Comparative analysis of retail cuts, muscle physico-chemical properties and meat
tenderness of indigenous castrate sheep finished off under feedlot conditions

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ABSTRACT

A 4x3 factorial design experiment involving 120 indigenous castrate sheep fed for a total of 84 days in
feedlot conditions was carried out to evaluate age at entry to feedlot (AEF) and level of concentrate
feeding (LCF) on retail cuts yields, muscle physico-chemical properties and meat tenderness. The AEF
were 9, 12, 15 and 18 months designated as AEF9, AEF12 AEF15 and AEF18 treatments while LCF
were 50%, 75% and 100% designated as LCF50, LCF575 and LCF100, respectively. The proportion of
neck, breast, chump and shoulder cuts to cold carcass weight (CCW) were not affected (p>0.05) with
AEF while that of hind leg decreased by 11% when LCF increased from LCF50 to LCF100. The fat
tissue increased (p<0.01) while muscle and bone tissues decreased (p<0.05) with increasing LCF50 and
LCF100. The pH decline at pH6 was 2.6% higher than pH24 which was 1.7% with increasing LCF.
Overall cooking losses of m. longissimus thoracic et lumborum, semimembranosus and supraspinosus
muscles decreased (p<0.001) while tenderness increased (p<0.001) from 26.8 to 21.2Ncm\textsuperscript{2} (21%)
with ageing duration from 0-d to 9-d. There was a significant (p<0.05) interaction between AEF and dietary
levels on the WBSF of the SM muscles such that the decrease of shear force was attained at AEF15.
Encouraging results have been obtained to suggest that feedlotting of AEF12 and AEF15 under LCF100
for 84 days gives maximum weights of retail cuts and tenderness.

Key words: Cooking loss; Feedlot; Indigenous sheep; Retail cuts; Tenderness

INTRODUCTION

There is a great variation in yield of retail cuts, distribution of tissues and physico-chemical properties
of tissues in sheep under feedlot conditions (van der Westhuizen, 2010). The yield and quality of retail
cuts have been evaluated in several studies among the ruminant animals (Santos et al., 2008; van der
Westhuizen, 2010). The size and quality of retail cuts are among the most important quality attributes of
sheep carcass and depends on many physical, chemical and biochemical factors. It is evident that,
inconsistency in size of cuts and tenderness are some of the major factors affecting consumers
satisfaction and has been identified as one of the major problems facing the sheep meat industry (van
der Westhuizen, 2010). Age of an animal and type and amount of diet during feedlot are some of the
components contributing to small size of retail cuts and meat toughness. On the other hand, two of the
main components contributing to meat toughness are the myofibrils and connective tissue (Christensen
et al., 2011). Purslow (2005) reported the amount and chemical composition of collagen to be the
primary source of toughness in meat even after optimal ageing time. The toughness of meat is therefore
cased by a variety of factors such as differences in pH and marbling (Barker et al., 1995), type of
connective tissue and ageing durations (Campo et al., 1999; Christensen et al. 2011)

Despite the importance of retail cuts and meat quality attributes in the carcass characteristics, variation
in yield and quality of retail cuts in indigenous sheep of Tanzania under feedlot conditions has not been
studied. Thus, the present study was designed to determine the effect of different AEF and LCF on
yields and quality of retail cuts, tissue distribution and physico-chemical properties in indigenous sheep of Tanzania.

**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 (36°30’E, 6°20’S). The climate of the two areas is semi-arid with mean annual rainfall of 550 mm with minimum and maximum temperatures range between 14°C and 32°C, respectively.

**Experimental design and treatments**
One hundred and twenty castrated Tanzanian long fat-tailed sheep aged 9, 12, 15 and 18 months with initial weight of 14.2±1.23, 17.9±2.01, 20.4±2.15 and 25.1±3.22 kg, respectively were subjected to a 4x3 factorial design experiment. The age at entry to feedlot were 9, 12, 15 and 18 months, designated as AEF9, AEF12, AEF15 and AEF18 and three levels of concentrate feeding (LCF) as 50, 75 and 100 percent of ad libitum concentrate intake, designated as LCF50, LCF75 and LCF100. Each AEF group comprised of 30 animals, which were randomly assigned into the LCF treatments, each 10 animals.

**Experimental animals and their management**
Experimental animals 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 housed and fed in a group of two per pen during adaptation period of 14-d and experimental period of 84-d. The feed and animals were weighed and recorded to determine feed intake and growth performance, respectively.

**Experimental diets**
Cenchrus ciliaris grass hay was used as roughage and concentrate diet composed of 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. Both roughage and concentrate diets were formulated to contain 10.9 MJ ME/kgDM and 160 g DCP kg/DM. Animals were fed once daily at 0.800 h and water was provided ad libitum. The diet offered to the ad libitum group was adjusted until when the refusals for each reached about 10 % of the amount offered and maintained for 3 days, then adjusted to LCF50, LCF75 and LCF100 for respective treatment groups. The amount of feed was adjusted weekly as the LCF100 group changed its intake.

**Slaughter procedures and measurements**
At slaughter, the head was removed at the atlanto-occipital joint and fore, hind feet removed at the carpal-metacarpal and tarsal-metatarsal joints, respectively (Garcia-Valverde et al. 2008). The left and right side half carcasses were separately weighed then stored in room temperature for 6 hours before they were chilled at 0°C overnight for subsequent measurements. After overnight storage, the half carcasses were re-weighed to determine cold carcass weight (CCW).

**Measurement of retail cuts and carcass tissue composition**
The half carcasses from the left side were jointed into seven retail cuts (wholesale primal cuts) according to AUS-MEAT (1998) namely neck, ribs, breast, loin, chump, hind leg and shoulder. The joints were weighed and expressed as a percentage of CCW and were further dissected into muscle, fat, bone and dissectible losses (trimmings). The four components were weighed separately to determine their relative proportions (composition) within the cuts and CCW.

**Measure of muscle pH and temperatures**
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 the m. longissimus thoracic et lumborum (LL) muscle between the 1st and 6th lumbar vertebrae of the left side carcasses. The pH meter was calibrated at room temperature of 28°C in standard buffer solution for pH 4.0 and pH 7.0 prior to sampling. The pH and temperature readings at 45 minutes PM were denoted as pH45 and Temp45 and those at 6 h PM as pH6 and Temp6 in the results. The pH meter was again calibrated at 4°C of buffer solution for measuring pH24 (pHu) and pH48. The temperatures were calibrated as internal temperature of the LL and designated as Temp24 and Temp48 in the results.

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

Percentage of cooking losses and WBSF values were determined from m. longissimus thoracic et lumborum (LL), semimembranosus (SM) and supraspinous (SP) muscles from the right side half carcass as described by Schönfeldt et al. (1993). The cooking loss was obtained by weighing muscle samples in the plastic bags (W1) 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). Subsequent to cooking, the bags including cooked muscle samples were cooled under running tape water for 2h, thereafter stored in refrigerator at 4°C overnight. The muscle samples were then blotted dry and re-weighed (W2) for determination of percentage cooking loss as \( W3 = (W1 - W2)/W1 \times 100 \). The cooked muscle samples used for measurements of cooking loss were then used to determine WBSF (tenderness) using the method described by Honikel (1998). Shear force measurement was done by shearing the cubes with 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. An average of four sub-samples was considered to be WBSF value of that sample. Further, two blocks of each muscle measuring approximately 6 cm long were prepared from each animal for 6 h (0 d) and 9 d ageing. The first anterior ends of the muscle blocks were immediately frozen at -25°C and these were considered as 0-d aged meat while the rest were stored in a fridge set at 4°C until the 9th day before being frozen at -25°C, for the 9-d aged meat.

**Statistical analysis**

Statistical analysis was conducted for a 4 x 3 factorial experiment with four AEF and three LCF as the main effects. All data were analyzed as a completely randomized design with PROC MIXED of SAS (2001). Covariance analysis was done to correct for the effect of initial body weight on the different parameters. Least square means were reported with pooled standard error and the difference between treatment means was compared using probability of difference of the GLM procedure of SAS (2001).

**RESULTS**

**Yield of retail cuts and tissue composition**

The proportion of rib and hind leg cuts to cold carcass weight (CCW) decreased (p<0.05) while the breast increased (p<0.05) with increased AEF (Table 1). The proportion of hind leg to CCW had the highest decrease of 11% with increasing LCF while the neck and chump joints were neither affected by AEF nor LCF. The proportion of bone tissue to CCW decreased (p<0.001) by almost 19% when AEF increased from AEF9 to AEF18 (Table 2). The fat tissue increased (p<0.01) while muscle and bone tissues decreased (p<0.05) with increasing LCF50 to LCF100. There was an interaction effect between AEF and LCF such that the proportion of bone decreased significantly after AEF12 and LCF50.

**pH and temperature of muscles**

Muscle pH recorded at pH45, pH6, pH24 and pH48 post-mortem (PM) declined rapidly in the first 6h PM but it was not significantly (p>0.05) affected by AEF (Table 3). There was a significant decline (p<0.05) of pH at pH6 and pH24 with increasing dietary levels. The pH decline at pH6 was 2.6% higher than pH24 and both increased with increasing LCF. Carcass temperatures measured at Temp45, Temp6, Temp24 and Temp24 PM tended to increase although effects of AEF and LCF on carcass temperature were small and insignificant.
Cooking losses and Warner Bratzler shear force values (WBSF)
The m. longissimus thoracis et lumborum (LL) and supraspinatus (SP) showed an increase (p<0.05) of cooking loss as the AEF increased with the lowest loss at AEF9 while the highest loss was observed in AEF18 (Table 4). The LL muscles had the highest loss (56.4%), followed by SP muscles (54.3%) and lastly SM muscle (53.2%). The overall cooking losses of all the three muscles measured decreased (p<0.001) significantly with ageing duration from 0 to 9 days. Also, WBSF values for LL, SM and SP muscles increased (p<0.001) with increasing AEF. The SP muscle was the most affected muscle with an increase of 6.8 units of Ncm$^2$ (from 24.1 to 30.9 Ncm$^2$) with increasing AEF9 to AEF18. The overall WBSF values increased significantly (p<0.001) with increasing AEF and decreased with increasing LCF. With ageing duration of 0 to 9 days, the overall tenderness increased from 26.8 to 21.2 Ncm$^2$ (21%), respectively. There was a significant (p<0.05) interaction between AEF and LCF on the WBSF of the SM muscles tested such that the decrease of shear force was attained at AEF15.

DISCUSSION

Yield of retail cuts and tissue composition
An increase or decrease of proportions of retail cuts in CCW observed in the present study reflects their differences in growth pattern in sheep carcass (Koyuncu, 2008). In our study, all the animals were slaughtered after AEF12, which was almost the marking end of growing phase, therefore it is possible that the yield of different cuts was very much influenced by the amount of fat deposition than that of the lean and bone tissues (Koyuncu, 2008). For this case, the fat tissues which developed later had more chance to be deposited in breast (Koyuncu, 2008). This is the reason why the cuts with high deposition of fats such as breast had shown the highest proportion in the CCW with increasing AEF. These results are similar those reported by van der Westhuizen (2010) in Merino lambs. From this hypothesis, hind leg and shoulder cuts which developed earlier due to their functional needs, had the lowest priority in fat deposition, and in our results they showed a tendency to decrease in proportion to CCW with increasing LCF as compared to the late developed joints such as chump or loin cuts. Contradictory results were reported by Fasae et al. (2011) in West African dwarf sheep where the weights of different retail cuts were not affected by dietary levels but similar to those reported by Atti and Mahouachi (2011) in fat-tailed Barbarine sheep. The increase of fat and decrease of lean and bone tissues proportions in CCW with increasing both AEF and LCF was very much governed by weight at slaughter. Since the fats are late developing tissues (Lawrence and Fowler, 1997) then the animals used in this study had more significant fat deposition and least proportion of bone tissues in AEF15 and AEF18 under LCF75 and above.

Muscles physico-chemical characteristics
The pH6 PM under LCF indicated that the carcasses had already undergone rigor mortis at high temperatures with pH of 5.70- 5.80 at 27.0 – 27.8°C, which allowed glycolysis to take place. The results of pHu of 5.70 – 5.80 observed under different LCF were within the quality range of pHu below <6.0 in sheep recommended by Miranda-de Lama et al. (2009). Consistent results have been reported by Gadekar et al. (2011) in native sheep breed of India. The decline of pHu in the current study is an important determinant of meat quality since it is very much related to glycogen breakdown and ultimate lactic acid production, which is responsible for decrease of pH in meat (Ekiz et al., 2012). These findings are similar by those reported by Hopkins et al. (2006), who concluded a close association between age of an animal during feedlot period and the muscle pH. As noted in LCF100 castrates, there was higher pH decline during pH24 than LCF75 and LCF50 because the later group had more access to the higher amount of glycogen reserved than the former group. Similar to the current study, Offaz et al. (2005) also reported higher pHu in Karayaka growing lambs fed higher levels of energy supply than those received lower levels of energy supply. However, contrasting results have been reported by Rodriguez et al. (2008) where higher energy concentrates diets did not have much influence on pH values in Assaf lambs. A slight increase in carcass temperature levels with increasing
AEF and LCF in this study is probably associated with the level of fat deposition occurred in the carcasses as it is known to play a role in the muscle cooling through protection of muscle from rapid refrigeration (Jones and Tatum, 1994).

Cooking loss and Warner Bratzler shear force (WBSF) value
The increase in percentage cooking losses and shear force values might have been caused by many factors including nutritional status of the animals at slaughter. The overall increase in cooking loss of LL, SM and SP muscles with increasing AEF suggests lower water holding capacity (WHC) within the muscles. The lower WHC might be caused by the lowest pH of meat observed from AEF15 and AEF18 animals due to higher net charges and bigger space between myofilaments (Huff-Lonergan and Lonergan, 2005). The overall decrease in cooking loss in the three muscles during ageing could also be linked with the increased volume of myofibrils in aged meat, which leads to higher WHC (Kolezak et al., 2007). The animals under AEF9 and AEF12 were slaughtered when their growing phase was in progress, and hence they had little fat deposition compared to AEF15 and AEF18 animals. The little fat deposition in the later group means less glycogen reserve and ultimately low lactic acid concentration in muscles, resulting into higher pH values PM. Also, the WBSF values of LL and SP muscles were lower in AEF9 and AEF12 groups and significantly higher in AEF15 and AEF18 groups because the later group were younger and were possibly had few intra muscular connective tissue (IMCT), lower shear force resulting to tender meat (Santos et al., 2008). The increase of WBSF values with increasing AEF means collagen cross links become more stable and the structural integrity of the IMCT increases. These changes increase the mechanical properties of IMCT, and contributing to the observed meat toughness (Nishimura, 2010). Therefore, higher WBSF values in the AEF15 and AEF18 animals were probably influenced by having higher calpastatin activity and higher collagen concentration as well as slower post-mortem proteolysis or lower solubility of intramuscular collagen than those of AEF9 and AEF12 animals or combination of these factors (Christensen et al., 2011). The overall decrease of WBSF values with increasing LCF in the present study is biologically consistent with an increase in collagen solubility and increased level of intramuscular fats in carcasses (Devine et al., 2002). The increased tenderness in aged muscles after 9 d ageing is also associated with lowering collagen solubility in the muscles during ageing. This also suggests possible weakening of structural integrity of the myofibrillar proteins of aged muscles and high availability of muscle protein turnover rate (Toohey and Hopkins, 2006). 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) ageing in Romney cross castrates with similar age to animals reported in this study. The WBSF values obtained from three muscles studied, however, ranged between 24.0 – 26.5Ncm\(^{-2}\) which is considered extremely tender, even before ageing and were below the threshold value of 49 Ncm\(^{-2}\) reported in sheep (Hopkins et al., 2006). It can be argued that, the higher tenderness in all AEF groups might also reflect favorable feedlot and slaughter conditions adopted in this study.

CONCLUSIONS
Both AEF and LCF increase or decrease the size, composition of retail cuts, muscle cooking losses and tenderness depending on the age of an animal and dietary level provided. When the animals are too young, the proportion hind leg, shoulder and bone is high. On the other hand, when the animals are too old, it is disadvantageous as the proportion of hind leg cut decreased with higher cooking loss in muscles and production of very tough meat. Also, when animals received very low level of concentrate feeding, there is likelihood of getting low pH meat which results into very tough meat while under very high LCF, there will be too much level of fats in carcasses and slightly tender meat. The AEF15 under LCF100 were optimal in terms of retail cuts size, tissue distribution and tenderness.

ACKNOWLEDGEMENTS
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REFERENCES


Annexure

Table 1: Least square means ±SE for yield of wholesale cuts under different age at entry to feedlot and level of concentrate feeding (n=120)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Age at entry to feedlot (months) [A]</th>
<th>Level of concentrate feeding (%) [C]</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Cold carcass weight (CCW), kg</td>
<td>7.54d</td>
<td>9.15c</td>
<td>10.2b</td>
</tr>
<tr>
<td>Weight of cut (as%CCW)</td>
<td>9.95</td>
<td>9.62</td>
<td>11.8</td>
</tr>
<tr>
<td>Neck</td>
<td>17.5a</td>
<td>17.4d</td>
<td>17.0b</td>
</tr>
<tr>
<td>Rib</td>
<td>13.5b</td>
<td>14.0b</td>
<td>15.4d</td>
</tr>
<tr>
<td>Breast</td>
<td>9.68</td>
<td>9.40</td>
<td>9.18</td>
</tr>
<tr>
<td>Loin</td>
<td>5.57</td>
<td>6.12</td>
<td>5.96</td>
</tr>
<tr>
<td>Chump</td>
<td>26.4a</td>
<td>26.0a</td>
<td>23.9b</td>
</tr>
<tr>
<td>Hind leg</td>
<td>17.4b</td>
<td>17.5</td>
<td>16.7</td>
</tr>
</tbody>
</table>

abcdWithin a row, least square means that do not have a common letter differ (p<0.05).
SE, Standard error of mean, NS, Not significant, *=p<0.05; **=p<0.01; ***=p<0.001

Table 2: Least square means for carcass tissues under different age at entry to feedlot and level concentrate feeding (n=120)

<table>
<thead>
<tr>
<th>Carcass tissue (as% CCW)</th>
<th>Age at entry to feedlot (months) (A)</th>
<th>Level of concentrate feeding (%) (C)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle</td>
<td>53.3</td>
<td>55.1</td>
<td>54.6</td>
</tr>
<tr>
<td>Fat</td>
<td>19.8</td>
<td>19.4</td>
<td>20.4</td>
</tr>
<tr>
<td>Bone</td>
<td>25.2a</td>
<td>23.8b</td>
<td>23.0a</td>
</tr>
<tr>
<td>Trimmings</td>
<td>2.59</td>
<td>1.63</td>
<td>1.99</td>
</tr>
</tbody>
</table>

abcdWithin a row, least square means that do not have a common letter differ (p<0.05), SE, Standard error of mean; NS, Not significant; *=p<0.05; **=p<0.01; ***=p<0.001

Table 3: Least square means ±SE for carcass pH and temperature of wethers under different age at entry to feedlot and level of concentrate feeding (n=120)

<table>
<thead>
<tr>
<th>Traits</th>
<th>Age at entry to feedlot (months) [A]</th>
<th>Level of concentrate feeding (%) [C]</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>pH Values</td>
<td>45 min</td>
<td>6.78</td>
<td>6.74</td>
</tr>
<tr>
<td></td>
<td>6 h</td>
<td>6.12</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>24 h</td>
<td>5.81</td>
<td>5.75</td>
</tr>
<tr>
<td></td>
<td>48 h</td>
<td>5.73</td>
<td>5.67</td>
</tr>
<tr>
<td>Temperature [°C]</td>
<td>45 min</td>
<td>38.5</td>
<td>39.3</td>
</tr>
<tr>
<td></td>
<td>6 h</td>
<td>26.3</td>
<td>27.2</td>
</tr>
<tr>
<td></td>
<td>24 h</td>
<td>2.48</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>48 h</td>
<td>2.20</td>
<td>2.00</td>
</tr>
</tbody>
</table>

abcdWithin a row, least square means that do not have a common letter differ (p<0.05); SE=Standard error; NS=Not significant, *=p<0.05
Table 4: Least square means ± SE for cooking loss (%) and Warner-Bratzler shear force (WBSF) of muscles

<table>
<thead>
<tr>
<th>Traits</th>
<th>Age at entry to feedlot</th>
<th>Concentrate level</th>
<th>Ageing (days)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(months) [A]</td>
<td>[C]</td>
<td>[D]</td>
<td>A</td>
</tr>
<tr>
<td>No. of</td>
<td>9  12  15  18</td>
<td>50  75  100</td>
<td>0  9</td>
<td></td>
</tr>
<tr>
<td>observation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooking loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>12.6*  14.5*  14.1*  15.4*  0.60</td>
<td>13.8  14.3  14.3  0.50  19.2*  8.38*  0.60</td>
<td>** NS  *** NS</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>15.2  17.7  16.8  18.6  1.20</td>
<td>5.40  5.22  4.44  0.50  23.3  10.9  1.00</td>
<td>NS NS  *** NS</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>14.9*  17.2*  16.4*  18.3*  0.50</td>
<td>16.5  17.1  16.7  0.50  22.3*  10.2*  0.50</td>
<td>*** NS  *** NS</td>
<td></td>
</tr>
<tr>
<td>Overall loss</td>
<td>14.2*  16.5*  15.8*  17.5*  0.13</td>
<td>11.9  12.2  11.8  0.50  21.6*  9.83*  0.67</td>
<td>** NS  *** NS</td>
<td></td>
</tr>
<tr>
<td>WBSF (Ncm⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>20.8*  21.8*  22.3*  23.5*  0.50</td>
<td>22.8*  23.8*  19.6*  0.50  27.8*  20.1*  0.60</td>
<td>** *** *** NS</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>23.7*  22.2*  26.0*  24.2*  0.60</td>
<td>23.8*  25.8*  22.9*  0.60  26.3*  21.0*  0.40</td>
<td>*** *** *** ***</td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>24.1*  28.0*  31.1*  30.9*  1.90</td>
<td>29.1  27.4  29.7  1.90  26.1*  22.0*  0.60</td>
<td>*** NS  NS NS</td>
<td></td>
</tr>
<tr>
<td>Overall WBSF</td>
<td>22.9*  24.3*  26.5*  26.2*  0.75</td>
<td>25.2*  25.7*  24.0*  0.79  26.8*  21.2*  0.50</td>
<td>*** *** *** NS</td>
<td></td>
</tr>
</tbody>
</table>

*Within a row, least square means that do not have a common letter differ (p<0.05); LL = m. longissimus thoracis et lumborum; SM = semimembranosus; SP = Supraspinosus; NS=Not significant, **p<0.01; ***p<0.001