

EFFECT OF FATNESS ON MEAT QUALITY OF THE LOIN CUT OF SA DORPER LAMB

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ABSTRACT

The effect of fat class (carcass fatness) on sensory quality, shear force and cooking loss was determined on the M. longissimus lumborum (M.LL) (loin) of Dorper lambs. The muscle samples obtained from the M.LL (loin), (carcasses distributed over five fat classes, were sampled, chilled at 0 – 5 °C for 24 hours, aged at 4 °C for 7 days, and then frozen at – 20 °C). The samples were used to determine the sensory characteristics, cooking losses and shear force resistance measurements of the lamb meat. The cuts were cooked according to a dry heat cooking method in an oven set at a temperature of 160 °C, to an internal temperature of 70 °C.

Total cooking loss had a high positive correlation with total drip loss ($r=0.888$) and fat mass ($r=0.888$). The percentage drip loss differed significantly between fat classes. Fat classes 1 and 2 differed significantly from fat classes 3 to 5 for total cooking loss in that it had a higher percentage cooking loss.

Quantitative descriptive sensory analysis was performed by a trained, ten-member panel, using an eight-point category scale. Sensory attributes evaluated were: aroma intensity, initial impression of juiciness, first bite tenderness, sustained impression of juiciness, muscle fibre and overall tenderness, amount of connective tissue (residue), overall flavour intensity, and off-flavour intensity followed a randomised complete block design.

According to the ANOVA results, two of the eight sensory attributes differed significantly ($p < 0.05$) between the different fat classes. Initial impression of juiciness and sustained juiciness

increased significantly ($p \leq 0.029$) with an increased fat class. A positive correlation ($r=0.739$) existed between initial impression of juiciness and sustained impression of juiciness.

A strong positive correlation was also found between the amount of connective tissue (residue) and first bite tenderness ($r=0.887$) as well as between the amount of connective tissue (residue) and tenderness ($r=0.931$). No significant differences were found by the trained taste panel for any of the texture attributes (first bite tenderness, residue and tenderness) between the five fat classes. The *M. longissimus lumborum* (M.LL) muscles from the loin cuts were described as "fairly tender" by the panel.

To conclude, results from this study revealed that cooking losses and juiciness were influenced by the amount of fat present in the M.LL and contrary to what was expected, aroma, flavour and tenderness were not affected by the degree of fatness.

Keywords: Fat class, meat quality characteristics, sensory, cooking loss, shear force, Dorper lamb.

INTRODUCTION

According to the South African national meat consumption survey of all nationalities and ethnic groups ($n = 2481$ households), performed by ACNielsen (2001), 16 % of the consumers ate lamb / mutton at least three times a week, with 10 % of the consumers never eating lamb / mutton. Older consumers (> 50 years) showed a greater decline in consumption of meat in comparison with their juniors. This could be attributed to various factors including the belief that eating red meat aggravates and / it causes "affluent diseases" such as heart disease (Scholtz, Vorster (jun), Matshego & Vorster, 2001:S39). Consumers' reluctance to include lamb in their diet can also be attributed to a specific taste perception ("lamb has a strong flavour"). Furthermore, lamb and mutton are perceived to be expensive, to contain high levels of cholesterol and to have a lower nutrient value than other meat products, although it is a protein-rich food. According to ACNielsen (2001), lamb was perceived as being lower in nutrients than other animal protein choices. Poultry was rated to be the most nutritious source (60 %), followed by fish (49 %), beef (39 %) and lamb was only rated by 32 % of the consumers to be nutritious. Consumers demand consistent quality and lean meat with minimum fat required for flavour and juiciness (Ward, Trent & Hildebrand 1995:69). Therefore, the quality and quantity of fat in meat products are critical drivers of food choice. Consumers are increasingly interested in healthy products and prefer lean meat and carcasses (Cunhal-Sendim, Murillo, Belenguer. & Castello, 1999:190-191).

The consumer's opinion of the most tender meat choices was poultry (46 %), lam and mutton (34 %), fish (32 %) and beef (30 %) (ACNielsen, 2001). The ten factors that were considered the most important when purchasing meat (including beef, lamb, poultry and pork) were flavour (75 %), colour

of meat product (48 %), amount of fat (45 %), price (36 %), tenderness (30 %), nutritional value (21 %), fresh products (not frozen) (20 %), packaging (17 %), classification (grading of meat cuts) (15 %) and preparation time (14 %) (Market Research Africa, 1996:15). According to Carpenter (1966:1235), consumers evaluate meat quality on the basis of aroma, juiciness, tenderness and flavour of the cooked meat, with tenderness being the most important attribute. Therefore, it is important to have sensory data on South African lamb to guide the consumer in their decision making

Texture, aroma and flavour characteristics are the main criteria used by consumers to evaluate the sensory quality of meat (Gorraiz, Beriain, Chasco & Iraizoz, 2000:137). Raw meat has little aroma and only a blood-like taste which could be affected by its pH, species, cooking method, type of cut and treatment prior to cooking (Bratzler: 1971:336, 344). The cooked aroma of meat can be described as the sensory attribute that represents certain volatile substances as perceived by the olfactory organ. According to Duckett and Kuber (2001), as cited by Duckett (2001:23), lamb fat has a very unique aroma.

The sensory attribute of juiciness, is determined by water retention and the lipid content of the meat, as well as by factors such as flavour and texture. For example, some flavour components in the fat and meat can cause the rapid release of saliva while chewing the meat, thus giving an impression of juiciness (Cross, Durland & Seideman, 1986:312). Marbling and fat around the edges of the cut of meat also help to retain water. The texture of meat determines the ease with which moisture can be expressed from the meat as it is being chewed and therefore contributes to the impression of juiciness (Cross *et al.*, 1986:312). Juiciness in cooked meat has two sensory phases (components) (Lyon & Lyon, 1989:335). The first impression of juiciness is the experience of wetness that is produced by the rapid release of meat fluid during the first few chews. Sustained impression of juiciness is largely due to the stimulatory effect of fat on salivation (Lawrie, 1998:182). The use of correct cooking methods and rate of heat penetration is another way of increasing (influencing) meat juiciness. Heat penetration is influenced by the rate at which energy is supplied and transmitted to the meat, the composition of the sample (lean, fat connective tissue and bone), the ratio and amounts of the sample as well as the characteristics of the surface where water loss and melting of fat appears (Paul & Palmer, 1972, Cross *et al.*, 1986:308-309). Therefore it is important to keep in mind that there are multiple factors influencing the eating quality of meat products.

Flavour contributes to meat quality and can be described as the complex combination of the olfactory and gustatory attributes perceived during tasting. Meat flavour can be affected by age of the animal, water retention during cooking and fat within the muscle as well as fat on the surface of the meat cut (Shahidi, 1994:1-2). According to Duckett (2001:23), species-specific flavours are unique flavours that are located in the lipid-soluble (fat) fraction (branched chain fatty acids, carbonyl compounds, sulphur-containing compounds, lipid oxidation products and phenols) and are believed to impact on lamb and mutton flavour and odour. Maddock, McKenna and Savell (2003:184) noted that countries with high per capita consumption of lamb found lamb flavour and odour to be appealing attributes, whereas countries with low per capita lamb consumption found it unappealing.

The challenge is to make sure that high yield traits will not be promoted at the expense of eating quality. Therefore, the objective of this study was to compare the sensory attributes, as well as

shear force resistance of the meat from lambs in five fat classes (Fat class 1 = ± 3 % SCF to fat class 5 with ± 16 % SCF) of Dorper *M. longissimus lumborum* (loin) lamb samples, using quantitative descriptive sensory analysis.

MATERIALS AND METHODS

Source of materials

In South Africa carcasses are classified according to age and fat class (National Department of Agricultural, Product Standards Act, ACT No. 119 of 1990, and its regulations). Age is described according to the number of permanent incisors with age class A = 0 tooth, AB = 1-2 tooth, B = 3-6 tooth and C = more than 6 tooth, while carcasses are grouped into seven fat classes by means of visual appraisal of subcutaneous fat (SCF) (fatness class 0 = less than 1.0 % SCF, to fat class 6 = more than 17.6 % SCF, excessively over-fat).

The lamb meat samples incorporated in this study (Table 1) comprised of the most commonly-consumed carcasses in South Africa (Van der Westhuizen, personal communication, 2003), namely the Dorper breed from five fat classes (Fat class 1 = ± 3 % SCF to a fat class 5 with ± 16 % SCF). The Dorper breed, a white-bodied sheep with a black head, was established in the 1940's, in the Karoo region of South Africa by crossing the Black Head Persian (a fat-rumped hair breed that is adapted to harsh arid environmental conditions) and the British Dorset Horn (Snowder & Duckett, 2003:368).

TABLE 1.
EXPERIMENTAL DESIGN FOR THE SENSORY EVALUATION OF A AGE CLASS, FAT CLASS 1-5
LOIN CUTS FROM SOUTH AFRICAN LAMB

Breed type	Dorper (wethers)				
Number of animals in study	66				
Starting weight (kg)	23 - 26				
Days on feed	90 – 120 days (4 - 6 months)				
Slaughter weight (kg)	30	36	42		
Number of animals in slaughter group	20	24	20		
Distribution of carcasses per fat class	1	2	3	4	5
	15	15	19	9	8
Sample	<i>M. longissimus lumborum</i> (loin cut) of the left sides				

On average, the animals were four to six months old and were fed intensively to obtain three different live weights (30, 36 and 42 kg) with a subsequent variation in carcass fatness (fat class 1-5). In this study, the animals were fed a high energy, high protein commercial feedlot diet on an ad lib basis and only Dorper lambs were included. All the male animals were slaughtered pre-puberty and no secondary male development was observed. On the day following slaughtering, carcasses were sectioned down the vertebral column by using a band saw. The loin cut (bone-in) containing the M.LL

(the first to the last lumbar vertebra) of one side (left) of all carcasses were sampled from chilled carcasses, coded and labelled, vacuum packed and aged for seven days at 4 °C and then frozen at -20 °C until required for sensory evaluation.

Sensory analysis and cooking properties

The cuts were prepared and evaluated according to the American Meat Science Association and National Livestock and Meat Board (1995:7-8) research guidelines on the cooking and sensory evaluation measurements of fresh meat. The M. LL cuts were thawed over a 24 hour period at 4 °C before cooking. The samples were prepared according to a standardized dry heat cooking method in identical Mielé ovens (Mielé ovens, model H217). The dry heat cooking method entailed the oven roasting of meat, uncovered on a flat open pan, with a rack to keep the meat out of the drip. No water (liquid) was added during the cooking of the meat in the oven at a temperature of 160 °C to an internal meat temperature of 70 °C (45 minutes per kilogram). A hand-held digital probe (model Kane-May 1012) was used to record the internal temperature at the geometric centre of the meat (American Meat Science Association, 1995:7-8). Cooking losses (thawing loss, drip loss, evaporation loss and fat mass calculated from the total volume of fat according to the following: volume fat x 0.9 g / ml) were measured as part of the standard procedure (Annexure 1). After cooking, all samples rested at room temperature (centrally controlled at 22 °C), for 10 minutes. The M. LL muscle was then removed from the bone and halved (transverse). One half was used for sensory analysis and the other half of the cut was used for shear force measurements. Ten cubed samples (10 mm x 10 mm x 10 mm) were cut from the middle of the muscle half and immediately wrapped individually in pre-coded (with 3 - digit random numbers) aluminium foil squares (9 cm x 9 cm). These samples, were served warm (± 40 °C) on pre-warmed plates to a trained sensory panel within 20 minutes from the time the cut was removed from the oven.

Sensory panel procedures

An external experienced trained sensory panel consisting of ten members was used for sensory analysis at the Meat Industry Centre (ARC-Irene). The sensory analysis facility contains all the elements necessary for an efficient sensory program and was originally constructed according to the American Society for Testing and Material's (ASTM, 1989:15) design guidelines for sensory facilities. During the four-day training sessions (two hours per day), panellists received representative samples of each of the different treatments (fat codes) of Dorper loin one at a time. They were trained in order to increase their sensitivity and ability to discriminate between specific samples and the sensory attributes of each sample. A clear definition of each attribute was developed, based on ASTM to describe the specific product attribute (lexicon) to be evaluated (Table 2). A score sheet, using an eight-point category rating scale was used. Each sensory category attribute was verbally labelled, e.g. eight indicated extremely tender and juicy meat, extreme flavour and aroma intensity and no residue,

while one referred to extremely tough and dry meat, extremely bland flavour and aroma intensity and excessive residual connective tissue (Meilgaard, Civille & Carr, 1991:53-55). The following sensory quality characteristics were evaluated: aroma intensity, initial impression of juiciness, first bite tenderness, sustained impression of juiciness, muscle fibre and overall tenderness, amount of connective tissue (residue), overall flavour and off-flavour.

TABLE 2.
DESCRIPTION OF EACH ATTRIBUTE AS USED BY THE TRAINED SENSORY PANEL TO
EVALUATE THE LAMB SAMPLES

Attributes	Instructions and Lexicon
Aroma Intensity	Take a few short sniffs as soon as you remove the foil. This aroma is associated with cooked lamb and has an important influence and contribution to the flavour of the cooked lamb cut.
Initial impression of juiciness	It is the amount of fluid exuded on the cut surface when pressed between thumb and index finger.
Sustained juiciness	The impression of juiciness that is formed when chewing. It is either dry with no fluid or juicy with moisture.
First bite tenderness	The impression of tenderness of the meat when biting into the meat is formed during the first bite.
Muscle fibre and overall tenderness	Chew sample with a light chewing action. The impression of tenderness of the meat when chewing, and evaluating whether the meat breaks easily between the teeth (tender) or has become tough/difficult to bite through.
Amount of connective tissue (residue)	Chew sample with a light chewing action. This is the chewiness of the meat.
Overall flavour	The combination of taste while chewing and swallowing the sample.
Off-flavour	Flavour not associated with lamb.

Two evaluation sessions per day, with three samples served in every session over 11 days were conducted. During a tasting session, 3-digit coded samples representing one of the different treatments were served randomly to the individual panellists. The ten panellists were seated in individual sensory booths to ensure unbiased objectivity and consistent responses, without being influenced by external factors. In order to ensure that the panel members did not suffer from sensory fatigue, a short break of 20 minutes was introduced between the two tasting sessions per day. For each session, samples were evaluated under red light conditions to mask possible colour differences and were presented on a preheated (100 °C) glass plate. Water at room temperature was provided to cleanse the palate between samples.

Shear force resistance measurement

The meat portion (remaining half of the cut) allocated to shear force resistance evaluation, was cooled covered and kept in a refrigerator (4 °C) overnight (12 hours). Subsequently the samples were removed from the refrigerator and allowed to reach room temperature (centrally controlled at 22 °C) before being cored. Eight cylindrical samples with a diameter of 12.7 mm were removed

parallel to the grain of the meat. One shear value from each core (perpendicular to the fibre direction) was obtained using an Instron Universal Testing Machine (Model 4301) (Instron Corporation, 1990) with a Warner-Bratzler shear force device mounted on a Universal Instron apparatus. The reported value in kg force represented the average peak force measurement.

STATISTICAL ANALYSES

Data was statistically analysed using the GenStat for Windows (2000) statistical computer program. The significance of all the sensory attributes measured for each fat class of the Dorper loin cut was tested by means of analysis of variance (ANOVA), using a split plot design which tested the main effect of the sample, panellists, as well as the sample-by-panellist interactions at a 5 % level of significance. If the sample main effect was significant, Fisher's protected t-test least significant difference (LSD) was applied to separate the sample means. A correlation matrix was constructed to test for significant correlations between attributes (Annexure 3).

A multivariate statistical analysis technique, Principal Component Analysis (PCA) was performed to reduce a large set of variables into a much smaller set of composite variables, the principal components, that explains most of the variance in the population of samples. The PCA is a graphical presentation of the data and is used to better classify and group samples using the sensory variables (Shaw, Moshonas, Buslig, Barros & Widmer, 1999:1951). PCA is discussed according to the sensory attributes measured in the loin samples which explain most of the variation found in the entire data set.

RESULTS

The fatness of the various loin cuts from five fat classes had an effect on the following cooking-related variables significantly: total cooking loss (%), drip loss (%) and cooked fat mass (g) (Table 3). The percentage total cooking loss, drip loss and cooked fat mass of the loin cuts increased significantly with the increase in carcass fatness. Variation in total cooking loss was the result of variation in drip loss, as evaporation loss was not influenced by carcass fatness. Drip loss in fat class 5 was almost four times higher compared to fat class 1 and almost double as much as fat class 2. According to the ANOVA, no significant differences were found ($p < 0.05$) in the percentage thawing loss, evaporation loss and drip loss (density) of the loin cuts of the five fat classes indicating that fat class probably only have a significant effect on the total cooking loss and cooked fat mass (calculated from the total volume of cooked fat).

The results, as obtained from the sensory panel, for the Dorper loin cuts from five fat classes are summarized in Table 3. Two of the eight sensory attributes differed significantly ($p < 0.05$), namely initial impression of juiciness and sustained juiciness. No significant difference ($p < 0.05$) was found for the aroma of the loin cut for the five fat classes. The aroma was described as fairly intense (range 6.08 – 6.21).

TABLE 3.
LEAST SQUARE MEAN VALUES FOR THE SENSORY ANALYSIS OF DORPER LOIN CUT
SAMPLES (N=66)

Sensory attributes	p-value	Fat class				
		1	2	3	4	5
		±3 % SCF	±7 % SCF	±10 % SCF	±13 % SCF	±16 % SCF
Fat thickness (mm)	< 0.001	0.650 ±0.426	2.193 ±0.411	4.353 ±0.365	5.178 ±0.531	7.550 ±0.563
Aroma Intensity	0.910	6.21 ±0.108	6.21 ±0.108	6.12 ±0.096	6.08 ±0.140	6.16 ±0.148
Initial impression of juiciness	0.002	5.73 ^a ±0.106	6.12 ^{ab} ±0.106	6.19 ^{ab} ±0.094	6.43 ^b ±0.136	6.15 ^{ab} ±0.145
First bite tenderness	0.334	5.93 ±0.161	6.33 ±0.161	6.23 ±0.143	6.38 ±0.208	6.03 ±0.221
Sustained juiciness	0.029	5.20 ^a ±0.129	5.50 ^a ±0.129	5.63 ^{ab} ±0.115	5.87 ^b ±0.166	5.44 ^a ±0.176
Muscle fibre and overall tenderness	0.701	6.05 ±0.169	6.34 ±0.169	6.23 ±0.150	6.36 ±0.218	6.09 ±0.231
Amount of connective tissue (residue)	0.855	5.87 ±0.139	6.05 ±0.139	6.98 ±0.124	6.01 ±0.180	5.85 ±0.191
Overall flavour	0.943	6.01 ±0.087	6.07 ±0.087	6.10 ±0.077	6.08 ±0.112	6.02 ±0.119
Off flavour	0.259	6.80 ±0.169	6.98 ±0.169	7.23 ±0.150	7.29 ±0.218	7.24 ±0.231
Objective tenderness measurement						
Shear force measurement (kg force)	0.992	2.60 ±0.207	2.56 ±0.207	2.61 ±0.183	2.73 ±0.267	2.62 ±0.283
Cooking-related properties						
Total cooking loss (%)	< 0.001	11.88 ^a ±0.622	13.35 ^a ±0.622	15.25 ^b ±0.552	15.59 ^{bc} ±0.803	17.14 ^c ±0.851
Thawing loss (%)	0.764	0.229 ±0.050	0.253 ±0.050	0.198 ±0.045	0.198 ±0.065	0.146 ±0.069
Drip loss (%)	< 0.001	1.86 ^a ±0.390	3.59 ^b ±0.390	5.38 ^c ±0.346	6.22 ^c ±0.503	7.79 ^d ±0.534
Evaporation loss (%)	0.650	10.02 ±0.325	9.75 ±0.326	9.87 ±0.290	9.38 ±0.421	9.34 ±0.446
Cooked fat mass (g) (calculated) (total volume of fat)	< 0.001	3.67 ^a ±5.10	17.73 ^a ±5.10	38.71 ^b ±4.53	59.70 ^{cd} ±6.58	76.27 ^d ±6.98

p-value: F-probability to test for significant differences between samples
Means with different letters (a, b, c or d) are significantly different ($p \leq 0.05$) within row
± These values are standard error of least square means
Sensory ratings: Sensory ratings: Each sensory category attribute was verbally labelled, e.g. eight indicated extremely tender and juicy meat, extreme flavour and aroma intensity and no residue, while one referred to extremely tough and dry meat, extremely bland flavour and aroma intensity and excessive residual connective tissue (Meilgaard, et al. 1991).
SCF Subcutaneous fat

With regard to the significant difference of the initial impression of juiciness, samples from fat class 1 were described by the trained panel as slightly juicy (5.73) compared to fat class 4 that was rated to be fairly juicy (6.43). Although small, a significant difference ($p = 0.029$) was found between the five fat classes for sustained juiciness. Samples from fat class 1, 2 and 5 were less juicy (initial

impression of juiciness and sustained impression of juiciness) than the other fat classes but only significantly different between fat class 1 and 4 (initial impression of juiciness).

No significant differences were found by the trained taste panel in any of the texture attributes (first bite tenderness, residue and tenderness). No significant differences ($p = 0.992$) were found in the shear force values of the loin cuts of the five fat classes. The shear force values (Table 3) were the lowest for fat class 2 (2.56 kg force) and the highest for fat class 4 (2.73 kg force), and therefore tender. This correlates with the tenderness attribute evaluated by the panel. In general, the loin cuts were described as fairly tender (scores of 6.05-6.36).

No significant differences ($p < 0.05$) were found by the trained panel for the two flavour attributes. The overall flavour of the loin cuts were described as fairly intense (6.01 – 6.10) and the off-flavour as very intense as described (scores of 6.80-7.24).

Relationship between attributes

Correlations with values higher than 0.7 were investigated. Generally, a correlation coefficient (r) of approximately 0.7 is regarded as indicating a fairly strong correlation (Rayner, 1969). Refer Annexure 3.

A positive correlation existed between initial impression of juiciness and sustained impression of juiciness ($r = 0.739$). Strong positive relationships were found between tenderness and first bite tenderness ($r = 0.929$); first bite tenderness and connective tissue (residue) ($r = 0.887$); and connective tissue (residue) and tenderness ($r = 0.931$).

A strong positive correlation existed between percentage total cooking loss ($r = 0.734$) and the total fat mass ($r = 0.734$). The total percentage drip loss correlated strongly with fat mass (total volume of fat) ($r = 0.888$), fat mass ($r = 0.888$) and total cooking loss ($r = 0.907$). This is an indication that the total cooking loss consists mainly of fat and that evaporation loss is consistent, as shown in Table 2.

Multivariate statistical analyses: Principal Component Analysis

The interpretation of descriptive sensory evaluation data is often simplified with the assistance of multivariate statistical procedures such as Principal Component Analysis (PCA) and Canonical Variate Analysis (CVA). PCA is a statistical procedure that identifies the smallest number of latent variables, called principal components that explain the greatest amount of observed variability. It is possible to explain 75 – 90 % of the total variability in a data set containing 25 - 30 variables with as few as two to three principal components. Through PCA, the correlation structure of a group of multivariate observations is analysed and the axis along which maximum variability of the data occurs is identified and referred to as the first principal component or PC1 (horizontal axis). The PC2 (vertical axis) is the axis along which the greatest amount of the remaining variability lies subject to the constraint that the axes must be perpendicular (at right angles) to each other (Meilgaard *et al.*, 1991: 277).

PCA was performed on the full data set obtained from sensory analysis (aroma, juiciness first bite tenderness, tenderness, residue and off flavour), cooking-related properties and shear force values (see Figure 1). The first two principal components of the PCA (Figure 1) accounted for 77.3 % of observed variability. The first principal component (PC1) accounted for 40.0 % of the total variation in the data with a latent root of 4.00. The main variates discriminating between the five fat classes of the lamb loin cut in PC1 (horizontal axis) were, first impression of juiciness ($r = 0.893$); tenderness ($r = 0.889$); residue ($r = 0.881$) as well as sustained impression of juiciness ($r = 0.797$). The second principal component (PC2) accounted for 37.30 % of the total variation with a latent root of 3.73. For PC2 (vertical axis) drip loss ($r = -0.950$), fat mass ($r = -0.936$) and total cooking loss ($r = -0.862$), were the main variates discriminating between the five fat classes.

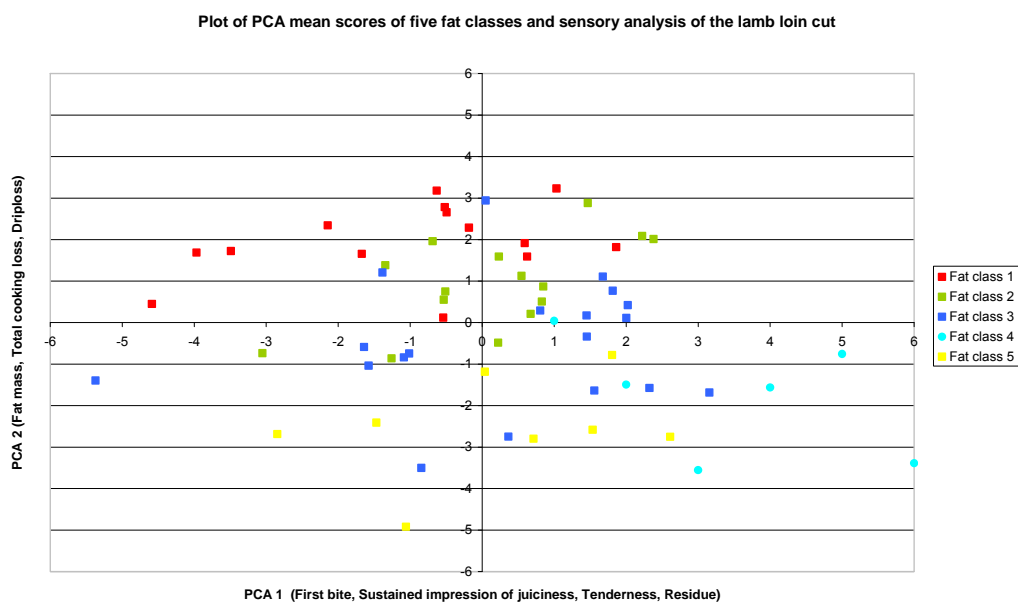


FIGURE 1: PRINCIPAL COMPONENT ANALYSIS: DISCRIMINATION OF LAMB LOIN CUTS FROM FIVE FAT CLASSES ON SENSORY AND COOKING RELATED PROPERTIES AS WELL AS SHEAR FORCE

These results were confirmed by the ANOVA. According to the results summarized from the ANOVA and the graphical presentation (Figure 1) for PC1, of the sensory attributes of the lamb loin cuts for the five fat classes, fat class 1 contrasted the strongest with fat class 4. Fat class 1 was slightly juicy for the initial impression of juiciness (5.73) as well as for the sustained impression of juiciness (5.20) and fat class 4 was rated fairly juicy (6.43) for initial impression of juiciness and slightly juicy for sustained impression of juiciness (5.87). Fat classes 1 and 5 were rated to be fairly tender (6.05, 6.09) with a slight amount of residue (5.87, 5.85), and fat class 3 and 4 were evaluated as having traces of connective tissue (6.98).

With regard to the percentage total cooking loss in PC2 fat class 1 and 2, again contrasted with fat class 3, 4 and 5. Fat class 1 had the lowest percentage cooking loss (11.88) compared to fat class 5 that had the highest percentage cooking loss (17.14) of the five fat classes. The same trend

was followed for the percentage drip loss. Fat class 1 had the lowest percentage drip loss (1.86) compared to fat class 5 that had the highest percentage drip loss (7.79) of the five fat classes.

DISCUSSION

This study confirms the fact that, during growth and development, certain significant changes occur in the composition of the body of the animal which have a direct effect on the palatability of the end-product as evaluated by the consumer. Differences detected in the meat quality between the five fat classes of the loin cut were small (only the two juiciness attributes differed) more differences were found for the total cooking loss, drip loss and cooked fat mass of the loin cut. The significant increase in sustained juiciness between the samples from different fat classes could be due to the stimulatory effect of the fat on salivation and also explain why the meat gives an initial impression of juiciness (Lawrie, 1998:182). According to Bratzler, (1971:334) the sensation of juiciness in cooked meat is closely related to fat content. The results from this study are different to those by Péreze, Maino, Tomic, Mardones and Pokniak, (2002:237) who found that juiciness did not differ between fat groups. Schönfeldt (1989:208) also found that with an increased fatness, the juiciness of the cooked cuts tends to decrease. According to Lawrie (1998:183), the process of freezing does not affect juiciness and therefore it can be assumed that differences in juiciness must be attributed to other factors such as fatness level, breed and treatment before slaughter, the length of storage or cooking method.

The overall flavour of the loin cuts was described by the trained panel as fairly intense with a very intense off-flavour although there was no significant difference between the fat classes. Shahidi, (1994) also reported that fat cover has no significant effect on sheep meat flavour. On the other hand, Shahidi, (1994) mentioned that off-flavours in lamb were common when sheep had soft oily fat arising from a high energy-diet, which might be the reason for the high off-flavour rating in this trial where the animals were fed a high energy, high protein commercial feedlot diet. However, it was not tested in this study. The fact that the aroma, flavour and off-flavour attributes did not differ significantly from each other between the five fat classes in this study can be attributed to the fact that the lambs were younger than 16 months. According to Channon, et al. (2003) the aging effect on sheep meat odour and flavour may not be obvious until animals are much older. Jeremiah (1998) who reported that the role of fatness in lamb quality and its relationship to palatability is not well understood and is still a contentious issue also supports these findings. Nutritional regimen can impact on fat composition and therefore flavour ratings as well. In this study the animals were fed a high energy, high protein commercial feedlot diet on an *ad lib* basis and only Dorper lambs were included. Duckett (2001:23) reported research indicating that genetics had a minor influence on lamb flavour but, however, interactions between breed and nutrition may occur. Young, Reid, Smith, and Braggins (1994:84) concluded that there was no consensus between the cause of the typical flavour and odour of sheep meat. This is also applicable to this study, as all samples are from young grain-fed fed animals.

The sensory panel for this study rated the lamb samples fairly tender (6.05-6.36) (Table 2) and these results were similar to those reported by Péreze *et al.* (2002:237) who found lamb meat as fairly tender. Parrish (1974:119) found that the degree of marbling had little effect on tenderness however

the cooking loss increased with increased marbling. According to Savell & Cross (1986:3) there is a high significant correlation between tenderness and fat content of the longissimus muscle.

Warner-Bratzler shear force resistance measurements are an objective measure of tenderness used to evaluate relative differences in tenderness or toughness of meat. In general, the overall shear force values reported in the literature (Duckett, 2001:22) for lamb are lower than for most beef values. In beef (broiled chops, cooled and four half-inch cores were used) the threshold values for shear force is considered to be around 4.5 kg force. Values below 4.5 kg force (threshold) would indicate that consumers would rate it slightly tender or better in overall tenderness. Prior to this study, no threshold values were available for lamb, but based on shear force values for tenderness reported for beef, it can be concluded that consumers would consider similar lamb shear force values acceptable and palatable (Duckett, 2001:22). Results from this study correlate well with the values obtained by the sensory panel. The taste panel evaluated the loin cuts from all five fat classes to be fairly tender with traces of connective tissue (residue). Shear force resistance results in the present study showed an average value of 2.6 kg force for the Dorper loin chops from five fat classes which could be considered as highly acceptable, taking into consideration that values for beef of < 4.5 kg force is proven to be acceptable to the consumer. According to results from Schönfeldt (1989:208), a low resistance to shear force with increased fatness may be attributed to the increased muscle volume relative to the structural component, although the mechanism of toughening is not yet understood. Meat from animals of the A age groups showed less resistance to shear force according to the study conducted by Schönfeldt (1989:207).

Variation in total cooking loss was the result of variation in drip loss (increased with increase in fat class), as evaporation loss was not significantly influenced by carcass fatness. Drip loss in fat class 5 was almost four times higher than fat class 1 and almost twice as much as fat class 2. The differences in cooking loss can be attributed to the increase in fatness over the five fat classes. This is in accordance with results from Solomon, Kemp, Moody, Ely and Fox (1980:1106), and Schönfeldt (1989:208), who described differences in cooking losses amongst roasts cooked under similar conditions as primarily due to differences in fatness, with leaner roasts generally having more evaporation loss while roasts with a higher fat content having more drip loss. Carpenter and King (1965:103) also reported higher cooking losses with increased marbling or intramuscular fat content. Although Parrish (1974:118) found that the degree of marbling had little effect on the flavour, tenderness, juiciness, overall acceptability and Warner-Bratzler shear force, they reported a higher percentage total cooking loss, with increasing amount of marbling. Ockerman, Emsen, Parker and Pieterse (1982:1368) also found a negative relationship between cooking yield and fat content.

CONCLUSION

The focus of the present study was on the differences in the sensory attributes of the *M. longissimus lumborum* (loin) as effected by the fat class. There are numerous factors that may affect quality, texture and flavour of lamb and sheep meat such as age, fat class, breed, nutrition and sex. However, from this study it seemed as if differences were smaller because only one age group

was investigated. With the exception of juiciness, the results in this study showed that contrary to expected carcass fatness (in the same age over five fat classes), as portrayed in the SA Classification system, does not have a significant effect on the sensory qualities of *M. longissimus lumborum* (loin) from lambs of the same age.

The study found that meat cuts within the same age (A age class, fat class 2) do not differ significantly from each other in tenderness. Meat from animals in the same age (A2) with increasing fat classes (up to 16 % SCF) is juicier with a higher percentage total cooking loss.

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Annexure 1

LAMB COOKING DATA FORM

DRY HEAT COOKING METHOD (OVEN ROASTING)

CUT:.....DATE:.....	
Taste panel leader:..... Taste panel assistant..... Panel date:..... Sample code: SE code:.....	
THAWING DATA	
Mass raw sample + thawing loss + bag	.....g
Mass bag + exudates	.....g
Mass bag without exudates	.....g
COOKING DATA	
Time in:.....	Cooking time (h)
Time out:.....	(calculated).....
Thermocouples:	
Number.....	Start temp.....End temp:.....
Oven: no.....	
Sample:..... °C	..... °C
..... °C	..... °C
Cooking tempo (calculated):.....(°C/g/min)	
	Mass (g)
Mass of pan + rack	.....g
Mass pan + rack and raw meat	.....g
Mass raw meat (calculated (g))	
Mass pan + rack + drip loss + cooked meat	.....g
Mass pan rack + drip loss	.....g
Mass total drip loss (calculated (g))	
Mass cooked meat (calculated (g))	
Mass pan + rack + residue drip	.....g
Mass residual drip loss in pan (calculated (g))	
CYLINDER READING	
Total drip loss	.....g
Stock	.....g
Fat	.....g
Total volume of fat (calculated (ml))	
Mass of fat ((g) (calculated, volume fat X 0.9 g/ml))	
Thawing loss (calculated)	
Evaporation loss (calculated)	
Drip loss (calculated)	
Total cooking loss (calculated)	

Annexure 2

SCORE SHEET

Sensory analysis of South African Dorper lamb

Name:.....

Date:.....

Panellist no:.....

Please evaluate the following samples of LAMB for the designated characteristics.

Attribute	Rating scale	Sample codes			
AROMA INTENSITY Take a few short sniffs as soon as you remove the foil	1 = Extremely bland 2 = Very bland 3 = Fairly bland 4 = Slightly bland 5 = Slightly intense 6 = Fairly intense 7 = Very intense 8 = Extremely intense				
INITIAL IMPRESSION OF JUICINESS The amount of fluid exuded on the cut surface when pressed between thumb and forefinger	1 = Extremely dry 2 = Very dry 3 = Fairly dry 4 = Slightly dry 5 = Slightly juicy 6 = Fairly juicy 7 = Very juicy 8 = Extremely juicy				
FIRST BITE TENDERNESS The impression that you form on the first bite tenderness	1 = Extremely tough 2 = Very tough 3 = Fairly tough 4 = Slightly tough 5 = Slightly tender 6 = Fairly tender 7 = Very tender 8 = Extremely tender				
SUSTAINED IMPRESSION OF JUICINESS The impression of juiciness that you form as you start chewing	1 = Extremely dry 2 = Very dry 3 = Fairly dry 4 = Slightly dry 5 = Slightly juicy 6 = Fairly juicy 7 = Very juicy 8 = Extremely juicy				
MUSCLE FIBRE & OVERALL TENDERNESS Chew sample with a light chewing action	1 = Extremely tough 2 = Very tough 3 = Fairly tough 4 = Slightly tough 5 = Slightly tender 6 = Fairly tender 7 = Very tender 8 = Extremely tender				
AMOUNT OF CONNECTIVE TISSUE (RESIDUE) The chewiness of the meat (note the scale is reversed)	1 = Extremely abundant 2 = Very abundant 3 = Excessive amount 4 = Moderate 5 = Slight 6 = Traces 7 = Practically none 8 = None				
OVERALL FLAVOUR INTENSITY This is the combination of taste while chewing and swallowing	1 = Extremely bland 2 = Very bland 3 = Fairly bland 4 = Slightly bland 5 = Slightly intense 6 = Fairly intense 7 = Very intense 8 = Extremely intense				
OFF FLAVOUR This is the flavour not associated with lamb	1 = Extremely bland 2 = Very bland 3 = Fairly bland 4 = Slightly bland 5 = Slightly intense 6 = Fairly intense 7 = Very intense 8 = Extremely intense				

1 **Annexure 3**

2 **Correlation matrix of sensory data of the A age class, fat class 1-5 for the loin cut of the South African Dorper**
 3 **lamb**

Aroma intensity	1	1.000															
Initial impression of juiciness	2	0.010	1.000														
First bite tenderness	3	-0.059	0.400	1.000													
Sustained impression of juiciness	4	-0.161	0.739	0.568	1.000												
Tenderness	5	-0.109	0.339	0.929	0.551	1.000											
Residue	6	-0.124	0.357	0.887	0.538	0.931	1.000										
Overall flavour intensity	7	0.346	0.089	0.253	0.222	0.238	0.201	1.000									
Off flavour	8	-0.463	0.186	0.235	0.137	0.218	0.197	-0.427	1.000								
Shear force	9	0.237	-0.285	-0.554	-0.510	-0.567	-0.613	-0.104	-0.090	1.000							
Drip density	10	-0.173	0.025	-0.067	-0.042	-0.061	-0.046	-0.128	0.228	0.052	1.000						
Fat volume	11	0.028	0.270	-0.010	0.170	-0.032	-0.053	-0.024	0.231	0.157	0.379	1.000					
Fat mass	12	0.028	0.270	-0.010	0.170	-0.032	-0.053	-0.024	0.231	0.157	0.379	1.000	1.000				
Total cooking loss	13	-0.036	0.189	-0.007	0.071	-0.004	-0.057	-0.082	0.267	0.162	0.389	0.734	0.734	1.000			
Drip loss	14	0.021	0.264	-0.007	0.125	-0.029	-0.068	-0.031	0.225	0.177	0.337	0.888	0.888	0.907	1.000		
Evaporation loss	15	-0.124	-0.073	-0.004	-0.077	0.047	-0.001	-0.130	0.184	0.031	0.253	-0.015	-0.015	0.570	0.170	1.000	
Thawing loss	16	0.176	0.073	-0.010	-0.068	-0.042	-0.061	0.075	-0.161	-0.114	0.234	-0.187	-0.187	-0.082	-0.135	0.070	1.000
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

4