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## RESEARCH DESIGN AND METHODOLOGY

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### THE RESEARCH OBJECTIVES

The research objective formulated for this study was to determine the quality of selected raw and cooked wholesale cuts of South African lamb – carcass, nutrient and sensory attributes.

The specific objectives were:

1. To determine the carcass and cut (physical) composition of seven raw wholesale cuts of South African lamb of the A age class, representing five of seven fat classes.
2. To determine the nutrient content of the boneless portion of three selected raw and cooked wholesale cuts (leg, loin and shoulder) of South African lamb (A age, fat class 2 with an average of  $\pm 7$  % subcutaneous fat).
3. To determine the effect of fatness on meat quality (sensory attributes) of the loin cut of South African Dorper lamb.

### Assumptions

1. The left side of each carcass was considered to be identical to the **right** side.
2. The trained sensory panel evaluated each sample objectively and consistently.
3. Once the methods and techniques had been standardized during the preliminary study, each meat sample was treated identically throughout the project.

### Null hypothesis ( $H_0$ )

There will be no significant differences in the carcass, nutrient and sensory attributes of selected raw and cooked primal (wholesale) cuts of the A age class of South African lamb, when compared to current local South African and international data.

Alternative hypothesis ( $H_1$ )

There will be significant differences in the carcass, nutrient and sensory attributes of selected raw and cooked primal (wholesale) cuts of the A age class of South African lamb when compared to existing and international data.

## **PURPOSE OF THE STUDY**

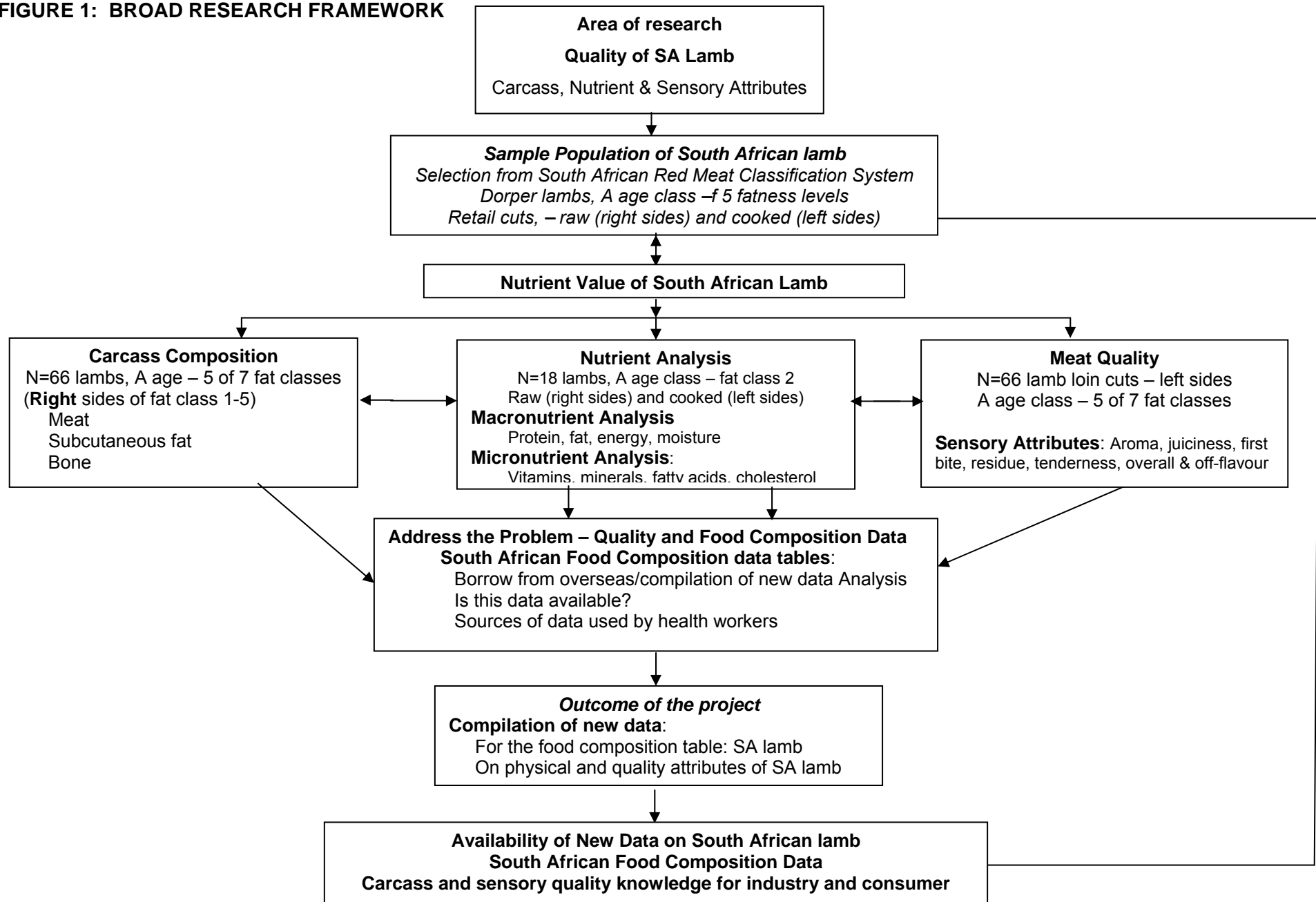
The purpose of the study was to describe the quality of South African lamb in terms of carcass, nutrient and sensory attributes. When the data of the nutrient content is incorporated into South African food composition tables, it will serve as a reliable standard reference to the users of these tables. The data will provide useful information to the red meat industry, the producers, the retail industry and consumers.

## **EXPERIMENTAL DESIGN**

The framework indicates the steps that were followed during the process of data collection, in an attempt to answer the research objectives posed. The design (Figure 1) clearly indicates the steps, methods and procedures of sampling, measurements, data-collection and data-analysis that were followed throughout the study in order to execute the study.

The research design can be described as an empirical design using an exploratory approach. It addresses the “what is the case?” and “what are the key factors?” and focuses on primary data.

**FIGURE 1: BROAD RESEARCH FRAMEWORK**



## CONCEPTUALISATION

Certain concepts are fundamental to this study and were identified from an extensive literature review conducted for the various components of this study (also see Chapters 3, 4 and 5). These concepts were defined as follows:

### Lamb and mutton

Lamb is the red flesh (muscle) of sheep slaughtered at a young age with white fat, a milder taste and finer texture than mutton. Mutton is the flesh of sheep older than 6 months also referred to as sheep meat. It has a deep red to purple colour and a stronger flavour with a coarser texture than lamb.

### Sample (sample population)

For this study, sample refers firstly to the animals that was selected namely A age class, fatness 1-5. Secondly it refers to the individual retail (wholesale) cuts that were selected and thirdly, to the three portions it was dissected in to viz. lean (meat), fat and bone.

### South African Red Meat Classification System for lamb and sheep

The Red Meat Classification System is especially designed to make the purchase of red meat (beef, lamb, sheep and goat) as simple as possible for customers. The main characteristics used to classify beef, lamb (for this study), sheep and goat carcasses, are the age of the animal and the fatness of the carcass. No actual age according to months can be given, as the age of these animals is determined by the number of permanent incisor teeth - the more permanent incisors, the older the animal. The age of an animal is considered to be an indication of the tenderness of the meat - the meat of younger animals is more tender than that of older animals.

The age classes are known as:

- A = meaning the youngest animals (0 incisors)
- AB = meaning older animals (1-2 incisors)
- B = meaning even older animals; (3-6 incisors) and
- C = meaning the oldest animals (7-8 incisors)

The fatness classes are known as class zero (no fat) to class 6 (excessively over fat). The roller mark on a carcass includes the age class (AAA, ABA, BBB or CCC) and the fatness class (000 (no fat), 111 (very lean), 222 (lean), 333 (Medium), 444 (fat), 555 (Over fat) or 666 excessively fat)). When referring to the class of a carcass, both the age class and fatness class are implicated (SAMIC s.a.).

According to the fatness classification of sheep, (National Department of Agriculture, 1990:9-14, in SAMIC s.a), the seven fat classes are described as follows:

Fatness class	Guideline for the determination of the thickness of the subcutaneous fat layer (mm)	Guideline for the percentage subcutaneous fat
0	Zero	Less than 1.0
1	Less than one	Not more than 5.6
2	At least 1 but not more than 4	> 5.6, but not more than 8.6
3	More than 4 but not more than 7	> 8.6, but not more than 11.6
4	More than 7 but not more than 9	> 11.6, but not more than 14.6
5	More than 9 but not more than 11	> 14.6, but not more than 17.6
6	More than 11	> 17.6

In this study, animals were selected from the A age class and fat class one to five of seven. No animals from the zero and six fat class were included.

### **Carcass (physical) composition**

The carcass composition done in this study, comprises the proportions of body tissue present in a carcass and it refers to the composition of the anatomical proportions of the various tissues e.g. meat (muscle plus inter- and intramuscular fat), fat (subcutaneous) and bone. Physical composition refers to either the carcass or the cut composition.

### **Subcutaneous fat (SCF) and Intermuscular fat (IMF)**

Subcutaneous fat comprises the peripheral layer of fat to the level of the connective tissue covering the peripheral muscle layer, but excluding *M. cutaneous trunci* which lies on top of the subcutaneous fat (Kempster, 1980:85). Intermuscular fat (IMF) was not analysed for this study but comprises of the fat lying between the muscles, together with thin connective tissue, small blood vessels and small quantities of muscle that are physically difficult to separate (Kempster, 1980:85).

### **Nutrition**

Nutrition is the science of foods and nutrients and the other substances they contain (Whitney & Rolfes, 2002:3, 5).

## **Nutrients**

Nutrients are chemical substances in or obtained from food and are used in the body to provide energy, structural materials and regulating agents to support growth, maintenance and repair body tissue. Nutrients may also reduce the risk of some diseases (Whitney & Rolfes, 2002:3, 5).

## **Nutritional value**

Nutritional value could be an indication of the quantity of a specific nutrient and its absorption or bioavailability of the nutrient from the food item (West & Schönfeldt, 2002:258). In this study the nutritional value (profile of nutrients) for three wholesale cuts were examined.

## **Nutrient analysis**

To determine the quantity of macro- and micronutrients in a sample. The macronutrients analysed (also called proximate analysis) for this study were the percentage water (moisture), fat, protein ( $N \times 6.25 = \text{protein}$ ) and ash (minerals). They were determined according to AOAC methods (2005). The energy (kJ / 100 g) for meat was calculated using the percentage protein multiplied by 17, plus the percentage fat, multiplied by 37 (Greenfield & Southgate, 2003:146). The micronutrients determined for this study were certain water soluble vitamins, minerals, fatty acids and cholesterol. The proximate analyses were done on the wholesale cuts (raw and cooked). No fat-soluble vitamins were analysed due to budget constraints.

## **Nutrient content**

Nutrient content refers to the variety of nutrients and their bioavailability in a food product (lamb meat). The nutrient value of a food can be expressed in terms of its content of nutrients and energy and how each relates to the Recommended Dietary Allowances (RDA) for that specific food (Whitney & Rolfes, 2002:3, 5).

## **Nutrient composition**

The nutrient composition of the food sample (in this case, lamb) consists of different levels of vitamins (fat- and water-soluble), minerals, fatty acid profile, total cholesterol and amino acid profile (total protein content).

## **Raw and cooked samples**

For this study, the terms can be defined as follows: Raw means that the meat is fresh and frozen and has not been exposed to heat. Cooked means, that meat has been processed by exposing it to heat. According to Paul and Palmer (1972:395) heat changes the composition of meat, due to the denaturation and coagulation of proteins, melting of fat, alterations in pH and in water-holding capacity as well as in chemical changes in heat labile compounds.

## **Dry heat cooking method**

It is the process that takes place when the meat is cooked without added water and with no lid on the pan so that moisture from the meat can evaporate. Roasting, broiling, pan broiling and frying are all dry heat cooking methods. Dry heat cooking methods are usually used for tender cuts of meat (Charley, 1986:406).

## **Moist heat cooking method**

Is the process where by meat is cooked in a covered utensil (saucepan, foil wrapping, or cooking bag), whether or not water is added, or the meat is cooked in the steam or liquid which is released from the meat as the protein coagulates. Braising and boiling in water are moist heat cooking methods. This cooking method is recommended for less tender cuts of meat (Charley, 1986:409; Cross, 1988:162).

## **Primal (wholesale) cuts for lamb and mutton**

In the South African meat industry, a sheep carcass is usually subdivided into the following primal (wholesale) cuts: neck, thick rib, flank, shoulder, breast rib, loin, chump, leg and shins (shank) and thereafter into retail cuts by the retailer. For this study the carcass was divided into the following seven wholesale cuts: neck, shoulder (plus shin), thick rib, breast, leg (plus shin), flank and loin. A large number of methods exist whereby carcasses (sheep) can be jointed (cut up). In the past, various efforts have been made to provide an internationally accepted, technical description of sheep carcasses. These studies have, however, been hampered by differences in consumer habits, in the definition of joints, in dissection methods and cooking methods (The cuts of a beef carcass, 1981:1). These differences occur between countries, or due to personal preferences and individual butchers, as well as consumer habits of the population groups in various geographical and economical areas.

## **Meat quality**

Meat quality is a comprehensive concept with different components that affect consumer decisions when purchasing meat. Relevant to this study is:

Carcass composition, visual appraisal - factors associated with classifying.

Eating quality: sensory attributes namely aroma, juiciness, tenderness and overall flavour.

Nutrient quality: proportions protein, vitamins and minerals relative to energy density and their biological availability (SAMIC, s.a.).

## **Food composition tables**

This is also referred to as the food composition database and consists of an alphabetical list of selected foods with data on the content of selected nutrients in each food. It also gives information on the portion, composite sample, collection and analysis of the composition of foods (Southgate, 1998: 264). The tables are organized according to the classification of foods into food groups (West & Schönfeldt, 2002: 250-251). From this study, the nutrient value of three raw and cooked lamb cuts will be available to be included in the South African food composition tables.

## **EXPERIMENTAL DESIGN**

### **MATERIALS AND METHODS**

Sheep meat is produced in all the regions of South Africa, except the far northern areas. Since South African lamb is mostly produced on natural pastures in semi-arid areas, certain breeds were specifically developed for these conditions. The two most important sheep breeds in South Africa are the Dorper and Mutton Merino breeds (SAMIC, s.a.)

The Dorper breed, a white-bodied sheep with a black head, was developed in the 1940's, in the Karoo region of South Africa, by crossing the imported Blackhead Persian (a fat-rumped hair breed that is adapted to harsh arid environmental conditions) and the British Dorset Horn (Snowder & Duckett, 2003:368). The Dorper breed is currently the second largest breed in South Africa and has spread throughout the world. A live weight of about 36 kg can be achieved by the Dorper lamb at the age of 90 - 120 days (3 - 4 months), with a carcass weight of approximately 16 kg (Breeds of livestock, 1999:1).

The South African Mutton Merino breed is a dual-purpose (mutton and wool) sheep breed, which was developed from an imported German Merino breed. It has adapted to most environmental conditions of South Africa. It was bred specifically to produce a slaughter lamb at an early age (35 kg at 100



days of age) and at the same time produces good volumes (4 kg) of medium to strong wool (Breeds of livestock, 1999:1). The breed is characterised by a high growth rate and produces slaughter lambs with good meat quality attributes (Neser, Erasmus & Van Wyk, 2000:172).

The lamb meat samples incorporated into this study, comprised of the most commonly consumed carcasses in South Africa (Van der Westhuizen, personal communication, 2003), namely the Dorper breed. Sixty six Dorper male and female animals from five fat classes were selected from two different abattoirs that slaughter carcasses for three production areas in South Africa namely the Karoo, Kalahari and Ermelo districts.

## SAMPLE AND SAMPLE PREPARATION

In this study lambs were raised intensively to different levels of carcass fat, to investigate the pattern of fat accumulation in different cuts, in accordance with the separation of carcasses in the South African classification system. Different groups of animals were drawn for various sections of the study, depending on the availability of funding.

### Carcass composition

#### Sample for carcass composition

Sixty six lambs (males and females) with an initial weight of between 23 - 26 kg were divided into three groups with equal mean weights (Table 1). The animals were randomly allocated to three slaughter groups (viz. 30, 36 and 42 kg). They were grain-fed fed in individual pens (1.5 m x 1 m) and slaughtered when reaching the target weight (30, 36 and 42 kg) in each slaughter group were on average, 90 - 120 days (4 - 6 months) old. All the male animals were slaughtered pre-puberty and no secondary male development had yet occurred. For this study the carcass was divided into seven wholesale cuts: neck, shoulder and shin, thick rib, breast, leg and shin, flank and loin.

TABLE 1: EXPERIMENTAL DESIGN FOR EVALUATION OF CARCASS AND CHEMICAL COMPOSITION OF SOUTH AFRICAN LAMB

Breed type	Dorper				
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	Carcass (7 primal cuts)				

## Sample preparation for carcass composition

Commercial slaughtering and dressing procedures were followed. On the day following slaughter, the chilled carcasses were sectioned down the vertebral column by band saw and one side (**right** side) subdivided into the following seven primal (wholesale cuts): neck, shoulder and shank, breast, rib, loin, leg (Figure 2) (Casey, 1982). The kidneys were removed and weighed for each carcass. The cuts were dissected into meat (muscle and intermuscular fat), bone and subcutaneous fat (SCF) in order to determine the physical (carcass) composition of each cut as well as cumulatively for the whole carcass. This was also done to determine the distribution of the various tissue types (% meat, % bone and % subcutaneous fat) in the carcass. The total soft tissue (fat and muscle) of the deboned side was used for proximate analysis (chemical composition) to determine the percentage protein, moisture, ash and fat (AOAC, 2005).

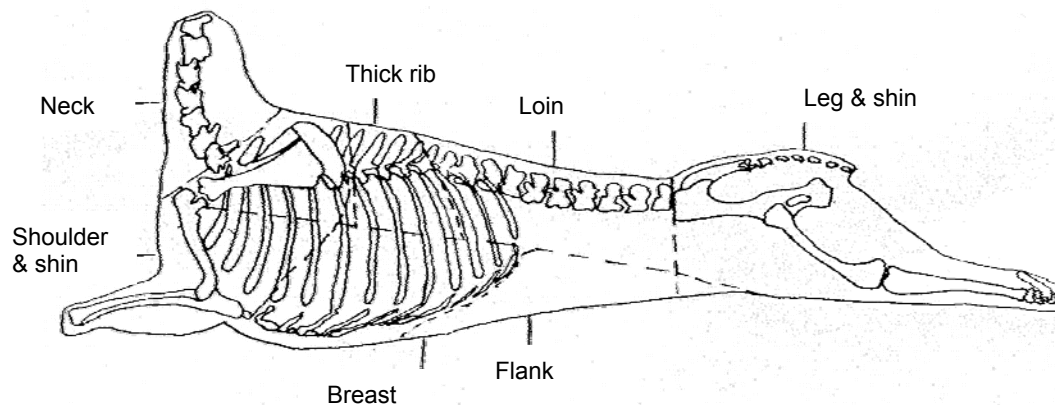


FIGURE 2: DISSECTION DIAGRAMME (CASEY, 1982:36)

## Nutrient analysis

### Sample for nutrient analysis

Three wholesale cuts (leg, loin, shoulder) of South African lamb (Dorper and Mutton Merino, from three regions) of an A-age group (0 incisors) with a fat code 2 (lean,  $\pm 7\%$  SCF) were selected (Table 2). The meat and fat of each of the three wholesale cuts of one side (**right**) were analysed for raw nutrient content and three wholesale cuts of matching side (**left**) were analysed for cooked nutrient content (proximate, vitamins, minerals fatty acid and cholesterol).

TABLE 2: EXPERIMENTAL DESIGN FOR NUTRIENT ANALYSIS OF SOUTH AFRICAN LAMB (A2 CLASS)

18 A, Age class, fat class 2 lamb carcasses – wethers					
9 Dorper			9 Mutton Merino		
Ermelo		Kalahari		Karoo	
3 Mutton Merino 3 Dorper		3 Mutton Merino 3 Dorper		3 Mutton Merino 3 Dorper	
6 <b>Right</b> sides Raw	6 <b>Left</b> side Cooked	6 <b>Right</b> sides Raw	6 <b>Left</b> side Cooked	6 <b>Right</b> sides Raw	6 <b>Left</b> side Cooked
Composite sample	Composite sample	Composite sample	Composite sample	Composite sample	Composite sample
<ul style="list-style-type: none"> <li>• Macronutrient analysis on meat &amp; fat of 7 cuts</li> <li>• Micronutrient analysis on meat, &amp; fat of 3 cuts</li> </ul>	<ul style="list-style-type: none"> <li>• Macro- &amp; micro nutrient analysis on meat, fat of 3 cuts</li> </ul>	<ul style="list-style-type: none"> <li>• Macronutrient analysis on meat &amp; fat of 7 cuts</li> <li>• Micronutrient analysis on meat, &amp; fat of 3 cuts</li> </ul>	<ul style="list-style-type: none"> <li>• Macro- &amp; micro nutrient analysis on meat, fat of 3 cuts</li> </ul>	<ul style="list-style-type: none"> <li>• Macronutrient analysis on meat &amp; fat of 7 cuts</li> <li>• Micronutrient analysis on meat, &amp; fat of 3 cuts</li> </ul>	<ul style="list-style-type: none"> <li>• Macro- &amp; micro nutrient analysis on meat, fat of 3 cuts</li> </ul>

### Sample preparation for nutrient analysis

The same procedure as for carcass composition was followed for the raw nutrient analysis namely: the lamb carcasses were sectioned down the vertebral column by band saw, chilled and subdivided into the following seven wholesale cuts: neck, shoulder with shank, breast (cranial and caudal), rib, loin, leg with shin). The **right** sides of all the carcasses were used to determine the proximate analysis (macronutrients analysed) on raw cuts.

Earlier work done by Kirton, Barton and Rae, (1962:383) has shown that the composition of either side of the carcass has a similar composition. To prepare the composite samples of 18 animals for proximate and nutrient analysis, the meat and fat, respectively, of all three repetitions for each raw cut, from the **right** sides, (n = 7 cuts) and three cooked cuts from the **left** sides, were combined and cubed, thoroughly mixed and then minced, first through a 5 mm and then through a plate with 3 mm diameter holes. Samples of 300 g meat and separable fat were homogenized with an Ultra Turrax T25 homogenizer after mincing and put into aluminium trays covered with a vacuum bag prior to the meat from being freeze-dried and sent of to the ARC analytical laboratory at Irene for proximate analysis (macronutrients analysed).

All the analytical procedures (Table 3) for the nutrient content of the lamb samples were done on a double blind basis in the various laboratories that form part of the South African National Accreditation Services (SANAS).

TABLE 3: METHODS USED FOR THE NUTRIENT ANALYSES OF RAW AND COOKED LAMB

Analysis	Method
Moisture (water)	Official Method 950.46 AOAC (2005)
Ash	Official Method 920.153 AOAC (2005)
Protein (N)	Official Method 992.15 AOAC (2005) (Dumas combustion)
Fat	Official Method 960.39 AOAC (2005) (Soxtec ether extraction)
Energy	Calculated (Atwater & Bryant, 1900)
Minerals	Ion Chromatography (IC) sub-contracted laboratory
Water-soluble vitamins	
B <sub>1</sub> , B <sub>2</sub>	High Performance Liquid Chromatography (HPLC) (Fellman et al. 1992)
B <sub>3</sub>	Official Method 961.14 AOAC (2005)
B <sub>6</sub>	Official Method ALASA 7.2.3
B <sub>12</sub>	Official Method AOAC 986.23 (2005)
Fatty acid profile	Gas Chromatography (GC) (Christopherson & Glass, 1969)
Cholesterol	Gas Chromatography (GC) (Smuts et al., 1992)

### Proximate analysis

#### Total fat

For determination of total fat, the AOAC method 960.39 (2005) was used where the content of a 2 g freeze-dried sample was used to ensure that all the moisture had escaped. The Tecator Soxtec System 1034 extraction unit with reagent petroleum ether (40-60 °C) was used for the extraction.

#### Moisture

For determination of moisture content the weight loss of a 5 g sample was measured in triplicate (AOAC, 2005).

#### Total ash

The total ash is the inorganic matter of a sample and analysed according to the AOAC method 920.153 (2005). The organic matter of a sample is removed by heating at 550 °C overnight. The remaining residue is inorganic matter (ash).

#### Protein

The analysis is based on the Dumas Combustion method, AOAC 992.15 (2005), which is approved, by the AOAC, AOCS, ASBC and the AACC. The sample is combusted at ± 1100 °C – 1350 °C and

10 cm<sup>3</sup> of the sample gas is analyzed. A thermal conductivity cell detects the difference in thermal conductivity caused by the presence of Nitrogen. A conversion factor of 6,25 was used in the calculation of the protein content. Duplicate samples were analysed.

### **Food energy content**

The energy content was calculated from the percentage protein and fat by using the following factors:

Energy (kJ / 100 g) = 37 (% fat) + 17 (%protein) + 17 (% Carbohydrates) (Atwater & Bryant, 1900)

### **Fatty acid profile**

A gas chromatographic method is used for the determination of long chain fatty acids. The fat extracts are trans-methylated with methanol-potassium hydroxide. Fatty acid methyl esters are extracted with n-hexane and analysed by gas liquid chromatography with flame ionisation detection. Nonadecanoic acid (C19:0) is used as internal standard (Christopherson & Glass, 1969).

### **Total cholesterol**

Fat and cholesterol are extracted by soxtec, followed by a saponification-extraction step and clean-up procedure. The cholesterol content is then determined by gas chromatography with flame ionization detection. Stigmasterol is used as an internal standard (Smuts et al., 1992).

### **Water soluble vitamins**

Thiamin (Vit B<sub>1</sub>) and riboflavin (Vit B<sub>2</sub>) were determined according to HPLC technique with fluorescence detection (Fellman et al., 1992). All analyses were performed in duplicate. Niacin (Vit B<sub>3</sub>) was determined according to a colorimetric method AOAC 961.14 (2005) and pyridoxine (Vit B<sub>6</sub>) according to an ALASA 7.2.3 method. Cyanocobalamin (Vit B<sub>12</sub>) was determined using a turbidmetric method AOAC 986.23 (2005).

### **Minerals**

The following minerals were determined: sodium, potassium, iron, magnesium and zinc. Freeze-dried samples were ashed, dissolved with hydrochloric acid and analysed with an Ion Chromatograph (IC) by a sub-contracted laboratory.

Three cuts, representing the most commonly consumed cuts (shoulder, loin and leg), from the **left** sides were used to determine the cooked nutrient composition. These cuts were vacuum packed and frozen for two months at -20 °C until the cooking process commenced. The leg, loin and shoulder

cuts from the **left** sides were cooked before they were dissected into meat (muscle, intramuscular fat), bone and subcutaneous fat (SCF) in order to determine the nutrient analysis (proximate, vitamins, minerals, fatty acids and cholesterol) in the cooked composite sample (**left** sides) of the carcass (meat and fat, respectively).

## Sensory analysis: Meat Quality

### Sample for sensory analysis

Bratzler (1971:344) mentioned that, because of the greater size and uniformity of the longissimus (dorsi and lumborum parts) of the loin section, it has been used most frequently for studies on meat tenderness and juiciness. Therefore the loin cuts (bone-in) containing the *M. longissimus lumborum* (M.LL) (the first lumbar vertebra to the last lumbar vertebra) of one side (left) of 66 Dorper wethers from the A age from five fat classes were used (Table 4). To achieve the five fat classes the lambs were fed intensively to three different live weights (30, 36 and 42 kg).

TABLE 4: EXPERIMENTAL DESIGN FOR EVALUATION OF SENSORY ANALYSIS ON THE M. LONGISSIMUS LUMBORUM (LOIN) CUT OF SOUTH AFRICAN LAMB

Breed type	Dorper				
Number of animals in study	66				
Sex of animals	Wethers				
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	M. longissimus lumborum cut of the <b>left</b> sides				

### Sample preparation for sensory analysis

Loin cuts were prepared and evaluated according to the American Meat Science Association research guidelines (AMSA, 1995:7 - 8) on the cooking and sensory evaluation measurements of fresh meat. The cuts were thawed over a 24 hour period at 4 °C before cooking. The samples were then prepared according to a standardized dry heat cooking method in identical Mielé ovens (Mielé ovens, model H217) at 160 °C to an internal endpoint temperature of 70 °C (45 minutes per kilogram). The dry heat cooking method entailed the oven roasting, of the meat uncovered on a flat open pan, with a rack to keep the meat out of the drip. No water (liquid) was added during cooking. A hand-held digital probe (model Kane - May 1012) was used to record the internal temperatures at the geometric centre of the meat according to the American Meat Science Association (AMSA, 1995: 7 - 8). Cooking losses were

measured as part of the standard procedure. A standing period of ten minutes at room temperature (centrally controlled at 22 °C), following cooking, was allowed for all the samples. Thereafter, the M.LL (loin) muscle was removed from the bone and halved (transverse) for sensory analysis and shear force measurements respectively. Ten cubed samples (10 mm x 10 mm x 10 mm cubes) were cut from the middle of the muscle and immediately wrapped individually in pre-coded (with 3 - digit random numbers) aluminium foil squares (9 cm x 9 cm). These samples, at an internal temperature of  $\pm 60$  °C, were served in a monadic sequential order (one at a time, consecutively) on pre-warmed plates to the trained sensory panel within 20 minutes from the time the cut was removed from the oven.

### **Shear force resistance measurement**

The remaining (half) portion of the sensory samples containing the M.LL were cooled overnight (12 hours) to a point where the internal temperature stabilized at 4 °C. The samples were 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, 1990) with a Warner-Bratzler shear device mounted on a Universal Instron apparatus. The reported value in kg force represents the average peak force measurement.

### **Sensory and taste panel procedures**

The purpose of quantitative descriptive analysis is to determine how samples (products) differ in specific sensory characteristics. An external trained sensory panel consisting of ten members was used for sensory analysis at the Meat Industry Centre (MIC). Potential candidates were recruited to take part in the research project. After a personal interview with each panellist, to establish his or her interest, availability for the entire project and health, the candidates were screened by determining the threshold of each panellist for the four basic tastes viz. sweet, sour, bitter and salt. The panel members were then selected to participate based on their ability to taste and smell (acuity), as well as their ability to evaluate meat sample attributes, i.e. tenderness, toughness and juiciness.

During a four-day training session (two hours per day), panellists received representative samples of each of the different treatments (fat codes) of Dorper loin samples (one at a time) and were trained in order to increase their sensitivity and ability to discriminate between specific samples and the sensory attributes of each (product) sample. A clear definition of each attribute (lexicon) was developed to describe the specific product attribute to be evaluated (Table 5).

A score sheet, with an eight-point category rating scale was used. Each sensory category attribute was verbally labelled, e.g. with one (1) denoting the least intense condition (e.g. extremely bland

aroma) and eight (8) denoting the most intense condition (e.g. extremely intense aroma) was constructed (Annexure 1) and used to evaluate the different samples (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. In order to ensure that panellists were not influenced in any way, no information regarding the nature of the samples was provided. Six samples were analysed on a blind basis during two sessions per day (three samples per session).

TABLE 5: DESCRIPTIONS 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. An aroma associated with cooked lamb that 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 that 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 biting into the meat 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	This is a 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, three - 3-digit coded samples representing the different treatments were served randomly (one at a time) to the individual panellists. 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. The ten panellists were seated in individual sensory booths to ensure unbiased objectivity and consistent responses, without being influenced by external factors. The samples were evaluated under red light conditions to mask possible colour differences. The sensory analysis facility used, is constructed with all the elements necessary for an efficient sensory program and is constructed according to the American Society for Testing and Materials (ASTM, 1989:15) design guidelines for sensory facilities. The samples were presented on a preheated (100 °C) glass plate. Water at room temperature was provided to cleanse the palate between samples. At each session, the panellists were instructed to evaluate the samples for the different sensory attributes.



## **DATA COLLECTION**

According to Mouton (1996:146), "The objective of data collection is to produce reliable data". Therefore the first step was to collect the raw data. For this research study raw data entailed capturing of weights of all carcasses and cuts onto laboratory reports by hand. The physical cut composition data was captured by hand on a physical dissection data sheet in the abattoir. Cooking data in the sensory laboratory was captured on a cooking form. The same procedure was followed by the analytical laboratory during the determination of the nutrient and chemical content of the samples. All raw data obtained was entered checked and coded on spreadsheets using Microsoft Excel (2000), before statistical analyses were done.

## **STATISTICAL ANALYSES**

### **Carcass composition**

Data was statistically analysed using the GenStat for Windows (2000) statistical computer programme. The significance of variables measured for each sample was tested by means of a one-way factorial analysis of variance (ANOVA) testing for fat class (unbalanced). Fat class (five) was used as the main effect and tested at a significance level of 99 % ( $p \leq 0.01$ ). If the sample main effect was significant, Fisher's protected t-test least significant difference (LSD) was applied to determine the direction of the differences between mean values (Snedecor & Cochran, 1980: 234-35).

### **Nutrient composition**

Nutrient data obtained from the analysis were entered on a spreadsheet using Microsoft Excel (2000). Data was statistically analysed by the ARC-Biometry Unit using GenStat for Windows (2003). The significance of all the variables measured for each sample was analysed using analysis of variance (ANOVA). The design was a split-plot design whereby the main effect of the cuts (whole plots) and treatments (raw and cooked – sub-plots), as well as the cut-by-treatment interactions were tested at the 5 % level of significance ( $p \leq 0.05$ ). If a main effect was significant, the Fishers' protected t-test Least Significant Difference (LSD) was applied, to determine the direction of the differences between mean values (Snedecor & Cochran, 1980: 234-35). A correlation matrix was constructed to test for significant correlations between attributes.

## **Sensory analysis: Meat quality**

The significance of all the sensory attributes measured for each fat class of the Dorper loin cut was tested by means of factorial analysis of variance (ANOVA), which tested the main effect of the sample and sensory attributes, as well as the sample-by-sensory attribute interactions at a 5 % level of significance ( $p \leq 0.05$ ). If the sample main effect was significant, Fisher's protected t-test least significant difference (LSD) was applied to determine the direction of the differences between mean values (Snedecor & Cochran, 1980: 234-35). A correlation matrix was constructed to test for significant correlations between attributes.

## **RESULTS**

In Chapter 3, the carcass composition is discussed (as composition) in terms of the subcutaneous fat, meat and bone that was determined by expressing the yield of each type as a percentage of the carcass side weight. The results of the analysis of variance (ANOVA) are presented in tables and then discussed. The results for the subcutaneous fat, meat and bone are presented in a bar graph for visual interpretation of results.

The nutrient analysis of South African A age class, fat class 2 is presented in Chapter 4. The results are discussed as raw and cooked lamb, as three raw and cooked cuts and their contribution to the Recommended Dietary Allowances (RDA). The results of the analysis of variance (ANOVA) are presented in tables and then discussed.

In Chapter 5, the sensory analysis on the loin cut of A age lamb, fat class 1-5 are discussed in terms of meat quality attributes. The results of the analysis of variance (ANOVA) are presented in a table and then discussed. The Principal Component Analysis (PCA) with the sensory results are presented in a scatter plot and discussed.

## **Reliability**

Reliability depends on consistency and this was followed by having the same abattoir and laboratory team working throughout the study. Accurate data recording was done by hand on data collection forms; captured on computer onto a spreadsheet and double-checked, before the statistical analyses were done. Nutrient analysis on raw and cooked lamb meat were conducted on a double blind basis in a SANAS accredited laboratory (ISO/IEC, no 17025:2005), according to standardized methods to ensure accuracy, precision, delectability, repeatability as well as reliability. The use of control samples forms part of the daily routine in these laboratories to assure the quality of results. Sufficient replications of each sample were also used to ensure statistically reliable data. A steering group of

external specialists were appointed to assess all the phases of the project and therefore unnecessary errors were limited. This process identified inconsistencies in the quality of the data and indicated possible problem areas in time. Training of people (abattoir team) during the pilot study ensured that all the criteria were met for reliability (Greenfield & Southgate, 2003:76). A proper statistical plan and analysis, in this case GenStat for Windows (2000) statistical programme were implemented during the study to ensure reliable results.

## **Validity**

Validity refers to the extent to which an empirical measurement provides adequate data that relates to the accepted meanings of particular concepts (Babbie & Mouton, 2002:123). Care was taken to ensure that the concepts were neither too complex nor vague. On the operational level, all sampling was representative and handled with utmost accuracy. A proper sampling plan was followed with representative samples from each area and sufficient replications of each sample were used to ensure statistically reliable and valid data.

Furthermore all the nutrient analyses were determined by a SANAS (South African National Accreditation Service) accredited laboratory on a double blind basis. All the analytical procedures (Table 1) for the nutrient content of the lamb samples were done on a double blind basis in laboratories (ISO/IEC 17025:2005) that forms part of the South African National Accreditation Services (SANAS). Control samples form part of the daily routine in these laboratories to assure the quality of results. Furthermore, all methods used for the nutrient analysis of lamb were validated. Finally in order to have been able to do a proper interpretation of the results, data were compared to findings in similar studies (literature) to substantiate the arguments.

## **Outcome of the study**

Various outcomes were envisaged for this research study:

- Firstly the data will be published in three scientific articles.
- Secondly, the nutrient data and information will be included in the Medical Research Council's food composition tables to be used primarily for the assessment and the planning of South African human nutrient intake. For example, this data will also be used in food assistance or food delivery in epidemiological and clinical research, in food monitoring for nutritional content and safety, nutritional status of populations and food manufacturing.
- Thirdly, the carcass composition and quality information should be put to use by the retailer to trim certain cuts to the acceptable fat proportion for the consumer. The knowledge will also inform the consumer and assist them to make informed decisions when purchasing meat.

- Booklets and informative articles will be published to communicate this information to the consumer.

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