Original Research Article

Comparison of growth performance, carcass yield and meat quality of Blackhead Persian with Red Masai sheep under feedlot in Tanzania

ABSTRACT

The 90 days feedlot study was conducted using 16 Black Head Persian (BHP) and 16 Red Masai (RM) lambs, with ages ranging from 9 to 10 months and average live weight of 14.5kg. The lambs were subjected to four different treatments (T1, T2, T3 and T4). The control was T1, which was feeding 435g of barley straw daily while T2, T3 and T4 were feeding daily 435g of barley straw with concentrate supplementation amounting 174g, 261g and 348g, respectively. The concentrate composed of maize bran (77%), sunflower seed cake (21%) and vitamin/mineral premixes (2%). The concentrate had 16% Crude Protein and 12.4MJ ME/kg DM. The study employed a 2^2 x 4 factorial design. Feedlot levels, carcass yield and meat quality of treatments were evaluated. Dry matter intake was significantly higher for BHP than RM (48.5 vs 47.2g/kg $W^{0.75}$/day) and energy intake (10.8 vs. 8.32MJ ME/day), respectively. The average daily gains (ADG) were 31.2, 42.4, 42.9 and 46.9 g/day for BHP in T1, T2, T3 and T4, respectively, and 30.7, 30.9, 38.7 and 45.1g/day for RM in T1, T2, T3 and T4, respectively. For T1, the breeds did not differ in terms of ADG, whereas T4 expressed no significance between sex in ADG. The BHP and RM breeds were comparable in pre-slaughter weights (18.5 vs 17.9 kg), hot carcass weights (7.77 vs 7.12 kg) and empty body weights (14.1 vs 13.7 kg). Conversely, BHP displayed higher loin eye area (LEA) than RM (14.6 vs 12.9 cm^2, respectively). Nonetheless, T4 was the economical treatment with a profit margin of Tanzanian shillings 2,395 and 1,195 for BHP and RM, respectively. It was concluded that, doing feedlot using barley straw as basal feed to BHP and RM is comparable in terms of meat productivity and quality performance.

Keywords*: Barley straw, growth response, carcass evaluation, lambs, small ruminant*

1. INTRODUCTION

Small ruminants' production in Tanzania is divided into the traditional and the commercial production systems [1]. The former is further divided into agro-pastoral, pastoral and mixed farming sub systems [2]. The traditional sector is the most dominant and it accounts for over 98% of Tanzanian small ruminants [3]. There has been an emerging private sector involvement in small ruminant production associated with marketing large numbers of live sheep and goats, but also these animals are processed to some prime meat carcasses cuts which are normally exported to the Middle East Markets [2]. Processing of prime cuts, sausages and packaging are now emerging in the inland supermarket outlets, modern urban butchers and food services for tourism institutions [2].

It suffices to say that Tanzania is now improving in providing high-quality mutton to the local and export markets. It is also known that sheep are among the important meat producing animals worldwide [4]. So, Tanzania is aspiring to use the opportunity for such demand to enhance sheep sector commercialization [1]. To indulge in commercialization one needs to have information on the internationally required qualities of the primal cuts and meat. In Tanzania, such information has recently been documented in few studies [5, 6, 7]. Nonetheless more information is needed by the market. This study was therefore aimed at comparing the effect of feedloting Blackhead Persian (already known in international markets) and the Tanzanian indigenous Red Masai sheep breeds using barley straw-based diets on carcass yield and meat quality.

2. MATERIALS AND METHODS

2.1 Study area

This was an on-station feedloting study, which was conducted at Tanzania Livestock Research Institute (TALIRI) - West Kilimanjaro in Tanzania. TALIRI – West Kilimanjaro is the custodian of producing and transferring technologies to smallholder and large livestock farmers in Northern Tanzania. The place is located at Latitude 3^{o} South and Longitude 37^{o} East. The area has annual rainfall ranging between 450 and 750 mm, which is insufficient to support adequate availability of pastures and forages in the dry season, and instead necessitates storage and use of barley straw as basal feed. Desiccating winds normally blow during the dry season with wind speed reaching up to 25 km/hr which results into higher evaporation rates favoring their preservation.

2.2 Data collection

2.2.1 The experimental design

The feedlot experiment was carried out for a period of 90 days, after which the animals were slaughtered for comparing breed responses for growth, carcass yield and quality characteristics. Equal numbers of female and male lambs born at the same farm were used in the experiment. A total of 32 lambs were used (16 RM; 16 BHP; 16 males and 16 females) with ages ranging from 9 to 10 months, having an average weight of 14.5 kg. The study employed a 2^2 x 4 factorial design [8], where factors were: 2 sexes (female and male); 2 breeds (BHP and RM). Before feedlotting, lambs were subjected to a 14 days adaptation period, when they were kept in individual pens and fed using feed troughs prepared as per [9] standards. The experimental animals were then subjected to four dietary treatments (T1, T2, T3 and T4). Treatment T1 was feeding an animal 435 g of good quality barley straw and this was the control. Treatments T2, T3 and T4 were feeding animals 435 kg of good quality barley straw plus 174g, 261g and 348g of concentrate formulated from maize bran (77 %), sunflower seed cake (21 %) and vitamin/mineral/salt premixes (2 %). The concentrate had 16% Crude Protein and 12.4 MJ ME/kg DM. Feeds were offered at 08:00 h and refusals were weighed daily at 07:00 h on the following day. Daily feed intake was obtained by taking the difference between the offer and the refusal. Feeds were analyzed at TALIRI - Mpwapwa as per [10]. Metabolizable Energy (ME) was calculated as per [11].

2.2.2 Animal slaughter and carcass evaluation

Animals were kept in a lair-age and fasted for 18 hours with free access to water. Slaughter weight was taken at 16:00h prior to slaughter using mechanical weighing balance (100 kg, Animal Tech weighing scale, UK). Lambs were slaughtered according to the standard procedures where bleeding was achieved by cutting the carotid arteries and jugular vein in a single cut, according to Halal practice [12].

Carcass and non-carcass components were weighed immediately after slaughter using Ohaus LS2000 portable standard digital weighing machine (Switzerland®) for components less than 2000g and mechanical weighing balance (100 kg, Animal Tech weighing scale, UK) was used for the heavier components. Lungs, trachea and heart were weighed as one portion referred as pluck. Weight of the digestive tract contents was determined by calculating the difference between the weight of full and empty digestive tract. Empty body weight (EBW) was obtained as the difference between slaughter weight and weight of digestive track contents.

Weight of blood was determined as the difference between weight of lamb before slaughter and weight after slaughter just before skinning. Before skinning, the head was removed at the atlanto-occipital joint. Fore and hind limbs were removed by cutting at the carpus-metacarpal and tarsus-metatarsal joints, respectively [13, 7]. Hot carcass weight (HCW) was taken just prior to chilling. Mesenteric, omental, pelvic and kidney fats were separated and weighed. Carcasses were then chilled at 4°C for 24 hours. Back-fat thickness was measured after exposing the rib eye area at 12^{th} and 13^{th} rib using meat vernier caliper by measuring at three sites of the 12^{th} rib edge and taking the average.

The loin eye area (LEA) was recorded by tracing the area on a transparent paper and the portion indicating the size of muscle was shaded with black ink which was then passed through an electric planimeter that automatically measured the portion area in square centimeters. Using a hand saw, carcasses were halved longitudinally along the median plane and jointed into hind leg, loin, chump, shoulder, main ribs, breast, neck and foreleg as described by [14] and [7]. The joints (Figure 1) were then weighed and separated into dissectible muscle (lean), bone and fat.

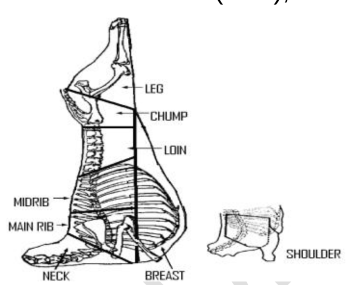

Figure 1: The seven joints of the half carcass (adopted from [7])

2.2.3 Evaluation of meat quality

Within 20 minutes after carcass preparation *longissimus dorsi* muscle was removed, its fat trimmed out and chilled at 4^{o} C for 24 hours. Some cubes of at least 500g of the meat sample were prepared for quality assessment after first cooking for 20 minutes with 0.5% salt. Some meat cubes (≈2.54 cm) were chopped from samples using a coring device and prepared for Warner Bratzler shear force assessment. A total of 72 cubes were assessed, where 64 were for breeds (i.e. two cubes from each carcass) and eight for treatments (i.e. two from each treatment). The cubes were then evaluated by a panel of 10 scientists. Panelists' evaluation was a subjective sensory taste and visual assessment on palatability, tenderness, juiciness, odour and colour of each breed and treatment samples. The scores used by the panelists had a 5 points scale (1=very poor, 2=poor, 3=Average, 4=Good, 5=Excellent).

Drip loss was evaluated after meat being chilled at 4^{o} C for 24 hours and expressed as a percentage loss in weight after chilling the meat for 24 hours in a refrigerator while sealed in polyethylene covers. Levels of pH were taken on the left side of the carcass at the same point on the muscle *longissimus thoracis et lumborum* between the 5^{th} and 6^{th} rib and recorded at 45 minutes after carcass dressing (which was termed as pH 45m) using a digital pH meter, and then subsequently as pHµ at 3h, 6h, 12h and 24h post-mortem, which were designated as pH3h, pH6h, pH12h and pH24h. Ultimately, pH levels (pHu) and temperature levels were taken after complete glycolysis at 24 h post-mortem. Temperature readings were taken at 45 minutes and then at 3h, 6h, 12h and 24h and these were designated as $Temp_{45m}$, $Temp_{3h}$, $Temp_{6h}$, $Temp_{12h}$ and $Temp_{24h}$, respectively. The temperatures were recorded using *FUNKUTION Digital* meat thermometer.

2.3 Data analysis

Data were analyzed using General Linear Model procedures as per [15]. The model presented in equation 1 below was used to express the lamb performance due to breed, feeding regimes, sex and interaction effects:

$$Y_{ijklm} = \mu + B_i + F_j + S_k + (\mathrm{BxF})_{ij} - \varepsilon_{ijklm} \quad \ldots (1)$$

where:
Y_{ijklm} = performance of individual lamb,
µ = overall mean,
B_i = effect of i^{th} breed (i: 1=BHP, 2=RM),
F_j = effect of j^{th} feeding treatment regime (j: 1=T1, 2=T2, 3=T3, 4=T4),
S_k = effect of k^{th} lamb sex (k: 1=Male, 2=Female) ,
$(BxF)_{ij}$ = interaction between i^{th} lamb breed and j^{th} feeding regime, and
ε_{ijklmn} = random error.

Carcass characteristics were determined using equation 2 below:

$$\mathrm{DPPSW} = \frac{\mathrm{HCWx100}}{\mathrm{BW}} \quad \ldots (2)$$

where:
DPPSW = Dressing percent based on pre-slaughter live weight,
HCW = Hot carcass weight, and
BW = Live body weight

Dressing percentage per empty body weight was estimated using equation 3 below:

$$\mathrm{DPEBW} = \frac{\mathrm{HCWx100}}{\mathrm{EBW}} \quad \ldots (3)$$

where:
DPEBW = Dressing percentage per empty body weight,
HCW = Hot carcass weight, and
EBW = Empty body weight

3. RESULTS AND DISCUSSION

3.1 Dry matter and energy intake levels

Dry matter and energy intakes were as summarized in Table 1. On average, for the whole feedlot period, a BHP lamb consumed 38.5 kg and a RM lamb consumed 37.9 kg of barley straw. In addition, each lamb subjected to treatments T2, T3 and T4 consumed extra 18.6, 27.6 and 39.7 kg of the concentrate, respectively. Lambs fed with the formulated diets in treatments T2, T3 and T4 displayed almost similar feed intakes, a trend which was reported also by [16]. Dry matter intake (48.5 vs 47.2 g/kg $W^{0.75/}$day) and metabolizable energy intake (10.8 vs. 8.32 MJ ME/day) were both significantly higher (*P*= .05) for BHP than RM.

Table 1: Basal feed, concentrate, dry matter and energy intake levels for Blackhead Persian and Red Masai in the entire feedlot period

	BHP	RM	*P*	T1	T2	T3	T4	*P*
Barley straw consumed in the entire period (kg)	38.5	37.9	NS	39.0	38.2	38.1	36.9	*
Dry matter intake (g/kg $w^{0.75}$/day)	48.5	47.2	*	47.8	48.4	48.6	48.7	NS
Energy intake (MJ ME/day)	10.8	8.32	*	9.65	9.72	10.1	10.1	NS
Concentrate consumed in the entire period (kg)	30.8	30.5	NS	0.00	18.6	27.6	39.7	*

*significant at *P*= .05, NS= non - significant, kg= kilogram, g= gram, MJ=mega joule, ME = metabolizable energy, $w^{0.75}$ = metabolic weight, BHP=Blackhead Persian, RM= Red Maasai, T1-T4= dietary treatments

3.2 Weight gain and feed conversion efficiency of the sheep

Weight gain responses by breed and sex were as shown in Tables 2 and 3. Initial body weights of BHP and RM lambs were 14.6 and 14.4 kg, respectively (Table 2). Weight gains in treatment T1 were 31.15 and 30.77 g/day for BHP and RM, respectively (Table 3) and didn't differ significantly (*P*=.05) between breeds. In T2, T3 and T4 BHP grew faster at 42.4, 42.9 and 46.9 g/day than their RM counterparts which grew at 30.9, 38.7 and 45.1 g/day, respectively (Table 3). Average daily gain was significantly higher (*P*=.05) for males than females in treatments T1, T2 and T3 (31.1, 41.4 and 43.5 vs 30.1, 30.9 and 38.2, respectively) (Table 3). Males and females didn't differ significantly in T4 only, where males recorded 46.5 g/day and females recorded 45.78 g/day (Table 3). Blackhead Persian recorded better feed conversion ratio (8.54) than 9.56 recorded by RM (Table 2).

Table 2: Overall least square means of body weight gain and feed conversion performance of fedlotted Blackhead Persian and Red Masai Sheep

	Breed		Dietary treatment			
	BHP	**RM**	**T1**	**T2**	**T3**	**T4**
Trait/item	**LSM±se**	**LSM±se**	**LSM±se**	**LSM±se**	**LSM±se**	**LSM±se**
Initial body weight (kg)	14.6±0.60	14.4±0.8	14.6±0.91	14.7±0.75	14.5±0.72	14.5±0.72
Final body weight (kg)	18.5±1.57	17.9±1.68	17.4±1.69[a]	18.2±1.71[b]	18.6±1.66[bc]	18.9±1.68[c]
Body weight gain (kg)	3.87±0.65	3.64±0.71	2.88±0.82[a]	3.47±0.76[ab]	3.97±0.81[b]	4.52±0.71[c]
ADG (g)	43.0±0.72[a]	40.4±0.83[b]	32.0±0.80[a]	38.5±0.71[ab]	44.1±1.81[b]	50.2±1.77[c]
TFC (kg)	33.1±1.20	34.7±1.50	35.2±1.33	35.1±1.41	34.9±1.25	34.9±1.32

FCR	8.54±0.75[a]	9.56±0.97[b]	12.2±0.90[a]	10.1±0.76[b]	8.79±0.79[c]	7.72±0.71[d]

BHP=Blackhead Persian, RM=Red Masai, LSM=least significant means, [a, b, c, d] LSM with different superscripts within a row for breeds and within row for dietary treatments are significantly different at *P*=.05; ADG=average daily gain, TFC = total feed consumed, FCR= feed conversion ratio (Feed consumed in kg for 1 kg body weight gain)

This study revealed gains of 32, 38.5, 44.1 and 50.2 g/day for rations T1, T2, T3 and T4, respectively, all of which based on barley straw. Another study on fattening Arsi Bale sheep using Urea-treated barley straw in Ethiopia allowed meeting maintenance requirements and a daily gain of 40 g/day [16]. Therefore, gains in T1 and T2 were lower than that reported by [16]. However, the motive behind this study was to test the farmers' practice, where farmers feed untreated barley straw with supplementation. Regarding this, a little bit different trends have been reported by [17] and [18].

Table 3: Total and average daily gain response of breeds and sex on treatments

Treatment	**Breed total gain (LSM±se kg)**		***P***	**Breed ADG (LSM±se g/day)**		***P***	**Sex ADG (LSM±se g/day**		***P***
	BHP	RM		BHP	RM		M	F	
T1	2 .80±0.88	2.77±0.72	NS	31.2±0.73	30.7±0.71	NS	31.1±0.73	30.1±0.74	*
T2	3.82±0.88	2.78±0.72	*	42.4±0.82	30.9±0.83	*	41.4±0.80	30.9±0.82	*
T3	3.86±0.72	3.48±0.88	*	42.9±0.72	38.7±0.71	*	43.5±0.71	38.2±0.71	*
T4	4.22±0.88	4.02±0.72	*	46.9±1.83	45.1±0.81	*	46.5±0.77	45.8±0.78	NS

LSM=Least significant means, se=standard error; *significant at *P*=.05; NS=non significant, ADG= Average Daily Gain, BHP=Blackhead Persian, RM=Red Masai, M=male, F=female, T1-T4= dietary treatments

3.3 Carcass characteristics of the sheep

Results from the weighed and calculated carcass composition were presented on the basis of the chilled (at 4^{o} C) carcass weight. Least squares means for effect of diets on physical carcass composition of BHP and RM sheep are presented in Table 4. Blackhead Persian and RM sheep carcasses had comparable pre-slaughter mean weights (18.5 vs 17.9 kg), HCW (7.77 vs 7.12 kg) and EBW (14.1 vs 13.7), respectively. In this study, almost all carcass traits for breeds were not significantly different between breeds (*P*=.05) except for the LEA. Loin eye area was 14.6 and 12.9 cm^2 for BHP and RM, respectively. Further, dietary treatments had a highly significant effect (*P*=.01) on HCW, EBW, DPPSW, LEA, DEBW and BFT. Furthermore, the treatments had a significant effect (*P*=.05) on hind leg and loin carcass joints. The values obtained in this study were a bit smaller to those observed by [4] and [7] for some of the parameters analyzed.

Table 4: Least squares means for effect of dietary treatments on various physical body parts and carcass composition of Blackhead Persian and Red Maasai sheep

Trait	BHP LSM±se	RM LSM±se	*P*	T1 LSM±se	T2 LSM±se	T3 LSM±se	T4 LSM±se	*P*
PSW (kg)	18.5±0.57	17.9±0.56	NS	17.2±0.86	18.3±0.90	18.9±0.89	18.4±0.89	NS
HCW (kg)	7.77±0.33	7.12±0.32	NS	5.96± 0.24	7.91±0.28	7.54±0.25	8.36±0.25	**
EBW (kg)	14.1±0.55	13.7±0.54	NS	11.6±0.74	14.7±0.85	14.4±0.76	14.9±0.76	**
DPPSW (%)	41.1±0.77	39.5±0.75	NS	34.0±0.48	43.2±0.56	39.8±0.50	44.2±0.50	**
DEBW (%)	51.4±0.67	50.4±0.66	NS	45.3±0.82	52.9±0.95	52.4±0.85	53.0±0.85	**
LEA (cm^2)	14.6±0.78	12.9±0.76	*	10.81±0.42	14.43±0.49	13.23±0.44	16.54±0.44	**
BFT (mm)	4.41±0.74	4.67±0.72	NS	1.00±0.53	5.08±0.76	6.22±0.58	5.84±0.58	*

Hind leg (kg)	0.98±0.07	0.88±0.07	NS	0.61±0.04	0.93±0.04	1.20± 0.04	0.96±0.04	*
Fore leg (kg)	0.75±0.08	0.71±0.07	NS	0.49±0.01	0.72±0.02	0.93±0.01	0.78±0.01	NS
Shoulder kg)	0.71±0.04	0.65±0.04	NS	0.55±0.03	0.68±0.04	0.67±0.03	0.80±0.03	NS
Loin (kg)	0.90±0.06	0.88±0.06	NS	0.52±0.06	0.87±0.07	1.08±0.06	1.08±0.06	*
Neck (kg)	0.37±0.02	0.31±0.02	NS	0.28±0.03	0.34±0.04	0.33± 0.03	0.40±0.03	NS
Breast (kg)	0.28±0.01	0.19± 0.01	NS	0.11±0.03	0.31±0.03	0.23±0.03	0.28±0.03	NS
Mid ribs (kg)	0.41±0.05	0.39± 0.06	NS	0.27±0.03	0.36±0.03	0.30±0.03	0.43±0.02	NS
Main ribs (kg)	0.38±0.04	0.36±0.05	NS	0.30±0.06	0.33±0.06	0.39±0.05	0.41±0.05	NS
Chump (kg)	0.45±0.05	0.34±0.06	NS	0.29±0.04	0.37±0.04	0.36±0.03	0.45± 0.03	NS
Blood (kg)	0.68±0.07	0.73±0.06	NS	0.60±0.06	0.63±0.07	0.98±0.06	0.59±0.06	NS
Head (kg)	1.45±0.08	1.42±0.07	NS	1.30±0.04	1.55±0.05	1.38±0.05	1.48±0.05	NS
Skin (kg)	1.53±0.07	1.42±0.08	NS	1.20±0.05	1.53±0.06	1.66±0.05	1.59±0.05	NS
Heart (g)	83.0±0.40	85.0±0.40	NS	70.8±0.39	85.3±0.07	84.6±0.54	98.4±0.54	NS
Pluck (kg)	0.46±0.05	0.53±0.06	NS	0.39±0.05	0.63±0.06	0.43±0.05	0.49±0.05	NS
Liver (kg)	0.46±0.05	0.51±0.05	NS	0.40±0.04	0.64±0.05	0.41±0.04	0.46±0.04	NS
EGIT (kg)	2.07±0.07	1.89±0.07	NS	1.82±0.13	2.08±0.15	1.80±0.13	2.22± 0.13	NS

*significant at *P*=.05; **highly significant at *P*=.01, NS=non-significant, PSW=Pre-slaughter weight, HCW=Hot carcass weight, EBW=Empty body weight, DPPS=Dressing percent basing on pre-slaughter weight, DEBW=Dressing percent basing on empty body weight, LEA=Loin eye area, BFT=Back fat thickness, EGIT=Empty gastro-intestinal tract.

Slaughter weight, HCW and EBW in [4] were 28.5 kg, 14.9 kg and 26.7 kg, respectively whereas for [7] were 22.3 kg, 9.5 kg and 20.2 kg, respectively in comparison to this study which were 18.5 kg, 7.77 kg and14.1 kg for slaughter weight, hot carcase weight and empty body weights, respectively. Almost all other traits reported by [4] were higher than those observed in this study. It was reported further by [4] that, BFT of Avikanagar sheep fedlotted at the Central sheep and wool research Institute located in hot semi-arid area of India was 10.2 mm. The difference may be due to good genetic make-up for meat characteristics of the sheep used in their trial. The sheep used in [4] trial were 12 months of age after being stall fed for 3 months and those in [7] trial were aged between 18 and 24 months, while in this study the age averaged at 12 months after a feedlot period of 90 days. Furthermore, parameters in terms of fat from [4] study may be much higher due to the genetic composition of the sheep having the ability of depositing fat at the back, tail and rump as compared to the breeds used in this study, which mostly deposit more fat on the tail area. Records for left half cold carcass weight and composition are presented in Table 5.

Table 5: Least squares means of left half carcass compositions from Blackhead Persian and Red Masai fedlotted sheep

	Breed				Dietary treatments					
Component	BHP	RM	SEM	P	T1	T2	T3	T4	SEM	P
LCCW kg)	3.64	3.28	0.28	NS	3.18	3.50	3.63	3.68	0.33	*
Lean (kg)	2.38	2.07	0.16	*	2.18	2.43	2.49	2.54	0.18	*
D-fat (kg)	0.32	0.25	0.02	**	0.21	0.31	0.42	0.45	0.04	*
Bone (kg)	0.94	0.96	0.02	NS	0.79	0.76	0.72	0.69	0.02	*
L+D (kg)	2.70	2.32	0.16	*	2.39	2.74	2.91	2.99	0.19	*
Tissue % of LCCW										
Lean (%)	65.4	63.1	0.57	*	68.6	69.4	68.2	69.0	0.68	*
D-fat (%)	8.79	7.62	0.73	*	6.60	8.86	11.6	12.2	0.81	*
Bone (%)	25.8	29.3	0.65	*	24.8	21.7	20.2	18.8	0.74	*

L+D%	74.2	70.7	0.72	*	75.2	78.3	79.8	81.2	0.75	*
Tissue ratio										
Lean: bone	2.53	2.16	0.15	*	2.76	3.19	3.46	3.68	0.18	*
L+D: bone	2.87	2.42	0.17	*	3.03	3.61	4.04	4.33	0.19	*

LCCW=Left cold carcass weight; SEM=Standard error of the mean; D-fat=Dissectible fat; L+D=Lean+D-fat, *Significant P=.05; **Significant P=.01; NS=non-significant, BHP=Blackhead Persian, RM=Red Masai

The left cold carcass weight (LCCW) and bone components were not significantly different (*P*=.05) between BHP and RM. However, the ratios of dissectible parameters of BHP were observed to be superior to RM as BHP had significantly (*P*=.05) more lean plus dissectible fat than RM (2.7 vs 2.3 kg). Further results indicated that BHP were significantly (*P*=.05) superior than their counterparts in lean to bone ratio (2.53 vs 2.16). These results could be interpreted that, BHP sheep carcasses had proportionally higher ratio of lean meat to bone and lean meat plus fat to bone, but also considerably greater ratio of dissectible fat than RM sheep carcasses. Treatment T4 was found to be superior in almost all parameters than the other three treatments. Treatment T4 was superior in LCCW, lean and dissectible fat and also had a small percent of bones and had the highest ratio of lean to bone. On the other hand, RM could produce meat of choice to consumers who prefer meat with low amount of fat based on preferences and health requirements. The financial value of a carcass is largely determined by the quantity of saleable meat, which is the weight of the muscle relative to other tissues.

3.4 Meat quality characteristics of the sheep

Producing higher yielding lambs for slaughter is beneficial to producers, processors, retailers and consumers, which is envisaged to improve the efficiency of the mutton supply chain [19, 20]. Organoleptic attributes of any carcass is an important aspect to any lamb producer [4, 21, 7]. Most meat customers pay prime prices to the meat which meets standards on aspects of tenderness, juiciness, palatability, odour and colour [22]. The organoleptic attributes of BHP and RM meat in this study are shown in Table 6. In this study, taste panel perception for tenderness of BHP and RM carcasses were rated 4.43 and 4.41, respectively. Other perception ratings were juiciness, palatability, odour and colour, all of which showed non-significant differences between breeds.

Table 6: Organoleptic attributes of mutton from fedlotted Blackhead Persian and Red Maasai sheep subjected to four dietary treatments

	Breed				**Dietary treatment**					
Trait	BHP	RM	SEM	*P*	T1	T2	T3	T4	SEM	*P*
Tenderness	4.43	4.41	0.25	NS	4.45	4.42	4.37	4.30	0.22	NS
Juiciness	3.37	3.25	0.08	NS	3.25	3.51	3.95	3.92	0.19	NS
Palatability	3.96	3.89	0.73	NS	3.74	3.92	4.20	4.23	0.51	NS
Odour	3.62	3.57	0.50	NS	3.61	3.64	3.68	3.72	0.62	NS
Colour	3.72	3.78	0.36	Ns	3.81	3.65	3.91	3.89	0.40	NS

NS= non-significant, BHP=Blackhead Persian, RM=Red Maasai, SEM=Standard error of the mean, T1-T4= dietary treatments

Despite BHP appeared to surpass their counterparts in some of the carcass traits, but they were rated almost the same in the organoleptic and tenderness tests (Table 7). Meat from both breeds was comparable. According to the panel, meat from both breeds was appealing as good mutton. In meat science, tenderness is normally assessed by measuring the force needed to shear muscles [4]. The more force needed, the tougher the meat and vice versa.

The test used to measure tenderness is known as the “Warner-Bratzler shear force test”. The test units of measurement are kilograms of force needed to shear one cubic centimetre muscle sample. The rate of shear force ranges between 2.6 kg/cm^2 as tender meat and 5.3 kg/cm^2 as tough meat [21]. In this study, shear force test for BHP and RM meat were 3.85 and 3.89 kg/cm^2, respectively (Table 7), which were not different (*P*=.05). This means, mutton from both breeds were moderately tender. Results from the panellists and shear force score were comparable and both breeds mutton were moderately tender. It has been stated elsewhere by [23] that, a significant factor affecting meat tenderness is meat acidity. Toughness increases as the ultimate pH is approached. However, ultimate pH is normally reached after the post-mortem chemical reactions in the meat have ceased [21].

Table 7: Comparison of tenderness between panel score and shear force method for mutton from fedlotted Blackhead Persian and Red Masai lambs

Evaluation method	Breeds tenderness score		P	Treatment tenderness score				P
	BHP	RM		T1	T2	T3	T4	
Scientist panel (5 point scale)	4.43	4.41	NS	4.45	4.42	4.39	4.37	NS
Shear force (kg/cm^2)	3.85	3.89	NS	3.88	3.86	3.84	3.81	NS

NS=non-significant, BHP=Blackhead Persian, RM=Red Maasai, T1-T4= dietary treatments, kg=kilogram, cm=centimeter

Physico-chemical attributes of the meat in this trial are as shown in Table 8. In this study the within meat chemical reaction activities were reflected by a decrease in pH from 6.21 and 6.30 for BHP and RM at 45 minutes post-slaughter to 5.86 and 5.94 for BHP and RM, respectively at three hours. The decrease in pH went further to the ultimate pH results resembling the trend reported by [4 and 7]. In meat science, it is generally acknowledged that the cut-off point for optimum acceptability is maximum pH of 5.7 [23]. The cut-off point in this study was a little bit lowered to 5.49 and 5.52 for BHP and RM, respectively. Water-holding capacity of fresh meat (which is the ability to retain inherent water) is also an important property of fresh meat as it affects both the yield and the quality of the end product. This property is affected by other factors like pH, meat physical handling and genetics of an animal [23]. However, thawing and cooking loss are worthy for evaluation as they influence meat quality and economics of meat processing [21]. In this study BHP and RM did not differ significantly in all physico-chemical parameters. This means that, despite the animals being genetically different their physico-chemical attributes were almost similar. However, treatments had an effect on cooking loss and water holding capacity. It is therefore important to establish the best levels of feeding regime. Nonetheless, meat processors still need to abide to meat handling to avoid some alterations of the acceptable attribute standards of parameters like thawing loss, cooking loss, shear force and water holding capacity.

Table 8: Physico-chemical attributes of fedlotted Blackhead Persian (n = 16) and Red Maasai sheep (n = 16) carcasses in terms of thawing loss, cooking loss, water holding capacity, pH and temperature

	Breeds				Dietary treatments					
Trait	**BHP**	**RM**	**SEM**	**P**	**T1**	**T2**	**T3**	**T4**	**SEM**	**P**

Thawing loss (%)	3.66	3.60	0.12	NS	3.75	3.68	3.65	3.60	0.17	NS
Cooking loss (%)	22.87	22.54	1.05	NS	23.43	22.90	22.51	22.44	1.35	*
*WHC (%)	58.60	60.05	1.75	NS	57.55	57.64	60.68	62.72	1.86	*
P^H45m	6.21	6.30	0.96	NS	6.31	6.35	6.33	6.25	0.89	NS
P^H 3h	5.86	5.94	0.16	NS	5.83	5.92	5.80	5.91	0.43	NS
P^H 6h	5.56	5.58	0.17	NS	5.67	5.70	5.61	5.60	0.74	NS
P^H 12h	5.49	5.53	0.16	NS	5.61	5.66	5.57	5.54	0.42	NS
P^H 24h	5.49	5.52	0.84	NS	5.39	5.38	5.40	5.51	0.79	NS
Temp 45m	34.54	33.64	1.52	NS	34.56	34.61	34.62	34.65	1.47	NS
Temp 3h	25.28	24.75	1.12	NS	24.83	24.87	25.30	25.32	1.21	NS
Temp 6h	23.57	22.64	1.16	NS	23.42	23.55	23.57	23.61	0.93	NS
Temp 12h	4.72	4.68	0.18	NS	4.60	4.65	4.68	4.75	0.72	NS
Temp 24h	3.46	3.42	0.15	NS	3.44	3.45	3.49	3.50	0.66	NS

*WHC = water holding capacity; *significant P=.05, NS= non-significant, Temp=temperature, BHP=Blackhead Persian, RM=Red Maasai, m= minutes, h=hours, SEM=Standard error of the mean, T1-T4= dietary treatments, n=sample size, % percent

Tanzania as one of the potential producers of mutton needs to abide to the global production regulations. Some scientists [24, 21] have estimated a prevalence of about 30% of the tenderness of meat to be ascribed to all forms of genetic influences associated with calpain gene variance. Further, muscle fibre thickness has also been reported to affect tenderness, which has been observed to a tune of 28% in meat animals [21]. The former has been noted as cases from tender meat while the latter as a case from tough meat. These factors need to be considered in the growing sheep meat processing industry. Higher efficiency of lean meat production is required by most sheep producers [24, 25].

The best feeding regime was combining a basal diet of 348g of barley straw hay and 24g per kg body weight of the concentrate per day. However, it is suggested to try other feeding options to see how best other alternatives could be beneficial to farmers. It is important to test various feedlot packages in order to come up with options specific to various ecological zones. Sheep industry stakeholders should realize that traditional breeds dominate the livestock sector and therefore should support the intended livestock revolution. Local sheep are widely distributed and adapted to many agro-ecological zones, but their production coefficients are low. So, sheep feedlotting can be beneficial to farmers.

4. CONCLUSION

Fattening abilities, carcass and meat characteristics of the studied breeds were comparable. Blackhead Persian appeared to surpass RM in lean to bone ratio, lean plus dissectible fat to bone ratio, but they were rated almost the same in the organoleptic and tenderness tests. Because of low amount of dissectible fat than BHP, RM can produce meat of choice to consumers who prefer meat with low amount of fat. Both breeds are suitable for commercial production, but to achieve best results, good management must be provided in order to meet international standards. Feedlotting of both breeds using barley straw based diet is fairly profitable.

ETHICAL APPROVAL

This study was approved by the Research Ethical Committee of the Open University of Tanzania.

REFERENCES

1.Ministry of Livestock and Fisheries (MLF). Tanzania Livestock Sector Analysis. United Republic of Tanzania, Dar es salaam, 2017.

2. SNV. Red meat for local and export markets sub sector analysis Tanzania. Study report commissioned by Netherlands Development Organisation (SNV) Tanzania and conducted by Match Maker Associates (MMA) limited and Consultants for development programs (CDP-EA). 68 pp, 2008.

3. Ministry of Livestock and Fisheries (MLF). Tanzania Livestock Modernisation Initiative (TLMI). United Republic of Tanzania, Dar es salaam, 2015.

4. Sen A R, Santra A, Karim S A. Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. Meat Science 2004; 66: 757–763. https//www.elsevier.com/locate/meatsci.

5.Safari JG, Mushi DE, Mtenga LA, Kifaro GC, Eik LO. Effects of concentrate supplementation on carcass and meat quality attributes of feedlot finished Small East African goats. Livestock Science. 2009; 125:266-274.

6.Safari JG, Mushi DE, Mtenga LA, Kifaro GC, Eik LO. Growth, carcass yield and meat quality attributes of Red Maasai sheep fed wheat straw-based diets. Tropical Animal Health and Production. 2011; 43(1):89-97. Doi: 10.1007/ s 11250-010-9658-3.

7.Shija DS, Mtenga LA, Kimambo AE, Laswai GH, Mushi DE, Mgheni DM, Mwilawa AJ, Shirima EJ M, Safari JG. Preliminary Evaluation of Slaughter Value and Carcass Composition of Indigenous Sheep and Goats from Traditional Production System in Tanzania. Asian-Aust. Journal of Animal Sciences, 2013; 26 (1): 143-150. http://dx.doi.org/10.5713/ajas.2012.12431.

8. Morris TR Experimental design and analysis in Animal Science. CABI Publishing. Wallingford, Oxon Ox 10 8DE, UK. 208 pp, 1999.

9. Food and Agriculture Organization of the United Nations (FAO). Tropical animal feeding: a manual for research workers. pdf feeding trial methods document. http://www.fao.org/livestock/agap/frg/AHPP126/Ch10 pp. 241, 2014.

10. Otto JR, Bunmi S, Malau A, Rao A, Iain JC, Malau-Aduli EO. Effect of incremental levels of crude degummed canola oil on milk progesterone, plasma luteinizing and follicle stimulating hormones of primiparous Holstein–Friesian cows in a pasture-based system. International Journal of Veterinary Science and Medicine, 2014; (2): 122–129.

11. Noblet J, Perez JM. Prediction of digestibility of nutrients and energy values of pig diets from chemical analysis. Journal of Animal Science, 1993; 71:3389–3398.

12. Kebede T, Lemma T, Dinka H, Guru M, Sisay A. Growth performance and carcass characteristics of Arsi-Bale goats castrated at different ages. World Applied Sciences Journal, 2008; 4 (4): 545-553.

13. Bonvillani A, Peña F, de Gea G, Gómez G, Petryna A, Perea J. Carcass characteristics of Criollo Cordobés kid goats under an extensive management system: Effects of gender and live weight at slaughter. Meat Science, 2010 86:651-659.

14. Fischer TM, Van der Werf JHJ, Banks RG, Ball AJ. Description of lamb growth using random regression on field data. Livestock Production Science, 2006; 89: 175-185.

15. SAS Institute Inc 2008 SAS/STAT ® 9.2 User's Guide. Cary, NC: SAS Institute Inc. Copyright © 2008, SAS Institute Inc., Cary, NC, USA, 2008.

16. Nagireddy NK ,Yerradoddi RR. Effect of roughage to concentrate ratio of sweet sorghum (Sorghum bicolor L. Moench) bagasse-based complete diet on nutrient utilization and microbial N supply in lambs. Tropical Animal Health and Production, 2012 44(7):1717-1724. DOI: 10.1007/s11250-012-0129-x.

17. Abate D, Melaku S. Effect of supplementing urea-treated barley straw with Lucerne or vetch hays on feed intake, digestibility and growth of Arsi Bale sheep. Tropical Animal Health and Production, 2008; 41(2): 579-586.

18. Cacere RA, Morais MG, Alves FV, Feijó GL, Ítavo CB, Ítavo LC, Oliveira LB, Ribeiro CB. Quantitative and qualitative carcass characteristics of feedlot ewes subjected to increasing levels of concentrate in the diet. Arq. Brasilia Medicina Veterinaria e Zootecnia , 2014; 66 (5): http//www.dx.doi.org/10.1590/1678-6376.

19. Shirima EJ, Mtenga LA, Kimambo AE, Laswai GH, Mgheni DM, Mushi DE, Shija DS, Safari JG, Hozza WA. Effects of Days in Feedlot on Physico-Chemical Properties and Meat Tenderness from Tanzanian Long Fat-Tailed Sheep, 2014; J. Anim. Prod. Adv 3 (2): 40-48.

20. Bozidarka M, Bjørg E, Goran V, Milena B. Comparison of carcass characteristics and meat quality of Norwegian white sheep breed with two Western Balkan Pramenka sheep breeds, 2014; Agriculture and Forestry 60 (1): 53-61.

21. Kelly P. Improving lamb lean meat yield: A technical guide for the Australian lamb and sheep meat supply chain. Murdoch University. Australian government, Department of industry and science. , 2016. http://www.sheepcrc.org.au.

22. Young JM, Thompson AN, Kennedy AJ. Bio-economic modeling to identify the relative importance of a range of critical control points for prime lamb production systems in south-west Victoria. Animal Production Science, 2010; 50(8): 748-756.

23. Mendiratta SK, Kondaiah N, Anjaneyulu ASR, Sharma BD. Comparisons of handling practices of culled sheep meat for production of mutton curry. Asian-Australian Journal of Animal Science, 2008; 21(5): 738–744. http://www.ajas.info.

24. NIFA. Water-holding capacity of fresh meat. Report on new technologies for agriculture extension project under National Institute of Food and Agriculture (NIFA). Work supported by USDA, 2010; http://www.articles.extension.org/pages/27339/water-holding-capacity-of-fresh-meat.

25. Mtenga LA, Masae EE, Owen E, Muhikambele VRM, Kifaro GC. Studies on compensatory growth in Black Head Persian (BHP) lambs. Tanzania Journal of Agricultural Sciences, 2008; 8 (1): 79 – 86.

26. Buncha TD, Evans RC, Wanga S, Brennand CP, Whittier DR, Taylor BJ. Feed efficiency, growth rates, carcass evaluation, cholesterol level and sensory evaluation of lambs of various hair and wool sheep and their crosses. Small Ruminant Research, 2014; 52: 239–245.