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Original Article

Effects of Days in Feedlot on Physico-Chemical Properties and Meat Tenderness from Tanzanian Long Fat-Tailed Sheep

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Abstract

The objective of this study was to evaluate the effects of days in feedlot (DF) on physico-chemical properties and meat tenderness of Tanzanian long fat-tailed sheep (TLS) of Tanzania. Seventy castrated TLS (12 months old and mean live weight of 21.1 ±0.6 kg) were randomly assigned to seven treatment periods of DF in a completely random design experiment. The periods were 0, 14, 28, 42, 56, 70 and 84 days, designated as DF0, DF14, DF28, DF42, DF56, DF70 and DF84, respectively. Each treatment period had 10 experimental animals. Immediately after purchase, DF0 animals were slaughtered and their meat quality characteristics were determined. DF14, DF28, DF42, DF56, DF70 and DF84 groups were fed *Cenchrus ciliaris* hay as basal diet and molasses-based concentrate diet (160 g CP and 10.9 MJ ME/kgDM) and water on *ad-libitum* basis. At each period of stay, 10 experimental animals were randomly selected and slaughtered until the end of the feedlot period of 84-d was reached when the last group was slaughtered. Carcass pH and temperature were measured at 45 min, 6 h, 24 h and 48 h post mortem at the m. *longissimus thoracis et lumborum* (LL) muscle. The *m. longissimus thoracis et lumborum* (LL), *semimembranosu*s (SM) and *supraspinosus* (SP*)* muscles were then dissected from the carcass and evaluated for drip loss (%), cooking loss (%) and Warner-Bratzler shear force (WBSF) values, after zero and nine days of aging. The results from this study revealed that there was a significant ($P<0.001$) decrease of pH values at 6 h post mortem (pH6) as the DF increased. The pH at 24 h post mortem (pH24) ranged from 5.72 to 5.79 and was not significantly ($P>0.05$) affected by period of stay. Cooking losses decreased ($P<0.05$) with increasing DF and aging duration from 0 to 9 days. The WBSF values of cooked muscles were highest ($P<0.05$) in SP followed by SM and lastly LL and their overall tenderness increased with increasing DF. There was an interaction effects between DF and post mortem aging time on tenderness such that castrates under DF56, DF70 and DF84 showed the lowest shear force values in LL and SM

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muscles after nine days of aging. The results indicated that 42 days was optimal DF for production of high quality meat in Tanzanian long fat-tailed sheep.

Key words: Cooking loss, feedlot, meat quality, molasses, Tanzanian long fat-tailed sheep.

Introduction

The most important quality attributes of meat to the modern consumer are tenderness and nutritional value and these attributes are mainly influenced by amount and type of fat in the meat (van der Westhuizen, 2010). Determinant factors for meat quality attributes include post mortem pH and temperatures, color of meat and fat, fat distribution, flavor, water holding capacity and tenderness (Nishimura, 2010). Meat quality characteristics, however, depend on age of an animal, time spent in feedlot and slaughter weight and the type and amount of feed (Hopkins *et al,* 2006). In order to improve meat quality, feeding strategies are needed particularly for indigenous breeds of sheep raised under extensive system which are often characterized by low growth rate and production of low quality meat (Safari *et al*, *2011)*. Feedlot is one of the feeding strategies which maximizes growth rate, feed cost reduction and minimizes the number of days on feed. Many studies (Jacob *et al*, 2005; Toohey and Hopkins, 2006) show that there is a relationship between animal feedlotting period, nutritional status and meat eating quality attributes which can be explained by several biochemical and biophysical mechanisms. For instance, high plane of nutrition in sheep during feedlot has been reported to result in production of heavier carcasses and higher levels of subcutaneous and intra muscular fats (Hopkins *et al,* 2006) and these are associated with low pH, slow cooling rate and meat tenderness (Perrez *et al,* 2002). On the other hand, slow cooling rate leads to a more rapid rate of post mortem glycolysis which leads to rapid pH decline (Priolo *et al*, 2002). Previous studies have shown that manipulations of days in feedlot, the use of higher concentrate energy-based diets and proper selection of age to enter the feedlot improves meat quality in sheep breeds (Suliman and Babiker, 2007). An increase of period of stay in feedlot produces fatter carcasses, increases water holding capacity, enhances rapid rate of post mortem glycolysis, decrease cooking loss, lower pH and increases tenderness in sheep (Priolo *et al,* 2002; van der Westhuizen, 2010).

Although it is well documented in developed countries that duration of animal stay in feedlot can influence meat quality of sheep, there is however dearth of such information in indigenous sheep breeds in Africa. The present study therefore was aimed to evaluate the effects of period of stay in a feedlot on meat quality characteristics for indigenous Tanzanian long fat-tailed sheep.

Materials and Methods

Location of the study

The feedlot study was conducted at Kongwa Pasture Research Centre and animals were slaughtered at Dodoma Modern Abattoir, both located in Dodoma region in central Tanzania (35°44′31″E, 6°10′23″S), and 1120 m above sea level. The region is a semi-arid climate area with average annual rainfall of 550mm and minimum and maximum temperatures of 14^oC and 32^oC, respectively. The soil is low in nitrogen and phosphorous but adequate in potassium. The pH of the top soil is 5.6 to 7.7, while that of subsoil range between 5.6 to 8.6. The vegetation of the area is mainly dominated by *Commiphora*, *Acacia and Adansonia* trees, associated with *Aristida*, *Pennisetum*, *Cynodon* and *Themeda* grass species.

Experimental design and treatments

Seventy castrated indigenous Tanzanian long fat-tailed sheep (21.1 ± 0.6 kg initial body weight, aged 12 months) were randomly assigned to seven treatments of days of stay in feedlot (DF) in a completely randomized design experiment. The treatments were 0, 14, 28, 42, 56, 70 and 84 days designated as DF0 (control), DF14, DF28, DF42, DF56, DF70 and DF84 groups, respectively. Each treatment DF had 10 experimental animals allotted into five pens. Animals in the control group (DF0) were not subjected to feedlot; instead they were transported to the abattoir for slaughter. The animals were identified by ear tagging, weighed for initial body weight (IBW) and injected with ivermectin (Kelamectin® 1%) for control of endo- and ecto-parasites. The animals were then randomly allocated to the different DF treatments. An adaptation period of 14-d was allowed to enable experimental animals (60) to be acclimatized with experimental diet prior data collection.

Source of experimental feeds and feeding

Cenchrus ciliaris (Buffel grass, African foxtail grass) hay was harvested at Kongwa Pasture Research Centre in June 2010 towards the end of the rain seasons. Ingredients for concentrate were liquid molasses purchased from Mtibwa Sugar Industry Company while the other ingredients were purchased from local Agricultural input suppliers in Dodoma region. The grass hay was used as roughage while concentrate diet was formulated from 66.3% molasses, 15.5% maize bran, 11.5% cotton seed cake, 4.6% rice polishing, 1.6% urea, 0.4% mineral and 0.1% lime to contain 10.9 MJ ME/kgDM and 160g CP kg/DM. Fresh hay and concentrate were weighed and provided daily in the morning in separate containers. The hay and concentrate were offered *ad libitum* then adjusted until when the refusals reached about 10 % of the amount offered. The amount of feed offered was adjusted after every seven days as the animals changed their intake.

Body condition score, slaughter procedures and carcass scores

Prior slaughter, at each DF feed and water were withheld overnight and animals were weighed to record the shrunk body weight (SBW). Thereafter, subjective body condition scores (BCS) criteria as developed by Steele (1999) (Scale 1-5, where 1 is very thin and 5 is very fat) was done. Each animal was assessed by a team of three persons to obtain the average score for that particular animal.

After 14 days interval, a group of 10 experimental animals were randomly selected for slaughter. The animals were slaughtered by severing the carotid arteries and jugular vein in a single cut, as recommended slaughtering procedures in Tanzania. The dressed carcasses were obtained after removing the skin, head, fore feet, hind feet and viscera as described by (Garcia-Valverde *et al*, 2008). Carcass conformation (1 very poor and 5 very good), meat colour (1 red and 5 light red), fatness score (1 no fat cover and 5 very thick fat cover) and fat colour (1 yellow and 4 light yellow) were done as described by Russel (1991).

Measure of muscle pH and temperature

Muscles pH and temperatures were measured by using an electrode (Mettler Toledo) of a portable digital pH-meter (Knick Portamess ® 910, Germany) and digital meat thermometer (FUNKUTION® Digital stegetermometer), respectively. The electrode and thermometer were probed into *m. longissimus thoracis et lumborum* (LL) muscle between the 1st and 6th lumbar vertebra of the left side carcasses. The pH meter was calibrated at room temperature of 28^{o}C in standard buffer solution for pH 4.0 and pH 7.0 prior to measurement. The pH and temperature readings at 45 minutes PM were denoted as pH45 and Temp45 and those at 6 h PM were denoted as pH6 and Temp6 in the results. After 6 h post mortem, the carcasses were kept at chill room (4^{o}C) for subsequent measurements. The pH meter was again calibrated at 4^{o}C of buffer solution for measuring pH of cold carcasses at 24 h (pH24) and 48 h (pH48) post mortem. The temperatures were calibrated as internal temperature of the LL as described by Rosenvold *et al.* (2002). The temperature readings taken at 24 post mortem were designated as Temp24 and finally those at 48 h post mortem as Temp48.

Determination of drip and cooking losses and Warner-Bratzler shear force (WBSF)

Evaluation of drip and cooking losses (%) and WBSF was done for *m. longissimus thoracis et lumborum* (LL), *semimembranosu*s (SM) and *supraspinosus* (SP*)* muscles dissected from the right side of the carcasses as described by Schönfeldt *et al*. (1993). Further, two blocks of each muscle measuring approx. 6 cm long were prepared from each animal for 6 h (0 d) and 9 d aging. The first anterior ends of the muscle blocks were immediately frozen at -25^{o}C and these were considered as zero day aged meat (0 d). The rest of the muscle samples were conditioned in a fridge set at 4°C until the 9th day before being frozen at -25°C, and were considered as 9 d aging. Drip loss (%) was determined in frozen samples of muscles measuring 1.0-1.5 cm thick. The frozen muscles were weighed (W1), packed in vacuum bags and then kept at 4°C overnight. The bags were opened and meat was dried and re-weighed (W2). Drip loss (%) was then expressed as:= $\frac{W1-W2}{W1}x100$. Cooking loss (%) was determined by weighing the meat samples in the plastic bags (W3) and then cooked in a thermostatically controlled water bath (Fisher Scientific, Pittsburgh, PA) set at 75°C for a total of 60-min as described by Hoffman et al. (2003). The bags including cooked muscle samples were cooled under running tap water for 2 h, thereafter stored in refrigerator at 4°C overnight. The muscle samples were then removed from the plastic bags, dried and re-weighed (W4) for estimation of cooking loss (%) as:= $\frac{W3-W4}{W3}x100$. Cooked meat samples used for measurements of cooking loss were then used to determine WBSF value. The WBSF values from the aged muscles were determined following procedure as described by Honikel (1998). Shear force measurement was done by shearing the cubes with Warner Bratzler Shear Force (WBSF) blade attached to Zwick/Roell (Z2.5, German) instrument set at a cross head speed of 100 mm/min and fitted with a 1 kN load cell (both sites) and inverted V-blade positioned perpendicular to muscle fibre orientation. Averages of four sub-samples were considered to be WBSF value in Newton (Ncm^{-2}) of that sample.

Statistical Analysis

Differences in physical meat quality characteristics between slaughter groups and the effects of this variable were established by subjecting the data to Proc GLM (SAS, 2001). The full model i.e. the effect of DF was the main effect used for the preliminary analysis. Least square means were reported with pooled standard error. The difference between treatment means was compared using probability of difference (PDIFF) of the GLM procedure of SAS (2001).

Results

Subjective body and carcass evaluation score

Subjective carcass evaluation scores (carcass conformation, meat color, fatness) increased (*p<0.001*) and fat color (*p<0.01*) as the DF increased (Table 1). The carcass conformation increased by 2.8 units and fatness score by 3.2 units between 0 to 84 days in feedlot. Meat color also decreased from light red to red (3.5) to reddish colour (1.0) as the DF increased.

Table 1: Least-squares means ±SE for body condition and carcass evaluation scores for indigenous castrate sheep fed molasses based diet as affected by days in feedlot.

Variable	Days in feedlot							SE	Significance
	DF0	DF14	DF28	DF42	DF56	DF70	DF84		
Number of observations	10	10	10	10	10	10	10		
BCS (1-5)	2.06^{e}	2.80^{cd}	2.77^{d}	3.12^{c}	4.59^{b}	4.31^{b}	5.00^{a}	0.12	***
Carcass evaluation (1-5)									
Carcass conformation	1.89^{e}	2.99^{cd}	2.87^{d}	3.23^{c}	4.17^{b}	4.77^{a}	4.70^{a}	0.11	***
Meat color	3.13^{c}	3.54^{b}	3.20^{c}	3.19^{c}	3.87^{a}	1.03^{d}	1.00^{d}	0.07	***
Fat score	1.83^{d}	2.71^{c}	2.14^{d}	2.89^{c}	4.18^{b}	4.68^{ab}	5.00^{a}	0.20	***
Fat color	3.51^{bc}	3.43^{bc}	3.83^{ab}	3.30^{c}	3.64^{abc}	4.00^{a}	3.84^{ab}	0.16	*

[abcd]Least- squares means with a common letter superscript in the same row are not significantly different (P>0.05). Significance: *, P<0.05; ***, P<0.001; SE, standard error of mean and BCS, body condition score.

Carcass pH and temperature

There was no significant difference (*p>0.05*) found for pH45, pH24 and pH48 under feedlot conditions (Table 2). Carcass pH pH6 was significantly (*p<0.05*) higher in DF0, DF14 and DF28 groups than other treatment groups, and the pH decreased (p<0.001) with increasing days to stay in feedlot (DF). The carcass pH at pH24 were not affected (*p>0.05*) by DF ranging from 5.69 to 5.79. Generally, all the measured carcass pH levels were moderately decreasing with increasing time post mortem across DF treatment groups. The lowest (5.64-5.71) carcass pH levels were recorded at pH48 post mortem across DF groups.

The temperature readings taken 45 min, 6 h, 24 h and 48 h postmortem showed a gradual increase (*p<0.001*) with an increase DF (Table 2). The temperatures at Temp45 min were significantly (*p<0.001*) higher from DF42, DF56, DF70 and DF84 ranging from 36.45 to 36.70°C compared to those recorded between DF0, DF14 and DF28 that ranged from 34.20 to 34.25 °C.

Drip, cooking losses and Warner Bratzler shear force values

Drip loss of *m. longissimus thoracic et lumborum* (LL), *semimembranosus* (SM) and *supraspinosus* (SP) muscles decreased (*p<0.05*) with increasing days in feedlot (DF) and highest losses were recorded in DF0 groups (Table 3). The drip losses of all the three tested muscles decreased (*p<0.05*) with increased aging duration from 0 to 9 days.

Cooking losses of LL, SM and SP muscles was highest in DF0 and DF14 group of animals and decreased (p<0.001) with increasing DF (Table 3). The SP muscles had the highest losses, followed by SM and LL muscles. The overall cooking losses of the tested muscles decreased from 34.1 to 25.0% from DF0 to DF84 while with aging to 9 days, the losses reduced by 51.7%.

Table 2: Least-squares means ±SE for carcass pH and temperatures from castrate sheep under different periods of stay in feedlot (n=70).

Variable	Days in feedlot							SE	Significance
	DF0	DF14	DF28	DF42	DF56	DF70	DF84		
pH									
pH45	6.68	6.59	6.71	6.50	6.57	6.33	6.45	0.09	NS
pH6	6.03^{b}	5.91^{ab}	6.29^{a}	5.66^{d}	5.76^{cd}	5.76^{cd}	5.71^{d}	0.07	***
pH24	5.74	5.69	5.75	5.73	5.72	5.79	5.72	0.05	NS
pH48	5.68	5.64	5.68	5.65	5.71	5.67	5.68	0.05	NS
Temperature (°C)									
Temp45	34.20^{b}	32.60^{c}	34.25^{b}	36.45^{a}	36.20^{a}	37.55^{a}	36.70^{a}	0.51	***
Temp6	20.60^{e}	21.50^{d}	23.30^{c}	23.90^{c}	22.05^{d}	24.75^{b}	25.50^{a}	0.21	***
Temp24	1.25^{c}	1.70^{ab}	1.50b^{c}	1.50^{bc}	1.10^{c}	1.90^{ab}	2.10^{a}	0.15	***
Temp48	1.10^{c}	1.40^{b}	1.00^{c}	1.50^{b}	2.06^{a}	2.05^{a}	2.05^{a}	0.09	***

[abcd]Least- squares means with a common letter superscript in the same row are not significantly different (P>0.05). Significance: NS, not significant; ***, P<0.001; SE, standard error of mean and Temp, Temperature (°C).

Table 3: LSM ±SE for drip and cooking losses of muscles from castrated Tanzanian long fat-tailed sheep (n=70)

Variables	Days in feedlot [A]							SE	Aging days [B]		SEM	Significance		
	DF0	DF14	DF28	DF42	DF56	DF70	DF84		0	9d		A	B	AxB
Drip loss (%)														
LL	6.09^{a}	4.39^{b}	4.64^{b}	3.27^{c}	3.54^{c}	2.22^{c}	2.00^{c}	0.71	6.2^{a}	1.66^{b}	0.90	***	***	NS
SM	5.22^{a}	4.20^{b}	4.47^{b}	4.13^{b}	3.45^{c}	3.64^{c}	2.77^{c}	1.64	5.08^{a}	1.17^{b}	0.90	**	***	***
SP	8.56^{a}	6.21^{b}	5.6^{b}	4.73^{bc}	3.67^{c}	3.30^{c}	3.53^{c}	1.64	8.50^{a}	3.26^{b}	0.90	***	***	NS
Overall drip loss (%)	6.62^{a}	4.90^{b}	4.91^{b}	4.41^{b}	3.55^{c}	3.02^{c}	2.77^{c}	0.95	6.69^{a}	2.03^{b}	0.51	**	***	NS
Cooking loss (%)														
LL	29.1^{a}	26.7^{b}	24.3^{b}	23.5^{bc}	24.7^{b}	20.5^{c}	20.2^{c}	1.12	29.7^{a}	11.1^{b}	0.60	***	***	NS
SM	35.3^{a}	36.0^{a}	34.4^{b}	30.0^{c}	27.1^{c}	25.0^{c}	25.4^{c}	1.12	36.3^{a}	17.3^{b}	0.55	***	***	NS
SP	38.0^{a}	38.2^{b}	36.0^{b}	32.7^{c}	31.4^{c}	29.5^{c}	29.3^{c}	1.12	37.1^{a}	21.4^{b}	0.69	**	**	NS
Overall cooking loss (%)	34.1^{a}	33.6^{a}	31.6^{a}	28.7^{b}	27.7^{b}	25.0^{c}	25.0^{c}	0.66	34.4^{a}	16.6^{b}	0.35	***	**	NS

[abc]Least- squares means with a common letter superscript in the same row are not significantly different (P>0.05); Significance: NS, not significant; **,P<0.01; ***,P<0.001; SE, standard error of mean; LL, *m. longissimus thoracis et lumborum;* SM, *semimembranosus* and SP, *supraspinosus*.

The overall Warner Bratzler shear force (WBSF) values for all LL, SM and SP muscles were highest at DF0, DF14 and DF28 periods and decreased (*p<0.001*) with increasing DF (Table 4). The shear force value for all the tested muscles showed that the meat was significantly (*p<0.05*) tender after DF42 periods. Also, the overall muscles showed a significant (P<0.05) decrease in shear force values when aging was performed from day one to nine days ageing period.

Table 4: Least-squares means ±SE for Warner-Bratzler shear force (Ncm^{-2}) of muscles from castrated Tanzanian long fat-tailed sheep (n=70)

	Days in feedlot (A)							SE	Aging (B)		SE	Significance		
Muscle	**DF0**	**DF14**	**DF28**	**DF42**	**DF56**	**DF70**	**DF84**		**A**	**B**		**A**	**B**	**AxB**
LL	33.9^{a}	32.8^{a}	33.0^{a}	32.2^{a}	26.3^{b}	19.7^{c}	20.0^{c}	1.05	30.5^{a}	24.1^{b}	0.56	***	***	***
SM	34.9^{a}	34.3^{a}	31.9^{ab}	29.6^{b}	28.6^{c}	24.3^{c}	24.0^{c}	0.70	31.5^{a}	19.7^{b}	0.5	***	***	***
SP	35.3^{a}	33.9^{a}	32.0^{a}	31.9^{a}	29.6^{b}	28.3^{b}	26.6^{c}	1.40	29.4^{a}	22.4^{b}	0.80	***	***	NS
Overall	34.7^{a}	33.7^{a}	32.3^{a}	31.3^{b}	28.2^{c}	24.1^{c}	23.5^{c}	0.70	30.4^{a}	22.1^{b}	0.36	***	***	***

[abc]Least-squares means with a common letter superscript in the same row are not significantly different (P>0.05); Significance: NS, not significant; [***],P<0.001; SE, standard error of mean; LL, *m. longissimus thoracis et lumborum;* SM, *semimembranosus* and SP, supraspinosus.

Discussion

Body condition and carcass evaluation scores

Improvement of body condition, carcass conformation and fatness scores as well as meat colour were associated with increasing number of days that the sheep stayed in the feedlot. The increase of meat color from light red to reddish colour with increasing number of days in feedlot may be associated with the increase of myoglobin content available in the muscles (Teixera *et al*, 2005). Myoglobin content is said to be responsible for meat color, and is affected by age, diet, muscle type and physical activity (Priolo, 2002). In the present study, the animals between 0 to 42 days in the feedlot were considered to be younger, hence had lower concentration of myoglobin pigments, which were responsible for the observed lighter red color compared to those in 56 days and above which had more reddish meat. According to Sales (1999), the color of meat is also affected by the rate and extent of muscle pH decline. In the present study, there was also a fast decline in muscle pH with increase in number of days in the feedlot which could explain the observed increase in intensity of red colour in muscles. Martínez-Cerezo *et al.* (2005) concluded that color in meat is to a greater extent brought about by a change in diet, than either carcass weight or age.

Muscle physio-chemical properties

Higher pH levels in DF0, DF14 and DF28 groups was presumably caused by lower glycogen reserve in their carcasses leading to low lactic acid production. The DF0 animals were not subjected to feedlot and slaughtered directly from extensive system which implies that there was no enough glycogen supply from this system. Also, the days spent in feedlot for DF14 and DF28 groups seems not to be enough to allow glycogen accumulation and possibly the animals were still under compensatory growth. However, with increasing number of days in feedlot, there was a decline of pH postmortem in all the DF treatment periods indicating high level of glycogen accumulation. The decreasing trend of pH in sheep muscles with increasing DF has been reported by various authors (Priolo *et al*, 2002; van der Westhuizen, 2010). According to Hopkins *et al.* (2006), there is a close association between age of an animal during feedlot period and the muscle pH. Similarly, the decrease of pH with increasing DF at pH6 in this study indicate that the carcasses had already undergone rigor mortis at high temperatures with pH of 5.66-6.29 at 20.6 – 25.5^{o}C, which allowed glycolysis to take place. Similar results were reported by Toohey and Hopkins (2006) in meat from different breeds of sheep in Australia. Abdullah and Qudsieh (2008) reported that the rate of pH fall and the ultimate pH to be an important determinant of meat quality and are related to the rate of glycogen breakdown. The change in pH values also affects meat characteristics including modification of membranes and extracellular fluids which affects the meat electrical properties (Hopkins *et al*, 2006). The effects of days in feedlot and dietary offered on pH changes agreed with the observations made on Merino lambs fed high energy diets (van der Westhuizen, 2010) but contrast those reported by Safari *et al*. (2011) where there was no significant difference in pH changes in Red Maasai sheep offered concentrate diets. The pH24 values in this study ranged from 5.69-5.79 and are slightly below 6.0 reported in sheep under similar conditions (Miranda-de la Lama *et al*, 2009). The results of this study were comparable to those observed by Jacob *et al.* (2005) who reported that the level of muscle glycogen concentration was a major determinant of pH24 in red meat in which a low pH24 was achieved in animals with a high concentration of muscle glycogen at time of slaughter and vice versa.

The observed higher temperatures with an increase in the days spent under feedlot conditions could be associated with the increase in carcass fatness that act as an insulator. Similar observations were reported by van der Westihuizen (2010) in Merino sheep. The results are further supported by findings by Lawrie *et al.* (1998) and French *et al.* (2001) that reported a tendency of fatter carcasses to cool down at a slower rate than lean carcasses, with fatter carcasses attained their lower pH24 earlier and at a higher temperature.

Decreased cooking loss for LL, SM and SP muscles in later days under feedlot in DF42, DF56, DF70 and DF84 groups suggests higher water holding capacity (WHC) within the muscles. The higher WHC might be caused by the lower pH of meat observed from 42 days period and above due to higher net charges and bigger space between myofilaments (Huff-Lonergan and Lonergan, 2005). The lower cooking loss of LL and SM muscles at 9 d aging could also be linked with the increased volume of myofibrils in aged meat, which leads to higher WHC (Kolezak *et al*, 2007).

The high WBSF values of LL, SM and SP muscles in DF0, DF14 and DF28 groups in the present study is biologically consistent with lower collagen solubility and low level of intramuscular fats in carcasses (Devine *et al*, 1993). Meat tenderness is also dependent on the rate of pH decrease as well as ultimate pH which occurred at 24 h post mortem and can be influenced by an animal's growth pattern and level of fatness (Kristensen *et al,* 2006; Ekiz *et al*, 2012), explaining the reason for high shear force values observed in DF0, DF14 and DF28 groups. The decrease of WBSF of the muscles with increasing DF may be associated with increase in fatness level and increase in collagen solubility in muscles. The differences in shear force values among the LL, SM and SP muscle tested is caused by variations of myofibre percentage that exist between these muscles (Greenwood *et al*, 2007). The WBSF values at 9 d aging (30.5 Ncm^{-2}) in LL muscle are higher than that of 9 d aging reported by Safari et al. (2011) in Red Maasai sheep and that of 7 d aging reported by Abdullah and Qudsieh (2008) in Awasi ram lambs. Further, Devine *et al.* (2002) reported a decline of shear force value from 41.7 N to 8.6 N at 65 h (2.7 d) aging in Romney cross castrates of similar age to castrates reported in the current study. The observed differences in WBSF values from muscle aging could be associated with the type of diet, breed and age of the animals used.

There was a significant interaction between days in feedlot and post mortem aging time such that castrates under DF56, DF70 and DF84 groups produced LL and SM with lowest shear force after 9 days aging and exhibited the greatest decline in shear force with aging. This suggests possible weakening of structural integrity of the myofibrillar proteins and possibly the presence of adequate glycogen reserve in their muscles during aging (Toohey and Hopkins, 2006). The three muscles studied however, are considered extremely tender, even before aging as their values obtained were below the threshold of value of 49 N, above which meat is considered tough in sheep (Hopkins *et al*, 2006).

Conclusion

Our study concludes that meat quality attributes of one year old indigenous Tanzanian long fat-tailed sheep increases with increase in number of days in feedlot and the wisdom of aging such meat is in doubt in view of low shear force in muscles in these animals. There is however a need to study the economics of length of stay in feedlots in producing meat from indigenous sheep and the perception and willingness of the consumers in purchasing such meat.

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References

Abdullah AY, Qudsieh RI (2008). Carcass characteristics of Awassi ram lambs slaughtered at different weights. *Liv. Sci.* 117(2-3):165-175.

Devine CE, Graafhuis AE, Muir PD, Chrystall BB (1993). The effect of growth rate on ultimate pH on meat quality of lambs. *Meat Sci.* 35(1):63-77.

Devine CE, Payne SR, Wells RW (2002). Effect of muscle restraint on sheep meat tenderness with *rigor mortis* at 18°C. *Meat Sci.* 60:155-159.

Ekiz B, Ekiz EE, Kocak O, Yalcintan H, Yilmaz A (2012) . Effect of pre-slaughter Manag ement regarding transportation and time in lairage on certain stress parameters, carcass and meat quality characteristics in Kivircik lambs. *Meat Sci.* 90:967-976.

French P, O'riordan EG, Monahan FJ, Caffrey PJ, Mooney MT, Troy DJ, Moloney AP (2001). The eating quality of meat of steers fed grass and/or concentrates. *Meat Sci.* 57 (4):379-386.

Garcia-Valverde R, Barea R, Lara L, Nieto R, Aguilera JF (2008). The effect of feeding level upon protein and fat deposition in Iberian heavy pigs. *Liv. Sci.* 114 (2-3):263-273.

Greenwood PL, Harden S, Hopkins DL (2007). Myofibre characteristics of ovine *longissimu*s and *semitendinosus* muscles are influenced by sire. Breed, gender, rearing type, age and carcass weight. *Austr. J. Exp. Agric*. 47(10): 1137-1146.

Hoffman LC, Muller M, Cloete SWP, Schmidt D (2003). Comparison of six crossbred lamb types: sensory, physical and nutritional meat quality characteristics. *Meat Sci.* 65 (4):1265-1274.

Honikel KO (1998). Reference methods for the assessment of physical characteristics of meat. *Meat Sci.* 49 (4):447-457.

Hopkins DL, Hegarty RS, Walker PJ, Pethick DW (2006). Relationship between animal age, intramuscular fat, cooking loss, pH, shear force and eating quality of aged meat from sheep. *Aust. J. Exp. Agric*. 46:879-884.

Huff-Lonergan E, Lonergan SM (2005). Mechanisms of water-holding capacity of meat: The role of postmortem biochemical and structural changes. *Meat Sci.* 71 (1):194-204.

Jacob RH, Pethick DW, Chapman HM (2005). Muscle glycogen concentrations in commercial consignments of Australian lamb measured on farm and post slaughter after three different lairage periods. *Australian J. Exp. Agric*. 45(5):543-552.

Kolezak T, Kryysztoforski K, Pallka K (2007). The effect of post-mortem aging and eating on water retention in bovine muscles. *Meat Sci.* 75:655-660.

Kristensen L, Christensen M, Ertbjerg P (2006). Activities of calpastatin, *µ-calpain* and *m-calpain* are stable during frozen storage of meat. *Meat Sci.* 72 (1):116-120.

Lawrie, RA (1998). Lawrie's Meat Science. 6th edition, Woodhead Publishing. Martínez-Cerezo S, Sañudo C, Panea B, Medel I, Delfa R, Sierra I, Beltrán JA, Cepero R, Olleta JL (2005). Breed, slaughter weight and aging time effects on physico-chemical characteristics of lamb meat. *Meat Sci.* 69 (2):325-333.

Miranda-de la Lama GC, Villarroel M, Olleta JL, Alierta S, Sanudo C, Maria GA (2009). Effect of the pre-slaughter logistic chain on meat quality of lambs. *Meat Sci.* 83:604-609.

Nishimura T (2010). The role of intramuscular connective tissue in meat texture: a review. *J. Anim. Sci.* 81:21-27.

Perrez P, Maino B, Tomic G, Mardones E, Pokniack J (2002). Carcass characteristics and meat quality of Suffolk Down suckling lambs. *Small Rum. Res*. 44:233-240.

Priolo A, Micol D, Agabriel J, Prache S, Dransfield E (2002). Effect of grass or concentrate feeding systems on lamb carcass and meat quality. *Meat Sci.* 62 (2):179-185.

Rosenvold K, Petersen JS, Laerke HN, Jensen SK, Therkildsen M, Karlsson AH, Moller HS, Andersen HJ (2002). Muscle glycogen stores and meat quality as affected by strategic finishing feeding of slaughter pigs. *J. Anim. Sci.* 79:912 – 918.

Russel A (1991). Body scoring of sheep. In: Boben, E. (Ed.). Sheep and goat practices. Bailliere Tindall, London. Pp. 3-11.

Safari JG, Mushi DE, Mtenga LA, Kifaro GC, Eik LO (2011). Growth, carcass yield and meat quality attributes of Red Maasai sheep fed wheat straw-based diets. *Trop. Anim. Health Prod.* 43(1):89-97.

Sales J (1999). Slaughter and products, in The Ostrich, biology, production and health, (Ed.) D.C. Deeming, CABl Publishing, Wallinford, Oxon, 231-274pp.

SAS (2001). User's guide. Version 8.2.SAS Institute, INC., Carry NC. USA. Schönfeldt HC, Naude RT, Bok W, Van Heerden SM, Sowden L, Boshoff E (1993). Cooking and juiciness related quality characteristics of goat and sheep meat. *Meat Sci.* 34 (3):381-394.

Steele M (1999). Goats. (Ed. Rene Coste and J.M. Antony). The Tropical Agriculturalist. CTA MacMillan Publishers. Ltd. The Netherlands pp. 81-83.

Suliman GM, Babiker SA (2007). Effect of diet-protein sources for lamb fattening, *Res. J. Agric. Biol. Sci*. 3(5): 403-408.

Teixeira A, Batista S, Delfa R, Cadavez V (2005). Lamb meat quality of two breeds with protected origin designation.

Influence of breed, sex and live weight. *Meat Sci.* 71 (3): 530-536.
Toohey ES, Hopkins DL (2006). Eating quality of commercially processed hot boned sheep meat. *Meat Sci.* 72:660-665.
van der Westhuizen EJ (2010). The effect of slaughter age on the lamb characteristics of Merino, South African Mutton Merino and Dorper lambs. MSc Thesis, Stellenbosch University, US.
Warren HE, Scollan ND, Enser M, Hughes SI, Richardson RI, Wood JD (2008a). Effect of breed and concentrate or grass silage diet on beef quality in cattle of 3 ages. I: Animal performance, carcass quality and muscle fatty acid composition. *Meat Sci*. 78:256-269.

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