CHAPTER 3

3 MATERIALS AND METHODS

3.1 THE EXPERIMENTAL GOATS

A flock of goats was purchased from an auctioneer who buys goats from all over South Africa. The goats were kept at the Hatfield Experimental Farm, University of Pretoria prior to slaughter. The flock ranged from recently weaned kids to 6-teeth castrates and intact males and full-mouthed females. On arrival at the farm, the goats were vaccinated against pulpy kidney and pasteurellosis, and were dosed against major internal parasites. They were separated into males and females in two adjacent pens. Suckling kids were held in the same pen as the does. The goats were provided a maintenance diet of Silgro® ewe and lamb pellets fed at ca. 0.3% of total animal weight per pen. The pellets were formulated to provide 130g/kg crude protein, 34.9% non-protein nitrogen, 150g/kg crude fibre, 25g/kg crude fat, 15g/kg calcium and 3g/kg phosphorus. Clean water and *Eragrostis curvula* hay were available ad libitum.

The goats were divided into two groups for slaughter, which, as much as was possible, consisted of goats from all age and sex groups. One group were the non-conditioned goats, which were slaughtered within three months of purchase. Pre-slaughter conditioned goats were slaughtered between six and 10 months of purchase. All goats were slaughtered when they were at least 25kg live weight. As is typical of goats from smallholder producers (Simela, 1996), there were very few milk- and 2-teeth goats that weighed 25kg or more in the market. The majority of the young goats, especially the females, were about 13–15kg and hence for this study, they were raised to at least 25kg before slaughter. Consequently most of the 2-teeth goats were slaughtered in the pre-slaughter conditioned state.

In total 89 goats were slaughtered. The distribution of the slaughtered stock by age class (based on dentition), sex and pre-slaughter conditioning is shown in Table 3.1.

Chronological age of the goats was estimated from their dentition based on the findings of Horgan, King and Kurth (1988) and Singh and Saini (1998). According to these authors, the first pair of permanent incisors erupts at 15 to 17 months, the second at 20 to 26 months, the third at 24 to 26 months and the fourth pair at 28 to 30 months in medium and large goats. The age range at which each set of permanent incisors erupts is however very wide within and amongst the breeds,

especially for the later sets (Horgan et al., 1988; Singh and Saini, 1998). Nonetheless, dentition serves as a guideline for the estimation of the age of goats raised by smallholder farmers, which would otherwise be impossible to estimate since the farmers do not keep such records. Moreover dentition is said to be a more precise estimation of physiological age than methods such as degree of ossification of cartilage or the appearance of some bones of thoracic and lumbar vertebrae (Price, 1982).

Table 3.1 Distribution of experimental goats by age (dentition) class, sex and pre-slaughter conditioning

Age class (dentition)	Pre-slaughter conditioning	Castrates	Female	Males	Total
0-teeth	Non-conditioned	6	1	3	10
	Conditioned		3	4	7
2-teeth	Non-conditioned	7		1	8
	Conditioned	7	13	4	24
4–6 teeth	Non-conditioned	9	7	4	20
8-teeth	Non-conditioned		11		11
	Conditioned		9		9
Total	Non-conditioned	22	19	8	49
	Conditioned	7	25	8	40
Grand total		29	44	16	89

NB: Incisors were considered in pairs. Thus if one of the first pair of incisors had erupted then the goat was considered 2-teethed; if one of the second pair had erupted then the goat was taken as 4-teethed, etc.

Non-conditioned – slaughtered within three months of purchase

Conditioned - slaughtered between six and ten months of purchase

The delineation of the age classes using dentition was in line with the current ruminant carcass grading system in South Africa, which defines classes, A, AB, B and C as animals with milk teeth, one to two permanent incisors, three to six permanent incisors and more than six incisors, respectively.

CHAPTER 3

All the goats were slaughtered at the abattoir of the Animal Nutrition and Animal Products Institute (ANAPI) of the Agricultural Research Council (ARC) at Irene. In the morning of the day prior to slaughter, animals were randomly selected for slaughter from the different age and sex groups with a pre-slaughter conditioning group. The goats intended for slaughter were weighed and their chest girths were measured. They were held in a separate enclosure but had their daily ration of feed and water. During the mid afternoon, the slaughter animals were taken to the abattoir, which was a drive of about 30km (20 minutes). They were held in lairage overnight for about 17 hours with clean water ad libitum but no feed.

During slaughter, the goats were stunned using 300V applied across the head, at the base of the ears and behind the eyes. Judging from the research conducted on pigs (Wotton, Wilkins and Whittington, 2003), this voltage should have been well beyond the threshold necessary to break down the initial impedance and promote an effective and immediate stun.

A subset of four castrated males with 4-to-6 permanent incisors and nine does with full mouth were electrically stimulated immediately after exsanguination, with 220V, for one minute at a pulse of 12.5 per second. Electrically stimulated goats were taken from both the non-conditioned and pre-slaughter conditioned groups.

The dressed carcass comprised of the body after removing the skin, the head at the occipito-atlantal joint, the fore-feet at the carpal-metacarpal joint the hind feet at the tarsal-metatarsal joint and the viscera. The kidneys and kidney knob and channel fat (KKCF) were part of the dressed carcass. They were only removed after the chilled carcass had been weighed.

3.2 SAMPLING AND SAMPLE STORAGE

Within 10 minutes of slaughter, two samples of the *M. longissimus thoracis* (LT) of about 20g each were cut from the left side of the carcasses and immediately frozen in liquid nitrogen, put in marked self-sealing polythene bags and stored at –70ºC for myofibre typing (MFT), calpastatin and glycolytic potential (GP) determinations. The LT samples were collected from all 89 goats while *M. semimembranosus* (SM) samples for myofibre typing and calpastatin analyses were taken from 27 randomly selected goats for comparative purposes with LT samples. Several samples were cut from the goat that was slaughtered last and retained for the extraction of m-

calpain, which was to serve as reference for calpastatin analysis. This carcass was not included in further analyses.

After skinning and evisceration, omental fat was removed from the viscera of each goat and weighed separately.

At 24 hours post-mortem, *M longissimus lumborum* (LL) and SM samples were cut from each side of the carcass and weighed. Any fat (subcutaneous and/or intermuscular) that was attached to these muscles was separated and weighed. Samples for myofibrillar fragmentation length (MFL) and sarcomere length (SL) determinations were cut from the proximal end of the SM. Similar samples were cut from the cranial end of the LL muscle. All the samples (including the remainder of each muscle) were vacuum packed. Samples from the left side of each carcass were immediately frozen at –20ºC. Muscles from the right side of each carcass were aged for a further 72-hours and then stored at –20ºC.

The 96-hour ageing period was selected on the basis of the outcome from the surveys conducted in Zimbabwe, in which most of the goat carcasses in the commercial market were sold within four to five days after slaughter. Further to that, Kannan, Chawan, Kouakou and Gelaye (2002a) showed that there is no significant improvement in chevon tenderness beyond the first 96 hours of refrigerated storage.

3.3 CARCASS MEASUREMENTS

Immediately after removing GP, MFT and calpastatin samples, initial pH (pH_0) and temperature were measured on the left LT and SM within 15 minutes after slitting the throat of each animal. Subsequent readings were taken at three, six and 24 hour post-mortem and the pH readings are designated pH_3, pH_6 and pH_{24}/pHu, respectively. Hot carcass weight (HCW) was measured prior to washing and chilling. The carcasses were chilled at 2–4ºC for up to 24 hours post slaughter (about 23 hours in the chillers). Thereafter they were weighed to obtain cold carcass weight (CCW). All the KKCF and the kidneys were then removed. The KKCF was weighed, vacuum-packed and stored at –20ºC. Buttock circumference was measured according to Fisher and de Boer (1994) and then the carcass was split in half along the dorso-ventral plane. The right side was weighed and carcass dimensions (carcass depth, carcass length and side length) were measured as

prescribed by Fisher and de Boer (1994). Thereafter the side was jointed along the lines shown in Figure 3.1 into neck, fore limb, ventral trunk, dorsal trunk and hind limb.

The dorsal trunk was further split between the 12th and 13th ribs and the area of the LT was traced out on the surface of the 12t^{h} rib. The muscle area was later measured from the tracing using a visual image analyser (VIA, Kontron, Germany).

Each joint was dissected into the separable tissues; lean, bone, intermuscular and subcutaneous fat as defined by Fisher and de Boer (1994). Each tissue was weighed separately for each joint. The weights of the SM and of the LL samples and their fat were added to the weights of the hind limb and dorsal trunk, respectively.

Dressing out percentage and chilling losses were calculated as follows:

$$\text{Dressing out (\%)} = \frac{CCW}{Liveweight} \times 100 \qquad \text{Chilling losses (\%)} = \frac{HCW - CCW}{HCW} \times 100$$

Other variables that were calculated were the proportions of the dissectible tissues within the joints and within the right half carcass as well as the proportions of the joints within the side.

3.4 HISTOLOGICAL AND HISTOCHEMICAL ANALYSES

The SL and MFL of LL and SM samples aged for 24 and 96 hours where determined. MFT was carried out from LT and SM samples that were ultra frozen at -70°C immediately post slaughter.

3.4.1 Sarcomere Length

Portions of about 3g were cut out from the core of the frozen samples and prepared according to Hegarty and Naudé (1970). The frozen samples were homogenised in about 15ml of distilled water using an ultra Turrax blender at low speed. A few droplets of the homogenate were mounted on a slide, covered with a cover slip and immediately viewed under a microscope attached to a VIA, at a magnification of 100x. The SL were determined as the average sarcomere length of a hundred 5-sarcomere long sections taken randomly in VIA fields (Figure 3.2).

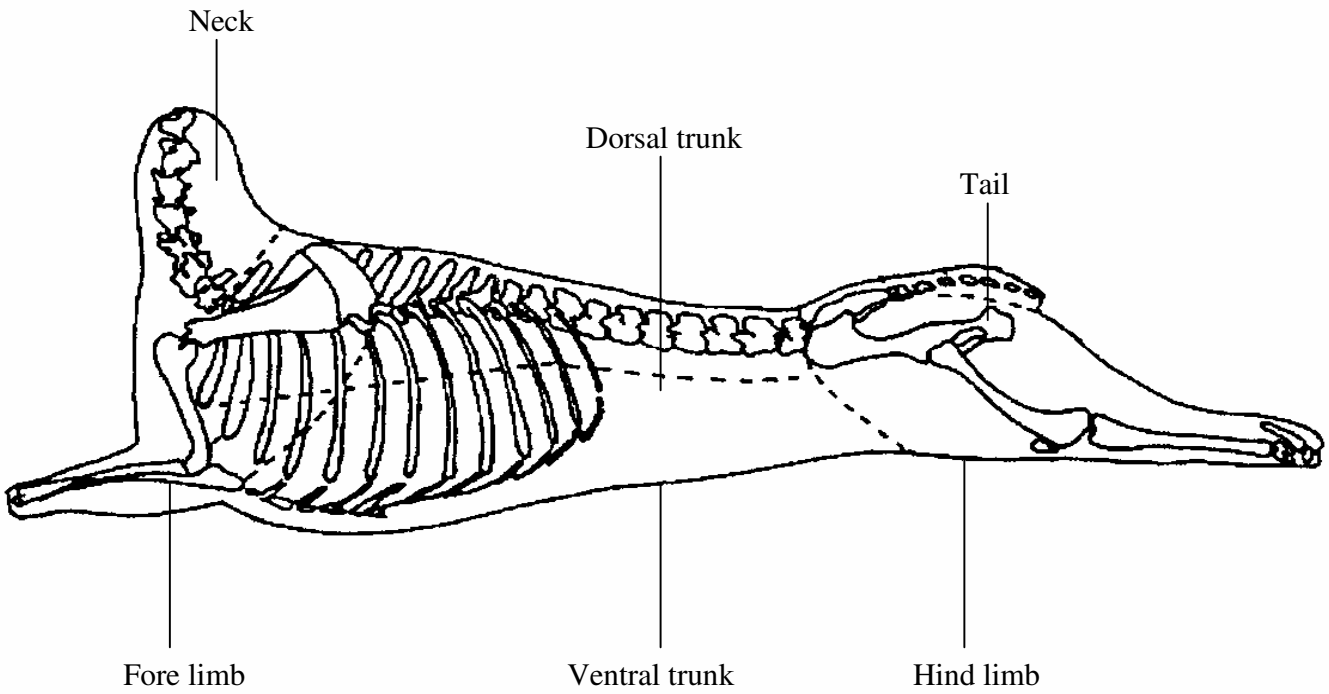
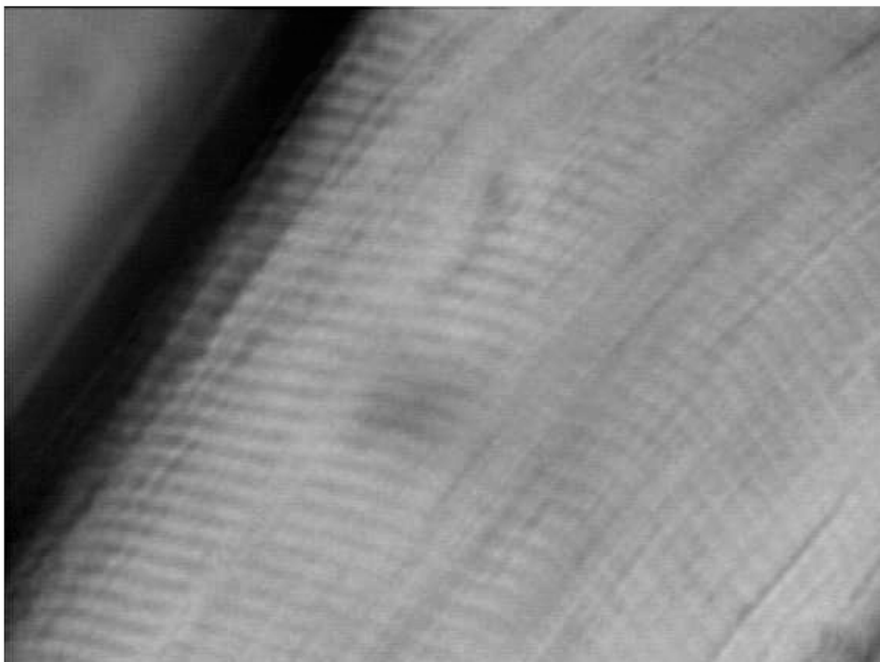


Figure 3.1 Diagram showing the joining lines for the goat carcasses (Casey, 1982)

i)



ii)

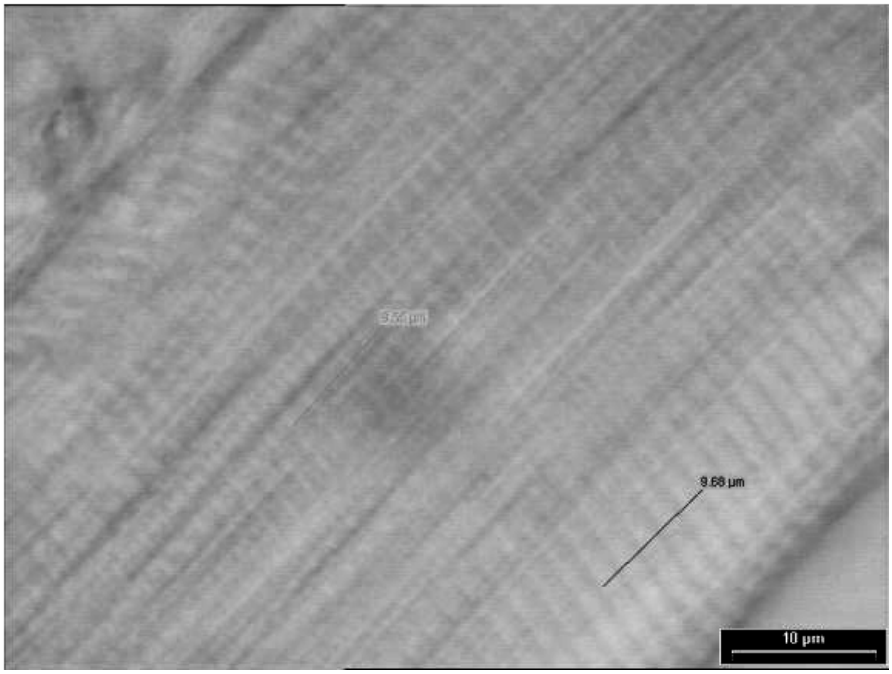


Figure 3.2 Illustrations of fields of (i) *M. longissimus lumborum* and (ii) *M. semimembranosus* samples prepared for sarcomere length determination as viewed under the visual image analyser (100 x magnification)

3.4.2 Myofibrillar Fragment Length

A sub sample of about 3g was cut from the interior of the frozen samples, blended in a cold potassium phosphate extraction buffer and prepared according to Culler et al. (1978). MFLs were determined according to Heinze and Bruggemann (1994). The methods involved the extraction of the myofibres in the buffer solution and under cold conditions (~4°C) in order to arrest any further proteolysis. Droplets of the extracted MFL solution were mounted on a slide, covered and viewed at a magnification of 40x under a microscope attached to the VIA. Myofibrillar fragment lengths were determined as the average length of the first 50 myofibrils that were longer than five sarcomeres and were in clear focus in VIA fields (Figure 3.3).

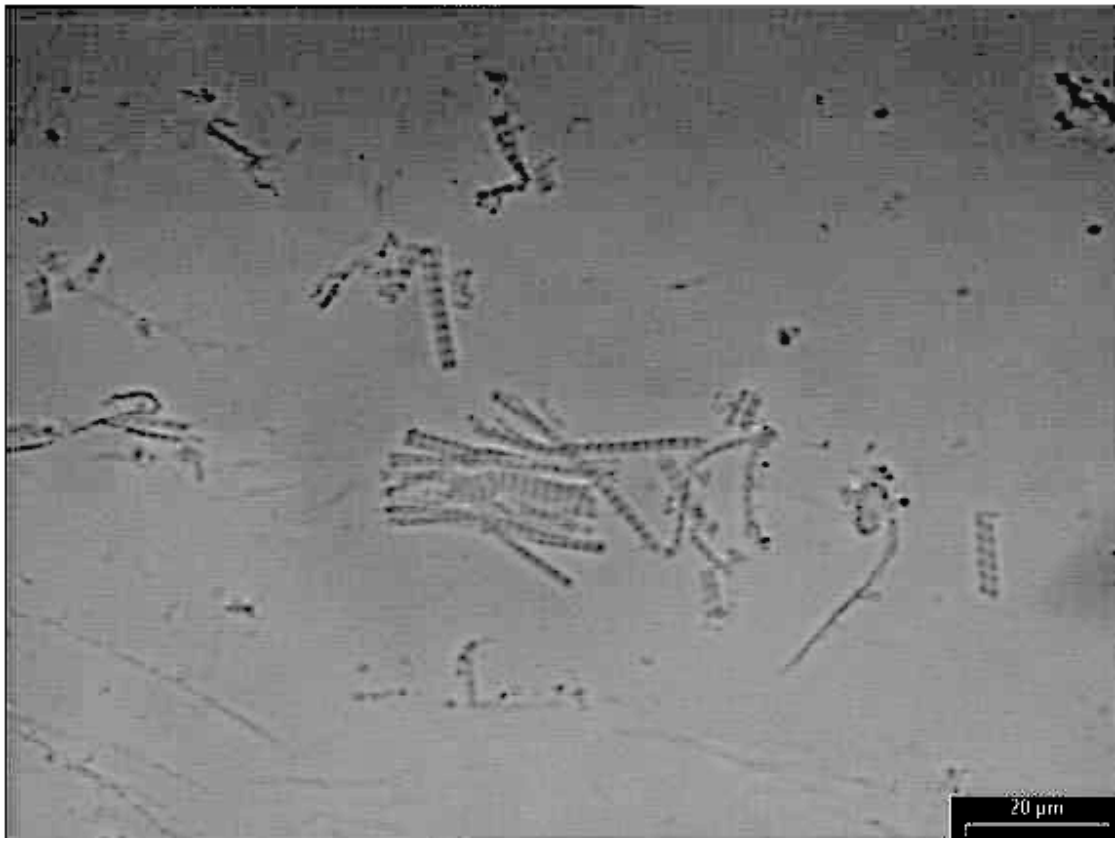


Figure 3.3 An illustration of a field of myofibrillar fragments as viewed under the visual image analyser at a magnification of 40x (*M. longissimus lumborum* sample aged for 96 hours)

3.4.3 Myofibre Typing

Sample blocks of about 50mm^2 cross sectional area were sectioned on a cryostat at -25°C to a thickness of 12µm. The sections were mounted on slides, stained for succinate dehydrogenase activity using nitroblue tetrozolium (Barka and Anderson, 1963), covered with cover slips and viewed under the microscope attached to the VIA at a magnification of 10x. From the VIA fields, the myofibres were classified as red, intermediate or white depending on intensity of the staining (Figure 3.4). The myofibre areas were determined as the average area of 50 fibres of each type. Additionally, the proportion of each myofibre type was estimated as the percent count of each MFT in five randomly selected fields.

3.5 PHYSICAL MEAT CHARACTERISTICS

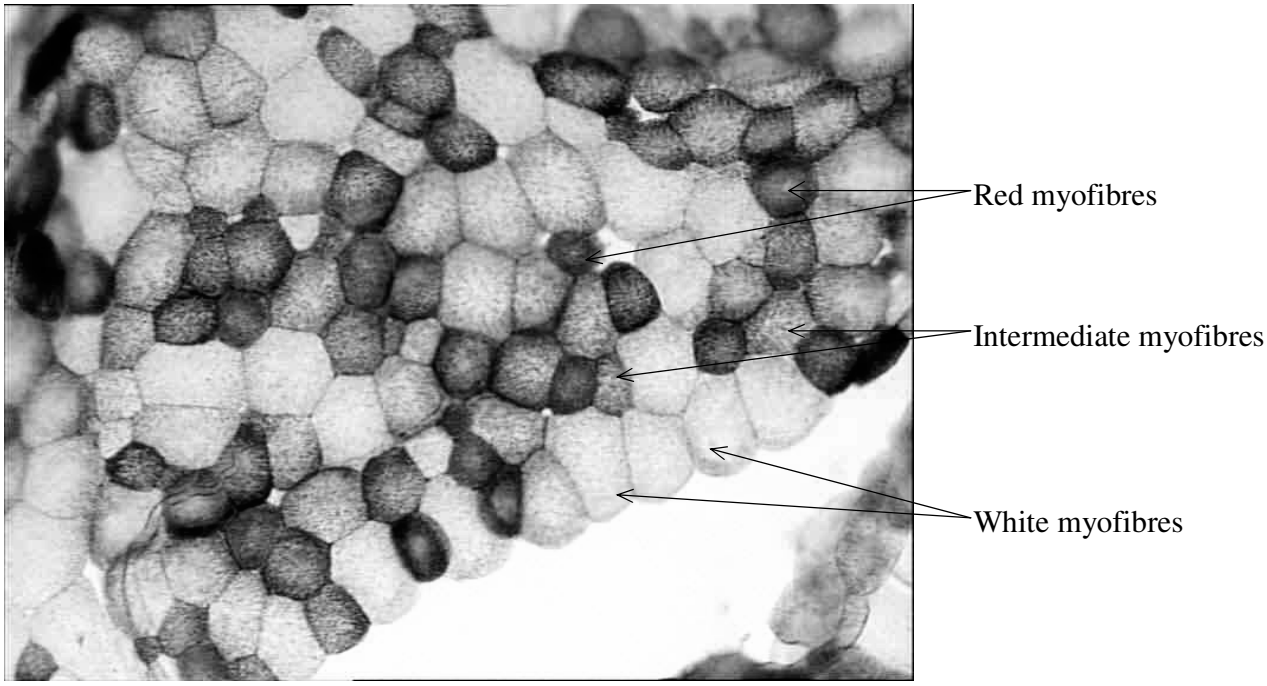
The physical parameters that were measured were the meat colour, cooking losses and shear force.

3.5.1 Colour, Cooking Losses and Shear Force

Samples of *M. semimembranosus* from both ageing periods were defrosted overnight at 2–4°C. Thereafter the vacuum seal was broken and a layer of about 0.5cm was cut off from the proximal end of the muscle to expose a fresh surface. The muscle was then wrapped in oxygen permeable polythene film and left to bloom for three hours at 2–4ºC with light. Subsequently, CIE L*, a* and b* values were determined on the cut surface with a Minolta chromameter, Model CR200 (Minolta, Japan). The chromameter was standardised against a white calibration tile that was wrapped in the same polythene cling film used for the meat samples. The calibration CIE values were L* 97.81, a*-5.56 and b* + 7.38. Three replicate measurements were taken per sample with special effort to avoid areas of connective tissue and intramuscular fat.

Following colour measurements, blocks of about 6 x 6 x 2.5cm (averaging 78.5g) were cut out, weighed and boiled in sealed polythene bags in a water bath at 76ºC for one hour. The temperature and cooking time were pre-determined in an earlier trial using mutton samples. The bags were then cooled under running water at room temperature for 30 minutes and stored in the chiller at about 2–4ºC overnight (Honikel, 1998).

i)



ii)

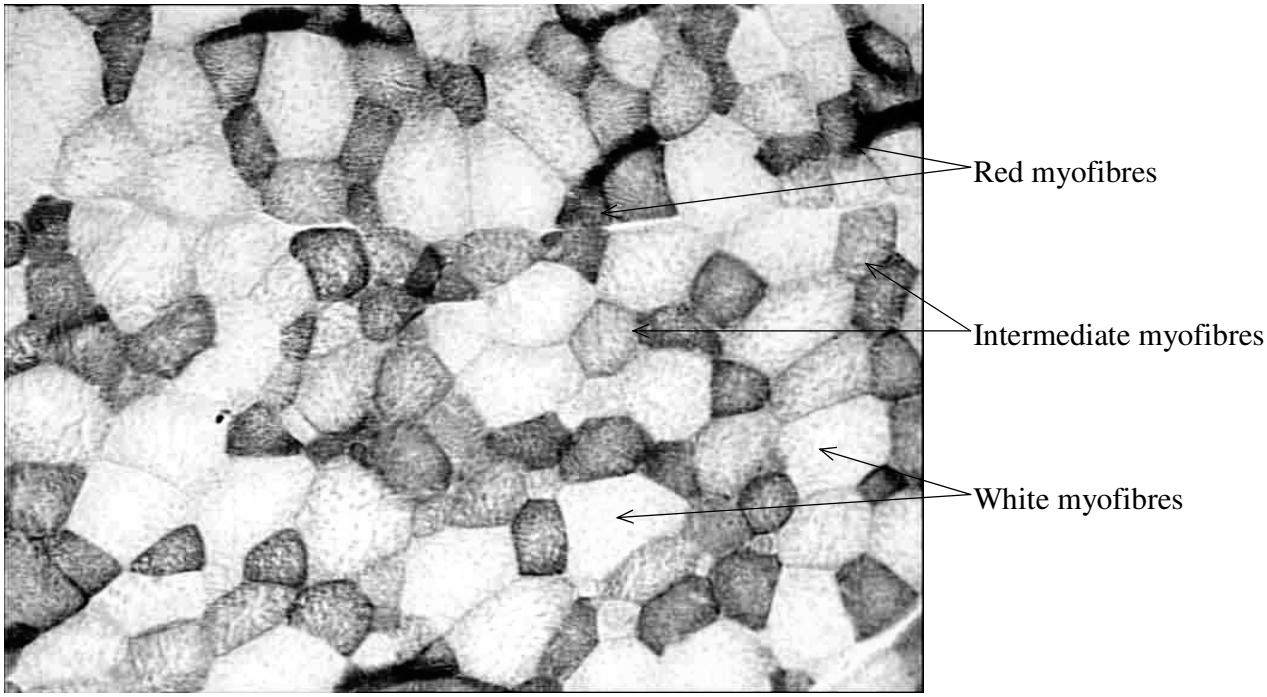


Figure 3.4 Illustrations of fields of (i) *M. longissimus thoracis* and (ii) *M. semimembranosus* muscles prepared for myofibre typing as viewed under the VIA (10x magnification)

The following day each sample was patted dry with a paper towel and weighed. Thereafter, as many cores as possible of 12.7mm diameter were cut out parallel to the myofibres. Each core was sheared perpendicular to the myofibres using a Warner Bratzler device fitted to an Instron Universal Testing Machine, Model 1011 (Instron Ltd, England), at a crosshead speed of 200mm per second (Honikel, 1998). The cores were sheared at one to three different points depending on their length and the number of cores obtained per sample. Toughness was taken as the average maximum force (Newtons) that was required to shear through cores of a sample.

The recommendation is that 10 cores should be sheared once for each sample (Boccard et al., 1981). However, goat SM were small such that only two to four cores that were about 3–6cm long could be obtained per sample. Therefore the longer cores were sheared two to three times.

Cooking losses were calculated as the percent weight loss of the sample after it had been cooked and dried with a paper towel.

3.6 BIOCHEMICAL ANALYSES

3.6.1 Glycolytic Potential, ATP and Creatine Phosphate

Samples for glycolytic potential (GP) were extracted from 3g of each of the 89 ultra frozen LT samples using perchloric acid, as described by Dalrymple and Hamm (1973). Glycogen concentration was determined as glycosyl units after hydrolysis with α-amyloglucosidase and correction for glucose concentration in the extract according to the method of Keppler and Decker (1974). Concentrations of ATP, glucose-6-phosphate and creatine phosphate were determined in the perchloric acid extracts according to Lamprecht, Stein, Heinz and Weisser (1974) and lactate concentration according to Gutmann and Wahlefeld (1974). Glycolytic potential was calculated according to Monin and Sellier's (1985) formula, as follows:

$$GP = 2([\text{glycogen}] + [\text{glucose}] + [\text{glucose-6-phosphate}]) + [\text{lactate}]$$

3.6.2 Calpastatin

Calpastatin concentration was determined using the boiling method described by Shackelford, Koohmaraie, Cundiff, Gregory, Rohrer and Savell (1994b) with some modifications. Frozen

samples of about 3g were homogenised for about 20 seconds in 12ml of the extraction buffer (100 mM Tris, 5 mM EDTA, with 15µl β-mercaptoethanol, pH 8.3, 4°C), using an ultra Turrax blender at high speed (13 500 revolutions per minute). The homogenates were centrifuged at 10 000 RCF for 15 minutes using a Sorvall Super T21 tabletop centrifuge (Sorvall™). The supernatant of each sample replicate was decanted into a measuring cylinder and made up to 20ml with the extraction buffer. For each sample, a 500µl aliquot was set aside for protein determination while the rest was transferred to bosilicate tubes and boiled in a water bath at 95°C for 15minutes. The samples were then cooled in an ice water bath for 15 minutes. After cooling, the coagulated protein was resuspended with a glass rod and the mixture was transferred to centrifuge tubes and centrifuged in one step at 4 000 RCF for at least 10 minutes.

Following centrifugation, the volume of the supernatant was determined and recorded for subsequent calculation of calpastatin activity. Calpastatin activity was determined according to the method of Koohmaraie (1990b). Azo-casein was used as the substrate for m-calpain and absorbance was determined at 366nm (Dransfield, 1996). The m-calpain used was extracted from goat meat samples that were set aside for that purpose. One Unit of calpastatin activity was defined as the amount that inhibited one Unit of m-calpain activity. A Unit of m-calpain activity was defined as the increase in absorbance of 1.0 per hour at 25°C determined at 366nm.

The Buiret method (Gornall, Bordawell and David, 1949 as cited by Bailey, 1967) was used to determine the extractable protein content. Calpastatin activity was expressed either as Units per gram sample or Units per milligram of protein (specific activity).

3.6.3 Fatty Acids

Fatty acid composition of LL samples that were aged for 24 hours and stored at -20°C was determined according to the method outlined by Webb (1994) and modified by Steenkamp (2000).

About 10g were cut from frozen meat samples, chopped into small pieces and stored in 20ml of chloroform with 0.01% butylated hydroxytoluene (BHT) to inhibit oxidation. The meat sample in chloroform was quantitatively transferred to a 50 ml boiling tube and a further 10ml of chloroform with BHT added. The sample was then boiled in a water bath at 60°C for about 15

minutes, until all chloroform had evaporated. Then a known volume of 10 to 15ml of chloroform was added and the meat sample was crushed with a glass rod to extract all the lipids from it. A 1ml aliquot was then taken for transesterification and determination of fatty acids concentration. A 5ml portion of the lipids in chloroform was kept aside for the determination of lipid concentration in the extract.

Transesterification was carried out at 60°C for 30 minutes (Steenkamp, 2000). Fatty acid concentration was determined using a Varian 3300 gas chromatograph equipped with a Varian 3300 integrator (Varian, California) as outlined by Webb (1994). The gas chromatography (GC) programme was as follows:

Initial column temperature:	150°C
Initial holding time:	2 minutes
Final column temperature	200°C
Rate:	5°C per minute
Holding time:	13 minutes
Injector temperature:	230°C
Detector temperature:	240°C
Range:	11

Prior to running the samples in the GC, a standards solution containing methyl esters of fatty acids known to occur in meat and in known concentrations was prepared and injected in order to determine and check the retention times of the different fatty acids.

The concentration of each fatty acid in the sample was determined by the following formulae:

$$\text{Fatty acid concentration (µg/g lipid)} = \frac{PAsa}{PAst} \times [FA]st \text{ µg/ml} \times \frac{1}{[Lipid]} \text{ g/ml}$$

$$\text{Fatty acid in meat (µg/g)} = [\text{lipid}] \text{ g/ml} \times \frac{extract}{sampleweight} \times [\text{fatty acid}] \text{ µg/g lipid}$$

Where PAsa = peak area in sample; PAst = peak area in standard; [Lipid] = lipid concentration in extract; [FA]st = fatty acid concentration in standard; extract = volume of lipid extract (ml); sample weight = weight of meat sample (g) from which lipids were extracted.

3.6.4 Amino Acids

The Pico.Tag method for amino acid determination (Bidlingmeyer, Cohen and Travin, 1984) was employed on 12 freeze-dried and defatted LL samples. The method involved three steps, which were the hydrolysis of the fat free meat sample with hydrochloric acid to yield free amino acids; derivatisation with phenylisothiocyanate to produce phenyltiocarbomyl amino acids. These derivatives were then separated by reverse column high pressure liquid chromatography and detected using a Water Associates Model 440 absorbance detector set at 254nm.

The objective of this analysis was to give an indication of the amino acid composition of chevon and hence the small number of samples used.

3.6.5 Crude Nitrogen and Crude Fat

Crude protein and crude fat were determined from freeze dried portions of the 45 LL samples that were used in the sensory evaluation. The conventional Association of Official Analytical Chemists (AOAC) methods were used for these analyses (AOAC, 1990).

3.7 SENSORY EVALUATION

Samples of LL muscle that were aged for 96 hours were used for sensory evaluations. The evaluation was conducted in two series. In the first series, LL of castrated (n=15) and female (n=15) goats with two to six permanent incisors were used. In the second series LL samples of male kids with no permanent incisors (n=6) and does with a full mouth (n=9) were used. In each of the series the goat samples were compared to mutton LL samples cut from twelve loins of ewes with four to six permanent incisors. The loin samples were obtained from a commercial retailer, from carcasses that were hung in the chillers for 48 hours. The samples were vacuum-packed and stored frozen at –20ºC for sensory analysis.

3.7.1 Preparation of Samples for Sensory Evaluation

Meat samples were taken from the -20°C deep freezer 24 hours before each session and thawed in a refrigerator at 4–5°C. Each thawed sample was weighed individually to determine cooking time. The samples were then salted slightly and roasted in an oven at 165°C until an internal temperature of 73°C was reached. The temperature was measured using a distance thermometer.

After roasting, each sample was weighed, allowed to set for one minute before it was cut into 4mm thick slices. Small samples were cut out because the goat LL were small.

3.7.2 Sensory Panels and Sensory Evaluation

A panel of 193 consumers who had previously eaten and had no objections to chevon, lamb/mutton were recruited on a voluntary basis through telephonic or personal contact. The profile of the panel in terms of population category (black or white), gender (male or female), age (21–30, 31–40, >40) and level of education (primary, secondary, tertiary) was recorded. The distribution of panellists of the first and second series of sensory analysis by these categories is shown in Table 3.2.

Table 3.2 Distribution of the consumers by population category, gender, age and level of education within the first and second series of sensory analysis

		Series I	Series II
Number of consumers per series		84	109
% per population category	Black	48%	77%
	White	52%	32%
% per gender group	Female	55%	38%
	Male	45%	62%
% per age group	21–30 years	44%	37%
	31–40 years	23%	31%
	> 40 years	33%	32%
% per level of education group	Primary	11%	29%
	Secondary	23%	38%
	Tertiary	67%	33%

There were 84 consumers in the first and 109 in the second series of analysis. No Indians or Muslims were included in the study because the goats had not been slaughtered according to their religious requirements. Two 15-minute sessions were conducted once a week under controlled conditions in a sensory evaluation laboratory.

The meat samples were randomly allotted and served to the consumer panel while still warm, to be evaluated in sequence according to an incomplete balanced block design. Three sensory tests were conducted in sequence. First the panellists rated the acceptability of flavour, aroma and tenderness on a five point hedonic scale, ranging from "extremely acceptable" (5), "acceptable" (4), "neutral" (3), "not acceptable" (2) to "extremely unacceptable" (1) (Bosman, van Aardt, Vorster, and Drewnowski, 1997). Secondly, they indicated the meat sample they preferred, if any. Finally the panellists indicated their consumption intent for each sample using a 5-point food action scale with response categories "eat it very often – everyday" (5), "eat it often – once a week" (4), "eat it occasionally – once a month" (3), "eat it only when no other food is available" (2) and "never eat it" (1). Panellists rinsed their mouths with water before and between tasting the samples (Bosman et al., 1997). At the end of each session, the panellists each received a slice of an apple to clean their mouths and a glass of fruit juice and a bar of chocolate for their participation.

3.8 STATISTICAL ANALYSIS

3.8.1 Live Animal, Carcass and Meat Quality Characteristics

General linear models (GLM) procedures of SAS (1996) were used to test the effects of sex, age classes and pre-slaughter conditioning (Table 3.2) and first order interaction effects on live animal, carcass and meat quality characteristics.

Pre-analysis tests were carried out for each of the variables. Where the data for a variable were not normally distributed, the rank transformation was performed and the transformed variable was used in the GLM analysis. For first order interaction effects sex was nested in age and age nested in pre-slaughter conditioning since not all sexes occurred in all age groups and not all age groups were represented in both pre-slaughter conditioning groups (Table 3.2). Where F-tests were significant ($P<0.05$), Scheffé's test was used to compare means.

3.8.1.1 Live animal and carcass characteristics

The main and first order interaction effects as described above were tested on slaughter weight, chest girth, carcass weights, carcass losses, carcass dimensions, carcass joint and tissue composition. The results of these analyses are presented in Chapter 4.

CHAPTER 3

3.8.1.2 Meat quality of chevon

The effects sex, age, pre-slaughter conditioning and first order interaction effects on the pH and temperature profiles, myofibre proportions and areas, MFL, SL, glycolytic metabolite concentrations and calpastatin concentration of the LTL muscle were tested as described in §3.8.1. The main effects and interaction effects on the pH and temperature profiles, myofibre proportions and areas, MFL, SL, cooking losses, shear force and colorimetric values of the SM muscle were similarly tested.

Pearson's correlations between the myofibre areas and proportions and meat quality traits were computed for each muscle. Furthermore, correlations between hot carcass weight, total carcass fat content and all the meat quality variables were investigated for each muscle. The effects of early post-mortem pH (pH_3) and ultimate pH (pHu= pH_{24}) on meat quality were further investigated for the variables that significantly correlated to these parameters.

Delineation of pH_3 groups was based on the concept that carcasses should attained a pH of 6.2 or less before the temperature drops below 15°C (Honikel et al., 1983) or a pH of 6 or less before 10°C (Cornforth et al., 1980). Carcass temperature averaged 13°C after three hours in this study, and hence it was taken that a pH of about 6.1 should have been attained by that time. Therefore the carcasses were divided into the following groups:

- $pH_3 < 6.1$
- $6.1 \leq pH_3 \leq 6.3$
- $pH_3 > 6.3$

Carcass in the $pH_3 < 6.1$ group were considered to be glycolysing at a fast enough rate to avert cold shortening. The second group were considered intermediate and the third slow and susceptible to cold shortening (Honikel et al., 1983).

Carcasses were further grouped as follows, based on pHu:

- pHu <5.8
- 5.8 ≤ pHu ≤ 6.0
- pHu >6.0

The assumption was that muscles with pHu of less than 5.8 would have normal quality characteristics. Those with pH_{24} between 5.8 and 6 would be tougher and darker and above 6, the muscles would have the dark cutting condition (Figure 2.3).

Where meat quality traits significantly correlated to pH_3 or pHu, Kruskal Wallis one-way ANOVA was performed to test the effects of pH group and compare the means (BMDP, 1983). The Kruskal Wallis' test is used if normality assumptions are not justified but the populations from which the samples are drawn have the same general shape, though possibly different medians (Steyn, Smit, du Toit & Strasheim, 1994).

Additionally, LTL and SM myofibre properties (SL, MFL, myofibre type areas and proportions and calpastatin activity) were compared using the Wilcoxon rank sum test (BMDP, 1983). The same test was used to compare the effects of 24-hour and 96-hour chilling on SL, MFL, cooking losses, shear force and colour parameters. The Wilcoxon rank sum test has similar assumptions to the Kruskal Wallis' test but is used to compare two samples (Steyn et al., 1994).

Results of these analyses are presented in Chapter 5.

3.8.1.3 Effects of electrical stimulation on chevon quality

The Wilcoxon ranked sum test (BMDP, 1983) was used to compare carcass and meat quality characteristics of non-stimulated (NES) and electrically stimulated (ES) carcasses. The LTL and SM meat quality characteristics were no significant different between females and castrates. Furthermore the carcass characteristics of the two sexes were similar. Consequently, data of the two sexes were pooled for each muscle and the overall effects of ES on meat quality tested. The results are presented in Chapter 6.

3.8.2 Fatty Acid and Amino Acid Composition of Chevon

Means and standard deviations were computed for the proportions and concentrations of all fatty acids detected in the meat samples. GLM procedures as described in §3.8.1 were used to test the effects of sex, age, pre-slaughter conditioning and first order interactions on the fatty acid proportions and concentrations. The analysis was carried out on fatty acids that were detected in at least 70% of the samples.

Means and standard deviations of the amino acid concentration in defatted lean of milk-teethed kids, 2-to-4 teeth castrates and females and mature does were computed. Kruskal Wallis' test (BMDP, 1983) was used to test for the effects of the four goat groups on the amino acid content and to compare means. The results of these analyses are presented in Chapter 7.

3.8.3 Sensory Evaluation

Comparisons of carcass and LTL meat quality characteristics were made between the goat classes in each of the two series using Wilcoxon's ranked sum test. Kruskal-Wallis' test was used to compare cooking losses of the mutton and chevon samples in each of the series.

The main effects of gender, age, population category and level of education of the consumers' ratings of aroma, tenderness, flavour and overall acceptability were tested using GLM procedures of SAS (SAS, 1996). Overall acceptability was calculated as the average of the ratings of the three sensory attributes for each consumer. GLM procedures were also used to compare the sensory ratings and overall acceptability of each meat type. Where the F-test was significant, Tukey's test was used for the comparison of means.

Kruskal Wallis test was use to compare consumption intent scores of different consumer categories as well as for the different meat types within each category. Medians and percentiles of consumption intent are presented. Spearman's correlations between hedonic scores and consumption intent were computed.

Multiple comparisons of proportions was performed to compare preference for each of the meats within each series (Millers, 1981). Stepwise discriminant analysis was performed to determine the sensory attributes that drove preference.

The results of these analyses are presented in Chapter 8.