fatter than entire males since they stop putting on muscle and enter fattening phase earlier than the later.

The lack of significant effect of sex on the percentage of bone contents in the half carcass found in the present study disagrees with Colomer-Rocher *et al.* (1992) who reported that male goats lay down bone in all joints at a faster rate than the females, hence have higher values for bone weight. Furthermore, Ruvuna *et al.* (1992) reported that intact males have carcass containing on average 1% more bone than the castrated males at 2 years of age. In the present study the percentage of bone in the carcasses of entire males and castrates were almost similar. This is probably due to the difference in age at slaughter, castrates being slaughtered normally at older ages than entire males and hence the similar percentage content of carcass bone.

The lack of significant effect of age on the proportion of muscle, fat and bone found in the present study disagrees with Ruvuna *et al.* (1992) who found that the proportion of the carcass due to lean and fat increases, while that due to bone decreased with age. This is probably due to small variability of goats slaughtered in Gairo markets, the goats were only two age groups. This observation further differs with the finding of Mtenga *et al.* (1984) who reported that there is great

variation in ages among the small ruminants slaughtered in the livestock markets in Tanzania. Although the age had no significant effect on carcass composition, the trend was for older goats to have lower percentage of muscle and higher percentage of fat and bone in their carcasses. This is probably due to the differential energy and protein retention with age.

Effects of sex, age and body condition score on carcass tissue distribution

The observed higher proportion of total muscle in the hind leg, followed by fore leg and ribs (Table 2) in the present study agrees with those found by Mtenga *et al.* (1995) for standard muscle groups I and VII – VIII (as described by Berg and Butterfield, 1976). The observed muscle distribution pattern depicts the agility and mobility nature of goats. Moreover, the superiority of entire males in muscle content in the neck (11.1%) and fore leg (23%) agrees with Berg and Butterfield (1976). This can be considered as a secondary sex characteristic (Pralomkarn et al., 1995) that is driven by male sex hormones. This observation is further supported by the significant effect of age on muscle distribution on these joints.

The observed higher proportion of joint muscle weight in neck and fore leg of entire male is due to their need to fulfil the double role of survival and struggle for the right to reproduce. However, the lack of difference in neck muscle weight distribution between entire males and castrates in the present study disagrees with the proposal by Berg and Butterfield (1976) that the high impetus muscles that have got special function in the entire males, like neck muscle, are inhibited by castration. This discrepancy is probably a function of age at which goats in Gairo are castrated, as the effect of castration depends on the age at which it is done (Devendra and Owen, 1983; Alkass *et al.*, 1985). It is possible that goats in Gairo were castrated when the potential for male sex hormones on muscle growth had been realised.

Goats with body condition score of four points had significantly ($P<0.05$) higher (11.9% vs. 10.9%) and lower (25.4% vs. 27.1%) percentage muscle in the loin and hind leg, respectively, than those with a score of five points (Table 2). These findings depict the direct relationship between the body condition scores and the fullness of muscling and fat cover over and around the vertebrae in the loin region (Assenga, 1997). Generally, goats with body condition score of four were leaner (higher percentage muscle content) than those with body condition

Table 2: Lsmeans (±SEM) for percent muscle in joints as affected by sex, age and body score

Factor		Joint muscle weight as % of carcass muscle						
		Neck	Breast	Ribs	Loin	Chump	Hind leg	Fore leg
Sex	Castrate	9.05 ±0.34^{b}	5.76 ±0.26	16.02 ±0.72	11.00 ±0.35	8.00 ±0.40	26.55 ±0.66^{ab}	23.65 ±0.31^{a}
	Female	7.70 ±0.33^{c}	5.93 ±0.25	17.00 ± 0.70	11.93 ±0.34	8.82 ±0.40	27.50 ±0.64^{a}	21.14 ±0.30^{b}
	Male	11.10 ±0.33^{a}	6.63 ±0.25	15.70 ±0.70	11.36 ±0.34	7.56 ±0.40	24.74 ±0.64^{b}	22.93 ±0.30^{a}
	Sign.	***	ns	ns	ns	ns	*	***
Age	2 to 3	8.68 ±0.26^{b}	6.04 ±0.20	15.77 ±0.56	11.50 ±0.27	8.18 ±0.31	26.37 ±0.52	23.45 ±0.24^{a}
	Above 3	9.87 ±0.28^{a}	6.17 ±0.21	16.70 ±0.60	11.34 ±0.30	8.06 ±0.32	26.16 ±0.54	21.69 ±0.26^{b}
	Sign.	**	ns	ns	ns	ns	ns	***
Score	5	9.31 ±0.28	5.96 ±0.22	15.40 ±0.61	10.93 ±0.30^{b}	8.57 ±0.33	27.13 ±0.56^{a}	22.70 ±0.26
	4	9.25 ±0.26	6.26 ±0.19	17.07 ±0.54	11.91 ±0.27^{a}	7.67 ±0.30	25.40 ±5.50^{b}	22.44 ±0.24
	Sign.	ns	ns	ns	*	ns	*	ns

score of five. The loin is leaner than hind leg, thus higher percentage muscle content than the latter.

In general, the hind leg, fore leg, ribs and breast joints showed higher values for fat content than other joints, in a decreasing order while neck showed the lowest values (Table 3). Sex affected significantly ($P< 0.05$) the distribution of fat in the loin and fore leg where the females had higher ($P< 0.05$) fat content in the loin and lower fat in the fore leg than entire males and castrates. The observation that females had higher fat percentage in the loin area than males which agrees with the those by Hogg *et al.* (1992) and Colomer-Rocher *et al.* (1992) who reported that female goats have about 5.8% more fat than males in mid part of their carcass. This is probably a secondary sex characteristic unique to the female goats brought up by hormonal interplay (Lawrence and Fowler, 1997). However, the lack of difference between entire males and castrates in fat content at the loin disagrees with Babiker *et al.* (1985) that castration reduces the amount of lean and increases fat and bone contents in the loin joint. This difference may be attributed to other factors including age at castration, nutrition and breeds.

In the present study, females had the least fat content (15.9%) in the fore leg than entire males (19.7%) and castrates (20%). The lower fat content in the fore leg of females compared to males is probably functionally and hormonally driven. Males are engaged in fighting, hence tend to have more developed fore quarter in terms of muscle weight (Berg and Butterfield, 1976). The increase in muscle in the fore quarter probably influences fat deposition simultaneously.

Table 3: Lsmeans (±SEM) for percent fat in joints as affected by sex, age and body score

Factor		Joint fat weight as % of carcass fat						
		Neck	Breast	Ribs	Loin	Chump	Hind leg	Fore leg
		55.33	6.67	15.68	11.87	8.58	21.87	20.00
	Castrate	±0.77	±1.35	±1.37	±1.11^{b}	±1.05	±1.31	±1.01^{a}
Sex	Female	4.34	14.53	18.52	16.97	11.37	18.40	15.86
		±0.75	±1.31	±1.33	±1.08^{a}	±1.02	±1.27	±1.00^{b}
	Male	7.10	15.32	14.72	12.50	9.05	21.70	19.64
		±0.74	±1.30	±1.31	±1.07^{b}	±1.01	±1.27	±1.00^{a}
	Sign.	ns	ns	ns	*	ns	ns	*
	2 to 3	5.50	15.55	17.23	12.91	9.44	21.32	18.07
		±0.60	±1.10	±1.07	±0.90	±0.82	±1.03	±0.80
Age	Above	5.70	15.46	15.40	14.65	9.90	20.00	18.94
	3	±0.63	±1.10	±1.12	±0.91	±0.86	±1.08	±0.83
	Sign.	ns	ns	ns	ns	ns	ns	ns
	5	5.42	15.67	16.64	13.37	9.04	20.67	19.20
		±0.65	±1.14	±1.15	±0.94	±1.00	±1.11	±0.85
Score	4	5.75	15.34	15.98	14.19	10.30	20.63	17.81
		±0.60	±1.02	±1.04	±0.84	±1.00	±1.00	±0.77
	Sign.	ns	ns	ns	ns	ns	ns	ns

The distribution of bone weight in joints was affected by sex and body score (Table 4). Sex affected significantly ($P<0.01$) the bone weight distribution in fore leg where females had lower bone weight (10%) than entire males (11.6%) and castrates (12.2%). Normally male animals have more developed fore quarter than females. This is the result of deferential development of

Table 4: Lsmeans (± SEM) For percent bone in joints as affected by sex, age and body score

Factor		Joint bone weight as % of carcass bone						
		Neck	Breast	Ribs	Loin	Chump	Hind leg	Fore leg
Sex	Castrate	5.11 ± 0.53	3.11 ±0.26	11.78 ±0.61	3.80 ±0.47	3.45 ±0.32	11.70 ±0.27	12.18 ±0.33
	Female	4.23 ±0.52	2.54 ±0.25	12.78 ±0.60	4.20 ±0.46	4.21 ±0.31	11.14 ±0.26	10.00 ±0.32
	Male	5.94 ±0.52	3.21 ±0.25	11.01 ±0.60	3.71 ±0.46	3.13 ±0.31	11.83 ±0.26	11.60 ±0.32
	Sign.	ns	ns	ns	ns	ns	ns	**
Age	2 to 3	4.73 ±0.42	2.97 ±0.20	11.84 ±0.50	3.72 ±0.37	3.87 ±0.25	11.44 ±0.21	11.14 ±0.26
	Above 3	5.45 ±0.44	2.93 ±0.21	11.86 ±0.50	4.08 ±0.40	3.33 ±0.26	11.70 ±0.22	11.36 ±0.27
	Sign.	ns	ns	ns	ns	ns	ns	ns
Score	5	4.83 ±0.45	2.86 ±0.21	10.75 ±0.52[b]	3.77 ±0.40	3.58 ±0.27	11.61 ±0.22	11.01 ±0.28
	4	5.35 ±0.41	3.04 ±0.20	12.96 ±0.47[a]	4.03 ±0.36	3.62 ±0.25	11.51 ±0.20	11.50 ±0.25
	Sign.	ns	ns	**	ns	ns	ns	ns

all the three carcass tissue in males and females (Lawrence and Fowler, 1997).

Conclusion and recommendation

It can be concluded that, sex of the Small East African goats affects both the proportion and distribution of carcass tissue to a greater extent than age and body condition score. Moreover, though it has been documented that castration has influence on carcass characteristics, the age at which it is done matters. This means that where carcass quality is a major goal, given the right guidelines, farmers could make use of the sex difference in carcass tissue proportion and distribution to serve the consumer markets with meat goat of their preference. It is recommended that more validation studies be carried out to take into account the use of a large sample size.

Acknowledgements

The authors are extremely grateful for the financial support provided by the SUA-MU ENRECA project and the TARP II – SUA (Small Ruminant project). Also we acknowledge the assistance and cooperation provided by the Livestock Field Officers and goats traders in Gairo division.

References

Alkass, J.E., Rashid, M., Ishak, A. and Tali, H., 1985. the combined effects of docking and castration on growth and fattening performance and carcass characteristics of Awassi ram lambs. *World Review of Animal Production. XXI(3): 49–52.*

Anous, M.R. 1992. relationship between bone weight and muscle/bone ratio of the hind limb in male and female lambs of different genotypes. *Small Ruminant Research. 9: 69–77.*

Berg, R.T. and Butterfield, R.M. 1976. New concepts of cattle growth. Sydney, University Press, Australia.

Babiker, S.A., Maglad, M. and Koudoda, M.E. 1985. effects of castration on performance and carcass characteristics of male Sudan desert goats. *World Review of Animal Production. XXI (1): 11-13.*

Colomer - Rocher, F., Kirton, A. H., Mercer, G.J.K., - Duganzich, D.M., 1992. Carcass composition of Newzealand Saanen goat slaughtered at different weights. Small Rumin. Res., 7, 161 – 173.

Dhanda, J.S., Taylor, D.G., McCosker, J.E., Murray, P.J., 1999. The influence of goat genotype on the production of Capretto and Chevo car-

casses.3. Dissected carcass composition. Meat Sci., 52, 369 – 374.

Devendra, C. and Owen, J.E. 1983. Qualitative and quantitative aspects of meat production from goats. World Animal Review. 47: 19 – 29.

Hogg, B. W., Mercer, G.J.K., Mortimer, B.J., Kirton, A.H., Duganzich, D.M., 1992. carcass and meat quality attributes of commercial goats in New Zealand. Small rumin.Res., 8, 243- 256.

Kirk, J.A., Cooper, R.A and Kamwanja, L.A. 1996. Growth, carcass composition and its prediction in the indigenous Malawi goat. In: *All Africa Conference on Animal Agriculture held at University of Pretoria, South Africa*

Kitalyi, A.J. 1982. Effects of supplementing low quality hay with different protein levels on growth performance of goats. MSc. Dissertation University of Dar es Salaam, Tanzania. Pp 90 – 95.

Kyomo, M.L. 1978. Meat from goats in Tanzania. Ph.D. Thesis submitted to University of Dar es Salaam. Tanzania.

Lawrence, T.L.J and Fowler, V.R (1997). Growth of farm animals. CAB international.

Mahgoub, O. and Lu, C.D., 1998. Growth, body composition and carcass tissue distribution in goats of large and small sizes. Small rumin. Res., 27, 267 – 278.

Malole, J.L. 2002. Studies on growth rate, carcass quality and helminth resistance of three strains of Tanzania local goats. MSc. Thesis, Sokoine University of Agriculture, Morogoro, Tanzania. pp 30

Mavoa, E.M. 1980. Improving the meat production characteristics of the meat goat kids by supplementary feeding. *M.Sc. Dissertation, University of Dar es Salaam. Tanzania.*

Mtenga, L.A., Mandari, G.C.H., Kitalyi A.J. and Sarwatt, S.V. 1984. Impact of past and current research on small ruminant meat production in Tanzania. In: *Proceedings of the Scientific conference* of the Tanzania Society of Animal Production. 11: 111 - 144.

Mtenga, L.A., Muhikambele, V.R.M. and Owen, E. 1995. Muscle distribution in goats: Comparison with other farm animals. *Proceedings of Tanzania Society of Animal Production. 22: 70 – 77.*

Naude, R.T and Hofmeyr, H.S. 1981. Meat production. Academic Press Inc.Ltd. London. Pp 285.

Nyakyi, F.P. 1981. Meat production from sheep. The effect of breed and concentrate supplementation on the growth performance and carcass composition. *M. Sc. Thesis University of Dar es salaam. Tanzania.*

Owen, J.E., Norman, G.A., Fisher, I.L and Frost, R.A. 1978. Studies on the meat production characteristics of Botswana goats and sheep. Part III. Carcass tissue composition and distribution. Meat Science 2: 59 – 74.

Pralomkarn, W., Saithanoo, S., Kochapakdee, S. and Norton, B.W., 1995. effect of Genotype and plane of nutrition on carcass characteristics of Thai native and Anglo –Nubian X Thai native male goats. *Small Ruminant Research 16:21-25.*

Ruvuna, F., Taylor, J.F., Okevo, M., Wanvoike, M and Ahuya, C. 1992. Effects of breed and castration on slaughter weight and carcass composition of goats. *Small Ruminant Research.* 7: 175 - 183.

SAS, 2000. Statistical Analysis System. SAS/STAT User's guide. Statistical Analysis Insitute, INC. Carry, NC. USA.

Simm, G. 1992. Selection for lean meat production. In: A.W. Speedy (ed) Progress in sheep and goat research 193 – 215. CAB international, U K. Redwood Press Ltd, Melksham.

Steele, M. 1999. Goats. (Edited by Rene Coste and Antony, J.M). The Tropical Agriculturalist. CTA, MacMillan publishers Ltd. The Netherlands pp 81 – 83.