PJN
ISSN 1680-5194

Pakistan Journal of Nutrition

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 11 (11): 1055-1060, 2012
ISSN 1680-5194

Carcass Measurement, Conformation and Composition of Indigenous and Crossbred (Dorper x Indigenous) F1 Sheep

Tsegay Teklebrhan, Mengistu Urge and Yoseph Mekasha
School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

Abstract: A study was conducted to evaluate carcass measurement, conformation and composition of local [Blackhead Ogaden (B1) and Hararghe highland (B2)] and cross breed [Dorper x Blackhead Ogaden (B3) and Dorper x Hararghe highland (B4)] F1 lambs at two levels of concentrate supplement. The two diets were native grass hay *ad libtum* + 150 g concentrate mix [D1 (low level), Wheat Bran (WB) and Noug Seed Cake (NSC), at a ratio of 2:1] and native grass hay *ad libtum* + 350 g concentrate mix (D2, high level) in stall feeding. The experiment was arranged in a completely randomized design in a factorial arrangement (four breeds and two levels of diet). B4 had ($p<0.05$) longer hind leg posterior buttock circumference, thoracic circumference and chest width than B2, but did not differ from B1. Lambs fed high level of concentrate supplement have longer leg length wider posterior and anterior buttock circumference, buttock and chest width than low level concentrate supplemented groups. The fat content of both cross breeds is lower compared to pure Blackhead Ogaden. Leaner carcass was harvested from lambs consumed low level of concentrate supplement compared to lambs consumed high level of concentrate supplement. Result suggests that crossing Dorper with pure Hararghe highland improved carcass measurement and conformation. However, pure Blackhead Ogaden tended to perform similar to crosses in some parameters measured indicating the possibility of improving this breed without cross breeding. The result also noted that good nutrient supply is necessary for better carcass measurement and conformation.

Key words: Carcass, hair type dorper, pure local lamb

INTRODUCTION

In meat industry, objective carcass measurement and conformation is considered to be important and carcasses with superior conformation can fetch higher prices. Moreover, carcass conformation is an important visual criterion that has a bearing on the perceived market value of a carcass. Subjective conformation assessment however, can be misleading, since its estimate of meat yield can deviate by about 10% from the actual yield (Bruwer, 1984). Hence, objective carcass measurement and conformation are important to avoid subjectivity. The importance of conformation as an indicator of commercial value is based on the assumption that carcasses with better conformation have advantages in terms of lean meat content, proportion of higher priced cuts and possibly greater muscle size or area (Kempster *et al.*, 1982). Carcass composition could be used as a tool to characterize breeds for possible identification of potential genetic resource for lean lamb production and also to identify management alternatives to different breeds (Snowder *et al.*, 1994). The need for accurate assessment of meatiness in slaughtered animals and carcass is more apparent as consumers demanding cuts that yield higher percent of lean.

Despite the huge number, nearly 25.9 million (CSA, 2010) and genetically diverse sheep population in Ethiopia (DAGRIS, 2006), the amount of carcass harvested from indigenous sheep breeds is not greater than 10 kg/sheep (FAO, 1996). Moreover, the carcass measurement and conformation is also assumed to be lower. Currently, a cross breeding program of indigenous sheep with Dorper is going on with the aim of improving meat production and export potential of the country. Dorper sheep is a well recognized tropical sheep for its better carcass traits, measurement and conformation scores (Snyman and Olivier, 2002). Therefore, the experiment was conducted with the objective to compare carcass measurement, conformation and composition of indigenous and crossbred (Dorper x indigenous) F1 lambs at two level of concentrate supplement.

MATERIALS AND METHODS

Description of the study site: The experiment was conducted at Haramaya University Sheep Farm. The University is located on the eastern escarpment of the Rift valley at about 520 km East of Addis Ababa, at latitude of 9° 26', longitude of 42° 03' and altitude of 1980 m.a.s.l. It has 780 mm of rain fall during the cropping season and the mean annual maximum and minimum temperature are 23.4 and 8.25°C (AUA, 1998).

Experimental animals and their management: A total of 48 Ram lambs, twelve from each local breed (Blackhead Ogaden) and Hararghe highland) and cross bred lambs

Corresponding Author: Tsegay Teklebrhan, School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

(Dorper x Blackhead Ogaden and Dorper x Hararghe highland) with an age of 6-8 month were used for the study. The cross bred lambs were obtained from Haramaya University-ESGPIP sheep breeding, distribution and evaluation center. The local lambs were purchased from Jijga and Chelenko local markets, respectively. The age of indigenous breeds was estimated by dentition and the information obtained from the owners. The purchased lambs were quarantined for three weeks in isolated house for observation of some known parasites and diseases abnormalities. The experimental animals were de-wormed with a broad-spectrum anti-helmentic (albendazole) against internal parasites, sprayed with acaricides (vetacidin 20% EC) against external parasites and vaccinated for pasteurellosis and anthrax when they are in the isolated house. Lambs were ear tagged for identification and acclimated to experimental diets for two weeks before the commencement of the experiment in order to create stable rumen ecosystem. The experimental house was cleaned and disinfected before placing the lambs and cleaned every day during the experimental period. The lambs were housed and fed in individual pens with a dimension of 70 x 120 cm that is equipped with feeding trough and watering bucket. The feedlot performance evaluation was lasted for 90 days. The feeding trial was followed by carcass measurement, conformation and composition studies.

Experimental feeds and feeding: Natural grass hay harvested from Haramaya University campus was used as source of roughage. The concentrate diets were wheat bran and noug seed cake mixed in 2:1 ratio, respectively, on dry matter basis and provided to lambs at 8:00 am and 4:00 pm in equal proportion. All animals were fed hay *ad libitum* and the intake of hay was adjusted at an interval of every four days and got free access to clean drinking tap water and mineral lick. The concentrate supplement was offered in a separate trough as per the pre-designed treatment.

Experimental design and treatments: A 4 x 2 (four breed with two diets, respectively) factorial arrangement with completely randomized design was used to conduct the experiment. Six lambs per breed were randomly assigned to each diet. The experimental treatments employed were the following:

Table 1: Treatment of the experiment

Concentrate levels	Breed type
D1	B1
	B2
D2	B3
	B4

B1 = Pure Blackhead Ogaden lamb; B2 = Pure Hararghe highland; B3 = Dorper x Blackhead Ogaden; B4 = Dorper x Hararghe highland lamb; D1 (Diet one, low level of supplementation): (Low level of concentrate supplementation). D2 (Diet two, high level): Hay *ad libtum* + 350 g/head/day of the concentrate mix (High level of concentrate supplementation)

Carcass measurement, conformation and composition: At the end of the growth experiment, three lambs per treatment were randomly selected and transported using truck well prepared to restrain animals and bedded with thick layers of grass during evening to Mojo Luna export slaughter house. The lambs were slaughtered at an age of between 9-11 months. The lambs were weighed after overnight withdrawal of feed, but with access to water and slaughtered by the Halal procedure (Kadim *et al.*, 2003). The lambs were slaughtered and dressed down using standard commercial techniques. Then, carcass was chilled at 4°C in cold room of the abattoir for 24 hrs to determine carcass and conformation measurement. Cold carcass was suspended with hind legs on the eight hock gambrel of constant width (20cm) between legs and carcass conformation measurement were recorded as follows:

Carcass length (cm) - from the basis of tail to the basis of the neck; Hind leg length (cm) - the smallest distance from the perineum to the interior face of the tarsal-metatarsal articular surface; Anterior Circumference of Buttocks (ACB, cm) - the circumference measured using a tape held horizontally around the buttocks at the level of maximum width of the trochanter, Posterior Circumference of Buttocks (PCB, cm) - the circumference measured using a tape held horizontally around the buttocks at the level of caudal insertion. Circumference of the Thorax (CT, cm) - the circumference measured using a tape held horizontally around the thorax at the level of the caudal portion of the scapula; Width of the Buttocks (WB, cm) - the width measured using the measuring caliper at the level of the proximal edge of the patellae; Width of Chest (WC, cm)- measured at the greatest width of the chest; Width of the Shoulders (WS, cm)- measured at the greater width of the shoulders; Carcass Compactness Index (CCI, cm)- was evaluated by the relation between Cold Carcass Weight (CCW) and Carcass Length (CCW/CL*100); Leg Compactness (LC) - was computed by the relation between the Width of the Buttocks and Leg Length (WB/LL*100), according to the procedure given by Pallson (1939); Fisher and De Boer (1994).

The cold carcass was split in to two equal halves along the dorsal mid-line with a band saw. The left half of the carcass was partitioned into fore and hind quarter at the rib section between 12 and 13. The left half of each carcass was dissected into lean, fat, bone and used to estimate the whole carcass composition. The weights of each of the left carcass components to the ratio of left side were multiplied by cold carcass weight to reflect full carcass composition (Casey and Van Niekerk, 1988).

Chemical analysis of feeds: Samples of feeds were dried overnight at 105°C in a forced draft oven for determination of DM. Ash was determined by burning the samples in muffle furnace at 550°C for 6 hrs. Nitrogen was analyzed by Kjeldahl method (AOAC, 1990) and CP was determined as N x 6.25. NDF, ADF and ADL were analyzed using the procedures of Van Soest and Robertson (1985).

Statistical analysis: Data on carcass measurement, conformation and composition were analyzed using SAS computer soft ware (SAS, 2002). No significant breed by diet class interaction was noted for carcass measurement, conformation and composition, so the main effects were presented and discussed. Mean differences were tested using Tukey.

The model used was modified as:

$$Yijk = \mu + bi + dj + eij$$

Where:

Yij = Response variable
μ = Mean of the population
bi = Breed effect
dj = Diet effect
eij = Random error component

RESULTS AND DISCUSSION

Chemical composition of feeds: The chemical compositions of the feedstuffs used in this study are shown in Table 2. The CP content of wheat bran was comparable with values reported earlier (Ensminger, 2002; McDonald *et al.*, 2002; Ameha, 2007). The CP content of noug seed cake is comparable to that reported by Ameha (2007). The low CP and high NDF of native grass render it to be categorized as low quality feed (Cheeke, 1999). Nonetheless, the CP content of native grass hay is enough for the maintenance and rumen microbial function, which is within the range of 7-7.5 CP (Van Soest, 1994).

Carcass measurement and conformation: Carcass measurement and conformation of local and their cross breed lambs is given in Table 3. Dorper x Hararghe highland breed had the longest ($p<0.001$) carcass length than the pure breed Hararghe highland and Blackhead Ogaden lambs. However, carcass length between the two crosses as well as between the two local breeds was not significantly different. No literature is available on carcass measurement of local Ethiopian sheep breeds and their crosses. The present result indicates that cross breeding can improve carcass measurement of the local breeds. Accordingly, Dorper x Hararghe highland has longer hind leg, posterior buttock and thoracic circumference ($p<0.05$, for all) than pure Hararghe Highland, but did not differ from pure Blackhead Ogaden. Snyman and Olivier (2002) observed the longest hind leg for pure Dorper, a trait from which the present crosses inherited. Dorper x Hararghe highland also has highest ($p<0.01$) anterior

Table 2: Chemical composition of feeds

	%DM						
Feed items	DM (%)	OM	CP	NDF	ADF	ADL	Ash
Native grass hay	94.6	88.3	7.7	75.8	47.9	8.7	11.7
Wheat bran	90.7	94.7	18.7	42.9	13.8	1.8	5.3
Noug seed cake	93.4	89.0	35.0	37.4	32.0	7.6	11.0

ADF = Acid Detergent Fiber; ADL = Acid Detergent Lignin; CP = Crude Protein; DM = Dry Matter; NDF = Neutral Detergent Fiber; OM = Organic Matter; fiber mix 2:1, wheat bran to noug seed cake, respectively

Table 3: The effect of breed and diet on carcass and conformation measurement of local and cross bred lambs (LS MEAN ± SE)

	Effect of breed					Effect of diet			
Parameters	B1	B2	B3	B4	SL	D1	D2	PSE	SL
CL (cm)	40.50^{b}	41.83^{b}	46.83^{ab}	52.33^{a}	***	44.00	46.75	1.25	ns
HLL (cm)	29.67^{ab}	27.67^{b}	32.50^{ab}	34.83^{a}	*	29.25^{b}	33.08^{a}	0.92	*
PBC (cm)	51.00^{ab}	46.83^{b}	55.00^{ab}	57.83^{a}	*	49.58^{b}	55.75^{a}	1.40	*
ABC (cm)	43.33^{b}	40.83^{b}	50.67^{ab}	55.33^{a}	**	43.17^{b}	51.92^{a}	1.67	**
TC (cm)	58.00^{ab}	53.50^{b}	58.67^{ab}	63.17^{a}	*	56.08	60.58	1.18	ns
BW (cm)	9.00^{ab}	6.67^{b}	11.17^{a}	11.00^{a}	*	7.67^{b}	11.25^{a}	0.66	**
SW (cm)	4.83^{b}	4.50^{b}	6.16^{ab}	8.00^{a}	*	4.92	6.83	0.50	ns
CW	5.67^{ab}	4.67^{b}	7.50^{ab}	8.33^{a}	*	5.42^{b}	7.67^{a}	0.50	*
CCI (g/cm)	212.70	185.10	209.90	240.20	ns	189.50^{b}	234.40^{a}	7.8	**

^{a,b}Values in the same row with different superscripts are significantly different, SL= Significant Level; *p<0.05; **p<0.001; ns p>0.05; B1 = Pure Blackhead Ogaden lamb; B2 = Pure Hararghe highland; B3 = Dorper x Blackhead Ogaden; B4 = Dorper x Hararghe highland lamb; CL = Carcass Length; HLL= Hind Leng Length; PBC = Posterior Buttock Circumference; ABC = Anterior Buttock Circumference; BW = Buttock Width; CCI = Carcass Compactness Index; CW = Chest Width; D1 = Hay *ad libtum* + 150 gram mix (2:1) wheat bran to noug cake; D2 = Hay *ad libtum* + 350 gram mix (2:1) wheat bran to noug seed cake; PSE = Pooled Standard Error; SW = Shoulder Width; TC = Thoracic Circumference buttock circumference than pure Hararghe highland and Blackhead Ogaden lambs. There was no significant difference in leg length, posterior and anterior buttock circumference and thoracic circumference, between crosses as well as between locals.

Both cross breeds had higher ($p<0.05$) Buttock width (cm) than pure Hararghe highland breeds. Shoulder width was higher ($p<0.05$) in Dorper x Hararghe highland compared to pure Hararghe highland and Blackhead Ogaden lambs. This result could be due to the wider shoulder of pure Dorper breed (Snyman and Olivier, 2002). Dorper x Hararghe highland has higher ($p<0.05$) chest width than pure Hararghe highland, but similar to Blackhead Ogaden. However, buttock, shoulder and chest width were not significantly ($p<0.01$) different between the crosses as well as between the locals. As opposed to other conformation variables, carcass compactness index was similar ($p>0.05$) among the lamb breeds. Previous work showed that the shorter the carcass length the higher the carcass compactness (Mourad *et al*., 2001).

Carcass Length (CL) was not affected ($p>0.05$) by diet levels. Similar to breed effect, some carcass measurement and conformation were affected ($p<0.05$) by diet levels. Accordingly, lambs fed the high level of concentrate supplement have longer leg length; wider posterior and anterior buttock circumference, buttock and chest width than low level concentrate supplemented groups. Unlike the breed effect, thoracic circumference and shoulder width were not affected by the diet levels. Lambs fed higher level of supplementation have higher ($p<0.01$) carcass compactness than low level concentrate supplemented groups indicating that carcass compactness is mainly affected by the plane of nutrition than breed.

Carcass composition: The results of percent lean, fat and bone and lean: bone, lean: fat and meat: bone ratios in the current study are shown in Table 4. Body composition in terms of dissectible components (muscle, fat and bone) change as animals grows from birth to maturity and follows the order that the growth of bone reaches its peak first, followed by muscle and adipose tissues, respectively (Orr, 1982; Enyew, 1999; Snowder *et al*., 1994). Significant difference ($p<0.05$) was observed between lamb breeds in the estimated whole carcass composition of lean and fat. Accordingly, Dorper x Hararghe highland lamb had higher ($p<0.05$) percentage lean than Blackhead Ogaden lamb, but did not differ ($p>0.05$) from pure Hararghe highland and Dorper x Blackhead Ogaden lambs. On the other hand, pure Blackhead Ogaden lamb has higher ($p<0.05$) percentage fat than both crosses, but did not differ from pure Hararghe Highland lamb (Table 4). However, percent bone was similar ($p>0.05$) among lamb breeds. No significant differences between crosses as well as locals were observed for lean to bone ratio. In contrast to the present result, Kassahun (2000) observed no significant differences ($p>0.05$) in lean to fat ratio between Menz and Horro sheep carcasses after 123 days of fattening. However, the two breeds studied by Kassahun (2000) have differed significantly ($p<0.01$) in their bone composition. Breed is known to influence carcass composition and differences in carcass merits between breeds are likely to govern the choice and development of breeds for specific production objectives. The present experiment showed that Hararghe highland x Dorper, in particular and the cross breeds in general may be the choice for market niches that require lean meat.

Generally, the result obtained in the experiment is expected, since the animals were slaughtered at younger age (10 months) and the level of the supplement is not that much high to allow the animal to store body fat. Low percentage fat composition in animals slaughtered at younger age is also confirmed by previous research results (Afonso and Thompson, 1996; Taylor *et al*., 1989). In both cases, it was stated that relative to empty body weight, bone tissue matured early, followed by muscle (lean) and fat tissues. Significant differences of lean: fat ratio was observed between lamb breeds. Accordingly, both crosses had higher ($p<0.01$) lean: fat ratio than pure Blackhead Ogaden lamb but did not differ from pure Hararghe

Table 4: The effect of breed and diet on carcass composition of local and cross bred lambs (LS MEAN ± SE)

	Effect of breed						Effect of diet		
Parameters	B1	B2	B3	B4	PSE	SL	D1	D2	SL
% Lean	61.5^{b}	65.4^{ab}	68.3^{ab}	74.9^{a}	4.03	*	83.6^{a}	51.4^{b}	***
% Bone	22.9	23.2	22.7	20.8	0.90	ns	24.6	20.2	ns
% Fat	13.1^{a}	11.2^{ab}	9.7^{b}	9.6^{b}	0.50	*	10.9	12.0	ns
Ratio									
Lean: bone	2.7	2.8	3.0	3.6	0.16	ns	3.5^{a}	2.6^{b}	**
Lean: fat	4.7^{b}	6.1^{ab}	7.2^{a}	7.8^{a}	0.29	**	7.6^{a}	5.2^{b}	**
Meat: bone	3.3	3.3	3.4	4.1	0.13	ns	3.9	3.1	ns

^{a,b}Values in the same row with different superscripts are significantly different *$p<0.05$; **$p<0.01$; ns $p>0.05$; B1 = Pure Blackhead Ogaden lamb; B2 = Pure Hararghe highland lamb; B3 = Dorper x Blackhead Ogaden; B4 = Dorper x Hararghe highland lamb; D1 = Hay *ad libtum* + 150 gram mix (2:1) wheat bran to noug cake; D2 = Hay *ad libtum* + 350 gram mix (2:1) wheat bran to noug seed cake; PSE = Pooled Standard Error highland (Table 4). This is because Blackhead Ogaden sheep had lower lean and higher fat (inter and intra) than the rest breeds. This is supported by Gaili *et al.* (1979) and Gatenby (1986) who reported that tropical sheep tend to deposit more intramuscular and internal fat and less subcutaneous fat compared to temperate breeds, which seems applies to the Blackhead Ogaden sheep. Previous work also reported lower lean to fat ratio in indigenous sheep breed (3.1:1 for local Menz and 3.3:1 for Horro sheep) carcasses compared to the value recorded in the present study (Kassahun, 2000). The sheep breeds used by Kassahun (2000) were slaughtered at mature age (one year and seven months), as a result tends to deposit more fat and lower lean percentage. Thus, the difference in lean to fat ratio is due to the difference in slaughter age and breed of sheep used. The value of carcasses is mostly determined by the lean (muscle) to bone ratio (Anous, 1991). Nonetheless, the current result revealed no significant difference in lean to bone ratio between crosses and pure breeds. In contrast to this, Kassahun (2000) observed significantly different ($p<0.05$) lean: bone ratios for the two breeds indicated above in which Menz sheep has higher lean to bone ratio compared to Horro.

The major non genetic factor influencing carcass composition is nutrition. Percentage of lean was significantly different between diet levels. Accordingly, lambs supplemented with low level of concentrate have leaner ($p<0.001$) carcass as compared to lambs fed high level of concentrate. This is due to the fact that lambs fed low level of concentrate can produce leaner carcass compared to lambs fed high level of concentrate. In line with the present finding Ameha (2007) reported that goats fed low level of concentrate produce leaner carcass than high level group. Similarly lambs fed low level of concentrate have higher ($p<0.01$) lean: fat and lean: bone than lambs fed high level of concentrate. In accordance with the present result, several works noted the effect of level of nutrition and feeding regime on carcass yield and quality and fat tissue development and composition (Gatenby, 1986; Canton *et al.*, 1992). Despite the numerical difference, percent of fat, percent of bone and meat: bone was not different between diet levels.

Conclusion: This study indicated that both breed and diet contributed to differences in carcass measurement, conformation and composition. Among breeds, Dorper x Hararghe highland had better carcass measurement and conformation compared to pure Hararghe highland and Blackhead Ogaden breeds. The result revealed that, Majority of carcass measurement and conformation was better in Lambs consumed high level of concentrate supplement than lamb under low level of concentrate supplement group. The fat content of both cross breeds is lower compared to pure Blackhead Ogaden. This is an important trait which meets the present demand of consumers and export market. Moreover, leaner carcass was harvested from lambs consumed low level of concentrate supplement compared to lambs consumed high level of concentrate supplement group.

Overall assessment of the present result leads to the conclusion that crossing Hararghe highland with Dorper improved most of the economically important traits. Whereas, pure Blackhead Ogaden is comparable to both crosses in some carcass measurement and conformation traits indicating that crossing Blackhead Ogaden sheep with Dorper may not be impressive. However, leaner carcass was obtained from both crosses than pure Blackhead Ogaden sheep breeds, which has higher fat content than the crosses.

REFERENCES

Afonso, J. and J.M. Thompson, 1996. Changes in body composition of sheep selected for high and low back fat thickness during periods of *ad libitum* and maintenance feeding. Anim. Sci., 63: 395-406.

Ameha Sebsibe, 2007. Growth performance and carcass characteristics of three Ethiopian goat breeds fed grainless diets varying in concentrate to roughage ratios. South Afr. J. Anim. Sci., 37: 221-232.

Anous, M.R., 1991. A comparative study of muscle-bone relationship in the hind limb of goats and sheep. Anim. Prod., 53: 81-87.

AOAC, 1990. Official method of analysis, 15th Edn., (Helrich, K., Ed.), Pub. By Association of Official Analytical Chemists, Washington, DC.

AUA (Alemaya University of Agriculture), 1998. Proceeding of the 13th annual research and extension review meeting, Alemaya University of Agriculture, February 26-28, 1996, Alemaya, Ethiopia.

Bruwer, G.G., 1984. Hoofstuk 6. Evaluering van karkasopbrengs en vleisgehalte met betrekking tot die huidige klassifikasie en graderingstelsel: 6.3.3.4. Subjektiewe vetheid- en bouvorm-evaluering ten opsigte van beramingsakkuraatheid. In: Objektiewe evaluering van die karkas-graderingstelsel vir lammers en skape in die R.S.A. MSc (Agric) thesis, University of Stellenbosch, South Africa.

Canton, J.G., M.A. Velazquez and R.A. Castellanos, 1992. Body composition of pure and crossbred Blackbelly sheep. Small Ruminant Res., 7: 61-66.

Cheeke, P.R., 1999. Applied Animal Nutrition Feed and feeding. 2nd Edn., Prince Hall Inc. New Jersy, pp: 525.

CSA (Central Statistical Authority), 2010. Ethiopian Agricultural Sample Survey 2009/2010, Vol. II. Report on Livestock and Livestock Characteristics, Bulletin 468.

DAGRIS, 2006. Domestic Animal Genetic Resources Information System (Dagris). (Eds. J.E.O. Rege, W. Yalew.

Ensminger, M.E., 2002. Sheep and Goat Science. 6th Edn., Interstate publisher, Inc., Denville, Illinois, pp: 342-385.

Enyew Negussie, 1999. Body composition and body reserves in indigenous Ethiopian fat tailed sheep breeds. Tierwissenschaft. Dissertation (Dr. agr.), Institut für Tierwissenschaften, Lehrstuhl für Tierzucht, Technische Universität München. Typoskript-Edition, Hieronymus Buchreprouktions GmbH, München.

FAO, 1996. Food and Agricultural Organization. Improving food security, the Ignored Contribution of livestock Monograph. Addis Ababa, Ethiopia, pp: 14-48.

Fisher, A.V. and H. De Boer, 1994. Carcass measurements and dissection procedures. The EAAP standard method of sheep carcass assessment. Livest. Prod. Sci., 38: 149-159.

Gaili, E.S.E., Y.S. Ghanem and A.M.S. Mukhtar, 1979. A comparative study of some carcass characteristics of Sudan Desert sheep and goats. Anim. Prod., 14: 351-357.

Gatenby, R.M., 1986. Sheep production in the Tropics and Sub-Tropics. Tropical Agriculture Series. Longman Group Limited.

Kadim, I.T., O. Mahgoub, D.S. Al-Ajmi, R.S. Al-Maqbaly, N.M. Al-Saqri and A. Ritchie, 2003. An evaluation of the growth, carcass and meat quality characteristics of Omani goat breeds. Meat Sci., 66: 203-210.

Kassahun Awgichew, 2000. Comparative performance evaluation of Horro and Menz sheep of Ethiopia under grazing and intensive feeding conditions. M.Sc., Animal Science, University of Wales, UK.

Kempster, A.J., A. Cuthberston and G. Harrington, 1982. The relationship between conformation and the yield and distribution of lean meat in the carcassesof British pigs, cattle and sheep: A review. Meat Sci., 6: 37-53.

Mourad, M., G. Gbanamou and I.B. Blade, 2001. Carcass characteristics of West African dwarf goats under extensive system. Small Ruminant Res., 42: 83-86.

McDonald, P., R.A. Edwards, J.F.D. Green halsh and C.A. Morgan, 2002. Animal nutrition. 6th Edn., Penfiee Hall, Halow, England London, pp: 693.

Orr, R.M., 1982. Animal production. Animal physiology. In: Haaley, R.T. (Ed.) The Agricultural Note Book 17th Edn., Butterworths and Co. (Publishers) Ltd., London, pp: 305-318.

Pallson, H., 1939. Meat qualities in sheep with special reference to Scotish breeds and crosses. J. Agric. Sci., 29: 544.

SAS, 2002. SAS user's guide (version 9, 3rd Edn.). SAS Inst. Inc. Cary, NC.

Snyman, M.A. and W.J. Olivier, 2002. Productive performance of hair and wool type Dorper sheep under extensive conditions. Small Ruminant Res., 45: 17-23.

Snowder, G.D., H.A. Glimp and R.A. Field, 1994. Carcass characteristics and optimal slaughter weights in four breeds of sheep. J. Anim. Sci., 72: 932-937.

Taylor, St. C.S., J.I. Murray and M.L. Thonney, 1989. Breed and sex differences among equally mature sheep and goats. 4. Carcass muscle, fat and bone. Anim. Prod., 49: 385-409.

Van Soest, P.J. and J.B. Robertson, 1985. Analysis of forages and fibrous foods. AS 613 Manual, Dep. Anim. Sci. Cornell Univ. Press, Ithaca, NY.

Van Soest, P.J., 1994. Nutritional Ecology of the Ruminant. 2nd Edn., Cornell University Press, London, pp: 476.