Sensory assessments and consumers' willingness to pay for Karoo lamb versus Karoo mutton using an experimental auction approach

by

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Declaration

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Abstract

Farm profitability of sheep production systems in arid and semi-arid regions is mainly shaped by grazing conditions, production losses, and abattoir price per kilogram (R/kg). Current pricing arrangements in the meat market reflect a price differentiation based on the official Carcass Classification System and the age of the animal, with A2 and A3 lamb being sold at a premium to older and fatter animals. The South African meat industry is currently debating potential changes to the current Carcass Classification System. One of the arguments being that the current pricing and classification systems do not reward the carcasses that have higher quality and better sensory and cooking attributes.

The quality and consumer preferences related to sheep meat is the main focus of this study and is shaped in the context of the existing South African Carcass Classification System. Little research has been done to evaluate sensory characteristics and consumer acceptance of sheep meat as a basis for determining wilingness to pay (WTP) for sheep meat. The need therefore exists to investigate whether the older animals (i.e. AB, B and C classes) from the Karoo will also carry a similar superior quality perception amongst South African consumers. The overall objective of this study is two-fold: to evaluate the effect of the age of Karoo sheep on consumers' sensory assessments of the meat, and on their willingness to pay for Karoo sheep meat.

Sensory assessments were conducted by a consumer panel who were representative of South African lamb and sheep meat consumers. The sensory ratings were established by using a 9-point hedonic category scale. Three different lamb and mutton age classes were used in order to have a representative meat sample distribution. The A lamb (no permanent incisors), AB mutton (1-2 permanent incisors) and C mutton (more than 6 permanent incisors) carcasses with fatness level 2 were selected. In addition, both standardised and optimal cooking methods were applied for the three meat cuts (stew meat, loin and leg) used in this study.

A random *n*th-price auction mechanism with its favourable features was held amongst the same participants to test consumers' WTP for Karoo lamb and mutton. The auction was applied with a pre-auction survey to acquire participants' demographic information, purchase behaviour and prior knowledge and perceptions regarding lamb and mutton meat.

The sensory assessments and experimental auction were efficient in capturing consumer preference differences and WTP. The results indicated participants' sensory scores and WTP for three meat cuts within the three mentioned age classes. The stew meat cuts of the C class were most preferred. Furthermore, the AB class obtained the highest average bid price for the loin cut. The leg of lamb was most preferred in the standardised cooking method, but the leg of lamb and the AB leg were most preferred in the optimal cooking method.

This study highlights the acceptable quality attributes of the different cuts within each age class. The findings further indicate the importance of focusing marketing strategies toward specific meat cuts in order to optimally use and market a carcass in its given age class.

Opsomming

Die winsgewendheid van skaapproduksiestelsels op plase in droë en halfdorre streke word deur weidingstoestande, produksieverliese en abattoirprys per kilogram (R/kg) bepaal. Huidige prysreëlings in die vleismark weerspieël 'n prysdifferensiasie gebaseer op die amptelike karkasklassifikasiestelsel en die ouderdom van die dier met A2 en A3-lammers wat teen 'n premie teenoor ouer en vetter diere verkoop word. Die Suid-Afrikaanse vleisbedryf ondersoek tans moontlike veranderinge aan die huidige karkasklassifikasiestelsel. Een van die argumente wat geopper word, is dat die huidige prys- en klassifikasiestelsels nie die karkasse van hoër gehalte en met beter sensoriese en gaarmaak eienskappe, beloon nie.

Die gehalte en verbruikersvoorkeure wat met skaapvleis verband hou, is die primêre fokus van hierdie studie en word gevorm in die konteks van die bestaande Suid-Afrikaanse Karkasklassifikasiestelsel. Beperkte navorsing is tot hede gedoen om sensoriese eienskappe en verbruikersaanvaarding van skaapvleis te evalueer as basis vir die bepaling van verbruikers se bereidwilligheid om vir skaapvleis te betaal. ‘n Behoefte ontstaan om te bepaal of die ouer diere (d.w.s. AB, B en C grade) uit die Karoostreek ook 'n soortgelyke persepsie van hoë kwaliteit onder Suid-Afrikaanse verbruikers sal geniet. Die oorkoepelende doelwit van hierdie studie is tweeledig: om die effek van die ouderdom van Karooskaapvleis op verbruikers se sensoriese assesserings te evalueer, en hulle bereidwilligheid om vir Karooskaapvleis te betaal.

Die sensoriese beoordelings is deur 'n verbruikerspaneel uitgevoer wat verteenwoordigend was van Suid-Afrikaanse lam- en skaapvleis verbruikers. Die sensoriese tellings is vasgestel deur 'n 9-punt-hedoniese kategorieskaal te gebruik. Drie verskillende lam- en skaapouderdomsklasse is in hierdie studie gebruik om 'n verteenwoordigende verspreiding van vleismonsters te bereik. A-lam (geen permanente snytande), AB-skaap (1-2 permanente snytande), en C-skaap (meer as 6 permanente snytande) karkasse met vetvlak 2 is gekies. Daarbenewens is beide gestandaardiseerde en optimale kookmetodes vir die drie vleissnitte (stowevleis, lende en boude) wat in hierdie studie gebruik is, toegepas.

'n ‘‘Random *n*th-price auction” met sy voordelige eienskappe is op dieselfde deelnemers toegepas om verbruikers se bereidwilligheid om vir Karoo-lam en skaapvleis te betaal, te toets. Die eksperimentele veiling is met 'n voor-veiling opname toegepas om

deelnemers se demografiese inligting, aankoopgedrag en voorkennis en persepsies rakende lam en skaapvleis te verkry.

Die sensoriese beoordelings en eksperimentele veiling was doeltreffend om verbruikers se verskillende voorkeure en bereidwilligheid om te betaal, vas te lê. Die resultate het die deelnemers se sensoriese tellings en bereidwilligheid om vir die vleissnitte binne die drie genoemde ouderdomklasse te betaal, aangedui. Die stowevleissnitte van die C-graad het die meeste voorkeur geniet. Daarbenewens het die AB-graad die hoogste gemiddelde bodprys vir die lendesnit behaal. In die gestandaardiseerde kookmetode was die lamsboud vleismonster die meeste verkies, maar die lamsboud en die AB-graad het die meeste aftrek in die optimale kookmetode gekry.

Hierdie studie beklemtoon die aanvaarbare kwaliteitseienskappe van die verskillende snitte binne elke ouderdomsgroep. Die bevindinge dui verder op die belangrikheid daarvan om bemarkingstrategieë op spesifieke vleissnitte te fokus ten einde 'n karkas optimaal in sy gegewe ouderdomsklas te benut en te bemark.

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List of acronyms and abbreviations

ANOVA	Analysis of variance
av.	Average
BCFA	Branched chain fatty acids
BDM	Becker-DeGroot-Marschak auction mechanism
BFAP	Bureau for Food and Agricultural Policy
CLT	Central location test
cm	Centimetre
DAFF	Department of Agriculture, Forestry and Fisheries
EOA	Ethyloctanoic
FPM	Flavour Profile Method
g	Gram
GM	Genetically modified
HUT	Home use test
ID	Identification
IMCT	Intramuscular connective tissue
kg	Kilogram
KMOO	Karoo Meat of Origin
ℓ	Litre
LSM	Living Standards Measure
LT	Laboratory tests
Max.	Maximum
Min.	Minimum
ml	Millilitre
MLA	Meat & Livestock Australia
MNA	Methylnonanoic
MOA	Methyloctanoic acid
PAA	Profile Attribute Analysis

QDA	Quantitative Descriptive Analysis
RMAA	Red Meat Abattoir Association
RMIF	Red Meat Industry Forum
RMRD	Red Meat Research and Development South Africa
SAARF	South African Audience Research Foundation
SAMIC	South African Meat Industry Company
SEM	Socio-economic segmentation
SPSS	Statistical Package for Social Sciences
STATA	StataCorp's statistics and data software
U.S.	United States of America
WTP	Willingness to Pay

CHAPTER 1: INTRODUCTION

1.1 Background

Animal production contributes 46.5% to the gross value of agricultural production in South Africa (Department of Agriculture, Forestry and Fisheries, 2017). This includes intensive production systems such as poultry production, dairy and feedlots. A large part of South Africa's surface area consists of arid or semi-arid regions which are only suitable for extensive livestock production, being dominated by small stock such as sheep and goats. Current sheep numbers in South Africa are 24 million (RMIF, 2017), with 75% of this total located in three provinces; Eastern Cape, Northern Cape and Free State.

Farm profitability of these extensive sheep production systems in arid and semi-arid regions is mainly shaped by grazing conditions, production losses, and abattoir price per kilogram (R/kg). Current pricing arrangements in the meat market reflect a price differentiation based on the official Carcass Classification System and the age of the animal, with A2 and A3 lamb being sold at a premium to older and fatter animals. The South African meat industry is currently debating potential changes to the current Carcass Classification System, and it could be argued that the current pricing and classification systems do not reward those carcasses with better quality and better sensory and cooking attributes.

The quality and consumer preferences related to sheep meat are therefore the main focus of this study. The study is shaped in the context of the existing South African Carcass Classification System which was established to provide a framework for use by individuals trading in livestock to facilitate trade and promote competition. According to the South African Meat Industry Company (SAMIC), meat classification is used by meat traders to describe their carcasses in "simple terms for purchasing, the use of variety in the market for consumer satisfaction, determination of sales prices and price differences" (Red Meat Research & Development South Africa, 2014).

The Carcass Classification System classifies lamb, mutton, beef and goat carcasses based on a set of characteristcs outlined in the Standards Act no. 119 of 1990, mainly focusing on animal age and carcass fat content (Vermeulen et al., 2015). The animal's age is one of the most important components of the current Carcass Classification System as the age of livestock is believed to affect meat quality. Age classes are classified in

Table 1.1 into four groups, namely A (0 permanent incisors), AB (1-2 permanent incisors), B (3-6 permanent incisors) and C (>6 permanent incisors) (DAFF, 2015). Each age class is also classified into six separate fat codes, ranging from 0 (no fat) to 6 (excessively overfat). The Classification System only permits classification of meat based on age and fat categories. However, additional attributes such as tenderness, flavour and overall product quality are not guaranteed by the meat being certified as being of a specific class.

Table 1.1: Classification of red meat

Age	**Class**
0 Incisors	A
1-2 Incisors	AB
3-6 Incisors	B
More than 6 incisors	C
Fatness	**Class**
No fat	0
Very lean	1
Lean	2
Medium	3
Fat	4
Slightly overfat	5
Excessively overfat	6

Source: SAMIC (2018)

As a result, the price determination of meat is largely based on the Classification System. The price per kilogram (R/kg) for carcasses received by farmers is based on weekly market prices. Furthermore, local auction prices are used to verify these prices and the "5th quarter" (hides and offal), also has an influence on the net return of a carcass (Van der Merwe, 2012). There is a substantial price difference between different classes of meat in the market. The average selling prices indicated by the Red Meat Abattoir Association (RMAA) for lamb and mutton as at 11 February 2018 are displayed in Table1.2.

Table 1.2 reveals a R7.60 price difference between the A2 and B2 classes as well as a R8.26 difference between the A3 and B3 classes. If the price of A2 lamb is compared with C2 mutton's, a R14.67 price difference is found. Class A meat therefore enjoys a higher market price than the AB, B and C classes as a result of having zero permanent incisors. The long-term trends for lamb and mutton prices also reflect these price differences, as depicted in Figure 1.1. This figure indicates the selling prices of the abattoirs to the meat trade. A continuous price difference can be seen over a four-year period between classes A2/A3, B2/B3 and C2/C3, where A2/A3 obtained the highest market prices. The question therefore is whether these price differentials are justified from the consumer's point of view and whether it reflects the true quality differentials between the different classes.

Table 1.2: National South African price information for lamb and mutton Week 10 (2018) (R/kg)

Class	Units	Av. mass	Av. purchase	Av. selling	Selling min.	Selling max.
A0	19	15,38	49,76	53,91	46,00	61,58
A1	239	14,41	66,71	66,59	62,44	69,50
A2	5660	21,54	71,35	71,51	70,20	74,35
A3	1081	24,48	72,18	71,24	70,31	74,31
A4	216	25,72	62,37	63,18	60,47	68,52
A5	36	25,53	51,86	52,92	43,58	60,88
A6	68	26,86	50,42	51,40	50,73	51,55
AB2	263	20,84	63,28	66,32	63,86	67,39
AB3	33	24,39	61,31	65,65	63,98	67,71
B2	110	22,46	64,04	63,91	59,10	64,99
B3	21	24,88	58,60	62,98	54,06	65,00
C2	1253	22,55	57,66	56,84	52,98	60,59
C3	212	25,58	52,93	57,36	54,09	64,00

Source: RMAA (2018)

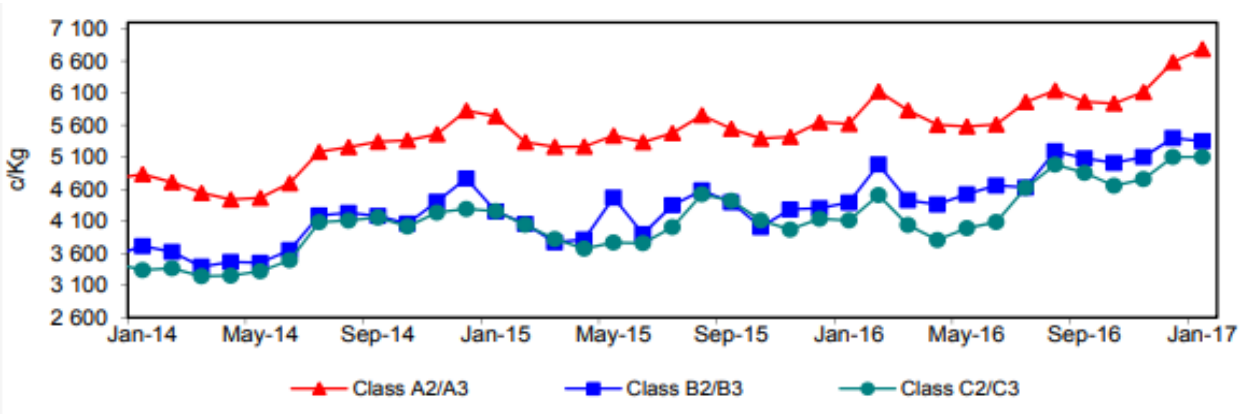

Figure 1.1: Long-term trends in lamb and mutton prices

Source: Red Meat SA (2017)

1.2 Quality perceptions

Quality is a critical factor when evaluating consumers' perception of food products. From the perspective of the consumer, quality refers to perceived quality, which is a perception process that may have different meanings for various people (Oude Ophuis & Van Trijp, 1995). Consumers use indicators of quality to determine their perceptions towards the quality of the product. The measurability of food quality is multifaceted as it depends on various product characteristics.

Becker (2000) defines product characteristics as "those features of a product which are used as technical indicators for product quality and are measurable with standardised analytical and sensory methods". They can further be classified into four categories, found in the literature of meat science: product characteristics indicating the nutritional value (for example protein, fat and carbohydrate content); characteristics indicating the processing quality (e.g. shear-force and sarcomere length); characteristics indicating the hygienic-toxicological quality (e.g. residues, contaminants); and characteristics indicating the sensory quality (e.g. tenderness, juiciness and flavour) (Becker, 2000). The nutritional, processing and hygienic-toxicological evaluation of meat relies primarily on laboratory methods, while the sensory studies rely on consumer and trained panels.

Steenkamp's (1990) conceptual model describes the consumers' quality perception process of a product during purchase decisions. A distinction is made between quality attributes and quality cues.

Quality attributes consist of search, experience and credence attributes. Search attributes can be identified immediately by consumers before purchase, such as the colour, price, label and country of origin. Experience attributes can be identified during consumption such as the taste, tenderness and juiciness of the meat. Credence attributes are intangible and are not accesible during the purchase process or through consumption. Consumers have to rely on the information of additional stakeholders to evaluate the product, for example word of mouth and information provided on labels (Northen, 2000; Vermeulen, Schönfeldt & Pretorius, 2014).

Quality cues can be determined by consumers' senses prior to consumption. Perceived quality, as reflected in Figure 1.2, is based on quality cues which are used to predict attributes. Consumers come into contact with these cues before consumption while making a purchase decision. Two types of quality cues exist: intrinsic and extrinsic (Oude Ophuis & Van Trijp, 1995; Becker, 2000; Henchion, Mccarthy, Resconi, & Troy, 2014).

The intrinsic cues are part of the physical product, for example the colour of the meat, and include experience attributes such as taste, tenderness and juiciness (Vermeulen, Schönfeldt & Pretorius, 2015). One of the most important determining factors of choice is the extent to which the experience attributes of meat influence the consumer. Davel, Bosman and Webb (2003) argue that consumers consider tenderness as the most important determinant of meat quality. In addition, Andrade, Sobral, Ares and Deliza (2016), and Van Wezemael, De Smet, Uealand and Verbeke (2014) indicate that tenderness and juiciness are quality attributes that positively influence consumers' preferences for lamb.

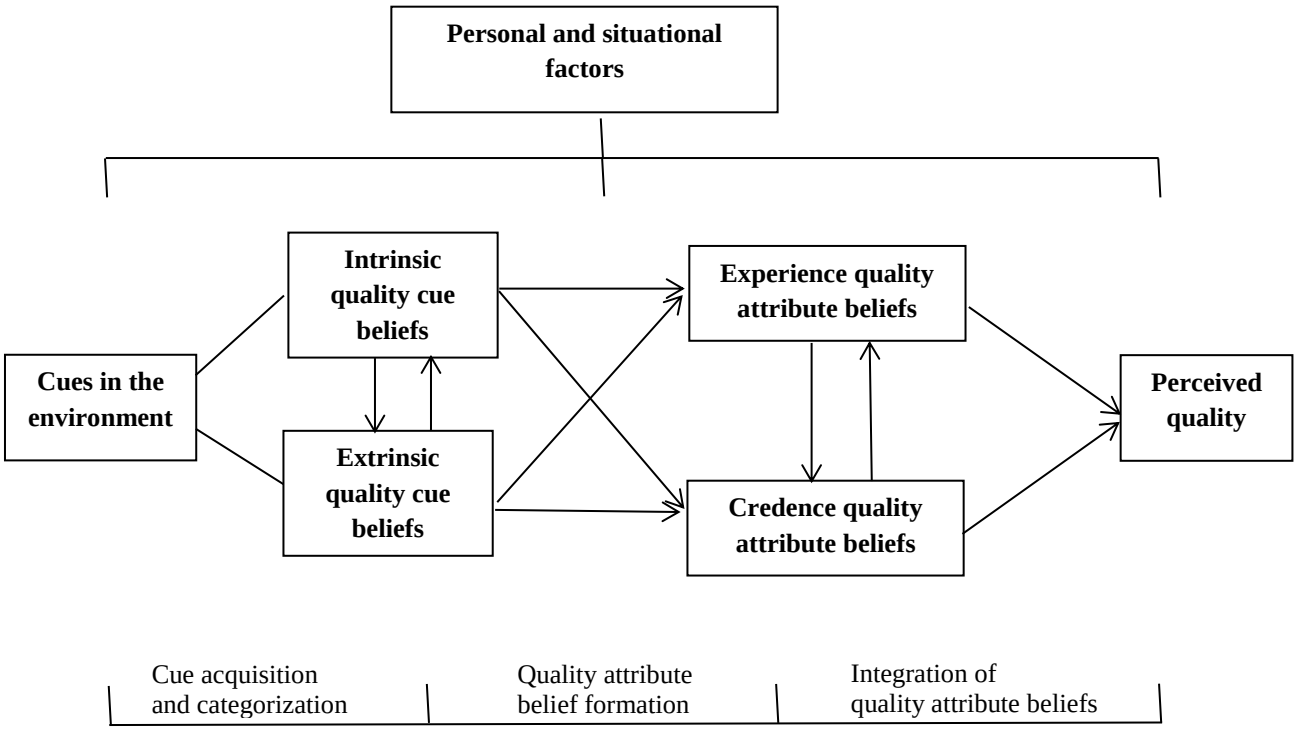

Figure 1.2: Conceptual model of the quality perception process

Source: Steenkamp (1990); Oude Ophuis & Van Trijp (1995)

Meat tenderness can be measured objectively by laboratory instruments, and subjectively by means of sensory analysis such as professional and consumer taste panels. Another important element highlighted in other studies which resembles quality is the taste, and therefore the flavour, of meat. Flavour is, next to tenderness, one of the most important determinant factors in a consumer's perception of quality (O'Sullivan & Kerry, 2009; Watkins, Kearney, Rose, Allen, Ball, Pethick & Warner, 2014; Khan, Jo & Tariq, 2015). Meat's flavour is thermally derived, since uncooked meat has only a blood-like taste with little or no aroma (Mottram, 1998). Thermal decomposition occurs between non-volatile components of lean and fatty tissues during cooking, which results in various reactions (Mottram, 1998). The volatile compounds formed during cooking are therefore responsible for and contribute most to the characteristic flavours of meat (Mottram, 1998). The flavour precursors can be measured and identified by means of chemical analyses as well as laboratory and consumer taste panels.

Extrinsic cues, on the other hand, are related to the product but not physically part of it, such as price and label of origin (Oude Ophuis & Van Trijp, 1995; Sepúlveda, Maza & Mantecon, 2010). The price and label of origin contribute to the perception of quality and influence consumers' purchase decisions (Lange, Rousseau & Issanchou, 1998; Font-i-

Furnols, Realini, Montossi, Sañudo, Campo, Oliver, Nute & Guerrero, 2011). According to Oude Ophuis et al. (1995), price is one of the best-known extrinsic indicators of quality. In addition to price as a determinant choice factor, other aspects such as health and perishability may also affect consumption. Vermeulen et al. (2014) studied consumers' concerns regarding red meat among three different income classes. Figure 1.3 below indicates that affordability is the overall key concerning factor in all of the marginalised, emerging and established income groups.

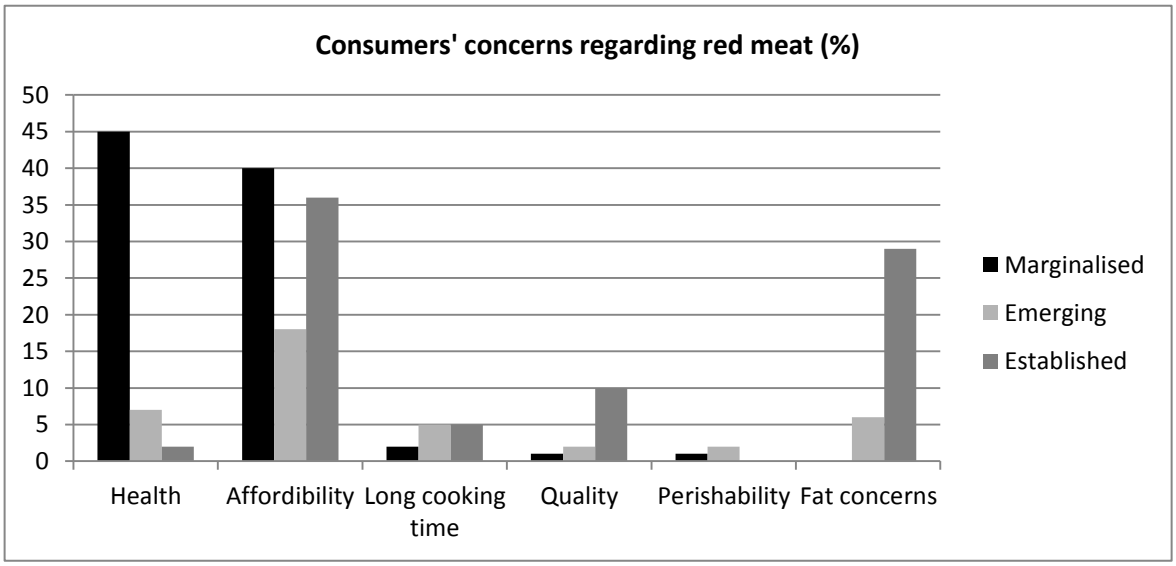

Figure 1.3: Consumers' concerns regarding red meat (%)

Source: Adapted from: Vermeulen et al. (2014)

In addition, Sepúlveda et al. (2010) evaluated quality aspects at the time of purchase and found that price was one of the most important aspects that consumers take into account when evaluating the quality of lamb. They indicated that consumers and producers equally value direct appraisals as the most important determinant factor of quality. Both consumers and producers also considered meat quality labels as a key determinant in evaluating quality. Meat labels are defined as "*a credence attribute as it cannot be evaluated before or during consumption of the product*". It can only be evaluated by the information provided by the label. Meat labelling became increasingly important to consumers as it delivers messages about the safety and wholesomeness of the product, such as product specific nutrient information (hormones, antibiotics, fat or cholestrol) (Gellynck, Verbeke & Vermeire, 2006).

The experience attributes; taste, tenderness as well as juiciness of meat, are highly correlated with overall experience quality, purchase intention and willingness to pay (Font-i-Furnols & Guerrero, 2014). The value consumers attach to specific product characteristics are therefore important and has to be measured. In addition, the level of consumers' acceptance towards the particular experience atttributes will influence consumers' willingness to pay for the product. In order to quantify the value consumers attach to a particular attribute, the willingness to pay (WTP) for a product attribute is obtained. It is therefore important to measure the actual monetary value consumers place on quality attributes in order to elicit consumer perceptions and preferences. A study to measure the effects of extrinsic factors, and consequently how they interact with the perception of intrinsic product characteristics, is therefore imperative (Lange et al., 1998).

1.3 Consumer perceptions related to meat quality

Meat quality is a complex concept which can be measured both objectively by means of laboratory instruments and subjectively by consumer sensory panels. It is essential to evaluate consumer perceptions toward product characteristics in order to correctly position a product in the market.

Tenderness, juiciness and flavour are three of the most commonly-used attributes to determine meat quality during consumer sensory assessments. At present, it is still believed by consumers that tenderness is influenced by the age of the animal. Aging is largely associated with tougher meat (Dreyer, Naude, Henning & Rossouw, 1977), and consumers therefore prefer the meat of younger animals. It is generally assumed that meat from older animals has a reduced consumer acceptance; however, older animals have more intramuscular fat which makes the meat more flavourful (Pannier, Gardner, Ball & Pethick, 2015). Flavour intensity consequently increases concomitantly with animals' age. The effect of animal age on meat tenderness has been investigated by several studies, but the results differ. Firstly, a number of studies reported a decrease in meat tenderness with an increase of animal age (Hiner & Hankins, 1950; Reagan, Carpenter & Smith, 1976; Shorthose & Harris, 1990; Pethick, Hopkins, D'Souza, Thompson & Walker, 2005; Schönfeldt & Strydom, 2011; Moholisa, Hugo, Strydom &

Van Heerden, 2016), while another have found an increase in tenderness as the animal ages (Duckett, Snowder & Cockett, 2000).

Meat & Livestock Australia (MLA) in turn studied the effect of animal age on sensory experience with consumer tastings of grilled lamb and mutton cuts. Figure 1.4 substantiates the current argument by indicating that tenderness and juiciness scores decrease as sheep age increase while flavour gradually increases as sheep age increases (Meat & Livestock Australia, 2012).

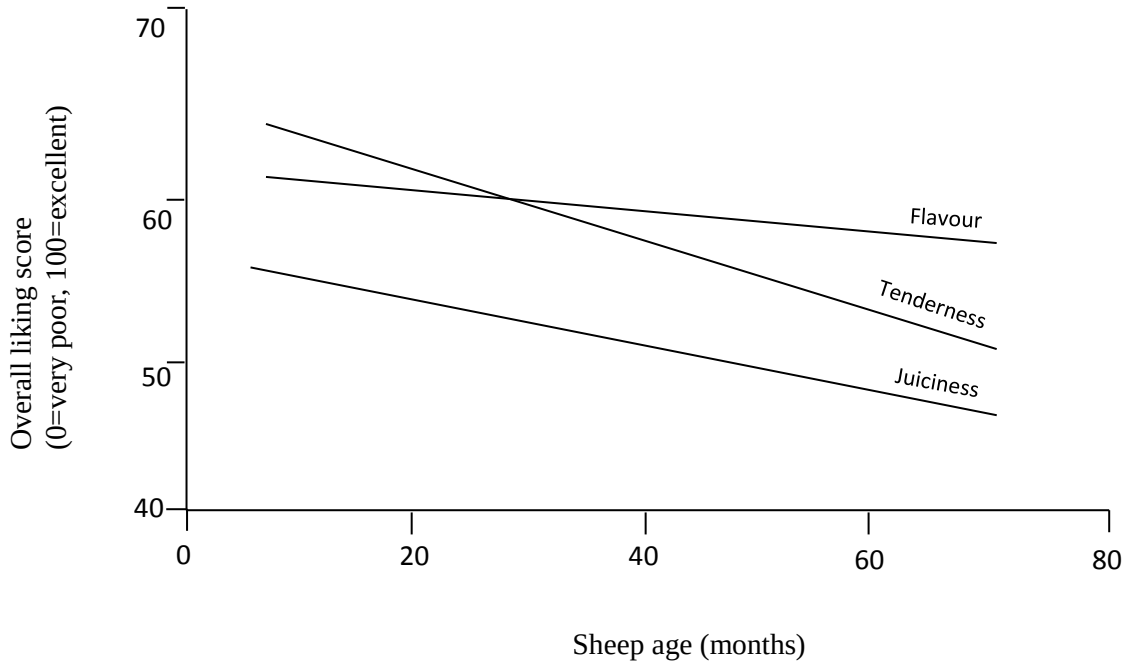

Figure 1.4: Change in eating quality attributes with sheep age

Source: Used from: MLA (2012)

The study argues that a perception problem arises regarding the relationship between the age of the animal and the quality of meat. Consumers perceive meat of class A-carcasses, which enjoy higher market prices, to have the best quality compared to the other age classes. The AB and B classes can have erupted permanent incisor teeth by the time they reach slaughter weight and thus cannot be classified in the A lamb category. However, sheep in the age bracket of 12-24 months (AB and B classes) may still produce consumer- acceptable eating-quality meat. In fact, Pannier et al. (2015) studied the impact of Australian Merinos' age on consumer sensory scores and found no significant difference in sensory scores of grilled loin samples between lamb of 8.5 months and

yearlings of 20 months. They concluded that the loin from yearlings has a similar acceptability to lamb among Australian consumers. In addition, Bruwer (1984), concluded in his study that there are no significant differences in terms of meat quality characteristics, i.e. juiciness, taste and total collagen, between the A and B classes. Given the change in tenderness and flavour of sheep meat as animals age, it is important to obtain consumer sensory information in order to determine the final consumer acceptance of sheep meat in a commercial context.

1.4 Problem statement

The preliminary investigation of this study showed that, while there is a large literature on the sensory and chemical aspects of lamb and mutton in general, academic work focusing on the relationship between the age and consumer sensory assessments of sheep meat is limited. A handful of studies set out to determine the effect of age on the sensory and chemical differences of sheep meat (Sink & Caporaso, 1977; Schönfeldt, Naude, Bok, Van Heerden, Sowden & Boshoff, 1993; Jeremiah, Tong & Gibson, 1998; Watkins, Rose, Salvatore, Allen, Tucaman, Warner, Dunshea & Pethick, 2010; Channon, Lyons & Bruce, 2003; Veiseth, Shackelford, Wheeler & Koohmaraie, 2004; Pethick et al., 2005; Pannier et al., 2015), while, in the case of commodities in the agro-food industry, other studies conducted sensory evaluations and experimental auctions simultaneously in order to investigate consumers' willingess to pay (Feuz, Umberger, Calkins & Sitz, 2004; Kiria, Vermeulen & De Groote, 2010; Drichoutis, Klonaris & Papoutsi, 2017). However, little work has been done to evaluate sensory characteristics and consumer acceptance of sheep meat as a basis for determining their wilingness to pay for it.

Leighton, Schönfeldt, Van Zyl, Van Heerden, Van Niekerk and Morey (2007) have also used sensory tests and chemical analyses to establish differences related to the origin of lamb and sheep meat in South Africa. Clear differences in taste and general sensory profiles were found between regions, with the Karoo region showing superior sensory attributes. In separate studies (Van Zyl, 2011; Van Zyl, Vermeulen & Kirsten, 2013; Hurter, 2018), researchers tested the evocative value of the Karoo region (its open spaces, pristineness and nostalgia) by means of experimental auctions, and thereby obtained a sense of consumers' willingness to pay a premium for lamb from the Karoo. At this point, no study has been conducted to test whether the older sheep (AB, B and C classes)

from the Karoo will also carry a similar superior quality perception amongst South African consumers.

Older animals, in this case mutton, have the potential to increase its share of the commercial market. However, as the preliminary investigation of this study has shown, it is generally assumed that meat from older animals enjoys reduced consumer acceptance. Therefore, additional academic work that explores ways to determine consumer perceptions of the quality of mutton is required (Pethick et al., 2005; MLA, 2012; Pannier et al., 2015). This study sought to fill this gap by conducting comprehensive sensory evaluations of Karoo sheep meat in the A, AB and C classes by means of consumer sensory assessments, in conjunction with an experimental auction, to determine consumers' WTP. These three classes were selected as the main focus in order to fully investigate the effect of age on consumers' acceptance of Karoo sheep meat. This study therefore sought to address the issue of whether the quality attributes between the mentioned classes are equivalent, and whether the reason for a price discount at the abbattoir for these respective classes can be questioned. The red meat industry will consequently have to adress the critical question of whether the current Carcass Classification System's categories are adequate and clearly linked to consumer preferences.

1.5 Research objectives

The overall objective of this study is two-fold: to evaluate the effect of the age of Karoo sheep meat on consumers' sensory assessments, and to measure their willingness to pay for Karoo sheep meat.

The specific objectives that underpin the overall objective of this study include:

1. Determine consumer sensory acceptance of different meat classes.
2. Test the impact of sheep age on consumer sensory scores.
3. Test the design and application of a random *n*th-price experimental auction on a niche agricultural product.
4. Determine if there is a difference in consumers' willingness to pay for class A, AB and C Karoo sheep meat.
5. Analyse the possible correlations between the consumer sensory scores and

consumer bidding behaviour for the respective classes of Karoo sheep meat.

1.6 Scope and limitations of the study

The scope of this study was limited to evaluating three sheep meat classes, namely A, AB and C, which implies that in terms of the South African Carcass Classification System, the B class was not considered due to unavailability. Secondly, this study did not analyse the chemical and sensory qualities of sheep meat by laboratory experiments, as this study is a consumer behaviour study. The scope would have been too broad if considered in conjunction with consumer behaviour traits and experimental economics. Thirdly, the geographic scope of this study was limited. The sheep meat was derived from the Karoo region, more specifically one certified Karoo Meat of Origin (KMOO) producer, who provided all three age classes for standardisation purposes. The consumer panel who participated in the experimental auction were also from specifically demarcated areas, namely the Cape Winelands district and the City of Cape Town metropolitan area.

1.7 Research strategy

An in-depth literature review was conducted, during which the effect of age on sensory and chemical differences between lamb and sheep meat was firstly discussed. Thereafter, experimental economics were discussed with specific reference to different methods of experimental auctions. Examples of previous studies were highlighted, dealing with the relationship of consumer sensory evaluations together with experimental auctions.

Following the literature review, primary data was collected by a written pre-auction survey on the day of the experiment. This information was solely used to arrive at a better understanding of participants' demographic composition. This was followed by a blind tasting at which consumers scored samples of meat based on tenderness, juiciness, flavour and overall liking on a 9-point hedonic scale (1 representing the least favourable condition and 9 the most favourable). A random *n*th-price auction was identified as the auction mechanism to be used in this experiment. The random *n*th-price auction

commenced after the consumer blind tastings and sensory assessments to determine consumers' WTP.

Lastly, the data was analysed for findings to emerge and possible correlations to be made under each research objective.

1.8 Chapter outline

Chapter 1 provides the introduction to the thesis, presenting the background, rationale for the study, problem statement, research objectives, scope and limitations of the study and the research strategy.

Chapter 2 consists of a literature review. The chapter opens with a review on the effect of age on sensory and chemical differences between lamb and sheep meat. The chapter continues with methods used to measure consumers' WTP for quality characteristics, with the focus on experimental auctions. This chapter also provides a review of previous studies dealing with the relationship of consumer sensory evaluations together with experimental auctions.

Chapter 3 provides the research design and methods used in this study. The application of the cooking methods, sensory evaluation method, the specific experimental auction and the random *n*th-price auction mechanism, are discussed in detail. Chapter 4 indicates a detailed analysis of the pre-auction survey and the consumers' sensory score results. Chapter 5 presents the results of the experimental auction and the multiple regression analysis of the sensory evaluations and participants' WTP. Chapter 6 serves as the concluding chapter. The aim of this chapter is to discuss the major findings, implications, shortcomings as well as their relevance in practice. The chapter concludes with recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A theoretical framework was created for this study, in which the first theme constituted the effect of animal age on sensory and chemical differences between lamb and mutton meat quality. Meat quality consists of combined quality parameters. Perceived quality is dependent on cues which are used to predict product attributes. Quality parameters depend on these cues, which are divided into intrinsic and extrinsic cues (Northen, 2000). Intrinsic cues are inherent to the animal and thus include factors such as animal age, sex, breed, carcass composition and nutrition. Extrinsic cues are dependent on the management of the product, for example information labels on the product, pre- and post-slaughter handling, and storage (De Lima Jùnior, de Carvalho, da Silva, Rangel, Novaes & Difante, 2016). The study will however predominantly focus on one intrinsic factor which influences the quality of sheep meat, namely the age of the animal.

A further discussion on sensory evaluation techniques is required as the second theme in the literature review. The demarcation of sensory evaluation tests is given, with an explanation of each sensory test.

The final theme of this chapter investigates how consumers value products in the market. Previous literature on methods used to establish consumers' preferences and willingness to pay for different food products is reviewed. The discussion progresses to the application of experimental auctions, and summarises it by considering the relationship between experimental auctions and consumer sensory evaluations.

2.2 The effect of physical and chemical differences in lamb and mutton meat quality

The difference in sheep meat quality at different ages is a result of the changes in the carcass composition and its relationship to physical and chemical aspects of meat (De Lima et al., 2016). Physical aspects relate to the tenderness of meat, whereas chemical aspects include the juiciness and flavour of meat. Consumers' eating satisfaction results from the interaction of these three independent components of tenderness, flavour and juiciness of cooked meat. The physical elements which encompass meat tenderness are

firstly discussed. Secondly, the chemical elements which encompass the flavour and juiciness of meat, will be examined.

2.2.1 Physical evaluation

Muscles consist of three protein fractions, namely myofibrillar, connective tissue and sacoplasmic proteins (Tornberg, 2005). The variation in tenderness among muscles can be explained by changes in the concentration of these protein fractions. Tenderness depends mainly on the the structure and state of the myofibrils as well as the contents and state of the connective tissue (Dutson, Hostetler & Carpenter, 1976).

Muscle fibres are the building blocks of striated muscle. The striated appearance of muscle is caused by the structure of myofibrils. The state of the myofibrils, which are subject to the process of proteolysis, explains most of the variation in tenderness of the *longissimus* muscle (Koohmaraie et al., 2002).

Intramuscular connective tissue (IMCT) is responsible for the background toughness of cooked meat (Hopkins, Allingham, Colgrave & Van de Ven, 2013; Bekhit, Carne, Ha & Franks, 2014). Collagen, as the main component of the IMCT, forms the structural framework of muscle tissue (Nishimura, Ojima, Liu, Hattori & Takahashi, 1996). Collagen molecules are bound together through intermolecular crosslinks (McCormick, 1994), and the amount and structure of collagen crosslinks together with elastin are tested in cooked meat as it greatly influences meat toughness. These crosslinks deteriorate with age to less soluble crosslinks, which results in meat toughness (McCormick, 1994). While this component is not influenced significantly by post mortem processing and handling, it can be affected by cooking, and the degree of temperature while cooked. Meat containing a higher concentration of connective tissue will, therefore, be less tender, depending on the nature of the connective tissue and the cooking conditions (Purchas, 2014). The extent of connective tissue concentration is also muscle dependent and is a main contributor of tenderness of the *biceps femoris*[1].

Approaches to measure meat tenderness include mechanical devices such as the widely-used Warner-Bratzler shear force device and sensory analyses such as taste panels. Mechanical devices are used to measure the forces needed to penetrate the meat to a

[1] The muscle located in the hindlimb of the carcass.

certain degree. The changes in the force together with movement are measured and the final outcome is registered as the peak force required to complete the test which is indicative of meat tenderness (Purchas, 2014). Alternatively, sensory taste panels are conducted by a gathering of people to assess the level of tenderness based on meat samples. According to Purchas (2014), sensory panels are the ultimate test because in addition to physically testing the tenderness of the meat through a taste test, they represent people's perceptions towards tenderness.

Several studies investigated physical and chemical interventions to improve the tenderness of meat. Dutson et al. (1976) indicated in their study that connective tissue content plays a role in the overall tenderness of meat. In addition, Schönfeldt et al. (1993) supported this by indicating that the higher the soluble collagen content, the more tender the meat. In contrast, Hopkins et al. (2013) investigated the interrelationship between measures of collagen, compression, shear force and tenderness and demonstrated that the collagen concentration did not relate to shear force or sensory tenderness.

It is believed that the age of an animal has a significant impact on the tenderness of meat. Several studies have investigated the relationship between animal age and tenderness. An increase in animal age is generally associated with a decrease in tenderness. Reagan, Carpenter and Smith (1976) concluded that percentages of soluble collagen and shear force values were correlated with the chronological age of the animal. In addition, Schönfeldt et al. (1993) evaluated sensory characteristics, shear force resistance and collagen measurements of muscles influenced by three age classes and reported a consistent trend for the meat of lambs to be more tender than that of B and C age groups. Their findings were supported by shear force values and a taste panel. Higher concentrations of IMCT content, which increase meat toughness, were found in older animals, as indicated by Purslow (2004). Veiseth et al. (2004), however, indicated that collagen concentration per gram (g) of cooked muscle was not affected by lamb age. Similarly, the findings of Devine, Graafhuis, Muir and Chrystall (1993) showed that there are also minor differences between the age and tenderness of young and older lambs ranging up to 14 months.

2.2.2 Chemical evaluation

Flavour and juiciness are the main chemical factors that have an influence on meat quality. Several ante- and post-mortem factors affect the development of meat flavour. Ante-mortem factors include age, gender, breed, nutrition and animal composition (Schönfeldt & Strydom, 2011), while post-mortem factors include the ultimate pH, aging and cooking method. The aroma and flavour of meat are mainly developed through heating, where volatile compounds form during cooking and are responsible, and contribute to, most of the characteristic flavours of meat. A complex series of thermally-induced reactions ocurr between these volatiles during cooking. The primary reactions involved in the formation of these flavour compounds are the oxidation of lipids, degradation of thiamine, and the Strecker and Maillard reaction (Resconi, Escudero & Campo, 2013). Through these chemical reactions, three categories of compounds are formed that are identified as the most important for meat flavour, i.e. carbonyls, sulphurous and pyrazine compounds. Carbonyls can be extracted from lipids which are found in fat; sulphur is formed from the degradration of the S-containing amino acids in meat protein; and pyrazines are only formed during the cooking of meat (Schönfeldt & Strydom, 2011). These respective categories contribute significantly to flavour development as they comprise numerous compounds which develop into important flavour precursors during heating. More than 1 000 volatile compounds have been identified that contribute to meat's aroma (Mottram, 1998).

According to Channon et al. (2003), flavour precursors of meat have been identified in the fat of mutton and in particular the carbonyl compounds found in mutton fat. The compounds associated with mutton flavour have been identified as branched chain fatty acids (BCFA) as well as unsaturated fatty acids. Furthermore, Brennand and Lindsay (1992) specifically indicated that 4-methyloctanoic acid (MOA), 4-ethyloctanoic acid (EOA) and 4-methylnonanoic acid (MNA) were present in all lamb fats at concentrations above threshold levels, and thus produce the characteristic mutton flavours. Mottram (1998) supported these findings by reporting the significant quanitities of methyl-branched fatty acids present in sheep. The BCFA concentrations can be used to distinguish between different age groups of sheep as it is expected to increase with chronological age. Watkins et al. (2010) found lower BCFA concentrations in lamb (<1y) and higher concentrations in mutton (>2y), where the concentrations of hogget were in-between lamb and mutton. The results specifically indicated lower MOA and EOA and a

higher concentration of MNA in lamb compared to hogget and mutton. The findings of Young, Lane, Podmore, Fraser, Agnew, Cummings and Cox (2006) confirmed this view by finding an increase of BCFA concentrations in carcass fat with chronological age.

Sink and Caporaso (1977) indicated the flavour of mutton may differ from lamb or may represent a change in concentration. However, it is generally believed that meat flavour increases with chronological age. In earlier studies Paul, Torten and Spurlock (1964) and Misock, Campion, Field and Riley (1976) confirmed this statement by reporting that lamb became more strongly flavoured with increase in age; the most acceptable flavour being developed at 12 months of age (Channon et al., 2003). In contrast, Schönfeldt and Strydom (2011) indicated that flavour between three age groups declined with an increase in age while sustained juiciness increased with increased age. The increase in sustained juiciness can be attributed to the amount of free fluids released by chewing. Jùnior et al. (2016) also indicated that older animals are more likely to have greater juiciness due to fat content. However, the findings of Jeremiah et al. (1998) are in contrast with this statement, as samples from older lambs in age groups of 9-12 months and 12-15 months released less moisture during chewing than lambs from the 3-6 months age group.

2.3 Sensory evaluation

Physical and chemical methods are usually applied in conjunction with sensory evaluations to interpret sensory scores. The physical and chemical properties of meat quality lead to the formation of sensory characteristics which consumers perceive during the sensory evaluation process. This further leads to the formation of consumers' attitudes and to their choice and purchase decisions. It is essential to investigate consumers' eating quality scores in order to determine their acceptance of lamb and sheep meat. Sensory evaluation has been defined as "*a scientific discipline used to evoke, measure, analyse and interpret reactions to those characteristcis of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing*" (Stone & Sidel, 2004). This method makes use of quantitative science where numerical data is collected to establish relationships between product characteristics and human perceptions (Lawless & Heymann, 2010). Sensory evaluation therefore plays an important role in determining meat quality, as taste and texture contribute to the palatability of meat.

The sensory assessment of meat characteristics can be measured either objectively by means of trained assessors in the form of professional taste panels, or subjectively by using consumers to provide hedonic judgements. Both of these methods evaluate the sensory components of tenderness, juiciness and flavour. Consumer panels are important to obtain responses on consumer preferences. The final assessment of palatability is determined by the target consumer market. It is, however, expensive and time consuming as a large number of consumers are needed to serve on the taste panel (Perry, Thompson, Hwang, Butchers & Egan, 2001). Professional taste panels are used when information on preferences is not essential. The panels are trained to assess the meat quickly and accurately, and consequently, are more sensitive in detecting differences in the sensory attributes (Perry, 2009).

Professional taste panel sensory scores, based on a 6-point scale in combination with shear force resistance measurements, are indicated in Table 2.1 (Schönfeldt et al., 1993). It is interesting to note the variation between the different sensory factors within each age group. The table indicates that the general flavour of the *M. semimembranosus* muscle[2] was more acceptable from the A age class than the B and C age classes. Additionaly, both muscles were significantly more tender in the A age class than the B and C age classes, as indicated by the panel scores and the shear force and collagen measurements.

The effect of animal age on lamb and mutton meat quality was examined on three respective muscles by Pethick et al. (2005), using untrained consumer taste panels. The data revealed that the eating quality of the *M. longissimus lumborum* (LL)[3] in Table 2.2 was the same for both groups (lambs versus 2-4 teeth yearlings), indicating that the animal's age had little effect on the eating quality of this muscle. The results indicate the potential to produce and develop high-quality mutton meat from the LL muscle in the 2-4 teeth yearling category. The authors suggest that the 2-4 incisor class will be inferior to lamb when cuts from a whole carcass are evaluated (Pethick et al., 2005). However, the study also highlights the acceptable eating qualities of older mutton which opens up the possibility of a new yearling (2-4 permanent incisors) category.

[2] A large muscle located on the posterior face of the hindlimb.
[3] Loin eye muscle.

Table 2.1: Mean and standard deviations for the sensory characteristics, shear force resistance and collagen measurements of muscles as influenced by three age classes

Parameters	*M. longissimus thoracis et lumborum*			*M. semimembranisus*		
	A	**B**	**C**	**A**	**B**	**C**
Flavour	4.18	4.02	3.99	4.27	4.03	3.97
Aroma intensity	4.48	4.40	4.35	4.31	4.42	4.32
Tenderness	3.87	3.22	3.16	3.83	3.21	3.03
Shear force resistance (N)	45.86	46.61	47.65	60.61	53.61	59.22
Collagen solubility (%)	20.55	16.30	10.05			
Collagen content	3.69	3.17	3.78			
Scores based on 6-point scales (6= extremely typical, extremely intense, excellent extremely tender, none; 1= extremely atypical, extremely bland, unacceptable, extremely tough, abundant, for species flavour, aroma intensity, flavour and tenderness ratings respectively.						

Source: Adapted from: Schönfeldt et al. (1993)

Table 2.2: Consumers' scores for the grilled *M. longissimus lumborum* from lamb and yearling sheep (compared at 3 days' aging)

Sensory characteristics	Lamb		Yearling	s.e.d.	Probability of an effect	
	2 days' aging	3 days' aging	3 days' aging		Meat aging	Lamb v. yearling
Tenderness	60.6	59.5	57.3	9.9	n.s.	n.s.
Flavour	63.0	62.5	62.1	7.9	n.s.	n.s.
Juiciness	55.2	54.1	52.9	7.5	n.s.	n.s.
Overall liking	62.6	61.8	60.3	8.8	n.s.	n.s.
n.s., not significant (p>0.05).						

Source: Pethick et al. (2005)

2.3.1 Sensory evaluation techniques

Sensory evaluation techniques are used to analyse quantitative data and qualitative information by applying an experimental design in controlled testing conditions. Information on specific sensory characteristics of food products is obtained through

product-oriented tests while information on consumers' preferences, likes and dislikes are obtained by consumer-oriented testing methods (Watts, Ylimaki, Jeffery & Elias, 1989).

The techniques that analytically measure food product characteristics can be classified as either discriminative or descriptive tests. These tests evaluate differences or similarities of sensory attributes of products. The second branch of sensory evaluation measures the subjective reactions of consumers toward a product by affective tests (Civille & Oftedal, 2012). These tests specifically evaluate preference and acceptance of products as shown in Figure 2.1.

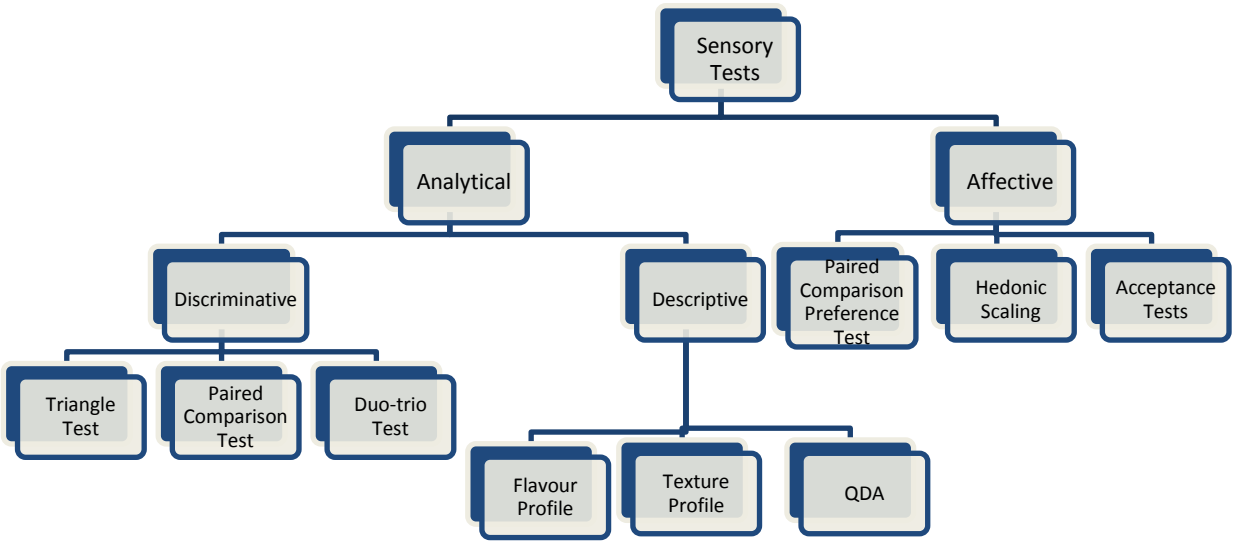

Figure 2.1: The demarcation of sensory evaluation tests

2.3.1.1 Analytical tests

The product-oriented tests are objective measurement tools to measure the sensory properties of products (Civille & Oftedal, 2012). Discriminative testing is carried out in order to determine if there is a noticeable difference between samples. The assessors must distinguish between the products or select the product which has more of a specific characteristic than the other (Stone & Sidel, 2004). It is therefore used to determine which product is preferred over another. Discriminative testing is conducted by the use of

three types of tests; triangle test, paired comparison test, and duo-trio test. Triangle tests are conducted where assessors are presented with three samples. From these three samples, two are identical and one is different, and the assessors have to identify the sample which is different from the others (Kemp, Hollowood & Hort, 2011). The paired comparison test is used to determine any difference between two samples according to a specific criterion, and only the most acceptable sample is indicated by the assessor. The duo-trio tests are similar to the triangle tests in that it involves three samples in which two are identical and one is different. The assessors are asked to determine which sample is different and to identify what attribute does the sample have that makes it unique.

Descriptive sensory methods are used to identify and measure the composition or to determine the presence and concentration of a particular characteristic (Piggott, Simpson & Williams, 1998). This technique captures the qualitative and quantitative sensory aspects of a product and thus requires a highly trained panel (Civille & Oftedal, 2012). The most commonly descriptive methods used for assessment of product attributes are the Flavour Profile Method (FPM), the Texture Profile and the Quantitative Descriptive Analysis (QDA) (Channon et al., 2003). Several studies have applied descriptive methods in the analysis of meat (Woodhams, Kirton & Jury, 1966; Hoffman, Muller, Cloete & Schmidt, 2003; Schönfeldt & Strydom, 2011; Cloete, Hoffman & Cloete, 2012). Most recently, Erasmus (2017) used a trained sensory panel with extensive experience in the sensory analysis of meat to scale the intensity of each aroma, flavour and texture attributes on a 100-point unstructured scale. Earlier, Schönfeldt et al. (1993) also used descriptive sensory methods to evaluate palatability attributes of different sheep meat cuts by a ten-member trained panel. The samples were evaluated according to different attributes on a 6-point scale.

The Flavour Profile Method was developed in the late 1940's. During the developing stages, a 9-point hedonic scale was incorporated, which resulted in the formation of the Profile Attribute Analysis (PAA). PAA is a qualitative descriptive test. It is mainly used for the identification and description of flavour characteristics in food samples tested by a panel (Channon et al., 2003). The flavours may change as different volatile compounds are released during consumption, however, in order to account for this flavour variable, a method called flavour profiling is applied. Flavour profiling also incorporates the sensory evaluation of flavour attributes by sensory panels, but panellists are first trained to identify these flavours (Channon et al., 2003). This allows flavour panels to identify the differences and intensity of the flavour attributes more accurately. The disadvantage of

this method is that panellists have to be trained in order to use the scale identically for each attribute and they are restricted to the assessment of set flavour attributes (Meilgaard, Civille & Carr, 1999). In addition, there is a considerable amount of time dedicated to planning the sessions in order to assemble the panel, and problems of non-attendance may arise.

The Texture Profile technique is originally based on the principles of the Flavour Profile method. This technique is defined by Civille and Liska (1975) as "*the sensory analysis of the texture complex of a food in terms of its mechanical, geometrical, fat and moisture characteristics, the degree of each present and the order in which they appear from first bite through complete mastication.*" It is thus used to assess and describe all the texture characteristics of a product by both their physical and sensory characteristics (Lawless & Heymann, 2010). The Texture Profile is time consuming as it requires extensive training for panel members. The panel members should be able to recognise, identify, and quantify degrees within each texture characteristic in a specific food category (Lawless & Heymann, 2010).

Quantitative Descriptive Analysis (QDA) was developed in order to correct some of the perceived complications associated with Flavour Profile Analysis. Data is collected through the use of unstructured line scales to describe the intensity of the product attributes. This method may either be used to fully describe the sensory characteristics of a product from initial visual assessment to aftertaste, or by focusing on a limited product characteristic. QDA has the same problem as the Flavour Profile method since, in both methods, panel members must be trained for the specific product category (Lawless & Heymann, 2010). Leighton et al. (2007) used a trained sensory panel to apply QDA on mutton from different regions in South Africa. The panellists were trained to increase their sensitivity and ability to discriminate between the mutton samples and sensory attributes of aroma, flavour and aftertaste. Samples were scored using an 8-point category rating scale. Similarly, Van Heerden (2007) performed QDA with a trained panel using an 8-point category scale. The quality of South African lamb was evaluated based on sensory attributes such as: aroma intensity, tenderness, flavour intensity and impression of juiciness.

In order to acquire the results of these sensory methods, the responses have to be recorded. There are various methods used for recording sensory responses. The four most commonly used are classification, grading, ranking and scaling, with scaling being the most favourable method used for sensory evaluations in the agro-food industry

(Dikeman, Reddy, Arthaud, Tuma, Koch, Mandigo & Axe, 1986; Schönfeldt et al., 1993; Leighton et al., 2007; Van Wezemael, Smet, Ueland & Verbeke, 2014).

Scales are applied by using words or numerical values to express the intensity of a particular characteristic. It is therefore most useful in recording the intensity of panellists' perceptions. The analyst may assign numerical values to the words, for example "like extremely = 9, dislike extremely = 1" (Meilgaard et al., 1999). The values are expressed by the use of three different scales; line scales, category scales and ratio scales. Line scales are used when the extremes of an attribute is measured. The panellist rates the intensity of a given stimulus by indicating a mark on a horizontal line which relates to the amount of the perceived stimulus. The left side of the scale represents the zero amount of stimulus while the right side of the scale represents a very strong level. The marks on the line scales are converted to numerical values by manually measuring the position of each mark. Category scales are applied when the panellist is asked to rate the intensity of a particular stimulus by assigning it a value (category) on a limited numerical scale (Meilgaard et al., 1999; Perry, 2009). Conversely, ratio scales are applied where the panellist receives the first sample assigned with a freely chosen number. The panellist is then asked to allocate all ratings of the following samples in proportion to the first sample rating (Meilgaard et al., 1999).

2.3.1.2 Affective tests

Consumers' final reactions to and preferences of a variety of stimuli are assessed through affective tests. The consumer-orientated testing should always consist of untrained consumers and has to be representative of the consuming population (Svensson, 2012). The participants should also be regular users of the product being tested. The ultimate goal of these tests is to assess consumers' preference in terms of a product's sensory characteristics population (Svensson, 2012).

There are two main approaches to consumer testing; the measurement of preference and the measurement of acceptance (Lawless & Heymann, 2010). In preference measurement, a paired comparison test is conducted. This test is similar to the paired comparison method for discriminative testing where two samples are compared with each other. Consumers are simultaneously presented with two samples and they have to choose one sample over the other. The limitation of the paired preference tests is that the

result does not indicate the degree of consumer acceptance towards the particular sample (Lawless & Heymann, 2010).

The most commonly used methods for the measurement of acceptance is the hedonic test and the preference ranking test. Consumer panellists have to rate their degree of liking a product on a category scale. The 9-point hedonic scale is most frequently used for consumer sensory scores. The scale consists of 9 categories ranging from "dislike extremely" to "like extremely" (Svensson, 2012). On the other hand, a preference ranking test is used to compare several samples according to one attribute (Meilgaard, Civille & Carr, 2007). The consumer has to rank the samples based on preference in a descending or ascending order, with a ranking of 1 denoting most preferred (Svensson, 2012). This test is similar to the paired preference test in which no degree of difference is indicated between samples.

Ultimately, analytical tests are more extensive due to the subdivision of two separate branches into discrimination and descriptive tests compared to affective tests. The key difference between these tests is due to the fact that analytical tests are product-orientated while affective tests are focused on consumer-oriented methods. A summary of the classification of these methods with the question of interest and the characteristics which panellists should possess, is furnished in Table 2.3 below.

Table 2.3: Summary of classification of test methods in sensory evaluations

Class	Question of interest	Type of test	Panellist characteristics
Discrimination	Are products perceptibly different in any way?	Analytical	Screened for sensory acuity, oriented to test method, sometimes trained.
Descriptive	How do products differ in specific sensory characteristics?	Analytical	Screened for sensory acuity and motivation, trained or highly trained.
Affective	How well are products liked or which products are preferred?	Hedonic	Screened for products, untrained.

Source: Lawless & Heymann (2010)

The test location has an influence on a panellist's perceived sensory properties and thus affects the results under study (Meilgaard et al., 2007). It is important to perform tests in

a controlled, standardised environment in order to achieve the best results. Affective tests can be conducted in sensory laboratory tests (LT), in central location tests (CLT), or in home use tests (HUT) (Resurreccion, 2007).

Sensory laboratory tests are most commonly used when the goal is to measure consumer acceptance of a product. The panel size is fairly large, with 50-100 candidates considered adequate, following pre-screening. The major advantage of sensory laboratory tests is the convenience of assembling a large number of participants for the study. Furthermore, the tests are conducted in a controlled environment where lighting and environmental conditions are maximised. All possible distractions are minimised by separating panellists from each other in separate testing booths. Admittedly, the sensory testing booths are standardised and therefore different from a real life eating environment, and sensory scores may therefore be affected (Resurreccion, 2007).

The central location test is the most frequently used sensory acceptance test (Boutrolle, Arranz, Rogeaux & Delarue, 2005). Potential buyers are assembled in one central location. The product samples are prepared out of sight and served on uniform plates, labelled with numeric 3-digit codes. The potential buyers then score the samples on the basis of how much they like it. The disadvantage of this method, similar to the laboratory tests, is that the product is usually tested in an artificial environment (Kiria et al., 2010). Van Wezemael et al. (2014) performed central location tests on beef steaks using untrained consumers to investigate relationships between sensory evaluations of beef tenderness and shear force measurements. The panellists tasted samples of three beef steaks and reported their sensory assessment of tenderness on a 9-point rating scale. The study reported that the sensory assessment ratings were independent of the shear force values.

Alternatively, the home use tests are more realistic where the product is tested under common daily use circumstances. The participants are most frequently families who are instructed to prepare the product under study in their own household. The family's opinions of the sensory characteristics of the product are obtained and the influence of each one's opinion against the others' are taken into account. Two products are generally compared separately, each one prepared and consumed in a time period of 4-7 days. The advantage is that the quality of the information obtained is of a higher standard due to repeated use of the product (Boutrolle, Delarue, Arranz, Rogeaux & Köster, 2007). Disadvantages on the other hand are that the test may be time consuming, and the possibility of a lack of response is greater unless the respondents are frequently reminded

of their task. Furthermore, the sample size used is much smaller than the central location test and variability in the preperation and time use of this product may be a concerning factor (Meilgaard et al., 1999).

2.4 Establishing consumers' preferences and willingness to pay

Economists, marketers and psychologists are frequently interested in eliciting people's values for market goods in order to understand the decisions made in terms of preferences for and beliefs about products (Lusk & Shogren, 2007). The monetary values consumers attach to the sensory characteristics of these products under study have to be measured. These monetary values are measured through consumers' willingness to pay (WTP) for a product. WTP could be defined as "*the maximum amount of money a consumer would pay for a given quantity of a product, given a specific set or bundle of attributes present in the product*" (Kalish & Nelson, 1991).

Over decades, researchers have developed many value elicitation methods to measure consumers' WTP to determine how people value goods and services. These methods can be categorised into stated and revealed preference methods (Lusk & Shogren, 2007).

Stated preference methods are conducted by directly or indirectly asking individuals to state the monetary value they attach to goods or services (Lusk & Shrogen, 2007). Kroes and Sheldon (1988, p.11) defined stated preference methods as "*a family of techniques which use individual respondents' statements about their preferences*" for a specific product or service. Survey-based techniques are used for these methods to estimate individuals' WTP through direct and indirect surveys (Breidert, Hahsler & Reutterer, 2006). The three most extensively applied methods are conjoint analysis, choice experiments and the contingent valuation method. The key advantage of the stated preference method is that the researcher can create a hypothetical market where individuals can buy or sell goods or services (Lusk & Shrogen, 2007). Adamowicz, Louviere and Williams (1994) claimed that it is the only viable method to elicit values in an environment with a variety of variables. The disadvantage of this method is that people are valuing the goods or services in a hypothetical setting, and the reliability of the responses can consequently be questioned. The values gained from the hypothetical surveys have been inconsistent as differences were observed between individuals' stated preferences and actual preferences. In reality, the WTP values stated could be higher than

what the person is actually willing to pay for the product as no actual monetary values are used (Wardman, 1988; Voelckner, 2006).

Revealed preference methods are used to obtain individuals' actual market choice behaviour, which result in more accurate data (Ben-Akiva, Bradley, Morikawa, Benjamin, Novak, Oppewal & Rao, 1994). The most widely used methods are hedonic pricing and the travel cost method (Van Zyl, 2011). The data gathered from revealed preference methods is however indirect, thus the observed behaviour has to be simplified and translated into valuations (Luck & Shogren, 2007). Smaller sample sizes are applied due to it being more expensive compared to stated preference methods (Kirsten, Vermeulen, Van Zyl, Du Rand, Du Plessis & Weissnar, 2017).

An approach was designed to combine the advantages of stated and revealed preference methods, namely experimental auctions. In the literature reviewed, experimental auctions are applied most frequently for food preference research and are one of the most commonly used experimental valuation methods in agricultural economics (Buhr, Hayes, Shogren & Kliebenstein, 1993; Hayes, Shogren, Shin & Kliebenstein, 1995; Lusk, 2003).

2.4.1 Experimental auctions

An experimental auction is a quantitative research method used by applied economists, psychologists and marketers to specifically elicit individuals' preferences for goods and services. The method is conducted in a non-hypothetical setting where real products are offered for sale and participants are compensated with cash to purchase the products, by means of which a real active market environment is created (De Groote, Kimenju & Morawetz, 2011). Individuals participate in an auction by submitting sealed bids in order to obtain a certain product. The highest bidder(s) win the auction and pay the purchase price which is determined by the individuals' bids (Rousu, Alexander & Lusk, 2007).

This method usually follows two strategies. Firstly, individuals bid to upgrade from one product to another, the products being identical except for the characteristic being valued (Lusk & Shogren, 2007). Secondly, individuals bid simultaneously on two or more products via multiple auction rounds, and a random draw determines which auction is binding (Lusk & Shogren, 2007).

An important characteristic of experimental auctions is the type of mechanism used to determine the market price for the specific product(s) being valued and the auction winner(s) (Lusk & Shogren, 2007). The auction mechanism is designed to collect bids which reflect individuals' true value for a product - the so-called "incentive compatible mechanisms". There are a number of incentive-compatible mechanisms used to elicit consumers' WTP. The three most commonly used mechanisms are the Vickrey second-price auction, the Becker-DeGroot-Marschak (BDM) mechanism and the random *n*th-price auction (Lusk, Feldkamp & Schroeder, 2004). The English auction, also called the first-price auction, is an ascending bid procedure where the price is increased until no person is willing to bid further. The highest bidder buys the auctioned product at the price equal to their bid (De Groote et al., 2011). This process is not incentive compatible, however, because a given bid determines the purchase price and the highest bid winner (Voelckner, 2006).

2.4.1.1 Vickrey's second-price auction

This auction mechanism is conducted by means of a sealed bid in which the highest bidder wins the auction and pays the price equal to the second-highest amount (Lusk & Shogren, 2007). Vickrey (1961) established that this auction mechanism provide bidders with an incentive to state their true value for the goods or services being auctioned, because they must purchase the goods if their bid is equal to the highest winning bid. Incentive compatibility is ensured where the purchase price is only determined by the participants' bids and the given bid value determines the right of the bidder to buy the goods (Wertenbroch & Skiera, 2002). Bidding less than the true value one attaches to it will reduce one's chance of winning the auctioned product, while bidding more than one's true value increases the chance of winning but at a price higher than the actual WTP. There is thus no gain from strategic bidding.

The Vickrey second-price auction has practical and empirical limitations. Firstly, operational problems may arise due to the fact that participants must be sourced and gathered in a designated facility. Secondly, the auction process is not necessarily conducted in a normal retail environment with an unlimited supply of goods. The bidders compete with one another for limited stock (Wertenbroch & Skiera, 2002). Furthermore, participants tend to overbid, thus bidding more than what the objects are worth and what

they are willing to pay (Kagel, Harstad & Levin, 1987). The overbidding phenomenon occurs when participants want to increase their chance of winning the product being auctioned (Kagel et al., 1987). The auction mechanism also does not engage low-value bidders, as they become discouraged in the design of the highest bid winner (Kagel et al., 1987).

2.4.1.2 Becker-DeGroot-Marschak (BDM) mechanism

The well-known BDM procedure was introduced in 1964 by the authors Becker, DeGroot and Marschak. This mechanism is established to overcome the limitations set out in the Vickrey second-price auction. The BDM is designed to be incentive compatible, realistic and transparent to participants (Wertenbroch & Skiera, 2002).

Unlike the Vickrey auction, the BDM mechanism is applied under real market conditions. The process starts by acquiring consumers to participate in the auction. The participants are asked to offer a price for the product being auctioned, which should equal the highest price they are willing to pay. Participants simultaneously submit their sealed bids. The bids are not compared to one another as in the Vickrey auction, but a randomly generated number is chosen. A random sale price (p) is drawn form a pre-specified distribution of prices. The distribution of prices consists of an interval from zero to a price greater than the maximum price (Breidert, Hahsler & Reutterer, 2006). Participants are required to buy the product if the drawn price (p) is less than or equal to their bid. If (p) is greater than their bid, they are not allowed to purchase the product (Wertenbroch & Skiera, 2002).

2.4.1.3 Random nth-price auction

This auction mechanism combines elements of the Vickrey auction, which encourages competition among bidders and the BDM mechanism, which gives all bidders an equal chance to win the auction (Lusk & Shogren, 2007). The key characteristic of the random *n*th-price auction is the random but endogenously determined market-clearing price (Shogren, Margolis, Koo & List, 2001). The auction is demand revealing because all

bidders are engaged and have a chance to be a winner and purchase the auctioned product.

The auction commences with each participant submitting a sealed bid for the auctioned product. The monitoring person collects the bids and sorts them from the highest to the lowest bid. A random number *(n)* is drawn between 2 and (*k)* where k is equal to the number of participants. The person will consequently sell one unit to each of the *(n-1)* highest bidders at the randomly drawn *n*th price (Shogren et al., 2001). It is important to note that the distribution starts from 2 to (*k)* and not 1 to (*k).* If the distribution was from 1 to (*k)* and the random number drawn is n=1, then there would be no winners as the winners of the auction would be equal to *(n-1)* which will be zero. The random number (*n)* being drawn is not the actual purchase price, however, but only the position being drawn (Van Zyl et al., 2013). The winners will have to purchase the auctioned product at the *n*th price. For example, if a random *n*th-price auction is held with 30 participants (*k*=30), a random *(n)* number will be drawn form the distribution 2 to 30. If the monitor draws a random number *n*=6, the five highest bidders will each have to purchase the auctioned product at the *n*th price, in this case, the sixth highest bid.

2.5 Application of experimental auction mechanisms

In the section to follow, the different auction mechanisms are compared with each other, followed by reviewing previous literature in the application of experimental auction mechanisms. The studies illustrate how experimental auction mechanisms were applied in eliciting consumers' values and preferences aimed at the agro-food industry.

The BDM mechanism was tested together with a Vickrey auction by Wertenbroch and Skiera (2002) for its ability to forecast WTP at the point of purchase. Two independent studies were conducted to test the feasibility, reliability and validity of applying the BDM mechanism at the point of purchase. Both studies suggest that BDM is a reliable and valid method to determine WTP and relatively little cost and time are needed to implement this method. The authors also concluded that there was no evidence of overbidding, as in the case of the Vickrey auction. However, the experience with De Groote et al. (2011) with the BDM mechanism showed that it required considerable time and effort to implement the method. The authors highlighted the importance of training participants during practice rounds with a popular consumer item before conducting the auction.

Findings from previous research have noted several differences between the different mechanisms. Shogren, Fox, Hayes and Kliebenstein (1994) found that Vickrey and random *n*th-price auctions generated similar results. In contrast, a difference between these two mechanisms was revealed by Shogren et al. (2001), in which it was suggested that the Vickrey auction works better for bidders with high valuations, whereas the random *n*th-price auction is more compatible for low valuation bidders. Participants with low valuations may become disengaged from an auction in which they are not able to win the auctioned product. Shogren et al. (2001) further indicated that the random *n*th price-mechanism does engage these off-margin bidders, but does not bring about more truthful bids from the on-margin bidders. However, the Vickrey auction mechanism does solicit more truthful bids from the on-margin bidders. The study by List and Shogren (1999) revealed that bids in the Vickrey auction tend to increase as the auction is repeated, which suggests unreliable data. In contrast, Noussair, Robin and Ruffieux (2004) compared the capability of the BDM mechanism and the Vickrey auction to reveal consumer WTP information. Their research indicated that the Vickrey auction is preferable to the BDM mechanism for the use of determining WTP for private goods. Table 2.4 indicates several advantages and disadvantages in utilising the different experimental auction mechanisms highlighted by Lusk (2003).

Table 2.4: Advantages and disadvantages of different auction mechanisms

Auction type	Vickrey auction	BDM auction	Random *n*th-price auction
Advantages	Easy to explain to participants and relatively easy to implement.	Can be used with individual participants in settings like grocery stores.	Keeps all bidders engaged in multiple bidding rounds.
	Only one unit of a product is sold, easing experiment preparation.	Values can be elicited relatively quickly.	High degree of market feedback if desired.
Disadvantages	Evidence exists that participants overbid their WTP.	No active market is present.	Difficult to explain to participants.
	Participants' with low values become disinterested and disengaged in multiple bidding rounds.	No market feedback.	Determining market price can be time intensive if session sizes are large.

Source: Adapted from: Lusk (2003)

Agricultural economists are increasingly involved in marketing research due to intense market competition and changes in consumer attitudes and lifestyles (Menkhaus, Borden, Whipple, Hoffman & Field, 1992). The need for non-hypothetical marketing techniques arose to assess consumers' preferences for products. The application of experimental auctions in the agricultural economics field is discussed through the use of previous studies. The majority of the relevant studies used the Vickrey second-price and the BDM auction. Only a few random *n*th-price auction mechanisms have been used, which can be due to the fact that it was only established by Shogren, Maroglis, Koo and List during 2001.

Menkhaus et al. (1992) investigated whether experimental auctions could provide useful information for marketing decisions and economic analyses. The study specifically focused on determining factors which influence the value consumers place on retail beef steaks with different types of packaging. The Vickrey second-price auction was used to auction off four beef steak packages. The results showed that physical appearance (amount of fat and shape) of beef plays an important factor in purchase decisions. The authors concluded that experimental auctions can provide useful information. In addition, consumers' WTP for organic food, specifically organic olive oil, were analysed through an experimental multiple round Vickrey second-price auction (Soler, Gil & Sanchez, 2002). It was found that the majority of consumers (70%) will pay a premium for organic olive oil.

Alphonce and Alfnes (2015) illustrated the application of experimental auctions by assessing consumer preference and WTP for organic, food safety-inspected tomatoes through the use of the BDM mechanism as well as other elicitation techniques. The study's results revealed that consumers were willing to pay a premium for organic and food safety-inspected tomatoes. Consumers' WTP for yellow versus fortified maize were compared using the BDM mechanism in three regions in Kenya (De Groote et al., 2011). The results showed that Kenyan consumers are willing to pay a premium of 24% for maize fortified with minerals and vitamins. This clearly indicates that the consumers are interested in nutritionally-enhanced maize meal. Several other studies have been conducted with the use of the popular BDM mechanism to elicit consumers' valuation of food products (Lusk, Fox, Schroeder, Mintert & Koohmaraie, 2001; Rozan, Stenger & Willinger, 2004; Corrigan & Rousu, 2008; Shi, House & Gao, 2013).

The random *n*th-price auction mechanism was applied by Rousu, Huffman, Shogren and Tegene (2004) to investigate if United States consumers are tolerant towards genetically modified (GM) foods. The consumer panel had to indicate their WTP by placing their bid on three food products that have different tolerance labels: a non-GM label, free from genetically engineered material; and two non-GM labels indicating a 1% and 5% presence of genetically modified material. It was found that consumers would pay less for food with genetically modified material but no difference was found in consumers' values on foods with a 1% and 5% presence of genetically modified material. This auction mechanism has gained popularity under academics over the years and is progressively more applied in the field of agricultural economics (Lee, Han, Nayga & Lim, 2011; Seetisarn & Chiaravutthi, 2011; De-Magistris & Gracia, 2016).

2.6 Relationship between experimental auctions and consumer sensory evaluations

Experimental auctions are frequently used in conjunction with sensory evaluation tests as they provide the opportunity to confirm whether the taste panel's sensory scores reflect the participants' true value indicated by their bids during the particular auction mechanism. Previous studies that have applied sensory evaluations and experimental auctions in the meat industry, relevant to the research topic, will be highlighted.

Agricultural economists and meat scientists have conducted studies to determine consumers' WTP for beef after consumer sensory assessments (Lusk et al., 2001; Umberger et al., 2002). The studies of Umberger and Feuz (2004) and Feuz et al. (2004) are highlighted as their methodological framework covers similar principles that will be implemented in this study.

Umberger and Feuz (2004) compared steak samples with different quality characteristics. The flavour variable of each steak sample was investigated, and steak tenderness, cooking methods and portion size were all standardised. Consumers evaluated each steak sample according to their sensory characteristics and then placed a sealed bid on each steak sample during an experimental auction. The ultimate goal of the study was to determine whether the experimental auction was efficient in capturing consumer preference differences and WTP. If this were the case, the difference in bids should be correlated with the difference in sensory ratings (Umberger & Feuz, 2004). The results

indicated that the relative bids for the steak samples were positively and significantly influenced by the overall sensory scores. A follow-up study done by Feuz, Umberger, Calkins and Sitz (2004) investigated U.S. consumers' WTP for flavour and tenderness in steaks, determined by experimental auctions. The steaks differed in marbling, tenderness, country of origin and aging method. A consumer panel was asked to taste and rate four pairs of steak samples for flavour, juiciness, tenderness and overall liking, using an 8-point hedonic scale. Thereafter, a random *n*th-price auction was conducted to elicit consumers' WTP for the different steak samples. The results revealed that tenderness had a significant impact on consumers' WTP values. Marbling and tenderness were the two most prominent sensory characteristics which had a statistically significant impact on consumers' sensory scores.

Additionally, a consumer research study conducted by Hobbs, Sanderson and Haghiri (2006), evaluated consumers' preferences for bison versus beef and their WTP for specific credence attributes using a Vickrey second-price experimental auction. Prior to the experimental auction, a consumer panel tasted and evaluated four value-added bison products. Consumers had to bid to exchange their beef sandwich for one of four bison sandwiches during multiple bidding rounds. The results revealed that the consumers did not substantially bid more for bison than beef. Furthermore, the results indicated that value-added product development is very important in the bison industry in order to appeal to their consumer market. Umberger, Feuz, Calkins and Killinger-Mann (2002) measured U.S. consumers' preference and WTP for domestic corn-fed beef versus international grass-fed beef, using a Vickrey second-price experimental auction. The objective was to measure consumers' preferences for flavour in beef steaks and to establish the premium that consumers would be WTP depending on their flavour preferences. The participants were asked to first taste and rate corn-fed and grass-fed beef steak samples by means of a blind tasting for various sensory characteristics. The experimental auction was conducted after the consumers' sensory assessments of the steak samples. The results indicated that sixty-two percent of the participants preferred the domestic corn-fed flavour to the grass-fed flavour, and they were also willing to pay a 30.6% premium on average for the corn-fed steak samples.

Melton, Huffman, Shogren and Fox (1996) further explained the application of experimental auction methods and sensory assessments by evaluating consumer perceptions and WTP for fresh pork chops. Consumers had to firstly evaluate the visual attributes of pork chops, and secondly had to taste and evaluate the chops according to

flavour, juiciness, tenderness and overall "eatability". The results confirmed that consumers can ascertain differences in the attributes of fresh pork chops. The authors further concluded that evaluations for fresh food products, based only on appearance without tasting the product, are unproductive. Most recently, Hung and Verbeke (2017) studied how sensory attributes influence consumers' WTP for newly-developed processed meats with added natural compounds and a reduced level of nitrate through a Vickrey second-price auction. The majority of participants preferred the new processed meat products over the conventional ones.

In South Africa research combining sensory evaluations and experimental auctions is limited. Very little research has been conducted to evaluate consumer preferences towards different age classes of Karoo lamb and mutton. In 2012, Du Plessis and Du Rand (2012) aimed to determine the product attributes that influence consumers' decision-making process towards purchasing Karoo lamb. The information was obtained through qualitative semi-structured interviews and focus groups as well as quantitative conjoint analyses. The results indicate price, as an extrinsic attribute, as the most important determining factor in consumers' purchase decisions, followed by food safety and quality. A more applicable study was conducted by Van Zyl (2011) to determine consumers' WTP for food attributes by using experimental auctions. A random *n*th-price auction was conducted to obtain consumers' WTP values for certified Karoo lamb. The participants in this study had to place sealed bids to upgrade from a base product to a certified Karoo lamb product. The auction results revealed a positive WTP for certified Karoo lamb with an average premium of R10.90 per 500 g of loin chops. Furthermore, a paper compiled by studies from Kirsten, Vermeulen, Van Zyl, Du Rand, Du Plessis and Weissnar (2017), reviewed different techniques in order to test South African consumers' perceptions, preference and WTP for Karoo meat. The studies used a combination of perception analyses, stated preference methods such as conjoint analysis, and revealed preference methods, including a random *n*th-price experimental auction and a retail store experiment.

More recently, Erasmus (2017) sought to determine the potential link between the diet of Karoo lamb and composition of the meat by means of chemical and sensory analyses. A professional sensory panel with extensive experience on descriptive sensory analysis of meat was used. The sensory panel concluded that the aroma and flavour of the meat are influenced by the origin of the sheep and the grass or plants they graze on. The chemical analysis revealed the presence of specific volatile compounds which give the unique taste

to Karoo meat above non-Karoo meat. The main compounds, α-pinene, β-pinene and limonene, were only detected in the meat of Karoo lamb, which contribute to its characteristic taste.

To date, research on the effect of age on consumers' sensory assessments of Karoo lamb and mutton has not been conducted. Schönfeldt et al. (1992) and Schönfeldt et al. (1993), evaluated quality characteristics of A, B and C class lamb and sheep carcasses through chemical analysis as well as a professional sensory taste panels. A further chemical analysis was also conducted by Schönfeldt, Van Heerden, Sainsbury and Gibson (2011) on the nutrient content of uncooked and cooked A2 lamb and C2 mutton, using three primary cuts (shoulder, loin and leg). The data on the chemical composition of lamb and mutton is beneficial to assess the dietary intake of consumers, but consumers' sensory attitudes and preferences of different sheep age classes need to be measured. Additionally, information on the monetary value consumers display towards different sheep age classes needs to be collected and investigated.

2.7 Summary

The first part of this chapter was dedicated to a discussion on the physical and chemical evaluations of lamb and mutton meat. The physical elements which encompass meat tenderness and the chemical elements which encompass flavour and juiciness were discussed with reference to previous literature. Thereafter, a discussion on sensory evaluation techniques with the demarcation of sensory evaluation tests were submitted.

The second part of the chapter presented an in-depth discussion on the use of experimental auction mechanisms to investigate consumers' attitudes towards and preferences for food products. The fundamental aspects of experimental auction mechanisms were highlighted with a discussion and comparison of the three most commonly used mechanisms: Vickrey's second-price auction, the Becker-DeGroot-Marschak (BDM) mechanism and the random *n*th-price auction. It was found that the random *n*th-price auction combines advantages of both the Vickrey auction, which encourages competition among bidders, and the BDM mechanism, which gives all bidders an equal chance to win the auction. Relevant studies which made use of different experimental auction mechanisms, specifically in the agro-food industry were discussed.

Finally, to conclude this chapter, the relationship of experimental auctions and consumer sensory evaluations were discussed. Previous studies which applied sensory evaluations together with experimental auctions in the meat industry were highlighted.

From the literature reviewed, the most commonly used method for the measurement of acceptance is the hedonic test. The test location was also found to have an influence on panellists' perceived sensory properties, and it was established that the central location test was the most frequently used sensory acceptance test. Experimental auctions were chosen as the most appropriate method to use for this study, as they are most frequently applied for food preference research and are the most commonly used experimental valuation methods in agricultural economics. In the following chapter, the research methods used will be discussed, followed by an overview of the consumer sensory assessment process and random *n*th-price auction procedure and design.

CHAPTER 3: EXPERIMENTAL DESIGN

3.1 Introduction

In the previous chapter, the three most commonly used auction mechanisms in experimental economics were discussed. It was concluded that the random *n*th-price auction mechanism is best suited for this study as it combines advantages of both the Vickrey auction and the BDM mechanism. The random *n*th-price auction is demand revealing because all bidders are engaged in a market created where real products and real money are exchanged. Furthermore, the random but endogenously determined market-clearing price engages high- and low-value bidders to bid truthfully due to the payment price being randomly determined (Shogren et al., 2001).

In the sensory evaluation process, affective hedonic scaling was applied by a selected consumer panel to provide hedonic judgements on meat samples. The research methods used for this study will be discussed, followed by a detailed overview of the consumer sensory assesment process and random *n*th-price auction procedure and design.

3.2 Research methods

The random *n*th-price auction mechanism with its favourable features was used in this study to test consumers' WTP for Karoo lamb and mutton after a blind tasting of different meat samples. The experimental design is therefore twofold: sensory assessments were conducted by a consumer panel and, thereafter, a physical random *n*th-price auction was held amongst the same participants. The auction was applied with a pre-auction survey (Appendix C) to acquire participants' demographic information, purchase behaviour and prior knowledge and perceptions about lamb and mutton meat. There was no additional information presented to participants before the pre-auction survey regarding Karoo lamb and mutton meat because the aim of the survey was to capture their true perceptions.

Each participant received an envelope which contained a piece of *droëwors*[4] wrapped in a plastic bag for the practice round, a booklet with bidding slips and a R200 note. They

[4] A Southern African snack food, based on the traditional coriander-seed spiced *boerewors* sausage.

received the cash prior to participating in the experiment. The cash was used to compensate participants for participating in the study, and to provide them with a budget to bid and purchase the meat. A practice round was held with the *droëwors* sample to familiarise the participants with the auction mechanism.

During the actual sensory assessments and auction rounds, participants were asked to taste and rate three samples of different ages (A, AB and C classes) of Karoo lamb and sheep meat in terms of flavour, juiciness, tenderness and overall liking by means of a blind tasting during each phase. The ratings were established by using a 9-point hedonic category scale (where 1= extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking, and 9= extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking). Thereafter, they had the opportunity to participate in a random *n*th-price auction and submit sealed bids for each meat sample they have tasted.

The sensory assessments and random *n*th-price auction were conducted in three phases. Phase one consisted of one round of three tasting and bidding rounds. The reference item for phase one was a 500 g packet of lamb stew meat cuts. The reference item was shown to the participants and information on the average full product price it currently holds in the market, and the weight of the reference item was provided. Participants had to bid the full product price they would be willing to pay for this reference item in the market based on the three different stew meat samples they had tasted.

Phase two entailed two rounds in which each round consisted of three tasting and bidding rounds. The reference item for phase two was a 500 g packet of lamb loin chops. The reference item was shown to the participants and information on the average full product price it currently holds in the market, and the weight of the reference item was provided. Participants had to bid the full product price they would be willing to pay for this reference item in the market, based on the three different loin meat samples they have tasted during each round.

Lastly, phase three also entailed two rounds in which each round consisted of three tasting and bidding sessions. The reference item for phase three was a 500 g deboned leg of lamb. The reference item was shown to the participants and information on the average full product price it currently holds in the market as well as the weight of the reference item was given. Participants had to bid the full product price they would be willing to pay

for this reference item in the market, based on the three different leg meat samples they have tasted.

The retail prices from five different retailers in the Western Cape were observed and recorded in order to obtain an average full product price to use as a reference price for each meat cut that was tested. The Western Cape was chosen because it is in the same geographical area where the consumer panel resides. The specific retailers were chosen because they are the best-known retailers for purchasing lamb and mutton meat. These prices were observed in August 2018. The retail prices for 500 g stew meat cuts, 500 g loin chops and deboned legs of lamb are indicated in Tables 3.1, 3.2 and 3.3. These respective prices are comparable with lamb for each cut due to lamb being predominantly available in the retail outlets.

Table 3.1: Observed prices for fresh stew meat cuts

Retailer / butcher	Price of stew meat cuts (R/kg)
Spar (generic lamb and mutton)	R129.99/kg
Checkers (certified natural lamb)	R119.99/kg
Woolworths (free-range lamb and mutton)	R149.99/kg
Food Lover's Market (generic lamb and mutton)	R129.99/kg
Pick 'n Pay	R139.99/kg
Ryan Boon Speciality Meats	R120/kg

Source: Prices observed in August, 2018.

Table 3.2: Observed prices for fresh lamb loin chops

Retailer / butcher	Price of loin chops (R/kg)
Spar (generic lamb and mutton)	R179.99/kg
Checkers (certified natural lamb)	R149.99/kg
Woolworths (free-range lamb and mutton)	R199.99/kg
Food Lover's Market (generic lamb and mutton)	R159.99/kg
Pick 'n Pay	R167.99/kg
Ryan Boon Speciality Meats	R170/kg

Source: Prices observed in August, 2018.

Table 3.3: Observed prices for fresh deboned leg of lamb

Retailer / butcher	Price of deboned leg of lamb (R/kg)
Spar (generic lamb and mutton)	R157.99/kg
Checkers (certified natural lamb)	R179.99/kg
Woolworths (free-range lamb and mutton)	R179.99/kg
Food Lover's Market (generic lamb and mutton)	R174.99/kg
Pick 'n Pay	R199.99/kg
Ryan Boon Speciality Meats	R190/kg

Source: Prices observed in August 2018.

3.3 Experimental design

The experimental design section provided the sample selection, consumer panel size and the specific sample demographics required for this study. Furthermore, an overview of the sampling method for the different lamb and mutton meat samples tested, was given. Subsequently, information on the cooking methods applied for the meat samples were discussed. The physical consumer sensory assessments and experimental auction were conducted on 23 August 2018 in an auditorium at the Stellenbosch Private Hotel School, Western Cape, South Africa.

3.3.1 Selection of consumer panel

It is important to have a representative sample which is a selected segment of a group that represents the population as a whole in terms of the key variables under study (Cherry, 2018). The collected results can then be generalised to a larger population.

The participants for this study had to be regular consumers of lamb and mutton meat. They also had to be classified into the higher-income consumer segment as measured by the Socio-Economic Measurement (SEM) segmentation tool. The SEM segmentation tool replaced the Living Standard Measurement (LSM) developed by the South African Advertising Research Foundation (SAARF), which was terminated in 2015. The SEM scale has ten groups from SEM 1, which represents low socio-economic living, to SEM 10, representing high socio-economic living, as reflected in Table 3.4 (BFAP Baseline, 2018).

Table 3.4: Main socio-economic sub-groups in South Africa

Sub-group	Estimated corresponding SEM segments
Marginalised consumers	SEM 1 & SEM 2
Lower middle-income consumers	SEM 3 to SEM 5
Upper middle-income consumers	SEM 6 to SEM 7
Affluent consumers	SEM 8 to SEM 10

Source: Adapted from BFAP Baseline (2018)

The participants in this study had to be classified into the SEM 8-10 group in order to be affluent enough to meet the expense of lamb and mutton meat as this is a niche product. The sample was selected from the Cape Winelands district and the City of Cape Town metropolitan area in the Western Cape.

Considerable time and effort was invested in compiling a sample that is representative of South African lamb and sheep meat consumers. Previous studies were reviewed to identify the specific demographics that should be included for the sample. There is, however, no specific demographic data available on South African lamb and sheep meat consumers. The only information that could be used as reference is the high prices of lamb and sheep meat. The meat is more expensive in nature and it is therefore expected that only the higher income consumers will be able to afford it. In previous studies, the LSM 8-10 consumer group (now SEM 8-10) was used to represent the lamb and sheep meat consumers (Van Zyl, 2011; Weissnar & du Rand, 2012; Vermeulen, Schönfeldt & Pretorius, 2015; Kirsten, Vermeulen, Van Zyl, du Rand, du Plessis & Weissnar, 2017; Bester, 2017; Hurter, 2018).

In addition to the income group, further elements were taken into consideration to compile a representative sample of the SEM 8-10 group. Quota sampling was applied to reflect the characteristics of the South African population in terms of SEM segment, age category and ethnic groups for the wealthy consumer group. The analysis of the sample demographics will be discussed in the following chapter.

3.3.1.1 Sample demographics

A representative sample of the SEM 8-10 group was compiled by referring to the latest establishment survey release. The demographics of the SEM 8-10 groups can be viewed in full detail in Appendix A.

The SEM 8-10 represents the most affluent consumer group with the highest average monthly household income ranging from R18 464 – R34 574 per month (BFAP Baseline, 2018). The dominant provincial locations of the SEM 8-10 consumer group are in the Gauteng Province, Western Cape and KwaZulu-Natal. The sample was selected from the Cape Winelands district and the City of Cape Town metropolitan area in the Western Cape. According to the latest BFAP Baseline Agricultural Outlook Report, a large segment of the population in the Western Cape consists of affluent consumers, as depicted in Figure 3.1 below.

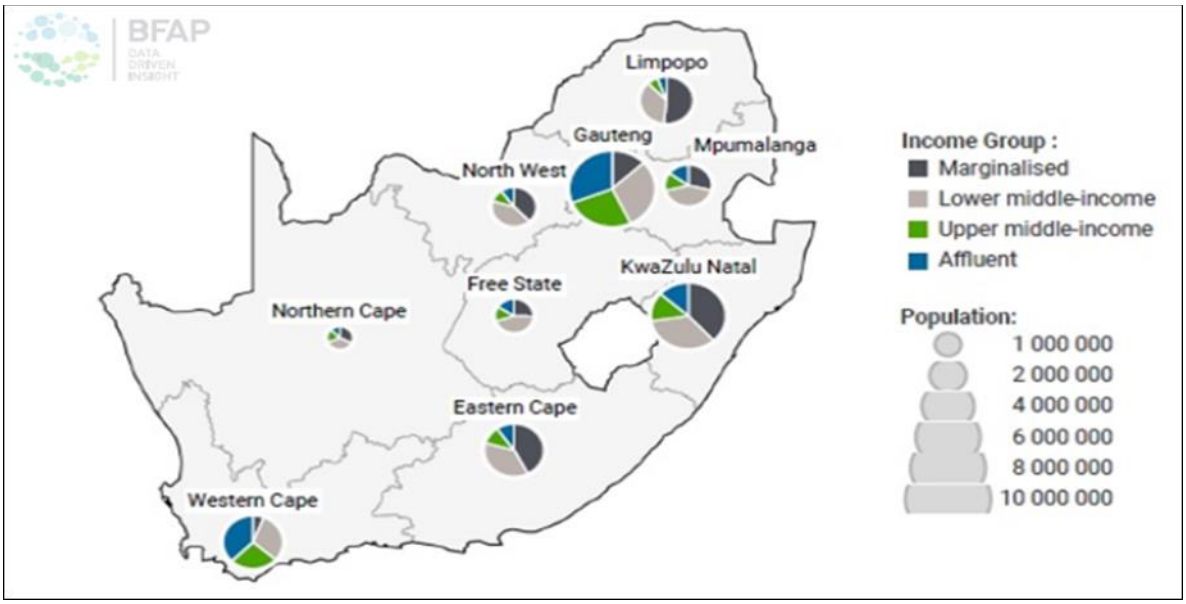

Figure 3.1: Provincial distribution of the main socio-economic sub-groups in South Africa

Source: BFAP Baseline 2018

Furthermore, the distribution of the age categories in this consumer group were determined as 25-34 years (21.9%), 35-49 years (29.5%), and 50-64 years (20.9%) (Reid, 2018). From an ethnic perspective, this group consisted of 41.4% white consumers, 36%

black consumers, 14% coloured consumers and 8.6% Indian or Asian consumers (Reid, 2018). This group also resided predominantly in urban areas.

3.3.1.2 Sample size

The sample size of an experimental auction depends on a variety of factors, including the research objectives and financial constraints (Lusk & Shrogen, 2007). According to Lusk and Shrogen (2007) the objectives of an experimental auction can either be to identify whether there are differences in valuation between goods or to provide an estimate of the mean WTP for goods among the population. They further indicate that the larger the sample size, the more statistically significant results will be obtained throughout the study.

It was evident from the literature reviewed that a variety of sample sizes have been used to conduct experimental auctions. Rousu et al. (2004) used a sample size of 44 consumers to elicit consumers' WTP for food products with different tolerant labels, while Lee et al. (2011) used a total of 100 auction participants. The study by Lusk et al. (2004) recruited 25 and 29 participants respectively to evaluate their preferences for different types of ribeye steaks in two random *n*th-price experimental treatments. Van Zyl (2011) applied experimental economics to determine consumers' WTP for certified Karoo lamb with a sample size of 31 participants. Hurter (2018) studied the impact of secondary information on consumers' WTP for differentiated fresh lamb meat products in South Africa, having had a total of 15 auction participants.

While this study investigates consumers' sensory assessments for particular meat characteristics and their WTP values, previous studies' sample sizes, which combine both these elements, have to be reviewed. A variety of sample sizes were used to conduct consumer sensory assessments in combination with experimental auctions in other similar studies observed in the literature reviewed. Umberger and Feuz (2004) used 12 panels, which varied from 6 to 12 participants, to determine consumers' taste preferences and to elicit consumers WTP for six different steak samples. In a study by Melton et al. (1996), a random sample of 36 consumers evaluated sensory attributes for pork chops and indicated their WTP. Hobbs et al. (2006) determined consumer preferences for bison and their WTP for specific credence attributes in 5 Canadian locations. The experimental auctions were carried out in groups averaging 12 people. Meanwhile, in a study by

Umberger et al. (2002) on U.S. consumers' preference and WTP for domestic corn-fed beef versus international grass-fed beef, a total of 248 consumers participated in the study, 124 from Chicago and 124 from San Francisco.

The sample size for the experimental procedure in this study consisted of 42 participants. A total of 128 participants were invited to take part in the sensory assessments and auction, with 45 accepting the invitation and 42 actually attending. Confirmation emails were sent to participants 4 days prior to the auction to increase attendance rates. Strict financial and time constraints prevented the inclusion of more consumers. All consumers were exposed to the same experimental treatments simultaneously; the sample size therefore had to be carefully managed in order to keep all the treatments standardised for each participant.

3.3.2 Meat sampling

Three different lamb and mutton age classes were used in this study in order to have a representative meat sample distribution. The A lamb (no permanent incisors), AB mutton (1-2 permanent incisors) and C mutton (more than 6 permanent incisors) carcasses with fatness level 2 were selected. Two carcasses of each age class were used in this study, amounting to a total of 6 carcasses utilised.

For the purpose of this study, it was essential to keep all the variables standardised. Therefore, the 6 carcasses (n=6) were obtained from one registered KMOO farmer in the Karoo's Carnarvon district. KMOO is a certification scheme whereby producers, abattoirs, butchers, traders and restaurants that produce or trade in Karoo sheep meat can apply to be certified to use the *Certified Karoo Meat of Origin* mark (Karoo Meat of Origin, 2018a). The registered producer has to abide by the set of production practice rules established by KMOO (Karoo Meat of Origin, 2018b). The sheep were thus exposed to identical environmental conditions, grazing on identical Karoo veldt and treated similarly. The carcasses further compromised one of the most commonly used meat producing breeds, namely the Dorper. Quality variation, especially meat flavour, exists between different breed types (Sink & Caporaso, 1976; Channon et al., 2003; Hoffman et al., 2003), and only Dorper sheep were consequently sourced. Gender also has a significant influence on the palatability of meat (Navajas, Lambe, Fisher, Nute,

Bunger & Simm, 2008; Hopkins & Mortimer, 2014; Junior et al., 2015), and only ewes were therefore selected for all 6 carcasses in the different age classes.

The animals were taken off the veldt 2 days prior to slaughter and were transported to Williston Abattoir on 13 August 2018. They were slaughtered using standard commercial procedures. Thereafter, the carcasses were classified according to the South African Classification System by a qualified classifier at the abattoir. Each carcass was weighed individually and clearly marked for the researcher so that the specific carcasses for the study were clearly identifiable. The carcasses were then stored in a refrigerated cooling chamber 30 minutes post-slaughter for 24 hours before transportation. On the morning of 15 August 2018, the carcasses were loaded in a refrigerated truck (4-6 °C) and transported to Ryan Boon Butchery, Paarl, Western Cape. The carcasses arrived the following morning.

Figure 3.2: The six carcasses used for the study

3.3.2.1 Physical dissection

Upon arrival at Ryan Boon Butchery, the carcasses were weighed again prior to being dissected into the respective wholesale cuts by the butcher under the supervision of the researcher and a trained deboning team was responsible for the physical dissection. Strict control mechanisms were in place during the dissection process. Each age class was

dissected separately so that the meat cuts could be held separate from the other age classes. The meat cuts of each age class were also placed in separate crates, clearly labelled. The first two C age class carcasses were completely dissected, then the two AB age class carcasses, and lastly the two A age class carcasses.

The carcasses were dissected down the vertebral column with a Freddy Hirsch BSB 4002 model band saw with a voltage of 380 V 50 Hz (SABS) and 1 500 wattage. Each carcass side was then subdivided into the following primary cuts: neck, flank, shoulder, breast, rib, loin, leg and shanks. The kidneys and subcutaneous fat were removed.

Figure 3.3: Physical dissection done with the use of a band saw

The neck was halved and dissected into 2.5 cm-thick slices, while the shoulder was dissected into 5 cm cuts, the shanks into 4 cm cuts and the ribs into 5 cm blocks. All the legs were deboned and excessive glands were removed from the inside of each leg. The loins of each age class were carefully dissected into the cannon loin cut. The cuts were trimmed so that all subcutaneous fat was removed (Hoffman et al., 2003; Veiseth et al., 2004; Pethick et al., 2005; Cloete et al., 2012).

Figure 3.4: Illustrating the measurement of each cut

Figure 3.5: The loin cut being trimmed and all subcutaneous fats removed

The wholesale cuts used in this study were the loin, leg, ribs, shanks, neck and shoulder. The ribs, shanks, neck and shoulder were used together as stew cuts. These cuts were chosen as they represent the most commonly consumed cuts among the South African lamb and sheep meat consumer (Schönfeldt et al., 2011; Cavalier, 2018). Bratzler (1971) indicated that the loin section has been used most frequently for studies evaluating meat tenderness and juiciness due to the size and uniformity of the loin section (Van Heerden, 2007). In addition, Woodhams et al. (1966) described it as a large, important muscle in the detection of palatability differences and the main contributor to the meat content of a chop.

After the dissection process, the wholesale cuts were vacuum packed and individually labelled with each label indicating the age class and the type of cut. The meat was

refrigerated for 2 days to further mature and after a total of 5 days of maturing, it was frozen at -20 °C until required for cooking (Pannier et al., 2015).

3.3.3 Cooking methods

Two cooking methods were applied for the sensory evaluation. Firstly, a standardised laboratory cooking method was applied. For this method, all variables were kept constant so that the only variable present was the age of the animal. The temperature and cooking duration were consequently identical for each age class. The method was carried out by cooking the meat until the optimal cooking time for the A class lamb. The same cooking time was applied to the AB and C age classes and it was therefore comparable in terms of cooking duration with the A class lamb. It was important to keep all treatments identical for each age class.

Secondly, an optimal home-use cooking method was applied. For this method, the meat was cooked until the optimal cooking time for each age class. The cooking time differed for each class, but the temperature was kept the same. Two variables were present in this method - the cooking time and the age of the animal. The reason for the application of this method is to test the effect of time and electricity. Due to physiological differences in each age class, the optimal cooking time will differ. For example, as the animal age, the connective tissue concentration in the muscle fibres increases (Reagan et al., 1976; Schönfeldt et al., 1993). Meat containing a higher concentration of connective tissue will be less tender (Purchas, 2014), thus longer cooking time will be necessary to get to an optimal state where the meat is tender. The amount of electricity used will also differ concomitant with the cooking duration. As this is a consumer behaviour study, the meat had to be evaluated under the same conditions as it would be in a typical consumer household. The domestic way of cooking was imitated to give a worthy replication of the cooking conditions in a household.

3.3.3.1 Cooking procedure

The meat was thawed 24 hours prior to cooking at 10 °C. The meat was cooked on the day of the sensory assessments and experimental auction (23 August 2018) by a

professional Chef team. Each meat cut in each age class was prepared and cooked separately. The ribs, shanks, neck and shoulder (stew meat cuts) were cooked together using a moist cooking method on the stove, while the deboned legs and loins were roasted separately in identical electric convection ovens using a dry heat cooking method. A moist or dry-heat cooking method refers to the atmosphere surrounding the meat (Schönfeldt et al., 1992). The moist cooking method entailed adding 2 litres (ℓ) of water prior to cooking in each pot. The dry heat cooking method required the meat uncovered in a flat open pan with a rack to keep the meat out of the drip; no water was added during cooking. A hand-held probe was used to record the internal temperatures at the centre of each meat cut. Great care was taken to standardise the methods of cooking. The final cooked samples were placed in tasting cups which were labelled with 3-digit codes representing each age class. Each participant received a white tray with three tasting cups, one of each age class.

First, the ribs, shanks, neck and shoulder (stew meat cuts) were cooked together on the stove according to a standardised moist cooking method at full gas flame. The age classes were cooked separately in large stainless steel casserole pots. The pots were individually labelled, indicating the meat age class. Prior to cooking, distilled water (2 ℓ) at room temperature was added to each pot. For standardisation purposes, only 15 ml Maldon salt were added to each pot prior to cooking. Only the optimal cooking method was used for each age class. The reason for only applying the optimal cooking method is due to the fact that the AB and C class meat will not properly be cooked off the bone in the same cooking time as the A class. It will therefore not be standardised and representative of all the meat cuts together if different individual samples of meat from different cuts are served to the participants to evaluate. The individual meat cuts also comprise varying flavours and textures. Hence, the cuts were cooked slowly to allow the meat to become tender enough so that it can be cooked off the bone and “pulled”, or easily broken into pieces.

All the C class meat cuts were first cooked off the bone after 3 hours and were set aside for a standing period of 10 minutes at room temperature following cooking. Thereafter, the meat was dissected into samples for sensory assessments. The AB class meat cuts started cooking an hour before the C class cuts were finished cooking. The meat was cooked off the bone after 2 hours and 15 minutes and was set aside for a standing period of 10 minutes at room temperature following cooking. Thereafter, the meat was dissected into samples for sensory assessments. The A class meat cuts started cooking 30 minutes

before the AB class cuts were finished cooking. The meat was cooked off the bone after 2 hours and was set aside for a standing period of 10 minutes at room temperature following cooking. Thereafter, the meat was dissected into samples for sensory assessments.

It was important to keep the three age classes separate while the meat was prepared; therefore each age class was prepared at a separate workstation with a clearly labelled 3-digit code. The same 3-digit code was indicated on the tasting cups. The following 3-digit codes were used: A class (645), AB class (536) and C class (312).

The cooked C class meat was prepared first by extracting the bones and pulling the meat into pieces. Thereafter the AB and the A class were treated with the same procedure. Figure 3.6 illustrates the flow of the cooking procedure. The pulled, cooked meat was measured into 30 ml samples and placed into the respective tasting cups.

Afterwards, the legs were roasted on a rack in identical convection ovens according to the dry heat cooking method at 175 °C to an internal temperature of 75 °C measured in the centre of the cut. The deboned legs were butterflied for standardisation purposes so that they were evenly cooked all-round. The age classes were cooked separately with two legs per age class in one oven. The ovens were individually labelled, indicating the age class, starting time of cooking and ending time. The standardised and optimal cooking methods were applied for these meat cuts.

Figure 3.6: The cooking procedure for the stew meat cuts

Two legs per age class were used for the standardised cooking method; therefore all 6 legs in the different age classes were roasted in the ovens at the same temperature and for

the same duration. Each leg was weighed prior to cooking as seen in Table 3.5. The cooking time was then calculated at 50 minutes per kg. As mentioned in the cooking methods, the legs were cooked until the optimal cooking time for the A class lamb. The A class legs weighed an average of 2 kg. The cooking duration had to be accurately calculated in order for the meat to be served at the desired temperature for evaluation. The legs for this method were roasted for 1 hour and 40 minutes in the ovens and were set aside for a standing period of 10 minutes at room temperature before evaluation.

The other two legs per age class were used for the optimal cooking method; therefore all 6 legs in the different age classes were roasted in the ovens at the same temperature but the cooking time differed. Each leg was weighed prior to cooking and the cooking time was then calculated at 50 minutes per kg. The A class legs weighed an average of 2 kg, the AB class an average of 2.4 kg, and the C class an average of 3.5 kg. The cooking duration for each class was as follows: A class (100 minutes), AB class (120 minutes) and C class (175 minutes). The cooking duration had to be accurately calculated in order for the different age classes with their varied cooking times to come out the oven at the same time. The C class legs therefore had to be placed in the oven before the AB and A class legs as the former takes longer to roast.

The meat from the three age classes was kept separate while being prepared; each age class was prepared in a separate work station with a clearly labelled 3-digit code. The same 3-digit code was indicated on the tasting cups. The meat was cut into 1.5 cm^3 cubed samples (Hoffman et al., 2003). Only the centre cubes were used while the dryer outsides were avoided. The samples were placed into the respective tasting cups labelled with a 3-digit code. Figure 3.7 illustrates the flow of the cooking procedure.

Table 3.5: The total weight (kg) of each leg per age class

Age class	Weight (kg)
A#1 leg	2.418 kg
A#1 leg	2.540 kg
A#2 leg	2.102 kg
A#2 leg	2.160 kg
AB#1 leg	2.646 kg
AB#1 leg	2.672 kg
AB#2 leg	2.310 kg
AB#2 leg	2.366 kg
C#1 leg	3.270 kg
C#1 leg	3.134 kg
C#2 leg	3.388 kg
C#2 leg	3.294 kg

Figure 3.7: The cooking procedure for the leg cut

The loins were roasted whole on a rack in the oven according to the dry heat cooking method in identical electric convection ovens at 220 °C to an internal temperature of 75 °C, measured in the centre of the cut. The age classes were again cooked separately with one loin per age class per oven. The ovens were individually labelled, indicating the age class, starting time of cooking and ending time. The standardised and optimal cooking method was applied for this meat cut.

One loin per age class was used for the standardised cooking method and one for the optimal cooking method. The standardised method was applied where the loins were first cooked until the optimal cooking time for the A class lamb. Each loin was weighed prior to cooking as seen in Table 3.6. The A class loins weighed an average of 0.834 kg. The cooking duration had to be accurately calculated in order for the meat to be served at a

desired temperature for evaluation. The loins for this method were roasted for 8 minutes in the ovens.

The other set of loins were used for the optimal cooking method. The loins in the different age classes were roasted in the ovens at the same temperature but the cooking time differed. Each loin was weighed prior to cooking and the cooking time was then calculated. The A class loin weighed an average of 0.892 kg, the AB class weighed an average of 0.872 kg and the C class an average of 1.272 kg. The cooking duration for each class was as follows: A class (8 minutes), AB class (9 minutes) and C class (13 minutes). The cooking duration had to be accurately calculated in order for the different age classes with their varied cooking times to be removed from the ovens at the same time. The C class loin therefore had to be placed in the oven before the AB and A class loins as the former takes longer to roast.

Table 3.6: The total weight (kg) of each loin per age class

Age class	Weight (kg)
A#1 loin	0.892 kg
A#2 loin	0.776 kg
AB#1 loin	0.754 kg
AB#2 loin	0.990 kg
C#1 loin	1.300 kg
C#2 loin	1.244 kg

The three age classes were kept separate while the meat was prepared. Each age class was prepared at a separate workstation with a clearly labelled 3-digit code. The same 3-digit code was indicated on the tasting cups. The meat were cut into 1.5 cm^3 samples and placed into the respective tasting cups labelled with a 3-digit code. Figure 3.8 below illustrates the flow of the cooking procedure.

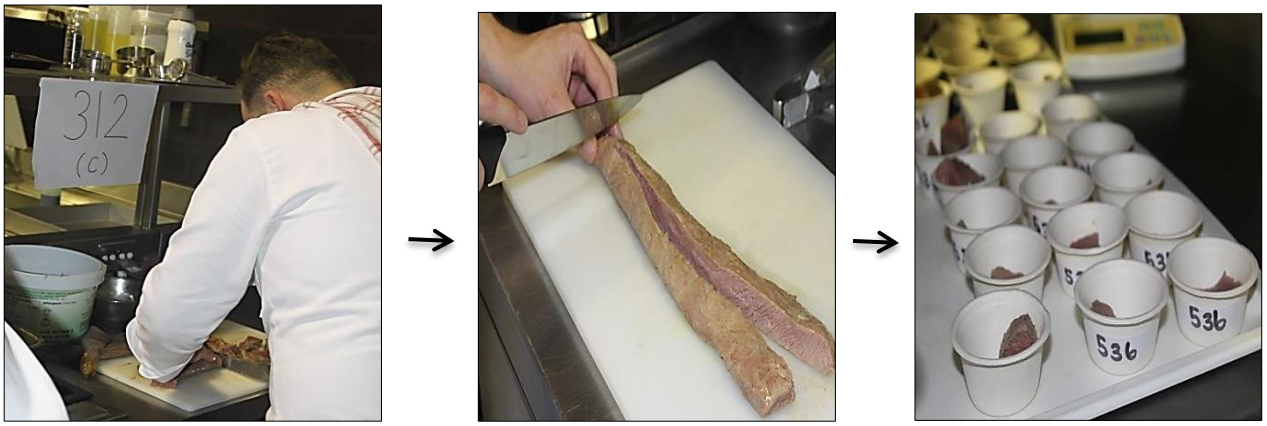

Figure 3.8: The cooking procedure for the loin cut

3.4 Auction procedure and design

The experimental auction was held during one evening on 23 August 2018 and consisted of a pre-auction survey (Appendix C), followed by the sensory assessment and one experimental auction. Participants were asked to complete a pre-auction survey on arrival. Thereafter, the surveys were collected and the sensory assessments together with the random *n*th-price auction commenced.

Consumers' sensory assessments and WTP were measured on an already-established market product, Karoo lamb and mutton. Consumer behaviour within the experimental auction could be explored as well as the influence of participants' demographics and their prior knowledge of the experimental product under investigation. The participants were treated as one group and were simultaneously presented with identical information.

There was one practice round, five sensory assessment rounds and five experimental auction rounds. The sensory assessments and random *n*th-price auction procedures were conducted in a total of 19 steps, as outlined in Table 3.7.

Upon arrival, participants were seated in the auditorium. An information sheet, containing written instructions (Appendix B), a survey (Appendix C) and a white envelope were placed on the desks in front of them. Inside each envelope, one 4 cm *droëwors* sample was wrapped in a plastic bag and a booklet with scoresheets and a R200 note were provided. The *droëwors* sample was the reference product used during the practice round. The booklet with scoresheets (Appendix D) was used by participants to

write each round's meat samples' sensory scores and bidding price. Participants were compensated with real money in order to create a real market environment as prescribed by Horowitz & McConnell (2002) and De Groote et al. (2010). The R200 note was used as bidding money in the auction and for compensation to each participant for participating in the study. The compensation amount had to be sufficient to use during all the auction rounds.

The participants were requested to complete a pre-auction survey. The survey was designed to obtain participants' demographic information, their prior knowledge of lamb and mutton, and their meat purchasing behaviour. It is important to gain participants' prior knowledge of a product in order to compare it with the real values stated during the experimental procedure. Lusk & Shogren (2007) define these values as home-grown values, which are values that participants possess from a real world experience of actual market products prior to the experimental procedure.

The completed surveys were collected by the auction monitors and instructions about the sensory assessments and auction procedure were given by the moderator. Participants were told that there would be one practice round held to familiarise them with the auction mechanism, followed by five tasting and auction rounds. They were informed that, during each round, they would first have to taste three samples of different ages of lamb and sheep meat and then rate them in terms of flavour, juiciness, tenderness and overall liking, using a 9 point-hedonic scale. Thereafter, they had to submit a sealed bid for each meat sample they had tasted, indicating their WTP.

Table 3.7: Framework of experimental procedure

Steps	Description
Step 1	Participants fill in pre-auction survey.
Step 2	Verbal explanation by the auction monitor of the sensory assessments and random *n*th-price auction procedure.
Step 3	Practice round with a *droëwors* sample; payment price and winners' ID numbers are revealed.
Step 4	The first three meat samples are served to each participant.
Step 5	The first sensory assessments and bidding round are done (scoresheets are collected after each round).
Step 6	Binding sample is randomly drawn; payment price and winners' ID numbers are revealed.
Step 7	Winners come forward to purchase their packet of meat with their R200 note.
Step 8	The second round of three meat samples is served to each participant.
Step 9	The second sensory assessment and bidding round are done.
Step 10	The third round of three meat samples is served to each participant.
Step 11	The third sensory assessment and bidding round are done.
Step 12	Binding round and binding sample are randomly drawn; payment price and winners' ID numbers are revealed.
Step 13	Winners come forward to purchase their packet of meat with their R200 note.
Step 14	The fourth round of three meat samples is served to each participant.
Step 15	The fourth sensory assessment and bidding round are done.
Step 16	The fifth round of three meat samples is served to each participant.
Step 17	The fifth sensory assessment and bidding round are done.
Step 18	Binding round and binding sample are randomly drawn; payment price and winners' ID numbers are revealed.
Step 19	Winners come forward to purchase their packet of meat with their R200 note.

Each meat sample was placed in a tasting cup with a labelled 3-digit code. It was clearly conveyed to the participants that it was very important to write the corresponding 3-digit code on the scoresheet with their auction identification number. An explanation was given on how each participant's ID number was determined. Those ID numbers were used for anonymity and to identify the auction winners. Each meat sample was scored on an individual scoresheet (Appendix D).

Furthermore, they were informed that they would taste three different meat cuts in three separate stages. In the first stage three samples of stew meat were tasted (in the different age classes), in the second stage three samples of loin were tasted (in the different age classes), in two sets. In the third stage, they tasted three samples of leg of lamb and mutton in two sets. The participants were asked to sensory assess the meat samples

according to their previous sensory experiences with lamb and mutton meat and then to compare it with a constant of lamb stew cuts, lamb loin cut and lamb leg cut found predominantly in the retail outlets. After the information session, the participants were asked to peruse the information sheet provided, which contained more detailed written auction instructions.

As mentioned above, a practice round was held first to familiarise the participants with the auction mechanism. Lusk & Shogren (2007) believe it is critical that people should receive a practice round with another product and be assured of anonymity prior to conducting an auction. The practice round made it clearer to participants that it was in their best interest to bid truthfully. The moderator presented an 80 g packet of *droëwors* as the reference product and announced the average full market price (R30). Participants were asked to taste their *droëwors* sample and indicate on their first bidding slip the maximum amount they would be willing to pay for an 80 g packet of *droëwors*, based on the sample they had tasted. The bidding slips were collected and sorted from the highest to the lowest bid. Thereafter, a random number was drawn by the moderator to determine the cut-off price. The cut-off price was revealed together with the ID numbers of the potential auction winners who bid higher than the cut-off price. As this was a practice round, no physical payment needed to be made by the potential auction winners.

Following the practice round, the first phase of sensory assessments and experimental auction began. This phase consisted of one round of three tasting and bidding rounds. A reference product, a 500 g packet of stew meat cuts, was shown with its average full market price (R65). Lusk et al. (2004) point out that participants can be endowed with a product and asked the amount they would be willing to pay for the full value of the product or the amount they would be willing to pay to upgrade the original product to a product with adjusted characteristics. The three meat samples were served and participants were asked to taste each meat sample individually and score it on the corresponding scoresheet with the maximum amount they would be willing to pay for a 500 g packet of stew meat cuts, based on the sample they had tasted. Participants were asked to bid in increments of R1 to simplify the purchase process.

The scoresheets were collected and the binding sample was determined by randomly drawing a number from 1 to 3 from a bag (1= sample one, 2= sample two, 3= sample three). Only one meat sample in this phase was binding, in other words, only one sample was determined where the auction winners had to purchase the reference product at the determined purchase price. The binding sample's bidding prices were captured on a

Microsoft Excel 2010 spreadsheet and sorted from the highest to lowest bid. Thereafter, a random number *(n)* was drawn by the moderator to determine the cut-off price. A random number *(n)* was drawn from the distribution between 2 and the number of participants (k). The main reason for drawing a random number as the cut-off price was to get a market clearing price with no influence by the monitor. Each participant who bid higher than the cut-off price had to purchase the reference product. The cut-off price was revealed together with the ID numbers of the auction winners. The auction winners had to purchase their packet of stew meat cuts with the R200 note at the determined purchase price.

Figure 3.9: A 500 g stew meat reference product with the average full market price indicated

The second phase of sensory assessments and experimental auction consisted of two separate rounds with a total of six tasting and bidding rounds. A reference product, a 500 g packet of loin chops, was presented and its average full market price (R88) given. The first round's three meat samples were served and participants were asked to taste each meat sample individually and score it on the corresponding scoresheet with the maximum amount they would be willing to pay for a 500 g packet of loin chops, based on the sample they had tasted.

Thereafter, the scoresheets were collected and the second round of meat samples was served to each participant. The participants were again asked to taste each meat sample individually and score it on the corresponding scoresheet with the maximum amount they would be willing to pay for it. The scoresheets were collected and the binding round and

binding sample were determined. Due to having two rounds in this phase, only one round and one meat sample had to be binding, in other words, only one round was determined where the auction winners of the round had to purchase the product at the determined purchase price. The binding round was determined by a coin toss, heads for round one and tails for round two. Subsequently, the binding meat sample was determined by randomly drawing a number of 1 to 3 from a bag (1= sample one, 2= sample two, 3= sample three). The binding sample's bidding prices were captured on a Microsoft Excel 2010 spreadsheet and sorted from the highest to lowest bid. Thereafter, a random number *(n)* was drawn by the moderator to determine the cut-off price. Each participant who bid higher than the cut-off price had to purchase the reference product. The cut-off price was revealed together with the ID numbers of the auction winners. The auction winners had to purchase their packet of loin chops with the R200 note at the determined purchase price.

Figure 3.10: A 500 g loin chop reference product with the average full market price indicated

The third phase of sensory assessments and experimental auction also consisted of two separate rounds with a total of six tasting and bidding rounds. A reference product, a 500 g deboned leg of lamb, was presented with its average full market price (R95). The first round's three meat samples were served and participants were asked to taste each meat sample individually and score it on the corresponding scoresheet with the maximum amount they would be willing to pay for a 500 g deboned leg of lamb, based on the sample they had tasted.

The scoresheets were then collected and the second round of meat samples was served to each participant. The participants were again asked to taste each meat sample individually and score it on the corresponding scoresheet with the maximum amount they would be willing to pay for it. The scoresheets were collected and the binding round and binding sample was determined. Due to having two rounds in this phase, only one round and one meat sample had to be binding, in other words, only one round was determined where the auction winners of the round had to purchase the product at the determined purchase price. The binding round was determined by a coin toss, heads for round one and tails for round two. Subsequently, the binding meat sample was determined by randomly drawing a number from 1 to 3 from a bag (1= sample one, 2= sample two, 3= sample three). The binding sample's bidding prices were captured on a Microsoft Excel 2010 spreadsheet and sorted from the highest to lowest bid. Thereafter, a random number *(n)* was drawn by the moderator to determine the cut-off price. Each participant who bid higher than the cut-off price had to purchase the reference product. The cut-off price was revealed together with the ID numbers of the auction winners. The auction winners had to purchase their deboned leg of lamb with the R200 note at the purchase price provided.

Figure 3.11: A 500 g deboned leg of lamb reference product with the full average market price indicated

The experimental procedure was concluded with a presentation by Mariette Crafford, a well-known journalist, chef, public speaker, and media and food consultant. Information on cooking methods for different ages of lamb and mutton was presented. The standard laboratory cooking method and the optimal cooking method, which were applied for the

different meat cuts, were explained to the participants. The 3-digit codes that represented the age of each meat sample were also revealed by the auction moderator.

3.5 Data analysis

For this research study, raw data was firstly collected by capturing the weights of all carcasses and the respective meat cuts by hand. The cooking preparation data for the sensory assessments, which included the cooking duration and temperature for each meat cut, was captured on an additional form. Prior to statistical analysis, all raw data obtained was entered and coded on spreadsheets using Microsoft Excel 2010.

The sensory assessment scores and WTP values were analysed using Friedman's analysis of variance (ANOVA) to test for any statistically significant differences in the mean values. Friedman's ANOVA test is a non-parametric statistical test which is the alternative to a one-way ANOVA with repeated-measures (Lawless & Heymann, 2010). This test is preferred when the data is significantly different than normally distributed data. The assumptions that have to be met by the data set are as follows:

- One group of test subjects is measured on three or more different occasions.
- The group is a random sample of the population.
- The dependent variable is at least an ordinal or continuous variable.
- The samples do not need to be normally distributed.

Furthermore, multiple regression analyses were applied to estimate any relationships among variables using STATA. Multiple regressions are used to predict the value of a dependent variable based on the value of two or more independent variables. Additionally, multiple regressions determine the overall fit of the model and the contribution of each of the independent variables to the total variance explained. The bid amounts recorded in the experimental auction were ultimately compared to the sensory scores and socio-demographic variables in the pre-auction survey.

3.6 Summary

This chapter presented a discussion of the experimental design and procedure implemented for the data gathering process. The chapter opened with a brief overview of the sensory assessments and experimental auction methods. Thereafter, the experimental design was discussed, indicating the sample selection for the consumer panel, the assortment of the consumer panel size and the specific sample demographics required for the study. An overview of the sampling method for the different lamb and mutton meat samples and the different cooking methods applied, was given. The last section of this chapter focused on the implementation of the consumer sensory assessment process and the random *n*th-price auction procedure. The specific design and implementation were outlined in 19 steps, presented in Table 3.7, followed by a detailed discussion of each step. The results obtained from the pre-auction survey and consumer sensory assessments from the scoresheets will be presented and analysed in the next chapter.

CHAPTER 4: SOCIO-ECONOMIC PROFILE AND CONSUMERS' SENSORY ASSESSMENTS OF LAMB AND MUTTON

4.1 Introduction

In this chapter the pre-auction survey and consumer sensory scores are analysed statistically. Firstly, the sample's key demographic characteristics will be discussed, with the focus on gender, age, ethnicity, education, monthly household income, average household size and geographic distribution. Secondly, the consumer panel's meat purchasing behaviour will be analysed in order to detect their meat consumption preferences as well as prior preferences towards lamb and mutton. Thirdly, the mean and standard deviations of the sensory characteristics for each meat cut as influenced by the three age classes and cooking methods, will be presented. The variables addressed in the pre-auction survey will also be compared to the sensory scores recorded to determine any relationship between these variables.

4.2 Sample demographics

The sample demographics were obtained from the pre-auction survey and are summarised in Table 4.1. The validity of the sample demographics is explained via the survey results.

In the specified consumer group, gender is required to be equal, with 50% males and 50% females (SAARF, 2014). The sample of this study consisted of 52% males and 48% females, which fits well within the gender specifications.

The sample's ages were classified into four categories with a minimum age of 25 years and a maximum of 64 years, as presented by SAARF (2014) in Table 4.2. The sample had a distribution of 40% of participants in the 25-34 years age category, 29% of participants in the 35-49 years age category and 31% of participants in the 50-64 years age category.

From an ethnic perspective, the three most dominant groups in the SEM 8-10 are firstly the white population, secondly the black population and thirdly the coloured population (Reid, 2018). The sample consisted of 83% white consumers, 10% black consumers, 5% coloured consumers and 2% Asian consumers.

Table 4.1: Sample demographics

Variable	Characteristics of the sample (n=42)
Gender	
Male (%)	52%
Female (%)	48%
Age	
25-34 years	40%
35-49 years	29%
50-64 years	31%
65 years and over	0%
Ethnicity	
White	83%
Black African	10%
Coloured	5%
Asian	2%
Other	0%
Education	
Grade 11 or lower	0%
Grade 12	7%
Technicon diploma/degree	2%
Bachelor's degree	21%
Postgraduate degree	64%
Other post-matric qualification	2%
Monthly household income	
<R10 000	0%
R10 000 – R29 999	17%
R30 000 – R49 999	40%
R50 000 – R69 999	10%
>R70 000	29%
Average household size	
Average household size	2
Household size range (largest; smallest)	5;1
Geographical distribution	
Rural	31%
Urban	69%

Table 4.2: Age categories of SEM 8-10 consumers

SEM group	Age categories
8	25-34 years (25.9%) 35-49 years (24.7%) 50-64 years (26.9%)
9	25-34 years (21.9%) 35-49 years (28.2%) 50-64 years (27.7%)
10	25-34 years (18.6%) 35-49 years (28%) 50-64 years (30.7%)

Adapted from: SAARF (2014)

The educational level for SEM 8-10, classified in Appendix A, indicates the majority of this group (46%) holds a post-matric qualification. This study's sample has a higher educational level with 64% of the sample obtained a postgraduate degree. Furthermore, 21% of the sample obtained a bachelor's degree while 7% had a matric qualification, 2% a technicon/diploma degree, and 2% with other post-matric qualifications.

The SEM 8-10 represents the most affluent consumer group with the highest average monthly household income, ranging from R18 464 to R34 574 per month (BFAP Baseline, 2018). The sample's monthly household income fell within these margins with 17% earning between R10 000 and R29 999 and 79% of the sample earning an average monthly household income exceeding R30 000. According to the BFAP Baseline (2018), the ratio of residential location of the SEM 8-10 consumer group is as follows:

Table 4.3: Residential location of SEM 8-10 consumers

SEM group	Residential location (rural / urban)
8	2% / 98%
9	1% / 99%
10	1% / 99%

Adapted from: BFAP Baseline (2018)

The consumer group reside predominantly in urban areas. The survey results indicate the geographic region consumers predominantly grew up in, viz. 31% are from rural areas and 69% from urban areas. It confirms that the majority of the sample's participants

come from urban areas too. Furthermore, the average household size within the SEM 8-10 consumer group is recorded as 3.5 people (BFAP Baseline, 2018). The average household size of this study's participants is smaller with 2 people per household. By referring to the discussion above, the sample is mostly comparable with the established SEM 8-10 consumer group.

4.3 Consumer behaviour

The panel's meat purchasing behaviour was analysed in order to detect their meat consumption preferences. The participants were asked to indicate whether they are the primary food and meat shoppers in the household, and the household's purchase and consumption frequency of lamb and mutton meat.

One of the criteria for participating in the study was that the person had to be a regular consumer of lamb and mutton meat. The survey therefore sought to determine in the end if participants are the primary meat shoppers, and the frequency of their meat consumption. The majority of the participants (71%) indicated they are the primary food shoppers in the household, as seen in Table 4.4. Similarly, 76% of the participants indicated that they are also the primary meat shoppers in the household. The participants further indicated that they regularly purchase lamb and mutton, with 40% of respondents purchasing it at least once or twice per week, and 57% consuming it at least once or twice per week. These figures show that the selected sample meets the specified criterion of participants who regularly consume lamb and mutton. The reasons for none of the participants purchasing or consuming lamb and mutton more than once or twice per week may be attributed to the fact that lamb and mutton is one of the more expensive meat types in South Africa and the search for variety in their diet.

Table 4.4: Lamb and mutton purchasing and consumption behaviour

Variable	Lamb and mutton meat
Are you the primary food shopper in your household?	
Yes	71%
No	29%
Are you the primary meat shopper in your household?	
Yes	76%
No	24%
How often do you purchase lamb or mutton?	
Every day	0%
3 - 4 times per week	0%
1 - 2 times per week	40%
At least once a month	36%
Less than once a month	12%
Only on special occasions	10%
How often do you consume lamb or mutton?	
Every day	0%
3 - 4 times per week	0%
1 - 2 times per week	57%
At least once a month	29%
Less than once a month	10%
Only on special occasions	5%

4.3.1 Factors influencing consumer purchasing behaviour

In the introductory chapter, a discussion was held to determine the quality cues that consumers come in contact with before consumption while making a purchasing decision. The survey aimed to determine how these quality cues influence consumer purchasing behaviour. A frequency analysis was completed to examine the factors influencing consumers' sensory assessment of meat.

Participants were asked to indicate which meat cut they preferred in the two different age categories (lamb/mutton). The goal was to establish consumers' preferences prior to the sensory assessments in order to determine whether their preferences prior to tasting the meat correlated with or differed from their actual sensory scores. The frequency

reflected in Table 4.5 below shows the percentage of the participants that indicated their preference for lamb versus mutton for the three respective meat cuts.

Table 4.5: Choice of cut between lamb and mutton

Lamb/Mutton	Cut		
	Stew	Loin	Leg
Lamb	21%	88%	81%
Mutton	79%	12%	19%

The results revealed that the majority of participants (79%) prefer mutton stew cuts rather than lamb (21%). In the loin category, 88% of participants preferred loins from lamb rather than from mutton (12%). The leg of lamb was also predominantly preferred (81%) compared to leg of mutton (19%).

Participants' prior sensory preferences for the two categories (lamb/mutton) in terms of flavour, tenderness and juiciness were also determined. The frequency in Table 4.6 shows the percentage of the participants who preferred lamb or mutton in terms of its sensory characteristics.

Table 4.6: Choice of sensory characteristics between lamb and mutton

Lamb/Mutton	Sensory characteristics		
	Flavour	Tenderness	Juiciness
Lamb	50%	90%	81%
Mutton	50%	10%	19%

Participants valued lamb and mutton equally in terms of flavour, while the majority (90%) indicated that lamb is the more tender meat. In addition, 81% of the participants also indicated that lamb has a higher degree of juiciness than mutton (19%). Overall, the prior sensory preferences of lamb are higher than for mutton. It will be interesting to see if these prior preferences accord with the participants' actual sensory scores.

The frequency of combinations of factors which consumers consider as important when consuming lamb or mutton meat are indicated in Table 4.7. The participants had to indicate the two most valued factors from the following sensory characteristics:

tenderness, juiciness, flavour, fat content/marbling and colour. The frequencies in the table indicate the percentage of participants that selected the specific group of sensory factors as most important.

Table 4.7: Combinations of lamb and mutton sensory factors

Combination of factors	Frequency of combinations
Tenderness, juiciness	17%
Flavour, fat content/marbling	5%
Tenderness, flavour	64%
Juiciness, flavour	2%
Flavour, colour	2%
Tenderness, fat content/marbling	10%

The most popular factor choice set that participants consider as most important, is the tenderness and flavour of lamb and mutton (64%). This result is aligned with previous studies' findings, which also indicated that tenderness and flavour has a great influence on consumers' meat purchasing decision (Watkins et al., 2014; Khan et al., 2015). Seventeen percent of participants rated tenderness and juiciness as the next most important set, followed by 10% for tenderness and fat content/marbling. Only 2% of participants indicated the juiciness and flavour combination as most important, with the flavour and meat colour combination recording the same figure.

4.4 Consumers' sensory assessment results

The first objective of this research was to determine consumers' sensory acceptance of different meat classes and secondly to test the impact of sheep age on consumer sensory scores. To address these two objectives, sensory assessments were performed by the consumer panel**.** It is important to keep in mind that the consumer panel is untrained in sensory assessment methods and will experience taste and flavour based on personal preferences. They also tasted the cooked meat samples which were prepared under normal home conditions with standard kitchen equipment**.**

The participants had to taste and rate three samples of different age classes of lamb and sheep meat in terms of flavour, juiciness, tenderness and overall liking, using a 9-point hedonic scale. As mentioned in Chapter 3, the participants tasted three different meat cuts (stew meat, loin and leg). The optimal cooking method was applied to the stew meat cuts whereas both standardised and optimal cooking methods were applied to the loin and leg cuts. The sensory mean and standard deviations scores for each meat cut within each age class were recorded. Participants' prior sensory preferences were compared to the actual sensory results in order to determine if any relationship exists between their prior preferences and the sensory scores.

Firstly, the mean sensory scores and standard deviations of the stew meat cuts as influenced by the three age classes were recorded and tabulated in Table 4.8. The mean sensory scores for flavour, juiciness, tenderness and overall liking of the C class were the highest, and thus most preferred in terms of the sensory characteristics. The pre-auction survey results indicated that the majority of participants (79%) prefer mutton stew cuts to lamb. The participants' prior tasting preferences are thus in harmony with their actual sensory scores.

Table 4.8: Mean and standard deviations for the sensory characteristics and auction bids of the stew meat cuts as influenced by three age classes (standard deviations in parenthesis)

Sensory characteristics and auction bids	Age classes		
	A	**AB**	**C**
Flavour	6.31 (1.55)	7.29 (0.89)	7.43 (1.25)
Juiciness	6.52 (1.80)	7.05 (1.23)	7.60 (1.21)
Tenderness	6.60 (1.52)	6.71 (1.60)	7.24 (1.25)
Overall liking	6.48 (1.38)	7.05 (1.23)	7.48 (1.19)
Bid amount	61.05 (11.76)	65.29 (9.23)	67.52 (10.04)

Note: Scores based on 9-point scales (1= extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking; 9= extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking)

Participants' prior sensory preferences indicated that they equally value lamb and mutton flavour (Table 4.6). Their prior stated preferences differ from the actual sensory scores where mutton flavour obtained the highest score and is preferred above lamb's flavour. Furthermore, the majority of the participants indicated that lamb has a higher degree of juiciness than mutton, which is not the case in the actual results. Lastly, lamb was also indicated as the most tender meat whereas the C class obtained the highest score in terms of tenderness.

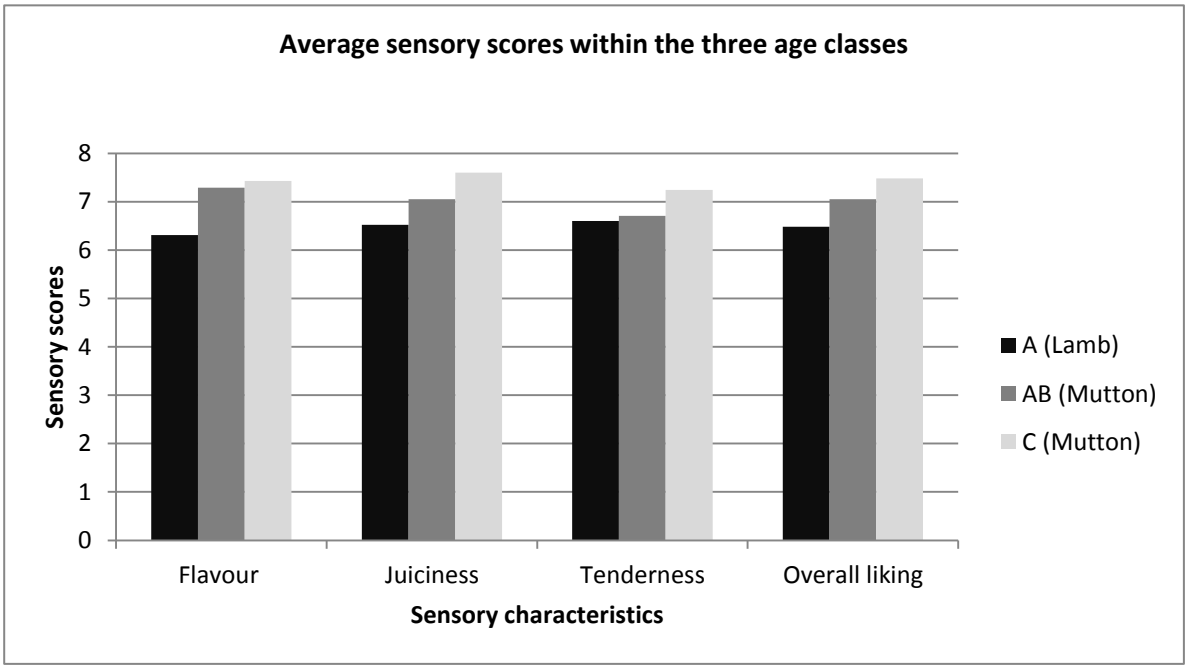

Figure 4.1: Average sensory scores within three age classes for the stew meat cuts

Secondly, the mean sensory scores and standard deviations of the loin cuts as influenced by the three age classes were recorded. The standardised cooking method results were obtained first, followed by the optimal cooking method results, for the loin meat samples. The results of the two cooking methods were evaluated separately as cooking time duration differed between the cooking methods and are thus not comparable.

For the standardised cooking method, the mean sensory scores of the A class were overall the highest, and thus most preferred in terms of the sensory characteristics (Table 4.9). The pre-auction survey results indicate that 88% of participants preferred the loins from lamb rather than from mutton (Table 4.5). The participants' prior tasting preferences are thus similar with the actual sensory scores.

The flavour characteristic for the standardised cooking method is not equally valued for lamb and mutton (Table 4.9). According to the mean sensory scores, the AB flavour is preferred over the flavour of the A and C class. Their prior stated preferences differ from the actual sensory scores (Table 4.6). Furthermore, the majority of the participants indicated that lamb has a higher degree of juiciness than mutton. The results also indicate this phenomenon with the highest juiciness score of 7.38 for the lamb category (Table 4.9). Lastly, the lamb loin cut indicated the highest tenderness degree with a score of 7.83, which is comparable to participants' prior stated preferences.

Table 4.9: Mean and standard deviations for the sensory characteristics and auction bids of the loin muscle as influenced by three age classes using the standardised cooking method (standard deviations in parenthesis)

Sensory characteristics and auction bids	Age classes		
	A	AB	C
Flavour	6.90 (1.36)	7.55 (1.38)	6.55 (1.48)
Juiciness	7.38 (1.13)	7.19 (1.15)	7.24 (1.25)
Tenderness	7.83 (1.08)	6.48 (1.74)	6.86 (1.54)
Overall liking	7.31 (1.18)	7.14 (1.93)	6.79 (1.46)
Bid amount	83.45 (13.53)	83.43 (11.59)	81.02 (11.24)

Note: Scores based on 9-point scales (1= extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking; 9= extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking)

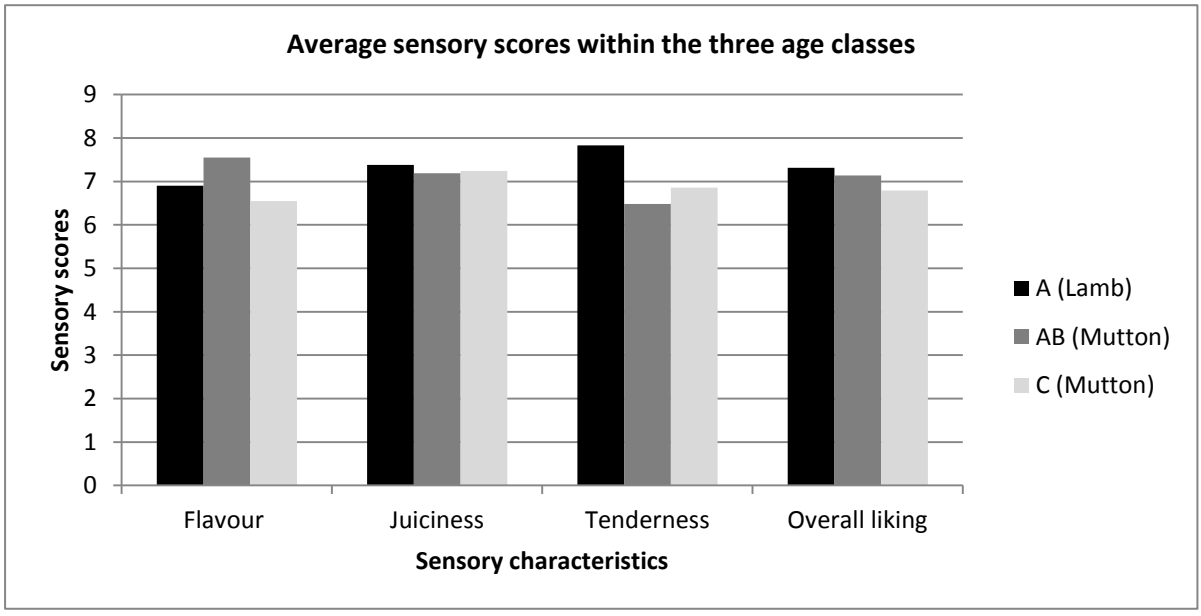

Figure 4.2: Average sensory scores for the loin muscle as influenced by three age classes using the standardised cooking method

When considering the optimal cooking method results for the loin cut, it transpires that the mean sensory scores changed, as the AB class was most preferred in terms of the sensory characteristics (Table 4.10). The participants' pre-auction survey preferences for loins from lamb thus differ from the actual sensory scores (Table 4.6).

Table 4.10: Mean and standard deviations for the sensory characteristics and auction bids of the loin muscle as influenced by three age classes using the optimal cooking method (standard deviations in parenthesis)

Sensory characteristics and auction bids	Age classes		
	A	AB	C
Flavour	6.45 (1.43)	7.71 (0.97)	7.19 (1.38)
Juiciness	7.07 (1.39)	7.31 (1.22)	6.95 (1.31)
Tenderness	7.40 (1.43)	7.50 (1.15)	6.60 (1.55)
Overall liking	6.81 (1.33)	7.52 (1.09)	7 (1.29)
Bid amount	82.50 (10.46)	86.86 (10.31)	84 (9.37)

Note: Scores based on 9-point scales (1= extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking; 9= extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking)

The flavour characteristic is again not equally valued for lamb and mutton. The mean sensory scores indicate the AB class as having the most preferred flavour, which result was also obtained with the standardised cooking method. Participants' prior stated preferences differ from their actual sensory scores. The AB class also enjoys the highest average juiciness score with 7.31, the lamb being second with an average score of 7.07. Lastly, participants' prior stated preferences indicated that the lamb category is most preferred for the tenderness characteristic. The AB and A classes were indicated as having the highest tenderness degree with scores of 7.50 and 7.40 respectively, and it can therefore be concluded that both these age classes are preferred in terms of tenderness.

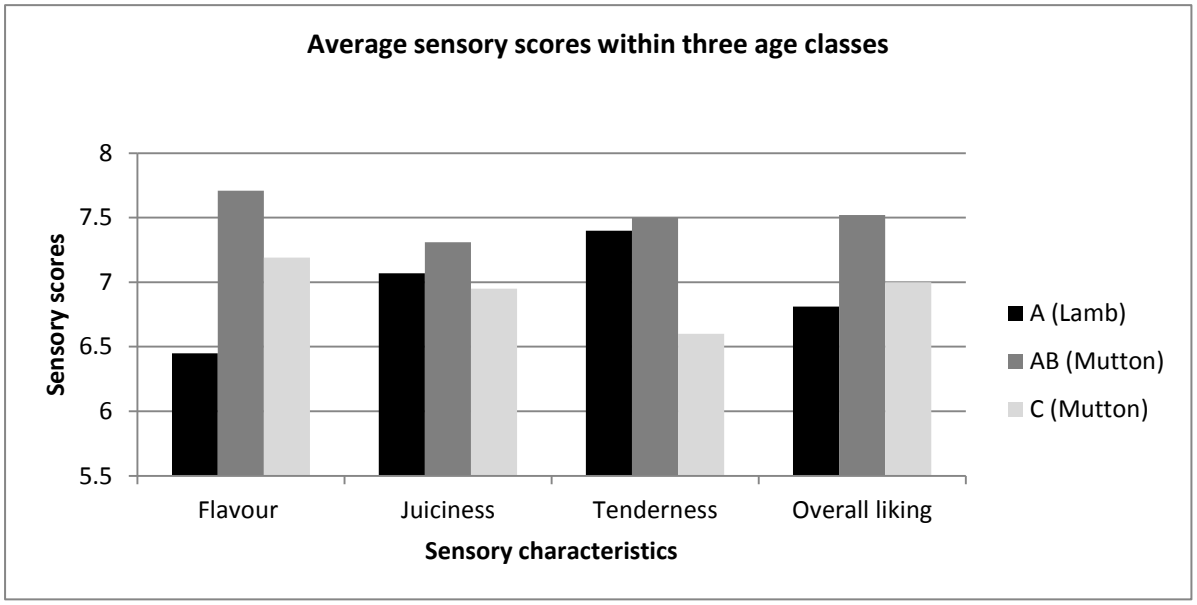

Figure 4.3: Average sensory scores for the loin muscle as influenced by three age classes using the optimal cooking method

Thirdly, the mean sensory scores and standard deviations of the leg cuts as influenced by the three age classes were recorded. The standardised cooking method results for the leg samples were obtained first, followed by the optimal cooking method's results.

The mean sensory scores of the A class lamb with the standardised cooking method were overall the highest, and thus most preferred in terms of its sensory characteristics (Table 4.11). The pre-auction survey results indicated that 81% of participants preferred the leg of lamb to a leg of mutton (Table 4.5). The participants' prior tasting preferences are thus congruent with the actual sensory scores.

The flavour characteristic is not equally valued for lamb and mutton. The lamb flavour is preferred over the AB and C class, as can be gleaned from Table 4.11 and Figure 4.4. Participants prefer the flavour of a younger animal in this case, and their prior stated preferences consequently differ from the actual sensory scores (Table 4.6). Furthermore, the majority of participants indicated that lamb has a higher degree of juiciness than mutton. The sensory results also indicate this with lamb having the highest juiciness score of 7.24 in contrast with the AB class (5.52) and C class (5.71). Lastly, the leg of lamb indicated the highest tenderness degree with a score of 8.05, which is far above the mean scores of the AB and C class and is thus comparable with the participants' prior stated preferences.

Table 4.11: Mean and standard deviations for the sensory characteristics and auction bids of the leg muscle as influenced by three age classes using the standardised cooking method (standard deviations in parenthesis)

Sensory characteristics and auction bids	Age classes		
	A	AB	C
Flavour	7.60 (1.04)	6.40 (1.65)	6.60 (1.47)
Juiciness	7.24 (1.66)	5.52 (1.69)	5.71 (1.88)
Tenderness	8.05 (1.08)	5.67 (1.88)	6.10 (1.48)
Overall liking	7.76 (1.10)	5.93 (1.70)	6.12 (1.40)
Bid amount	95.40 (12.59)	86.38 (12.04)	86.43 (11.88)

Note: Scores based on 9-point scales (1= extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking; 9= extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking)

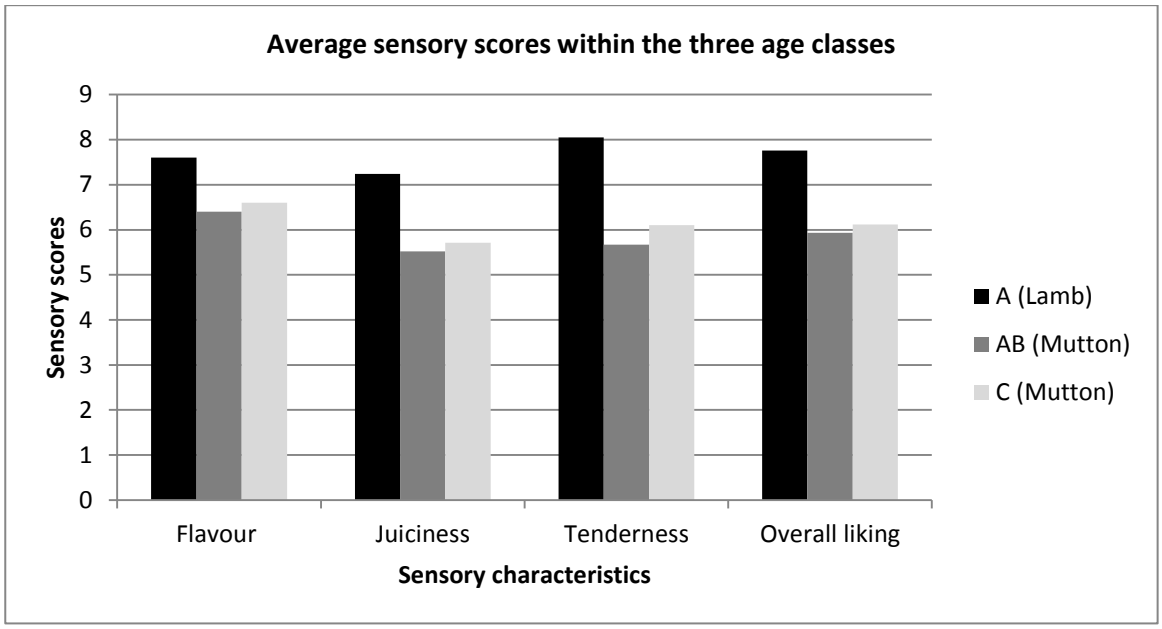

Figure 4.4: Average sensory scores for the leg muscle as influenced by three age classes using the standardised cooking method

The optimal cooking method results for the leg cut differ slightly from the standardised cooking method's as the A and AB classes are both preferred in terms of their sensory characteristics (Table 4.12). The flavour characteristic is again not equally valued for lamb and mutton. The AB class flavour is preferred over the A and C class. Participants' prior stated preferences differ from the actual sensory scores as the AB class obtained a mean score of 7.55 for flavour, while the C class obtained a mean score of 6.76 and the

lamb a mean score of 6.83. The majority of participants indicated that lamb has a higher degree of juiciness than mutton. The sensory results confirm this, with lamb obtaining the highest juiciness score of 7.12 in contrast with the AB class (6.90) and C class (5.83). Lastly, the leg of lamb and AB class achieved the highest tenderness rating, with mean scores of 7.71 and 7.52 respectively. This result is thus not comparable to participants' prior stated preferences.

Table 4.12: Mean and standard deviations for the sensory characteristics and auction bids of the leg muscle as influenced by three age classes using the optimal cooking method (standard deviations in parenthesis)

Sensory characteristics and auction bids	Age classes		
	A	**AB**	**C**
Flavour	6.83 (1.53)	7.55 (1.09)	6.76 (1.81)
Juiciness	7.12 (1.60)	6.90 (1.51)	5.83 (1.82)
Tenderness	7.71 (1.20)	7.52 (1.17)	5.98 (1.81)
Overall liking	7.21 (1.30)	7.38 (1.06)	6.17 (1.77)
Bid amount	93.67 (12.19)	93.29 (12.27)	87.10 (11.88)

Note: Scores based on 9-point scales (1= extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking; 9= extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking)

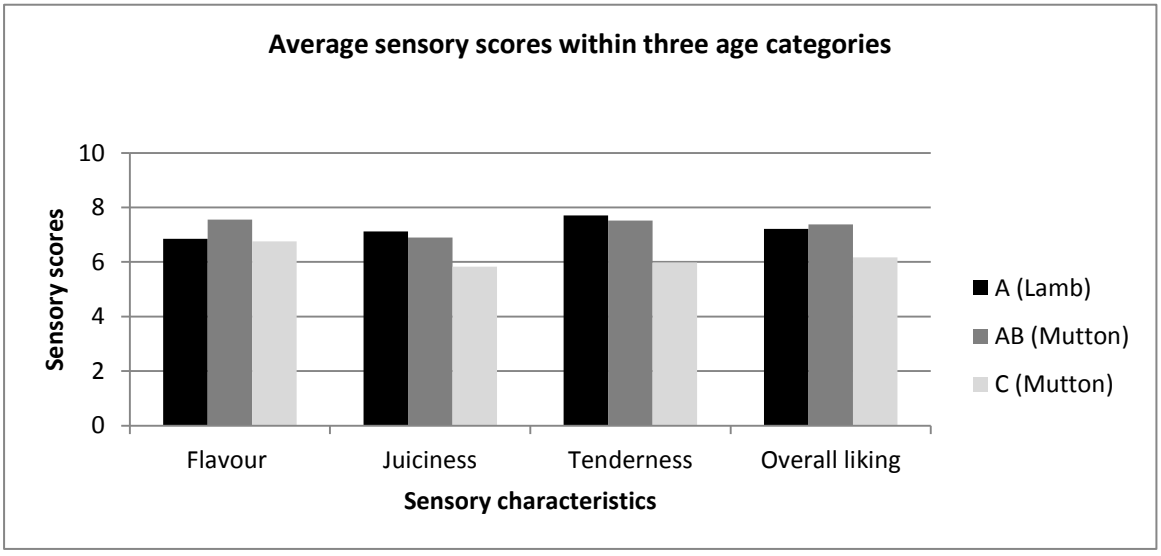

Figure 4.5: Average sensory scores for the leg muscle as influenced by three age classes using the optimal cooking method

4.5 Summary

This chapter presented participants' various demographic characteristics, factors influencing their meat purchasing behaviour and their sensory assessments results. The demographic characteristics indicate the composition of the sample in that it mainly consists of educated males and females in the higher income SEM 8-10 groups who are regular consumers of lamb and mutton meat.

The overall mean and standard deviations scores for each meat cut within each age class were not as volatile. The standard deviations for each sensory characteristic within each age group were relatively small. The cause of limited deviations between means may be a result of the restricted set of answers the participants had to score for each meat sample. Only a 9-point hedonic scale may be used, with 1 denoting extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking, and 9 denoting extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking. The sensory scores do not reflect a large variation in the study group; participants were overall consistent in their assessments of the various meat samples.

It was interesting to capture the factors influencing participants' purchasing behaviour and to determine whether any relationship exists between participants' prior stated preferences and their actual sensory scores. Overall, the C class sample for the stew meat cuts was preferred over the A and AB class meat samples. The pre-auction survey results indicate that the majority of participants (79%) preferred the stew meat cuts from mutton rather than lamb. Participants' prior tasting preferences were thus similar to their actual sensory scores. The A class sample was most preferred for the loin cuts in the standardised cooking method and the AB class sample for the optimal cooking method. The pre-auction survey results indicate that 88% of participants preferred the loins from lamb rather than from mutton. Participants' prior tasting preferences were comparable with the actual sensory scores for the standardised cooking method, but not for the optimal cooking method. Finally, the A class sample was most preferred for the leg cuts in the standardised cooking method and for the optimal cooking method; both the leg of lamb and the AB class sample were preferred. The pre-auction survey results indicate that 81% of participants preferred the leg of lamb rather than mutton. Participants' prior tasting preferences were analogous with the actual sensory scores for the standardised cooking method, but varied for the optimal cooking method.

Participants valued lamb and mutton flavour equally prior to the sensory assessments. However, the mean sensory scores for flavour for the different meat cuts varied. The C class sample's flavour obtained the highest mean score for the stew meat cuts, while the AB class sample's flavour obtained the highest score for the loin cut in both the standardised and optimal cooking methods. Additionally, the A class sample's flavour was most preferred for the standard cooking method and the AB class sample's flavour was most preferred for the optimal cooking method.

Considering the various sensory scores obtained for the three meat cuts within each age category, it can be concluded that the lamb and AB class sensory characteristics are overall more preferred over the C class. Participants' prior sensory preferences indicated a higher overall preference for lamb than for mutton. The actual sensory scores therefore indicate the opportunity for the AB class to compete with lamb meat in the loin and leg cuts. There may be an opportunity for the AB class to enjoy increased market share.

CHAPTER 5: EXPERIMENTAL AUCTION RESULTS AND THE ANALYSIS OF CONSUMERS' BIDDING BEHAVIOUR

5.1 Introduction

The experimental auction design and procedure were discussed in Chapter 3. There were five sensory assessment rounds and five experimental auction rounds. The sensory assessments and auction rounds were conducted in three phases. In each phase, participants had to taste three meat samples of three age classes (A, AB and C) individually and score them on the corresponding scoresheet with the maximum amount they would be willing to pay. The sensory scores were reported in detail in Chapter 4.

This chapter presents the results of participants' WTP bids for the different meat samples from the different age classes. The specific research objectives stated in Chapter 1, i.e. to test the design and application of a random *n*th-price experimental auction and to determine if consumers are willing to pay more for class A, AB and C Karoo sheep meat, will be addressed. Furthermore, possible relationships between the consumer sensory scores and consumer bidding behaviour for the respective age classes will be determined. The demographic variables addressed in the pre-auction survey will also be compared to the auction bids recorded in the experimental auction to determine any possible relationship between the variables.

5.2 Statistical analysis

To test whether the bid values for the meat cuts from the different age classes were statistically significantly different, Friedman's two-way analysis of variance (ANOVA) test was applied. In addition, the significant difference was tested between the different sensory scores recorded by the consumer panel as reported in Chapter 4. An analysis of variance test was also applied to determine any statistically significant differences at 5% between the mean values of the auction bids and the sample's demographic

characteristics. These tests were performed with the use of the statistical packages SPSS and STATA.

Multiple regression analyses were applied to determine any relationships among variables. These were used to determine the overall fit of the model and to predict the value of the bid prices, based on the value of each of the independent socio-demographic and sensory variables. The main effects and interactions were studied at the significance level p=0.05. The standardised and optimal cooking methods used for the different meat cuts were analysed separately.

5.3 Consumers' bidding behaviour and results

A summary of consumers' bidding behaviour and results for the different meat cuts within the three age classes is presented in Table 5.1. In order to present a more detailed analysis, the results from the random *n*th-price auction for each meat cut will be presented and discussed separately with is consequent Friedman ANOVA and multiple regression analyses. The purpose of the experimental auction was to determine for which age class the participants are willing to pay more, and thus which age class is preferred over the other.

Table 5.1: Overall auction results for each meat cut within three age classes (price in R/500 gram)

Meat cut	Cooking method	Age class		
		A	AB	C
Stew meat cuts	Optimal	R61.05	R65.29	R67.52
Loin cut	Standard	R83.45	R83.43	R81.02
	Optimal	R82.50	R86.86	R84
Leg cut	Standard	R95.40	R86.38	R86.43
	Optimal	R93.67	R93.29	R87.10

5.3.1 Average willingness to pay values for the stew meat cuts

As mentioned in Chapter 3, each participant was asked to indicate the amount they would be willing to pay for the meat sample they had tasted while taking the reference price into consideration. The reference price for a 500 g packet of stew meat cuts was indicated as R65. The average bid prices for each age class are indicated in Figure 5.1 below. Participants submitted an average bid price of R61.05 for the A class, with a standard deviation of 11.76. The average bid price for the AB class was R65.29, with a standard deviation of 9.23. The C class was most preferred in this meat cut with an average bid price of R67.52, with a standard deviation of 10.04. The standard deviations for the different age classes are fairly small; it therefore indicates the values in the statistical dataset are close to the mean of the data set.

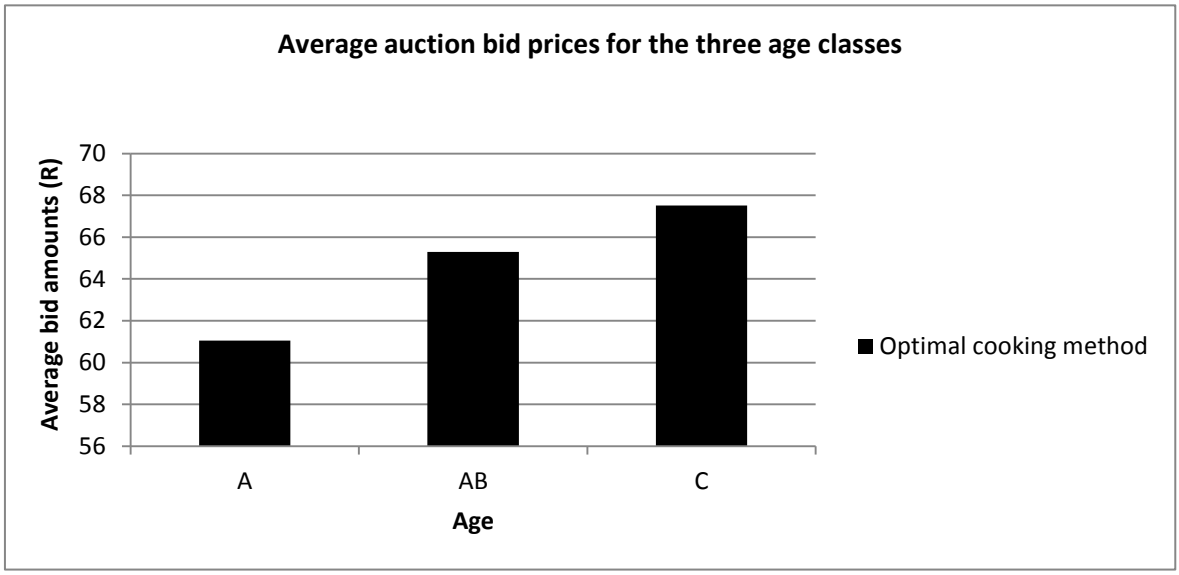

Figure 5.1: Average auction bid prices for the stew meat cuts within three age classes

It was interesting to note how these average bid prices for each participant deviated from the reference price. Table 5.2 indicates the percentage of participants who were willing to pay an amount above, below or equal to the reference price within each age class. The C class, which was the most preferred age class, obtained 57% of bid prices above the reference price while 17% of the participants were willing to pay the price equal to the reference price and 26% below. In the A class, two thirds (67%) of the participants indicated a bid price lower than the reference price. This clearly indicates a

preference for the C class rather than the A class for this specific meat cut. This finding corresponds with the sensory results in which the C class sample received higher scores on flavour, juiciness, tenderness, and overall liking than any of the other age classes for this specific meat cut.

Table 5.2: The percentage of average bid prices against the reference price for the stew meat cuts

Percentage bid prices (%)	Age classes		
	A	AB	C
Bid prices above the reference price	21%	38%	57%
Bid prices equal to the reference price	12%	21%	17%
Bid prices below the reference price	67%	40%	26%

5.3.2 Friedman's ANOVA results

In order to test whether the bid values for the stew meat cuts from the different age classes were statistically significantly different, the Friedman ANOVA test was applied. In addition, the significant difference was also tested between the different sensory scores recorded by the consumer panel as reported in Chapter 4.

The Friedman test indicated a statistically significant difference in bid prices depending on the age of the animal, $\chi^2(2) = 252$, $p < 0.001$. The significant difference in bid prices is displayed by the average bid prices within the three age classes, as depicted in Figure 5.1. A significant difference of R4.24 can be calculated between the mean bids of the A and AB classes. A greater preference is clearly indicated for the C class where a significant difference value of R6.47 exists between the mean bids of the A and C classes.

An insignificant difference was found in the sensory characteristics of lamb and mutton with $\chi^2(2) = 7.157$, $p = 0.067$. The insignificant difference can be substantiated by the sensory scores in Table 4.8. The consumer panel were consistent in their sensory assessment by denoting scores between 6 and 7 based on the 9-point hedonic scale. Although not significant at the 0.05 level, a significant difference in the sensory characteristics was reported at the 0.01 level.

5.3.3 Multiple regression results

Participants' bid prices in the experimental auction were influenced by more than just the sensory characteristics of the lamb and mutton meat. Participants' socio-demographics also have an influence on their bid prices. To account for the socio-demographic variables, several independent dummy variables were included in the model. A multiple regression analysis was carried out to test the relationship between these predictor variables and participants' bid prices.

It is important to determine how quality variables translate into value. Therefore, the parameters for the following regression model were estimated to determine the impact of the different sensory and socio-demographic variables on participants' WTP as measured through their bids for the individual meat samples. The function used for the regression model is as follows:

Bid_{ij} = *f*(flavour, juiciness, tenderness, overall liking, gender, incomelevel1, incomelevel2, incomelevel3, agelevel1, agelevel2),

where the dependent variable Bid_{ij} represents the *i*th panellist's bid in R for the *j*th meat sample. Bid is a real continuous variable. The subscript *i* indicates the panellist (i = 1-42) and the subscript *j* indicates the meat sample (j =1-3).

In the equation, gender, incomelevel1, incomelevel2, incomelevel3, agelevel1 and agelevel2 are all categorical variables. In the regression model, these values are represented by independent dummy variables. These variables contain values of 1 or 0, representing the presence or absence of the categorical variable, and they are now presented as ordinal variables.

The dummy variable gender is equal to 0 if panellist *i* is male and 1 if panellist *i* is female. The dummy variables for the income-and age levels are equal to 1 if panellist *i* falls within the specified level and 0 if panellist *i* does not fall within the level. In the model, multicollinearity is avoided by including one dummy variable less for the income and age levels than there are categories. The rule of thumb is applied if there is m number of categories – (m-1) categories should be used in the model. The value excluded from the model can be used as the reference value. Table 5.3 below indicates the description and measurement values used for the variables included in the regression model.

Table 5.3: Measurement values for the variables included in the regression model

Variables	Measurement values
Bid value	R
Sensory characteristics Flavour Juiciness Tenderness Overall liking	Numerical values of 1-9
Gender (dummy variable) Male Female	Numerical value of 0 or 1: 0 1
Income levels (dummy variable) IncomeLevel1 = R10 000-R29 999 IncomeLevel2 = R30 000-R49 999 IncomeLevel3 = R50 000-R69 999	Numerical value of 0 or 1: 0/1 0/1 0/1
Age levels (dummy variable) AgeLevel1= 25-34 years AgeLevel2 = 35-49 years	Numerical value of 0 or 1: 0/1 0/1

Table 5.4 summarises the results of the analyses. The model's output revealed that the various independent variables are a worthwhile addition to the regression model and statistically significantly predict the dependent bid prices with a value of $p<0.001$. The R-squared, which is the proportion of variance in participants' bid prices that can be explained by the independent variables, has a value of 0.5225. The independent variables therefore explain 52.25% of the variability in the participants' bid prices. The R-squared value is generally low when predicting human behaviour due to the variability in human preferences. While looking at the p-value of each predictor, we can see that the flavour variable contributes to the model with a value of $p<0.001$. The meat flavour therefore has a significant influence on participants' WTP. The income category of R30 000-R49 999 is positively and significantly correlated with the participants' bid prices with $p=0.043$ ($p<0.05$). This result may be attributed to the fact that 40% of the sample lies within this income category.

Table 5.4: Multiple regression determinants of bids for the stew meat cuts

Variables	Coef.	Std. Err.	t	P>|t|
Flavour	3.580509	.9633341	3.72	**0.000**
Juiciness	.1010967	.8880822	0.11	0.910
Tenderness	1.418128	.9406704	1.51	0.134
Overall liking	.8640491	1.515527	0.57	0.570
Gender	1.184758	1.39378	0.85	0.397
IncomeLevel1	-2.443409	2.595836	-0.94	0.349
IncomeLevel2	4.147059	2.027036	2.05	**0.043**
IncomeLevel3	1.713035	2.708454	0.63	0.528
AgeLevel1	.6943828	2.178431	0.32	0.750
AgeLevel2	1.07228	2.112002	0.51	0.613
_cons	20.38472	4.454301	4.58	0.000

Prob > F	=	0.0000
R-squared	=	0.5225
Adj R-squared	=	0.4810
Root MSE	=	7.6788

5.3.4 Average willingness to pay values for the loin cut

Each participant was asked to indicate the amount they would be willing to pay for the loin meat samples they tasted while bearing the reference price in mind. As mentioned in Chapter 3, the standardised and optimal cooking methods were used for this meat cut. These two cooking methods were evaluated separately. The reference price for a 500 g packet of loin chops was indicated as R88. The average bid prices for each age class in the two separate cooking methods are indicated in Figure 5.2.

The participants returned an average bid price for the A class loin cut for the standardised cooking method as R83.45, with a standard deviation of 13.53 and for the optimal cooking method, an average bid of R82.50 with a standard deviation of 10.46. The average bid price for the AB class was R83.43, with a standard deviation of 11.59 for the standardised cooking method, and R86.86 with a standard deviation of 10.31 for the optimal cooking method. Finally, participants indicated an average bid price of R81.02 for the C class, with a standard deviation of 11.24 for the standardised cooking method and R84 with a standard deviation of 9.37 for the optimal cooking method. The AB class obtained the highest overall average bid price. The standard deviations for the different

age classes in the loin cut are fairly small; it therefore indicates the values in the statistical dataset are close to the mean of the data set.

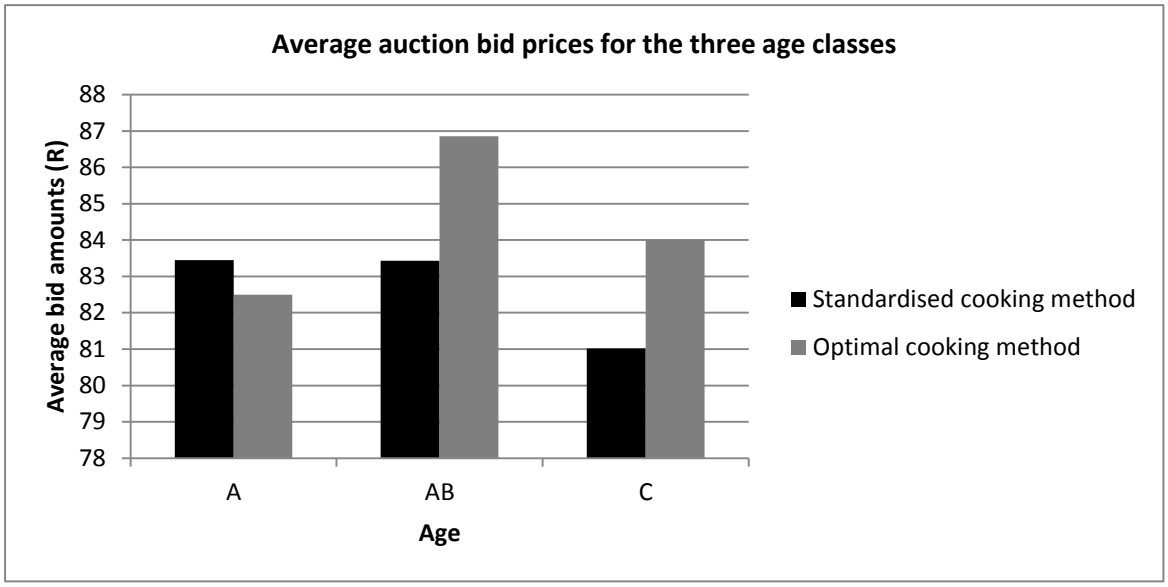

Figure 5.2: Average auction bid prices for the loin cut within three age classes for the standardised and optimal cooking methods

The percentage of participants who were willing to pay an amount above, below or equal to the reference price within each age class for the standardised cooking method are depicted in Table 5.5. The A class was equally valued, with 40% of the participants willing to pay above the reference price and 52% below the reference price. The AB class, which was most preferred, obtained 31% of bid prices above the reference price, while 19% of the participants were willing to pay the amount equal to the reference price, and 50% less than the reference price. The C class was least preferred with 64% of participants indicating a bid price below the reference price.

Table 5.5: The percentage of average bid prices against the reference price for the loin cut in the standardised cooking method

Percentage bid prices (%)	Age classes		
	A	AB	C
Bid price above the reference price	40%	31%	29%
Bid price equal to the reference price	7%	19%	7%
Bid price below the reference price	52%	50%	64%

The percentage of the average bid prices against the reference price for the optimal cooking method indicated different results compared with the standardised cooking method. Most participants indicated a bid amount below the reference price for the A and C class, with 57% and 52% respectively. In the AB class, 48% of participants were willing to pay above the reference price, while 38% were willing to pay below the reference price.

Table 5.6: The percentage of average bid prices against the reference price for the loin cut in the optimal cooking method

Percentage bid prices (%)	Age classes		
	A	AB	C
Bid prices above the reference price	26%	48%	38%
Bid prices equal to the reference price	17%	14%	10%
Bid prices below the reference price	57%	38%	52%

5.3.5 Friedman's ANOVA results

To test whether the bid values for the loin cut from the different age classes were statistically significantly different, the Friedman ANOVA test was applied. In addition, the significant difference was also tested against the different sensory scores recorded by the consumer panel as reported in Chapter 4. The standardised and optimal cooking methods applied for this cut were analysed separately.

In the standardised cooking method, the Friedman test indicated a statistically significant difference in bid prices depending on the age of the animal, $\chi^2(2) = 250.008$, $p < 0.001$. The significant difference in bid prices is displayed by the average bid prices within the three age classes in Figure 5.2. A difference of R2.43 can be calculated between the mean bids of the A and C class. A significant difference was found in the sensory characteristics of lamb and mutton meat with $\chi^2(2) = 7.594$, $p = 0.0055$. The most significant difference is displayed in the tenderness rating with the A class being most preferred with a rating of 7.83 and the AB class the least preferred with a rating of 6.48.

In the optimal cooking method, the Friedman test indicated a statistically significant difference in bid prices depending on the age of the animal, $\chi^2(2) = 252$, $p < 0.001$. The significant difference in bid prices can also be gleaned from the average bid prices within the three age classes in Figure 5.2. A significant difference of R4.36 can be calculated

between the mean bids of the A and AB class. Furthermore, a difference of R2.86 exists between the mean bids of the AB and C classes. A greater difference between the mean bids of the different age classes is displayed by the optimal cooking method than in the standardised cooking method. An insignificant difference was found in the sensory characteristics of lamb and mutton meat with $\chi^2(2) = 0.189$, $p = 0.979$.

5.3.6 Multiple regression results

The value of the bid prices were estimated based on the value of each of the independent socio-demographic and sensory variables. To account for the socio-demographic variables, several independent dummy variables were included in the model in order to test the relationship between these variables and participants' bid prices. The standardised and optimal cooking methods applied for this cut were analysed separately.

The parameters for the following regression model were estimated to determine the impact of the different sensory and socio-demographic variables on participants' WTP as measured by their bids for the individual meat samples. The function used for the regression model is as follows:

Bid_{ij} = *f*(flavour, juiciness, tenderness, overall liking, gender, incomelevel1, incomelevel2, incomelevel3, agelevel1, agelevel2).

In the above equation, gender, incomelevel1, incomelevel2, incomelevel3, agelevel1 and agelevel2 are all categorical variables. In the regression model, these values are represented by independent dummy variables. These variables contain values of 1 or 0, representing the presence or absence of the categorical variable, and they are now presented as ordinal variables.

Table 5.7 summarises the analyses results for the loin cut in the standardised cooking method. The model's output revealed that the various independent variables are a worthwhile addition to the regression model and statistically significantly predict the dependent bid prices with a value of $p<0.001$. The R-squared value of 0.2973 indicated that the independent variables explain 29.73% of the variability in participants' bid prices. The low R-squared values for both the standardised and optimal cooking method again illustrates the variability in human preferences. Additionally, other possible factors

that could have contributed to this low value are the sample's size and characteristics. While looking at the p-value of each predictor, we can see that the overall liking variable contributes to the model with a value of p=0.002 (p<0.05). Contrary to our expectation, the income variables have shown a negative coefficient which suggests that the bid prices are reduced with an increase in the income levels. The R30 000-R49 999 income category was significant at p=0.009 (p<0.05). The 25-34 years age category is further positively and significantly correlated with the participants' bid prices with p=0.004 (p<0.05).

Table 5.7: Multiple regression determinants of bids for the loin cut in the standardised cooking method

Variables	Coef.	Std. Err.	t	P>|t|
Flavour	-1.474991	1.502596	-0.98	0.328
Juiciness	-1.837373	1.464274	-1.25	0.212
Tenderness	-.3466963	1.115349	-0.31	0.756
Overallliking	7.313369	2.325815	3.14	**0.002**
Gender	-1.224273	1.920551	-0.64	0.525
IncomeLevel1	-6.52068	3.6307	-1.80	0.075
IncomeLevel2	-7.561077	2.828472	-2.67	**0.009**
IncomeLevel3	-6.279595	3.804713	-1.65	0.102
AgeLevel1	8.502918	2.91605	2.92	**0.004**
AgeLevel2	7.171795	2.85583	2.51	0.013
_cons	57.12594	6.448866	8.86	0.000

Prob > F	=	0.0000
R-squared	=	0.2973
Adj R-squared	=	0.2362
Root MSE	=	10.59

Table 5.8 summarises the analyses results for the loin cut in the optimal cooking method. The model's output revealed that the various independent variables are a worthwhile addition to the regression model and statistically significantly predict the dependent bid prices with a value of p<0.001. The R-squared value indicated that the independent variables explain 29.16% of the variability of participants' bid prices. While looking at the p-value of each predictor, we can see that the gender variable contributes to

the model with a significant value at p=0.047 (p<0.05). The negative coefficient suggests that the bid prices are reduced with an increase in female participants as they indicated a significant lower bid than males in the optimal cooking method. A significant difference was also indicated in Table 5.13, where the mean bids were linked to gender for the loin cut in the optimal cooking method. The 25-34 years age category is positively and significantly correlated with the participants' bid prices with p=0.003 (p<0.05). Furthermore, the model's output indicated a statistically significant difference of p=0.0309 (p<0.05) in Table 5.15 where the mean bids were linked to age.

Table 5.8: Multiple regression determinants of bids for the loin cut in the optimal cooking method

Variables	Coef.	Std. Err.	t	P>|t|
Flavour	1.116545	1.17541	0.95	0.344
Juiciness	-1.486477	1.282631	-1.16	0.249
Tenderness	.9087682	.9053424	1.00	0.318
Overallliking	2.544689	1.988751	1.28	0.203
Gender	-3.256569	1.62339	-2.01	**0.047**
IncomeLevel1	-1.679572	3.03656	-0.55	0.581
IncomeLevel2	-4.078687	2.392486	-1.70	0.091
IncomeLevel3	-4.204066	3.11717	-1.35	0.180
AgeLevel1	7.725899	2.544483	3.04	**0.003**
AgeLevel2	3.591023	2.401132	1.50	0.138
_cons	62.39474	5.449249	11.45	0.000

Prob > F	=	0.0000
R-squared	=	0.2916
Adj R-squared	=	0.2300
Root MSE	=	8.8961

5.3.7 Average willingness to pay values for the leg cut

Each participant was asked to indicate the amount they would be willing to pay for the leg meat samples they have tasted, while taking the reference price into consideration. The standardised and optimal cooking methods were again applied for this meat cut.

These two cooking methods were evaluated separately. The reference price for a 500 g deboned leg of lamb was indicated as R95. The average bid prices for each age class according to the two separate cooking methods are indicated in Figure 5.3.

The A class was the most preferred in the standardised cooking method with an average bid price of R95.40, with a standard deviation of 12.59. The average bid price in the optimal cooking method was R93.67, with a standard deviation of 12.19. The average bid price for AB class was R86.38, with a standard deviation of 12.04 for the standardised cooking method. The average bid price increased to R93.29 for the optimal cooking method, with a standard deviation of 12.27. A R6.91 difference is indicated between the two cooking methods, which points towards a preference for the optimal cooking method, in which the leg was cooked for a longer cooking duration until its optimal state was achieved. The A and AB leg samples in the optimal cooking method were the most preferred. The C class was less preferred with an average bid price of R86.43 with a standard deviation of 11.88 for the standardised cooking method and R87.10 with a standard deviation of 11.88 for the optimal cooking method. The standard deviations for the different age classes in the leg cuts are small, similar to the stew and loin cuts, which indicate the values in the statistical dataset are close to the mean of the data set.

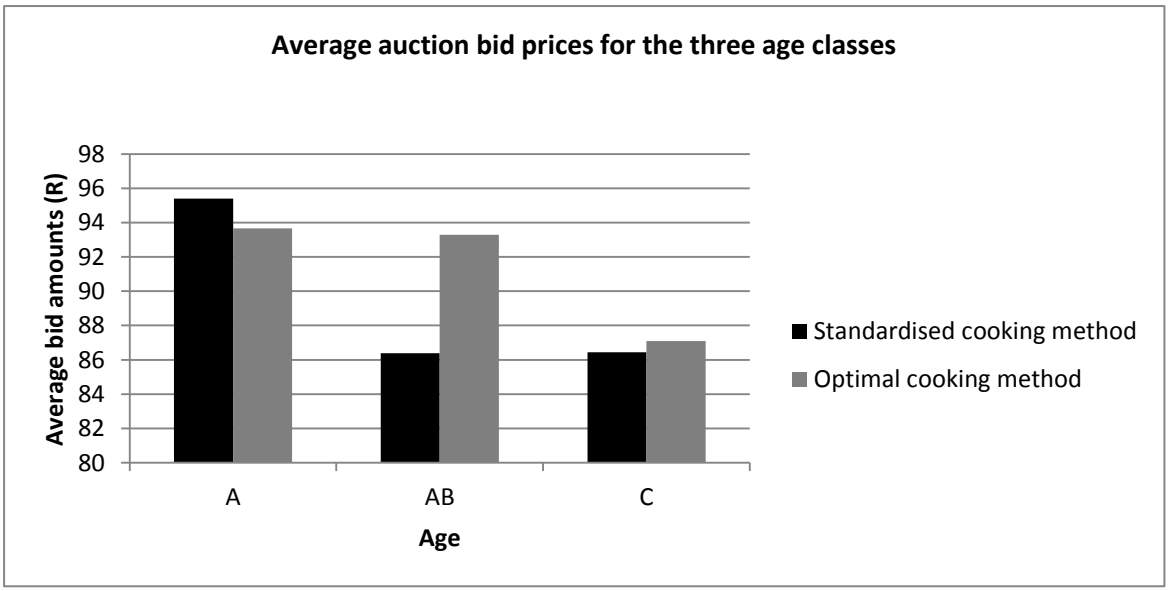

Figure 5.3: Average auction bid prices for the leg cut within three age classes for the standardised and optimal cooking methods

The percentage of average bid prices against the reference price for the standardised cooking method is indicated in Table 5.9 below. In the most-preferred A class, 50% of the participants were willing to pay above the reference price and 31% below. The

majority of participants (74%) were willing to pay a bid price below the reference price for the AB class, while only 10% of the participants indicated a bid price above the reference price. Similarly, 71% of the participants were willing to pay below the reference price for the C class.

Table 5.9: The percentage of average bid prices against the reference price for the leg cut in the standardised cooking method

Percentage bid prices (%)	Age classes		
	A	AB	C
Bid prices above the reference price	50%	10%	17%
Bid prices equal to the reference price	19%	17%	12%
Bid prices below the reference price	31%	74%	71%

The percentage of average bids against the reference price for the optimal cooking method revealed different results compared with the standardised cooking method. In the A class, only 38% of the participants were willing to pay a bid price above the reference price, followed by 12% of participants who indicated a bid price equal to and 50% below the reference price. In the AB class, 36% of participants were willing to pay more than the reference price, while 40% were willing to pay less than the reference price. The majority of the participants (71%) indicated a bid price below the reference price for the C class, with only 10% offering a bid price above the reference price.

Table 5.10: The percentage of average bid prices against the reference price for the leg cut in the optimal cooking method

Percentage bid prices (%)	Age classes		
	A	AB	C
Bid prices above the reference price	38%	36%	10%
Bid prices equal to the reference price	12%	24%	19%
Bid prices below the reference price	50%	40%	71%

5.3.8 Friedman's ANOVA results

To test whether the bid values for the leg cut from the different age classes were statistically significantly different, the Friedman ANOVA test was applied. In addition, the significant difference was also tested between the different sensory scores recorded

by the consumer panel as reported in Chapter 4. The standardised and optimal cooking methods applied for this cut were analysed separately.

In the standardised cooking method, the Friedman test indicated a statistically significant difference in bid prices depending on the age of the animal, $\chi^2(2) = 252$, $p < 0.001$. The significant difference in bid prices is displayed by the average bid prices within the three age classes in Figure 5.3. A significant difference of R9.02 can be calculated between the mean bids of the A and AB classes. A greater preference is clearly indicated for the A class in this cooking method, given the difference value of R8.97 between the mean bids of the A and C classes. A significant difference was found in the sensory characteristics of lamb and mutton meat with $\chi^2(2) = 48.859$, $p < 0.001$. The significant difference can be substantiated by the sensory scores in Table 4.11. A significant difference can be seen especially in respect of the juiciness, tenderness and overall liking sensory ratings between the three age classes.

In the optimal cooking method, the Friedman test indicated a statistically significant difference in bid prices depending on the age of the animal, $\chi^2(2) = 252$, $p < 0.001$. The significant difference in bid prices is also displayed by the average bid prices within the three age classes in Figure 5.3. A significant difference of R6.57 can be calculated between the mean bids of the A and C classes. Furthermore, a significant difference of R6.19 can be calculated between the mean bids of the AB and C classes. A significant difference was found in the sensory characteristics of lamb and mutton meat with $\chi^2(2) = 24.424$, $p < 0.001$. The significant difference can be substantiated by the sensory scores in Table 4.12. A significant difference can be seen regarding especially the juiciness, tenderness and overall liking sensory ratings if the A and AB class ratings are compared to the C class ratings.

5.3.9 Multiple regression results

The value of the bid prices were estimated based on the value of each of the independent socio-demographic and sensory variables. To account for the socio-demographic variables, several independent dummy variables were included in the model in order to test the relationship between these variables and participants' bid prices. The standardised and optimal cooking methods applied for this cut were analysed separately.

The parameters for the following regression model were estimated to determine the impact of the different sensory and socio-demographic variables on participants' WTP as measured by their bids for the individual meat samples. The function used for the regression model is as follows:

Bid_{ij} = *f*(flavour, juiciness, tenderness, overall liking, gender, incomelevel1, incomelevel2, incomelevel3, agelevel1, agelevel2).

In the above equation, gender, incomelevel1, incomelevel2, incomelevel3, agelevel1 and agelevel2 are all categorical variables. These values are represented by independent dummy variables. The variables contain values of 1 or 0, representing the presence or absence of the categorical variable, and are now presented as ordinal variables.

Table 5.11 summarises the analyses results for the leg cut in the standardised cooking method. The model's output revealed that the various independent variables are a worthwhile addition to the regression model and statistically significantly predict the dependent bid prices with a value of $p<0.001$. The R-squared value indicates that the independent variables explain 36.78% of the variability of participants' bid prices. While looking at the p-value of each predictor, we can see that the overall liking variable contributes to the model with a value of $p=0.003$ ($p<0.05$).

Table 5.11: Multiple regression determinants of bids for the leg cut in the standardised cooking method

Variables	Coef.	Std. Err.	t	P>|t|
Flavour	-.9290482	1.373839	-0.68	0.500
Juiciness	-1.851249	1.066512	-1.74	0.085
Tenderness	-.0233781	1.335199	-0.02	0.986
Overallliking	6.744337	2.237901	3.01	**0.003**
Gender	-1.25773	1.937018	-0.65	0.517
IncomeLevel1	.0581885	3.54898	0.02	0.987
IncomeLevel2	-5.110791	2.791756	-1.83	0.070
IncomeLevel3	-.4926999	3.723823	-0.13	0.895
AgeLevel1	5.422671	2.958057	1.83	0.069
AgeLevel2	5.259803	2.912381	1.81	0.074
_cons	61.835	4.932472	12.54	0.000

Prob > F	=	0.0000
R-squared	=	0.3678
Adj R-squared	=	0.3128
Root MSE	=	10.615

Table 5.12 summarises the analyses results for the leg cut in the optimal cooking method. The model's output revealed that the various independent variables are a worthwhile addition to the regression model and statistically significantly predict the dependent bid prices with a value of $p<0.001$. The R-squared value indicates that the independent variables explain 28.57% of the variability of participants' bid prices. The low R-squared values for both the standardised and optimal cooking method again illustrates the variability in human preferences. While looking at the p-value of each predictor, we can see that the gender variable contributes to the model with a significant value at $p=0.019$ ($p<0.05$). The negative coefficient suggests that the bid prices are reduced with an increase in female participants as they indicated a significant lower bid than males in the optimal cooking method. A significant difference was also indicated in Table 5.13, where the mean bids were linked to gender for the leg cut in the optimal cooking method.

Table 5.12: Multiple regression determinants of bids for the leg cut in the optimal cooking method

Variables	Coef.	Std. Err.	t	P>|t|
Flavour	.8396989	1.231613	0.68	0.497
Juiciness	-.5489833	1.152684	-0.48	0.635
Tenderness	-.7866611	1.145925	-0.69	0.494
Overallliking	3.702222	2.200183	1.68	0.095
Gender	-4.831317	2.029022	-2.38	**0.019**
IncomeLevel1	3.411076	3.544119	0.96	0.338
IncomeLevel2	-2.149578	2.863165	-0.75	0.454
IncomeLevel3	.0253485	3.792362	0.01	0.995
AgeLevel1	2.346681	3.04603	0.77	0.443
AgeLevel2	-.8078497	2.982882	-0.27	0.787
_cons	70.88569	5.853989	12.11	0.000

Prob > F	=	0.0000
R-squared	=	0.2857
Adj R-squared	=	0.2236
Root MSE	=	10.92

5.4 Bid prices in relation to socio-demographic variables

In this section, participants' average bid prices are linked to the variables recorded in the pre-auction survey. Particularly, the socio-demographic variables relating to gender, income level and age are evaluated against participants' mean bids.

5.4.1 Mean bids of socio-demographic sub-groups

Tables 5.13, 5.14 and 5.15 reveal the average experimental auction bids in terms of the socio-demographic variables included in the pre-auction survey. The purpose of this section is to determine if participants' demographic characteristics have an effect on their bidding behaviour during the experimental auction.

Table 5.13: Mean bids linked to gender in each phase

Phase	Variable levels	Percentage of total sample (n=42)	Mean bid		Significant difference	
			Standard	Optimal	Standard	Optimal
Phase 1 - Stew cut	Male Female	52% 48%		R65.28 R64.13		F=0.05 df=1 p>0.05
Phase 2 - Loin cut	Male Female	52% 48%	R83.98 R81.15	R86.73 R81.95	F=1.73 df=1 p>0.05	F=7.33 df=1 **p=0.0077**
Phase 3 - Leg cut	Male Female	52% 48%	R90.68 R88	R94.47 R87.92	F=1.38 df=1 p>0.05	F=9.37 df=1 **p=0.0027**

Generally speaking, male participants presented higher bids than female participants did. When the mean bids were ranked according to income level it was expected that participants' WTP would increase with income. In the evaluation of the stew meat cuts, this trend was followed until a turning point was reached at the >R70 000 income level. Those participants were willing to pay less than the lower income levels. In the

evaluation of the loin cut, the R50 000-R69 999 income level's mean bids were the highest in the standardised cooking method, and the R10 000-R29 999 income level's mean bids were the highest in the optimal cooking method - which do not follow the perceived trend. In the evaluation of the leg cut, it is interesting to note that the overall mean bids for the R10 000-R29 999 income category was the highest for both cooking methods.

Table 5.14: Mean bids linked to income level in each phase

Phase	Variable levels	Percentage of total sample (n=42)	Mean bid		Significant difference	
			Standard	Optimal	Standard	Optimal
Phase 1 - Stew cut	R10000-R29999 R30000-R49999 R50000-R69999 >R70 000	17% 40% 10% 29%		R61.10 R66.61 R66.10 R63.14		F=1.73 df=3 p>0.05
Phase 2 - Loin cut	R10000-R29999 R30000-R49999 R50000-R69999 >R70 000	17% 40% 10% 29%	R84.33 R81 R85.78 R82.39	R89.05 R83.41 R83.56 R83.69	F=0.85 df=3 p>0.05	F=1.76 df=3 p>0.05
Phase 3 - Leg cut	R10000-29999 R30000-R49999 R50000-R69999 >R70 000	17% 40% 10% 29%	R96.38 R86.41 R92 R88.28	R97.76 R88.16 R91.11 R92.25	F=3.55 df=3 **p=0.0165**	F=3.23 df=3 **p=0.0248**

The mean bids according to the different age groups indicate the participants between 35 and 49 years of age as offering the highest bid prices for the stew meat cuts. In the evaluation of the loin cut, the youngest age group (25-34 years) was found to bid the highest prices for both cooking methods. This trend can also be discerned in the evaluation of the leg cut, where the youngest age group indicated the highest bid prices for the leg cut in the standardised cooking method. In the optimal cooking method, the participants in the 25-34 years age and the 50-64 years age categories both indicated the highest mean bids.

Table 5.15: Mean bids linked to age in each phase

Phase	Variable levels	Percentage of total sample (n=42)	Mean bid		Significant difference	
			Standard	Optimal	Standard	Optimal
Phase 1 - Stew cut	25-34 35-49 50-64	40% 29% 31%		R62.73 R67.47 R64.46		F=2.14 df=2 p>0.05
Phase 2 - Loin cut	25-34 35-49 50-64	40% 29% 31%	R84.20 R83.72 R79.59	R87.29 R82.97 R82.10	F=1.82 df= 2 p>0.05	F=3.58 df=2 **p=0.0309**
Phase 3 - Leg cut	25-34 35-49 50-64	40% 29% 31%	R91.27 R89.11 R87.23	R92.90 R88.22 R92.21	F=1.12 df= 2 p>0.05	F=1.66 df=2 p>0.05

5.5 Summary

In this chapter, the results of the random *n*th-price auction were presented together with the statistical analysis of the sensory evaluations and participants' WTP. The purpose of the experimental auction was to determine for which age class the participants are willing to pay more, and thus which age class is preferred over the other. Further, the value of the bid prices, based on the value of each of the independent socio-demographic and sensory variables, was predicted.

The average bid prices from the random *n*th-price auction were evaluated for each of the three meat cuts. The standardised and optimal cooking method results were evaluated separately.

It was interesting to note participants' average WTP for the different meat cuts in the respective age classes. The C class was most preferred for the stew meat cuts, with an average bid price of R67.52. The A and AB classes were most preferred in the standardised cooking method for the loin cut, with average bid prices of R83.43 and R83.45 respectively. The AB class was most preferred in the optimal cooking method, with an average bid price of R86.86. The leg of lamb was most preferred in the standardised cooking method, reflecting an average bid price of R95.40. The leg of lamb

and the AB leg were most preferred in the optimal cooking method, having achieved average bid prices of R93.67 and R93.29 respectively.

The Friedman ANOVA results indicate a statistically significant difference in the bid prices for each meat cut depending on the age of the animal. A statistically significant difference was found between the sensory scores recorded by the consumer panel for each meat cut, except for the stew meat cuts and loin cut for the optimal cooking method.

The average bid prices were evaluated in relation to participants' sensory scores and socio-demographic variables in the multiple regression analysis. The model's output for each meat cut revealed that the various independent variables statistically significantly predict the dependent bid prices.

When the average bid prices were evaluated in relation to socio-demographic variables, it was found that men indicated an overall higher bid price than women during the experimental auction. A statistically significant difference was found in participants' average bid prices and gender with the optimal cooking method for the loin cut. Similarly, a significant difference was found with the optimal cooking method for the leg cut. The mean bids linked to income levels also indicated a significant difference between the two cooking methods for the leg cut. Additionally, the mean bids linked to age groups indicated a significant difference regarding the optimal cooking method for the loin cut. It was interesting to note that the 25-34 year age group indicated the highest mean bids overall for the different cuts.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The study argued that a perception problem arises regarding the relationship between the age of the animal and the quality (flavour, juiciness, tenderness) of meat. Consumers perceive meat of class A carcasses, which enjoy higher market prices, to have the best quality compared to the other age classes. The preliminary investigation of this study has shown that it is generally assumed that meat from older animals enjoys reduced consumer acceptance. The question therefore arose whether these price differentials are justified from the consumer's perspective, and whether it reflects the true quality differentials between the different age classes. Additional academic work that explores ways to determine consumer perceptions of the quality of mutton was required. The quality and consumer preferences related to sheep meat was therefore the main focus of this study.

Specific objectives of this study were to determine consumers' sensory acceptance of different meat age classes and to test the impact of sheep age on consumers' sensory scores. Furthermore, to determine if consumers are willing to pay a premium for different age classes of Karoo sheep meat. In order to address these objectives, comprehensive sensory evaluations of Karoo sheep meat in the A, AB and C classes by means of consumer sensory assessments, in conjunction with an experimental auction to determine the consumer's WTP, were conducted.

Chapter 2 provided a comprehensive literature review of the sensory evaluation techniques used in studies as well as methods used in determining consumers' WTP for goods or services. Experimental auctions were presented as the most applicable research tool to determine consumers' WTP for Karoo lamb and mutton meat. The consumers' sensory assessments of the different age classes and their WTP were recorded and presented. Futhermore, the bidding behaviour observed in the experimental auction was linked to the sample's socio-demographic characteristics to test for any relationships between the sub-groups.

6.2 Summary of major findings

Due to the overall objective of this study being two-fold - to evaluate the effect of the age of Karoo sheep meat on consumers' sensory assessments and on the WTP for Karoo sheep meat - the results were divided into two separate chapters. The results in Chapter 4 focused on the socio-economic profile and consumers' sensory assessments of Karoo lamb and mutton meat. In Chapter 5, the focused shifted towards the experimental auction results and the analysis of consumers' bidding behaviour.

The results of the pre-auction survey in Chapter 4 provided information on consumers' demographic characteristics, meat purchasing and consumption behaviour and prior preferences toward different meat cuts and its sensory characteristics. Participants' prior stated preferences for lamb and mutton meat were recorded and compared with the actual sensory scores in order to identify any relationship between these factors.

The pre-auction survey results indicated that the majority of participants (79%) preferred mutton stew over lamb's. Overall, the C class was preferred for the stew meat over the AB and A class meat samples. Participants' prior tasting preferences were therefore similar to the actual sensory scores. The pre-auction survey results indicated that 88% of participants preferred the loins from lamb rather than mutton. It transpired that the A class was most preferred for the loin cuts in the standardised cooking method and the AB class for the optimal cooking method. Participants' prior tasting preferences were similar to the actual sensory scores for the standardised cooking method, but not for the optimal cooking method. The results further indicated that 81% of participants preferred leg of lamb to leg of mutton. The A class was most preferred for the leg cuts in the standardised and for the optimal cooking method; the leg of lamb and AB legs were both preferred. Participants' prior tasting preferences were analogous with the actual sensory scores for the standardised cooking method, but varied for the optimal cooking method. The sensory scores indicated the opportunity for the AB class to compete with lamb in the loin and leg cuts.

Chapter 5 presented the results of the experimental auction and the multiple regression analysis of the sensory evaluations and participants' WTP. The average bid prices from the random *n*th-price auction were evaluated for each of the three meat cuts. The standardised and optimal cooking method results were evaluated separately. If the auctions were efficient at capturing consumer preference differences and WTP, the

relative difference in bids should be correlated with the relative difference in sensory ratings.

The C class was most preferred for the stew meat cut with an average bid price of R67.52. The average bids for the stew meat cut were correlated with the sensory ratings in Chapter 4. The A and AB class were most preferred in the standardised cooking method for the loin cut, with average bid prices of R83.43 and R83.45 respectively. The AB class was most preferred in the optimal cooking method, with an average bid price of R86.86. The average bids for the loin cut were correlated with the sensory ratings in the optimal cooking method, while in the standardised cooking method, the AB class was preferred in addition to the A lamb. The leg of lamb was most preferred in the standardised cooking method with an average bid price of R95.40. The leg of lamb and the AB leg were most preferred in the optimal cooking method, with average bid prices of R93.67 and R93.29 respectively. The average bids for the leg cut were correlated with the sensory ratings.

The Friedman ANOVA results indicated a statistically significant difference in the bid prices depending on the age of the animal for each meat cut. A statistically significant difference was also found between the sensory scores recorded by the consumer panel for each meat cut, except for the stew meat cuts and loin cut in the optimal cooking method.

The average bid prices were evaluated in relation to participants' sensory scores and socio-demographic variables in the multiple regression analysis. The model's output for each meat cut revealed that the various independent variables statistically significantly predict the dependent bid prices.

It was found that males indicated an overall higher average bid price than females during the experimental auction. A statistically significant difference was found in participants' average bid prices and gender within the optimal cooking method for the loin cut. Similarly, a significant difference was found with the optimal cooking method for the leg cut. The significant differences can be justified by the R4.78 price difference between males and females within the optimal cooking method for the loin cut, and a R8.55 price difference within the optimal cooking method for the leg cut. The mean bids linked to income levels also indicated a significant difference regarding both cooking methods for the leg cut. Additionally, the mean bids linked to age groups indicated a significant difference with the optimal cooking method for the loin cut. It was interesting

to note that the 25-34 year age group indicated the highest mean bids overall for the different cuts, except for the stew meat cuts.

6.3 Practical implications of results

It is proposed that the current marketing strategies regarding lamb and mutton meat be revised and adapted according to the findings of this study. Consumers' sensory assessment results and average bid prices via the experimental auction indicated a difference in preference towards the three age classes for the stew meat, loin and leg cuts respectively. This study highlights the acceptable quality attributes of the different cuts within each age class.

The findings, which were obtained from a sample of the sheep-eating population of the Western Cape, will have practical implications on three key stakeholders: butcheries, food retailers and restaurants will all be potentially affected by the findings. The focus of the overall marketing strategy for these stakeholders should be on how to optimally use and market a carcass of a given age class. The marketing of specific cuts in the different age classes is of paramount importance. Consequently, the stakeholders will have to consider which specific cuts from different age classes should be marketed to which consumers.

The participants' sensory scores and average bid prices indicated that the stew meat cuts of the C class were most preferred. The AB class obtained the highest average bid price for the loin cut, while the leg of lamb was most preferred in the standardised cooking method. The leg of lamb and the AB leg were most preferred in the optimal cooking method, however.

It would be valuable for butcheries and food retailers to launch marketing campaigns to educate consumers regarding the best cuts to purchase in the different age classes of lamb and mutton meat. The results of this study indicate which age class consumers generally prefer for particular meat cuts. The focus should be shifted toward the availability and marketing of the older C class mutton for the stew meat cuts. Furthermore, the AB class should be promoted with the A class in the loin cut, and the AB class should be promoted with the A class in the leg cuts. It is thus important that stakeholders communicate these findings to their consumers. The demand for the specific cuts in the different age classes

will potentially increase and consequently increase profitability. However, the possible negative externalities to this proposed marketing strategy leads to the problem of carcass balancing that the meat industry faces. For example, if more mutton stew cuts are provided to the consumers, a surplus of lamb stew cuts will arise. A possible outcome is to lower the price of lamb stew cuts due to the surplus caused by the preferred lamb loin and leg cuts. Consequently, the price of mutton stew cuts needs to be increased. This strategy has the potential to work considering the consumers' preferences and willingness to pay for the respective meat cuts.

6.4 Recommendations for future research

The research presented is insightful in the scope of consumer behaviour research as well as in practise for producers and other stakeholders. However, the study has shortcomings that need to be addressed. One limitation was the sample size of this study having been restricted due to having limited resources for this research. The sample size of 42 participants resulted in a limited quantity of data available for analysis. It is suggested for future research that a larger sample be assembled, which will allow for more valuable results from regular consumers of sheep meat. Additionally, more empirical research should be made available with regard to socio-demographic information about sheep meat consumers in South Africa. It is important for the sheep industry to understand the target market in order to sufficiently provide the preferred product to the market.

Another constraining factor is that the geographic scope of this study was limited to only the Cape winelands district and City of Cape Town metropolitan area in the Western Cape, South Africa. It will be useful to extend the geographical scope to include more provinces and regions within the country.

Finally, this study sought to investigate the reason for a price discount for these respective classes if the quality attributes between the mentioned classes are equivalent. The stated evidence indicates significant partiality among consumers towards mutton meat; the reason for a price discount, especially between the A and AB classes, can therefore be questioned. For example, if the abattoir prices as mentioned in Chapter 1 are compared to consumers' WTP for the loin cut, the reason for a price discount between the age classes can be questioned. The difference in abattoir price between the A2 and AB2

classes is R5.19 where only a R0.02 difference was found by the auction results. Furthermore, the difference in abattoir price between the A2 and C2 classes is R14.67 where only a R2.43 difference was found by the auction results. The study shows that, with the sensory and auction results taken into consideration, future research in terms of pricing strategies between the A and AB classes could be useful. Furthermore, consumers' sensory assessments and WTP can be determined for the B class in order to determine if there is a significant difference compared to the A class.

Individual consumers will perceive meat quality within the age classes differently from others. However, the average meat quality indicated by the consumers' sensory scores and bid prices revealed a high preference toward mutton for the different meat cuts. The way forward is to acknowledge and apply the understanding of this variability among individual consumers, and to improve the selection process through consumer education and proper information of the correct cut in the given age class given particular cooking methods.

References

Adamowicz, W., Louviere, J. & Williams, M. 1994. Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities. *Journal of Environmental Economics and Manageent,* 26(3): 271-292.

Alphonce, R. & Alfnes, F. 2015. Eliciting Consumer WTP for Food Characteristics in a Developing Context: Comparison of four methods in a field experiment. IDEAS Working Paper Series from RePEc, 2015.

Becker, T. 2000. Consumer perception of fresh meat quality: a framework for analysis. *British Food Journal,* 102(3): 158-176.

Bekhit, A., Carne, A., Ha, M. & Franks, P. 2014. Physical interventions to manipulate texture and tenderness of fresh meat: A review. *International Journal of Food Properties,* 17(2): 433-453.

Ben-Akiva, M., Bradley, M., Morikawa, T., Benjamin, J., Novak, T., Oppewal, H. & Rao, V. 1994. Combining revealed and stated preferences data. *Marketing Letters,* 5(4): 335-349.

Bester, M. 2018. Sheep meat consumer demographic information. [personal communication - 28/05/2018].

Boutrolle, I., Arranz, D., Rogeaux, M. & Delarue, J. 2005. Comparing central location test and home use test results: Application of a new criterion. *Food Quality and Preference,* 16(8): 704-713.

Boutrolle, I., Delarue, J., Arranz, D., Rogeaux, M. & Köster, E.P. 2007. Central location test vs. home use test: Contrasting results depending on product type. *Food Quality and Preference,* 18(3): 490-499.

Bratzler, L.J. 1971. Palatability factors and evaluation. Pp. 328-348. The Science of Meat and Meat Products, 2nd ed., J.F. Price, editor; and B.S. Schweigert, editor. , eds. San Francisco. W.H. Freeman.

Breidert, C., Hahsler, M. & Reutterer, T. 2006. A review of methods for measuring willingness-to-pay. *Innovative Marketing,* 2(4): 8-32.

Brennand, C. & Lindsay, R. 1992. Distribution of volatile branched-chain fatty acids in various lamb tissues. *Meat Science,* 31(4): 411-421.

Bruwer, G.G. 1984. *Objektiewe evaluering van die karkasgraderingstelsel vir lammers en skape in die R.S.A.* Stellenbosch: M.Com Thesis, Dept. of Meat Science, Stellenbosch University.

Buhr, B., Hayes, D., Shogren, J. & Kliebenstein, J. 1993. Valuing ambiguity: The case of genetically engineered growth enhancers. *Journal of Agricultural and Resource Economics,* 18(2): 175-184.

Bureau of Food and Agricultural Policy. 2018. BFAP Baseline – Agricultural Outlook 2018-2027, Pretoria: s.n.

Cavallier. 2018. Most commonly consumed lamb and sheep meat cuts. [personal communication - 25/05/2018].

Channon, H., Lyons, R. & Bruce, H. 2003. *Sheepmeat flavour and odour: A review Table of Contents,* St. Lucia: CSIRO Livestock Industries.

Cherry, K. 2018. *What is a representative sample?* [Online] Available at: https://www.verywellmind.com/what-is-a-representative-sample-2795798 [Accessed 26 May 2018].

Civille, G.V. & Liska, I.H. 1975. Modifications and Applications to foods of the general foods sensory texture profile technique. *Journal of Texture Studies,* 6(1): 19-31.

Civille, G.V. & Oftedal, K.N. 2012. Sensory evaluation techniques — Make "good for you" taste "good". *Physiology & Behavior,* 107(4): 598-605.

Cloete, J.J.E., Hoffman, L.C. & Cloete, S.W.P. 2012. A comparison between slaughter traits and meat quality of various sheep breeds: Wool, dual-purpose and mutton. *Meat Science,* 91(3): 318-324.

Cloete, S. n.d. *Sheep breeding in South Africa: New challenges, and how we should react to it.* [Online] Available at: http://www.karoofoundation.co.za/images/Presentations/Sessie5/Dr%20S.W.P.%20Cloete,%20Sheep%20breeding%20in%20South%20Africa.pdf [Accessed 28 June 2018].

Corrigan, J.R. & Rousu, M.C. 2008. Testing Whether Field Auction Experiments Are Demand Revealing in Practice. *Journal of Agricultural and Resource Economics*, 33(2): 290-301.

DAFF. 2017. *Economic Review of the South African Agriculture.* [Online] Available at: http://www.daff.gov.za/Daffweb3/Portals/0/Statistics%20and%20Economic%20Analysis/Economic%20Analysis/Economic%20Review%202016_17.pdf [Accessed 25 June 2018].

DAFF. 2015. *Regulations regarding the classification and marking of meat intended for sale in the Republic of South Africa.* [Online] Available at: http://www.nda.agric.za/docs/plantquality/...%20local/MEAT%20REG%202006.doc [Accessed 5 June 2018].

Davel, M., Bosman, M. & Webb, E. 2003. Effect of electrical stimulation of carcasses from Dorper sheep with two permanent incisors on the consumer accpetance of mutton. *South African Journal of Animal Science*, 33(3): 206-212.

De Andrade, J.C., de Aguiar Sobral, L., Ares, G. & Deliza, R. 2016. Understanding consumers' perception of lamb meat using free word association. *Meat Science*, 117(1): 68-74.

De Groote, H., Kimenju, S.C. & Morawetz, U.B. 2011. Estimating consumer willingness to pay for food quality with experimental auctions: the case of yellow versus fortified maize meal in Kenya. *Agricultural Economics*, 42(1): 1-16.

De Lima Jùnior, D., de Carvalho, F., da Silva, F., do N Rangel, A., Novaes, L. & Difante, G. 2016. Intrinsic factors affecting sheep meat quality: a review. *Revista Colombiana de Ciencias Pecuarias*, 29(1): 3-15.

De-Magistris, T. & Gracia, A. 2016. Consumers' willingness to pay for light, organic and PDO cheese: An experimental auction approach. *British Food Journal*, 118(3): 560-571.

Devine, C.E., Graafhuis, A.E., Muir, P.D. & Chrystall, B.B. 1993. The effect of growth rate and ultimate pH on meat quality of lambs. *Meat Science*, 35(1): 63-77.

Dikeman, M.E., Reddy, G.B., Arthaud, V.H., Tuma, H.J., Koch, R.M., Mandigo, R.W. & Axe, J.B. 1986. Longissimus Muscle Quality, Palatability and Connective Tissue

Histological Characteristics of Bulls and Steers Fed Different Energy Levels and Slaughtered at Four Ages. *Journal of Anmial Science,* 63(1): 92-101.

Dreyer, J., Naude, R., Henning, J. & Rossouw, E. 1977. The Influence of Breed, Castration and Age on Muscle Fibre and Afrikaner Cattle Type and Diameter in Friesland. *South African Journal of Animal Science,* 7(1): 171-180.

Drichoutis, A.C., Klonaris, S. & Papoutsi, G.S. 2017. Do Good Things Come in Small Packages? Bottle Size Effects on Willingness to Pay for Pomegranate Wine and Grape Wine. *Journal of Wine Economics,* 12(1): 84-104.

Duckett, S.K., Snowder, G.D. & Cockett, N.E. 2000. Effect of the callipyge gene on muscle growth, calpastatin activity, and tenderness of three muscles across the growth curve. *Journal of Animal Science*, 78(1): 2836–2841.

Du Plessis, H.J. & Du Rand, G.E. 2012. The significance of traceability in consumer decision making towards Karoo lamb. *Food Research International,* 47(1): 210-217.

Dutson, T.R., Hostetler, R. & Carpenter, Z. 1976. Effect of collagen levels and sarcomere shortening on muscle tenderness. *Journal of Food Science,* 41(1): 863-866.

Erasmus, S.W. 2017. *The authentication of regionally unique South African lamb.* Stellenbosch: MPhil Thesis, Dept. of AgriSciences, University of Stellenbosch.

Feuz, D., Umberger, W., Calkins, C. & Sitz, B. 2004. U.S. Consumers' Willingness to Pay for Flavor and Tenderness in Steaks as Determined with an Experimental Auction. *Journal of Agricultural and Resource Economics,* 29(3): 501-516.

Font-i-Furnols, M. & Guerrero, L. 2014. Consumer preference, behavior and perception about meat and meat products: An overview. *Meat Science,* 98(3): 361-371.

Font-i-Furnols, M., Realini, C., Montossi, F., Sañudo, C., Campo, M.M., Oliver, M.A., Nute, G.R. & Guerrero, L. 2011. Consumer's purchasing intention for lamb meat affected by country of origin, feeding system and meat price: A conjoint study in Spain, France and United Kingdom. *Food Quality and Preference*, 22(5): 443-451.

Gellynck, X., Verbeke, W. & Vermeire, B. 2006. Pathways to increase consumer trust in meat as a safe and wholesome food. *Meat Science,* 74(1): 161-171.

Hayes, D., Shogren, J., Shin, S. & Kliebenstein, J. 1995. Valuing food safety in experimental auction markets. *American Journal of Agricultural Economics*, 77(1): 40-53.

Henchion, M., McCarthy, M., Resconi, V.C. & Troy, D. 2014. Meat consumption: Trends and quality matters. *Meat Science*, 98(3): 561-568.

Hiner, R.L. & Hankins, O.G. 1950. The tenderness of beef in relation to different muscles and age in the animal. *Journal of Animal Science*, 9(1): 347-353.

Hobbs, J., Sanderson, K. & Haghiri, M. 2006. Evaluating Willingness- to- Pay for Bison Attributes: An Experimental Auction Approach. *Canadian Journal of Agricultural Economics*, 54(2): 269-287.

Hoffman, L.C., Muller, M., Cloete, S.W.P. & Schmidt, D. 2003. Comparison of six crossbred lamb types: Sensory, physical and nutritional meat quality characteristics. *Meat Science*, 65(4): 1265-1274.

Hopkins, D.L., Allingham, P.G., Colgrave, M. & Van de Ven, R.J. 2013. Interrelationship between measures of collagen, compression, shear force and tenderness. *Meat Science*, 95(2): 219-223.

Hopkins, D.L. & Mortimer, S.I. 2014. Effect of genotype, gender and age on sheep meat quality and a case study illustrating integration of knowledge. *Meat Science*, 98(3): 544-555.

Horowitz, J. K. & McConnell, K. E. 2002. A Review of WTA/WTP Studies. *Journal of Environmental Economics Management*, 44(3): 426-447.

Hung, Y. & Verbeke, W. 2017. Sensory attributes shaping consumers' willingness-to-pay for newly developed processed meat products with natural compounds and a reduced level of nitrite. *Food Quality and Preference*, 70(1): 21-31.

Hurter, T. 2018. The impact of secondary information on consumers' willingness to pay for differentiated fresh lamb meat products in South Africa. Pretoria: MSc thesis, Dept. of Agricultural Economics, University of Pretoria.

Jeremiah, L., Tong, A. & Gibson, L. 1998. The influence of lamb chronological age, slaughter weight, and gender. Flavor and texture profiles. *Food Research International*, 31(3): 227-242.

Kagel, J.H., Harstad, R.M. & Levin, D. 1987. Information impact and allocation rules in auctions with affiliated private values: A laboratory study. *Econometrica*, 55(6): 1275-1304.

Kalish, S. & Nelson, P. 1991. A comparison of ranking, rating and reservation price measurement in conjoint analysis. *Marketing Letters,* 2(4): 327-335.

Karoo Meat of Origin. 2018a. *Certification Scheme*. [Online] Available at: https://www.karoomeatoforigin.com/about/ [Accessed 5 February 2018].

Karoo Meat of Origin. 2018b. *Standards*. [Online]. Available at: https://www.karoomeatoforigin.com/karoo-standards/ [Accessed 5 February 2018].

Kemp, S., Hollowood, T. & Hort, J. 2009. Sensory evaluation: A practical handbook. Chichester: Wiley-Blackwell.

Khan, M.I., Jo, C. & Tariq, M.R. 2015. Meat flavor precursors and factors influencing flavor precursors— A systematic review. *Meat Science*, 110(1): 278-284.

Kiria, C.G., Vermeulen, H. & Groote, H.D. 2010. *Sensory Evaluation and Consumers' Willingness to Pay for Quality Protein Maize (QPM) using Experimental Auctions in Rural Tanzania.* Cape Town, 3rd African Association of Agricultural Economists (AAAE).

Kirsten, J.F., Vermeulen, H., Van Zyl, K., Du Rand, G., Du Plessis, H. & Weissnar, T. 2017. Do South African Consumers have an Appetite for an Origin-based Certification System for Meat Products? A Synthesis of Studies on Perceptions, Preferences and Experiments. *International Journal on Food System Dynamics, 8*(1): 54-71.

Koohmaraie, M., Kent, M.P., Shackelford, S.D., Veiseth, E. & Wheeler, T.L. 2002. Meat tenderness and muscle growth: Is there any relationship? *Meat Science,* 62(3): 345-352.

Kroes, E. & Sheldon, R. 1988. Stated Preference Methods: An Introduction. *Journal of Transport Economics and Policy,* 22(1): 11-25.

Lange, C., Rousseau, F. & Issanchhou, S. 1998. Expectation, liking and purchase behaviour under economical constraint. *Food Quality and Preference,* 10(1): 31-39.

Lawless, H. & Heymann, H. 2010. Sensory evaluation of food: Principles and practices (2nd ed., Food science text series). New York: Springer.

Lee, J.Y., Han, D.B., Nayga, R.M. & Lim, S.S. 2011. Valuing traceability of imported beef in Korea: An experimental auction approach.(Report). *Australian Journal of Agricultural and Resource Economics*, 55(3): 360-373.

Leighton, C., Schönfeldt, H.C., Van Zyl, J., Van Heerden, S.M., Van Niekerk, J.M. & Morey, L. 2007. *Sensory Profiles of Mutton From Different Regions in South Africa*, Pretoria: School of Agricultural and Food Sciences.

List, J.A. & Shogren, J.F. 1999. Price information and bidding behaviour in repeated second-price auctions. *American Journal of Agricultural Economics*, 81(4): 942-949.

Lusk, J.F., 2003. Using Experimental Auctions for Marketing Applications: A Discussion. *Journal of Agricultural and Applied Economics*, 35(2): 349-360.

Lusk, J., Feldkamp, T. & Schroeder, T. 2004. Experimental Auction Procedure: Impact on Valuation of Quality Differentiated Goods. *American Journal of Agricultural Economics*, 86(2): 389-405.

Lusk, J., Fox, J., Schroeder, T., Mintert, J. & Koohmaraie, M. 2001. In-Store Valuation of Steak Tenderness. *American Journal of Agricultural Economics*, 83(3): 539-550.

Lusk, J. & Shogren, J. 2007. Experimental Auctions: Methods and Applications in Economic and Marketing Research. New York: Cambridge University Press.

McCormick, R. 1994. The flexibility of the collagen compartment of muscle. *Meat Science*, 36(1): 79-91.

Meat & Livestock Australia. 2012. *The effect of animal age on eating quality*, Sydney: Meat & Livestock Australia.

Meilgaard, M., Civille, G. & Carr, T. 1999. *Sensory Evaluation Techniques.* 1st ed. New York: CRC Press.

Meilgaard, M., Civille, G. & Carr, T. 2007. *Sensory Evaluation Techniques.* 4th ed. New York: CRC Press.

Melton, B., Huffman, W., Shogren, J. & Fox, J. 1996. Consumer Preferences for Fresh Food Items with Multiple Quality Attributes: Evidence from an Experimental Auction of Pork Chops. *American Journal of Agricultural Economics*, 78(4): 916-923.

Menkhaus, D.J., Borden, G.W., Whipple, G.D., Hoffman, E. & Field, R.A. 1992. An Empirical Application of Laboratory Experimental Auctions in Marketing Research. *Journal of Agriculture and Resource Economics,* 17(1): 44-55.

Misock, J.P., Campion, D.R., Field, R.A. & Riley, M.L. 1976. Palatibilty of Heavy Ram Lambs. *Journal of Animal Science,* 42(6): 1440-1444.

Moholisa, E., Hugo, A., Strydom, P. & Heerden, I.V. 2016. The effects of animal age, feeding regime and a dietary beta-agonist on tenderness of three beef muscles. *Journal of the Science of Food and Agriculture,* 97(8): 2375-2381.

Mottram, D.S. 1998. Flavour formation in meat and meat products: a review. *Food Chemistry*, 62(4): 415-424.

Navajas, E.A., Lambe, N.R., Fisher, A.V., Nute, G.R., Bünger, L. & Simm, G. 2008. Muscularity and eating quality of lambs: Effects of breed, sex and selection of sires using muscularity measurements by computed tomography. *Meat Science*, 79(1): 105-112.

Nishimura, T., Ojima, K., Liu, A., Hattori, A. & Takahashi,K. 1996. Structural changes in the intramuscular connective tissue during development of bovine semitendinosus muscle. *Tissue and Cell*, 28(5): 527-536.

Northen, J.R. 2000. Quality attributes and quality cues Effective communication in the UK meat supply chain. *British Food Journal,* 102(3): 230-245.

Noussair, C., Ruffieux, B. & Robin, S. 2004. Revealing consumers ‘ willingness-to-pay : A comparison of the BDM mechanism and the Vickrey auction. *Journal of Economic Psychology*, 25(6): 725-741.

O’Sullivan, M.G. & Kerry, J.P. 2009. Sensory evaluation of fresh meat. *CRC Press: Woodhead Publishing Limited*, 178-196.

Oude Ophuis, P.A.M. & Van Trijp, H.C.M. 1995. Perceived Quality: A Market driven and Consumer Orientated Approach. *Food Quality and Preference,* 6(3): 177-183.

Pannier, L., Gardner, G., Ball, A. & Pethick, D. 2015. *Impact of age of Australian Merino's on consumer sensory scores*, France: 61st International Congress of Meat Science and Technology. [Online] Available at: http://icomst proceedings.helsinki.fi/papers/2015_05_29.pdf [Accessed 12 March 2018].

Paul, P.C., Torten, J. & Spurlock, G.M. 1964. Eating quality of lamb. *Food Technology*, 18(11): 121-124.

Perry, D., Thompson, J.M., Hwang, I.H., Butchers, A., Egan, A.F. 2001. Relationship between objective measurements and taste panel assessment of beef quality. *Australian Journal of Experimental Agriculture*, 41(7): 981-989.

Perry, D. 2009. Sensory Measurement of Meat Quality. [Online] Available at: https://www.woolwise.com/wp-content/uploads/2017/.../Meat-418-518-07-T-14.docx [Accessed 15 May 2018].

Pethick, D.W., Hopkins. D.L., D'Souza. D.N., Thompson, J.M. & Walker, P.J. 2005. Effects of animal age on the eating quality of sheep meat. *Australian Journal of Experimental Agriculture*, 45(5): 491-498.

Piggott, J., Simpson, S. & Williams, S. 1998. Sensory Analysis. *International Journal of Food Sciences and Nutrition*, 33(1): 7-18.

Purchas, R. 2014. Tenderness Measurement. *Encyclopedia of Meat Science*, 452-459.

Purslow, P.P. 2004. Intramuscular connective tissue and its role in meat quality. *Meat Science*, 70(3): 435-447.

Reagan, J.O., Carpenter, Z.L. & Smith, G.C. 1976. Age-Related Traits Affecting the Tenderness of the Bovine Longissimus Muscle. *Journal of Animal Science*, 43(6): 1198-1205.

Red Meat Abattoir Association. 2018. *Price Information Report.* [Online] Available at: http://rvav.co.za/wp-content/uploads/2012/03/Week-10-2018.pdf [Accessed 12 March 2018].

Red Meat Industry Forum. 2017. *Mutton Outlook Report March 2017.* [Online] Available at: http://www.redmeatsa.co.za/wp-content/uploads/2017/03/AMT-Mutton-Outlook-March-2017.pdf [Accessed 25 June 2018].

Red Meat Research & Development South Africa. 2014. *Relevance of the South African Carcass Classification System - 12th Meat Symposium.* [Online] Available at: http://www.rmrdsa.co.za/Portals/0/Documents/12th%20MEAT%20SYMPOSIUM%202014.pdf [Accessed 10 June 2018].

Red Meat Research & Development South Africa. 2018. *Overview of the Industry.* [Online] Available at: http://www.rmrdsa.co.za/REDMEATINDUSTRY/OverviewoftheIndustry.aspx [Accessed 25 June 2018].

Red Meat SA. 2017. *AMT Beef and Mutton Monthly Report July 2017.* [Online] Available at: http://www.redmeatsa.co.za/wp-content/uploads/2017/07/AMT-Monthly-Beef-and-Mutton-Report-July-2017.pdf [Accessed 23 March 2018].

Reid, B. 2018. *Getting to know the ES SEMs 8-10(Part 1).* [Online] Available at: http://themediaonline.co.za/2018/02/getting-to-know-the-es-sems-8-10-part-1/ [Accessed 8 September 2018].

Resconi, V.C., Escudero, A. & Campo, M.M. 2013. The development of aromas in ruminant meat. *Molecules,* 18(6): 6748-6781.

Resurreccion, A. 2007. Consumer Sensory Testing for Food Product Development. In: *Developing new food products for a changing marketplace.* 2nd ed. Boca Raton, Fla.: Taylor & Francis. 365-401.

Rousu, M.C., Alexander, C. & Lusk, J.L. 2007. Designing Experimental Auctions for Marketing Research: Effect of Values, Distributions, and Mechanisms on Incentives for Truthful Bidding. *Review of Marketing Science,* 5(1): 1-30.

Rousu, M., Huffman, W.E., Shogren, J.F. & Tegene, A. 2004. Are United States consumers tolerant of genetically modified foods? *Review of Agricultural Economics,* 26(1): 19-31.

Rozan, A., Stenger, A. & Willinger, M. 2004. Willingness-to-pay for food safety: An experimental investigation of quality certification on bidding behaviour. *European Review of Agricultural Economics*, 31(4): 409-425.

SAARF. 2014. *Demographics of the 10 SAARF LSM groups for SAARF AMP Dec 13 and SAARF AMPS Jun 14.* [Online] Available at: http://www.saarf.co.za/lsm/LSM%20Demographics%20(AMPS%20June%202014).pdf [Accessed 11 August 2018].

SAMIC. 2018. *Classification of Red Meat - A key to more effective marketing.* [Online] Available at: http://www.samic.co.za/downloads/Redmeat.pdf [Accessed 4 June 2018].

Schönfeldt, H.C., Naudé, R.T., Bok, W., Van Heerden, S.M., Smit, R. & Boshoff, E. 1993. Flavour- and tenderness-related quality characteristics of goat and sheep meat. *Meat Science*, 34(3): 363-379.

Schönfeldt, H.C., Naude, R.T., Bok, W., Van Heerden, S.M., Sowden, L. & Boshoff, E. 1993. Cooking- and juiciness-related quality characteristics of goat and sheep meat. *Meat Science,* 34(3): 381-394.

Schönfeldt, H.C. & Strydom, P.E. 2011. Effect of age and cut on cooking loss, juiciness and flavour of South African beef. *Meat Science,* 87(3): 180-190.

Schönfeldt, H., Van Heerden, S., Sainsbury, J. & Gibson, N. 2011. Nutrient content of uncooked and cooked meat from South African classes A2 lamb and C2 mutton. *South African Journal of Animal Science*, 41(2): 275-145.

Sepúlveda, W.S., Maza, M.T. & Mantecon, A.R. 2010. Factors associated with the purchase of designation of origin lamb meat. *Meat Science,* 85(1): 167-173.

Shi, L., House, L. & Gao, Z. 2013. Impact of Purchase Intentions on Full and Partial Bids in BDM Auctions: Willingness-to-pay for Organic and Local Blueberries. *Journal of Agricultural Economics*, 64(3): 707-718.

Shogren, J.F., Fox, J.A., Hayes, D.J. & Kliebenstein, J.B. 1994. Bid Sensitivity and the Structure of the Vickrey Auction. *American Journal of Agricultural Economics,* 76(5): 1089-1095.

Shogren, J.F., Margolis, M., Koo, C. & List, J.A. 2001. A random *n*th-price auction. *Journal of Economic Behavior and Organization*, 46(4): 409-421.

Shorthose, W. & Harris, P. 1990. Effect of animal age on cull cow beef tenderness. *Journal of Food Science*, 55(1): 1-14.

Sink, J. & Caporaso, F. 1977. Lamb and Mutton Flavour: Contributing Factors and Chemical Aspects. *Pennsylvania Agricultural Experiment Station,* 4989(1): 119-127.

Soler, F., Gil, J. & Sanchez, M. 2002. Consumers' acceptability of organic food in Spain. *British Food Journal,* 104(8-9): 670-687.

Steenkamp, E. 1990. Conceptual Model of the Quality Perception Process. *Journal of Business Research,* 21(4): 309-333.

Stone, H. & Sidel, J. 2004. *Sensory evaluation practices* (3rd ed., Food science and technology international series). Amsterdam: Elsevier/Academic.

Svensson, L. 2012. *Design and Performance of Small Scale Sensory Consumer Tests.* Sweden: Swedish University of Agricultural Sciences. Uppsala: SLU, Dept. Of Landscape Architecture, Planning and Management.

Tornberg, E. 2005. Effects of heat on meat proteins - Implication on structure and quality of meat products. *Meat Science,* 70(3): 493-508.

Umberger, W., Feuz, D., Calkins, C. & Killinger-Mann, K. 2002. U.S. consumer preference and willingness-to-pay for domestic corn-fed beef versus international grass-fed beef measured through an experimental auction. *Agribusiness*, 18(4):491 504.

Umberger, W. & Feuz, D. 2004. The Usefulness of Experimental Auctions in Determining Consumers' Willingness-to-Pay for Quality-Differentiated Products. *Review of Agricultural Economics*, 26(2): 170-185.

Van der Merwe. 2012. *Evaluating traceability systems within the South African sheep meat supply chain.* Pretoria: MSc Thesis, Dept. of Agricultural Economics, University of Pretoria.

Van Heerden, S,M. 2007. The quality of South African lamb-carcass, nutrient and sensory attributes. Pretoria: PhD, Dept. of Consumer Science, University of Pretoria.

Van Wezemael, L.V., Smet, S.D., Ueland, Ø. & Verbeke, W. 2014. Relationships between sensory evaluations of beef tenderness, shear force measurements and consumer characteristics. *Meat Science,* 97(3): 310-315.

Van Zyl, K. 2011. *Applying experimental economics to determine consumers' willingness to pay for food attributes.* Pretoria: M.Com Thesis, Dept. of Agricultural Economics, University of Pretoria.

Van Zyl, K., Vermeulen, H. & Kirsten, J.F. 2013. Determining South African consumers' willingness to pay for certified Karoo lamb: An application of an experimental auction. *Agrekon*, 52(4): 1-20.

Veiseth, E., Shackelford, S., Wheeler, T. & Koohmaraie, M. 2004. Factors regulating lamb longissimus tenderness are affected by age at slaughter. *Meat Science*, 68(4): 635-640.

Vermeulen, H., Schönfeldt, H. & Pretorius, B. 2014. *A consumer perspective on the South African Red Meat Classifiaction System,* Pretoria: Red Meat Research and Development South Africa.

Vermeulen, H., Schönfeldt, H. & Pretorius, B. 2015. A consumer perspective of the South African red meat classification system. *South African Journal of Animal Science,* 45(3): 275-354.

Vickrey, W. 1961. Counterspeculation, Auctions, and Competitive Sealed Tenders. *The Journal of Finance,* 16(1): 8-37.

Voelckner, F. 2006. An empirical comparison of methods for measuring consumers' willingness to pay. *Marketing Letters*, 17(2): 137-149.

Wardman, M. 1988. A Comparison of Revealed Preference and Stated Preference Models of Travel Behaviour. *Journal of Transport Economics and Policy,* 22(1): 71-91.

Watkins, P.J., Kearney, G., Rose, G., Allen, D., Ball, A. J., Pethick, D.W. & Warner, R.D. 2014. Effect of branched-chain fatty acids, 3-methylindole and 4-methylphenol on consumer sensory scores of grilled lamb meat. *Meat Science,* 96(2): 1088-1094.

Watkins, P.J., Rose, G., Salvatore, L., Allen, D., Tucman, D., Warner, R.D., Dunshea, F.R. & Pethick, D.W. 2010. Age and nutrition influence the concentrations of three branched chain fatty acids in sheep fat from Australian abattoirs. *Meat Science,* 86(3): 594-599.

Watts, B.M., Ylimaki, G.L., Jeffery, L.E. & Elias, L.G. 1989. Basic Sensory Methods for Food Evaluation. International Development Research Centre: Ottawa, Canada*:* 1-157.

Weissnar, T. & du Rand, G. 2012. Consumer Perception of Karoo Lamb as a product of origin and their consequent willingness to purchase. *Food Research International*, 47(2):1-16.

Wertenbroch, K. & Skiera, B. 2002. Measuring Consumers' Willingness to Pay at the Point of Purchase. *Journal of Marketing Research,* 39(2): 228-241.

Woodhams, P., Kirton, A. & Jury, K. 1966. Palatability characteristics of crossbred lambs as related to individual southdown sires, slaughter age, and carcass fatness. *New Zealand Journal of Agricultural Research,* 9(2): 268-275.

Young, O.A., Lane, G.A., Podmore, C., Fraser, K., Agnew, M.J., Cummings, T.L. & Cox, N.R. 2006. Changes in composition and quality characteristics of ovine meat and fat from castrates and rams aged to 2 years. *New Zealand Journal of Agricultural Research,* 49(4): 419-430.

Appendices

Appendix A: Typical characteristics of the main socio-economic sub groups in South Africa

Variables:		Marginalised consumer segment:		Lower middle-income consumer segment:			Upper middle-income consumer segment:		Affluent consumer segment:		
Population Share	StatsSA ED[1]'s	ED 1 to ED 3 (30%)		ED 4 to ED 6 (30%)			ED 7 to ED 8 (20%)		ED 9 to ED 10 (20%)		
	SEM[2]'s	SEM 1 & SEM 2 (28%)		SEM 3 to SEM 5 (35%)			SEM 6 to SEM 7 (18%)		SEM 8 to SEM 10 (19%)		
Population size (SEM[2]'s)		11.1 million		13.7 million			6.8 million		7.7 million		
Average monthly household income	SEM's (ES October 2017 release)	SEM 1: R3 404 SEM 2: R4 275		SEM 3: R5 210 SEM 4: R6 434 SEM 5: R7 442			SEM 6: R9 432 SEM 7: R12 914		SEM 8: R18 464 SEM 9: R26 683 SEM 10: R34 574		
	StatsSA ED's[3] (StatsSA LCS 2014/2015, inflation adjusted[3])	ED 1: R1 030 ED 2: R1 767 ED 3: R2 393		ED 4: R3 077 ED 5: R3 935 ED 6: R5 124			ED 7: R7 081 ED 8: R10 616		ED 9: R18 028 ED 10: R46 998		
Food expenditure share (StatsSA LCS 2014/2015)		33%		29%			20%		9%		
Average household size	StatsSA LCS 2014/2015	2.8 people		3.7 people			4.1 people		3.5 people		
	StatsSA IES 2010/2011	3.2 people		4.3 people			4.6 people		4.0 people		
Residential location	Rural / Urban & metro (ES March 2018 release)	SEM 1: 75%/25% SEM 2: 60%/40%		SEM 3: 48%/52% SEM 4: 24%/76% SEM 5: 13%/87%			SEM 6: 8%/92% SEM 7: 5%/95%		SEM 8: 2%/98% SEM 9: 1%/99% SEM 10: 1%/99%		
Education level (SEM[2]'s) (ES March 2018 release)		*SEM 1*	*SEM 2*	*SEM 3*	*SEM 4*	*SEM 5*	*SEM 6*	*SEM 7*	*SEM 8*	*SEM 9*	*SEM 10*
	Primary school	13%	12%	6%	6%	3%	3%	3%	2%	<1%	<1%
	High school	54%	47%	41%	38%	36%	33%	27%	21%	13%	12%
	Matric	31%	38%	48%	49%	50%	51%	49%	41%	40%	42%
	Post-matric	2%	3%	5%	7%	10%	13%	22%	35%	47%	46%
Work status (ES March 2018 release)	Unemployed share	32%	29%	30%	24%	20%	17%	15%	8%	5%	2%
Dominant provincial location: (ES March 2018 release)		KZN, EC, LP, GP		GP, KZN, EC, WC, LP			GP, WC, KZN		GP, WC, KZN		

Sources: Establishment Survey October 2017 release & March 2018 release; StatsSA IES 2010/2011; StatsSA LCS 2014/2015

[1] ED = Expenditure decile: Each expenditure decile represents 10% of the households in South Africa (StatsSA, 2017)

[2] Share of population aged 15 years and older

[3] Values for total household expenditure per expenditure decile from StatsSA Living Conditions Survey 2014/2015 was adjusted with inflation (StatsSA Consumer Price Index – all items, total country) (Sta tistics South Africa (StatsSA), 2018). *[4] Accounting for at least 70% of consumers in particular sub-group*

Source: BFAP Baseline (2018)

Appendix B: Auction information sheet

Faculty of Economic and Management Sciences
Department of Agricultural Economics

Carina Troost: MCom Thesis
Supervisor: Prof Johann Kirsten

Sensory Assessments and Consumers' Willingness to pay for Karoo lamb versus Karoo mutton using an Experimental Auction Approach

23/08/2018

GENERAL INFORMATION

Dear Participant,

Welcome and thank you for participating in this research study. Your inputs are greatly appreciated. Please use the following instructions to assist you during today's proceedings. Please read the instruction sheet as the auction continues. We kindly request you not to look ahead in the exercise.

- Please open the envelope that you have received.

Inside your envelope you will find one piece of ***droëwors*** wrapped in a plastic bag, a booklet with bidding slips and a R200 note.

The R200 note is your compensation for taking part in this study. You will also use the R200 as bidding money in the auction. The money you do not use is yours to keep.

BIDDING INSTRUCTIONS

Please make use of the instruction sheet as a guide while the sensory evaluations and auction procedures are underway.

Please follow the instructions carefully and do not talk to other participants for the entire duration of the auction.

The *droëwors* will be used in the bidding exercise and samples of Karoo lamb and mutton meat will be used for the sensory evaluation and experimental auction rounds.

EXPLANATION OF BIDDING EXERCISE

A bidding exercise will firstly be conducted to familiarize you with the auction method and process. This is merely a practice round with a practice product therefore no one will physically have to buy the product.

The auction process will start with a reference product presented with its full average product price in the market. The reference product will be an 80 g packet of ***droëwors*.** You will then be asked to taste the sample *droëwors* and write down the full product price you would be willing to pay based on your assessment of the sample product in relation to the given market price of *droëwors.*

You will do this by first writing your ID number on the bid slip, which is the **first three letters** of your **name** and your **birthday (day then month)** for example CAR1705. Secondly, you will place your bid on the bid slip, indicating your willingness to pay.

This information is confidential; therefore you cannot share it with other participants.

The bidding slips will be collected once every participant have placed their bids and will be sorted from the highest to the lowest bid. We will randomly pick one of these bids by drawing a random number *(n)* between 2 and *k (k* = the number of participants) from a bag. This will be the purchase price of this round.

The purchase price is the “cut-off” price. Everyone who bid higher than the purchase price will have to potentially purchase the packet of ***droëwors*** at the purchase price. Everyone who bid at or below the purchase price, will not have to purchase the product.

NOTE:

It is important to note that it is in your best interest to bid truthfully. Thus, the amount you write on your bidding slip should be the true value that the product is worth to you. If you bid more than what you are willing to pay for the product, you might end up paying more for the product than you intended to. On the other hand, if you bid less than what the product is worth to you, you might not have the opportunity to purchase the product.

You have to picture yourself in the market place and write down the amount you are willing to pay for the particular product. Bids must be placed in increments of R1.

PRACTICE ROUND

1. Please take out the *droëwors* from the envelope.
2. A reference product will be shown (80 g packet of *droëwors*) with its full average product price in the market. Participants will be asked to indicate their willingness to pay for such an 80 g packet in the market after tasting the product.
3. You may open the plastic bag and taste the *droëwors*.
4. You will now place a bid on the bid slip, indicating how much you would pay for this product. Please use the 1st bidding slip and also fill in your ID number. Remember to bid for the reference product as presented and not the price per kilogram (R/kg).
5. The bids will be collected once everyone has finished placing their bids.
6. The purchase price and the ID numbers of the potential winners will be revealed.

SENSORY EVALUATION AND EXPERIMENTAL AUCTION

(Explanation)

Participants will be asked to taste and rate three samples of **different ages** of lamb and sheep meat in terms of flavour, juiciness, tenderness and overall liking by means of a **blind tasting**. The ratings will be established using a 9 point hedonic category scale (where 1= extremely undesirable for flavour, extremely dry, extremely tough, extremely undesirable for overall liking, and 9= extremely desirable for flavour, extremely juicy, extremely tender, and extremely desirable for overall liking). Thereafter, you will have the opportunity to participate in an experimental auction and submit **sealed bids** for each meat sample you have tasted.

The sensory evaluation and experimental auction process will be conducted in **three phases**. **PHASE 1** will consist of one round of three tasting and bidding rounds. The reference item for phase 1 will be a 500 g packet of **lamb stew meat cuts**. The reference item will be shown to the participants and information on the average full product price it currently holds in the market as well as the weight per kg will be given. Participants will have to bid the full product price they would be willing to pay for this reference item in the market based on the different meat samples they have tasted.

PHASE 2 will consist out of two rounds in which each round will consist of three tasting and bidding rounds. The reference item for phase 2 will be a 500 g packet of **lamb loin chops**. The reference item will be shown to the participants and information on the average full product price it currently holds in the market as well as the weight per kg will be given. Participants will then have to bid the full product price they would be willing to pay for this reference item in the market based on the three different meat samples they have tasted.

PHASE 3 will consist out of two rounds in which each round will consist of three tasting and bidding. The reference item for phase 3 will be a 500 g **deboned leg of lamb**. The reference item will be shown to the participants and information on the average full product price it currently holds in the market as well as the weight per kg will be given. Participants will then have to bid the full product price they would be willing to pay for this reference item in the market based on the three different meat samples they have tasted.

Sensory Evaluation and Experimental Auction process

Phase 1:

This phase consists out of one round of three tasting and bidding rounds. Only one meat sample in this phase would be binding, in other words, only one sample will be determined where the auction winners will have to purchase the product at the determined purchase price. Thus, the most 500 g packets **lamb stew meat cuts** a participant could potentially purchase would be one. The binding sample will be randomly drawn at the end of the round.

Cooking method: the lamb and sheep stew meat cuts are cooked on the stove.

Round 1:

1. Take note of the reference product presented and the reference price indicated.
2. The three meat samples will be served on a plate with 3 digit sample identification codes.
3. You will have to individually taste and evaluate each meat sample.
4. You will now have to taste and rate the first meat sample for flavour, juiciness, tenderness and overall liking by the use of a 9 point hedonic scale.
5. Please write your ID number and the corresponding 3 digit sample identification code on the 2nd record sheet provided.
6. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
7. A bottle of water is provided to cleanse your palate in between sample tastings.
8. You will now have to taste and rate the second meat sample for flavour, juiciness, tenderness and overall liking.
9. You have to write the corresponding 3 digit sample identification code and your ID number on the 3rd record sheet provided.
10. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
11. Lastly, the third meat sample will be tasted and rated for flavour, juiciness, tenderness and overall liking.

12. You have to write the corresponding 3 digit sample identification code and your ID number on the 4th record sheet provided.
13. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
14. The bid sheets will now be collected by the auction monitors.
15. The binding meat sample will now be determined by randomly drawing a number 1-3 from a bag (1= sample one, 2= sample two, 3= sample three).
16. The winners of phase 1 will be announced and will have to purchase their packet of lamb stew meat cuts.

Phase 2:

This phase consists out of two separate rounds with a total of six tasting and bidding rounds. Only one round and one meat sample in this phase would be binding, in other words, only one round will be determined where the auction winners of this round will have to purchase the product at the determined purchase price. Thus, the most 500 g **loin chop** packets a participant could potentially purchase would be one. The binding round and sample will be randomly drawn at the end of the sixth round.

Cooking method: the loin cuts are roasted in the oven.

Round 1:

1. Take note of the reference product presented and the reference price indicated.
2. The first three meat samples will be served on a plate with 3 digit sample identification codes.
3. You will have to individually taste and evaluate each meat sample.
4. You will now have to taste and rate the first meat sample for flavour, juiciness, tenderness and overall liking by the use of a 9 point hedonic scale.
5. Please write your ID number and the corresponding 3 digit sample identification code on the 5th record sheet provided.
6. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
7. You will now have to taste and rate the second meat sample for flavour, juiciness, tenderness and overall liking.
8. You have to write the corresponding 3 digit sample identification code and your ID number on the 6th record sheet provided.
9. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
10. Lastly, the third meat sample will be tasted and rated for flavour, juiciness, tenderness and overall liking.

11. You have to write the corresponding 3 digit sample identification code and your ID number on the 7th record sheet provided.
12. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
13. The bid sheets will now be collected by the auction monitors.

Round 2:

The sensory evaluation process and auction will be re-conducted.

1. You will have to individually taste and evaluate each meat sample.
2. The three meat samples will be served on a plate with 3 digit sample identification codes.
3. Please write your ID number and the corresponding 3 digit sample identification code on the 8th record sheet provided.
4. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
5. After all three samples have been sensory evaluated and bids were placed, the auction monitors will collect the record sheets.
6. The binding round will now be determined by a coin toss, heads for round one and tails for round two.
7. Consequently, the binding meat sample in the binding round will be determined by randomly drawing a number 1-3 from a bag (1= sample one, 2= sample two, 3= sample three).
8. The winners of phase 2 will be announced and will have to purchase their packet of loin chops.

Phase 3:

This phase consists out of two separate rounds with a total of six tasting and bidding rounds. Only one round and one meat sample in this phase would be binding, in other words, only one round will be determined where the auction winners of this round will have to purchase the product at the determined purchase price. Thus, the most 500 g **deboned legs** a participant could potentially purchase would be one. The binding round and sample will be randomly drawn at the end of the sixth round.

Cooking method: the deboned legs are roasted in the oven.

Round 1:

1. Take note of the reference product presented and the reference price indicated.

2. The first three meat samples will be served on a plate with 3 digit sample identification codes.
3. You will have to individually taste and evaluate each meat sample.
4. You will now have to taste and rate the first meat sample for flavour, juiciness, tenderness and overall liking by the use of a 9 point hedonic scale.
5. Please write your ID number and the corresponding 3 digit sample identification code on the 11th record sheet provided.
6. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
7. You will know have to taste and rate the second meat sample for flavour, juiciness, tenderness and overall liking.
8. You have to write the corresponding 3 digit sample identification code and your ID number on the 12th record sheet provided.
9. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
10. Lastly, the third meat sample will be tasted and rated for flavour, juiciness, tenderness and overall liking.
11. You have to write the corresponding 3 digit sample identification code and your ID number on the 13th record sheet provided.
12. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
13. The bid sheets will now be collected by the auction monitors.

Round 2:

The sensory evaluation process and auction will be re-conducted.

1. You will have to individually taste and evaluate each meat sample.
2. The three meat samples will be served on the plate with 3 digit sample identification codes.
3. Please write your ID number and the corresponding 3 digit sample identification code on the 14th record sheet provided.
4. Directly after, you will have to place a bid on the same record sheet, indicating your willingness to pay for this sample.
5. After all three samples have been sensory evaluated and bids were placed, the auction monitors will collect the record sheets.
6. The binding round will now be determined by a coin toss, heads for round one and tails for round two.
7. Consequently, the binding meat sample in the binding round will be determined by randomly drawing a number 1-3 from a bag (1= sample one, 2= sample two, 3= sample three).

8. The winners of phase 3 will be announced and will have to purchase their deboned leg.

Mariette Crafford is a well-known writer, chef, public speaker, media and food consultant. She will now give a short presentation on cooking methods for different sheep meat (age) classes.

Thank you for participating!

Appendix C: Pre-auction survey

Faculty of Economic and Management Sciences
Department of Agricultural Economics

Carina Troost: MCom Thesis
Supervisor: Prof Johann Kirsten

Sensory Assessments and Consumers' Willingness to pay for Karoo lamb versus Karoo mutton using an Experimental Auction Approach

23/08/2018

PRE-AUCTION CONSUMER SURVEY

Please answer the following questions below by marking (x) in the appropriate box:

All information will be treated with strict confidentiality.

*Your ID number for this evening is **the first three letters** of your **name and your birthday** (day then month) for example CAR1705.*

Section 1: Demographics

1. **Panellist ID no:**

2. **Gender:**

	Male
	Female

3. **Age:**

	25 - 34 years
	35 - 49 years
	50 - 64 years
	65 years and over

4. Ethnicity:

	White
	Black African
	Coloured
	Asian
	Other

5. Highest level of education completed:

	Grade 11 or lower
	Grade 12
	Technicon diploma/degree
	Bachelor's degree
	Postgraduate degree
	Other post- matric qualification

6. Employment status:

	Employed for wages
	Self-employed
	Homemaker
	Student
	Military
	Retired
	Unable to work
	Other

7. Occupation:

8. Monthly household income:

	< R10 000
	R10 000 - R29 999
	R30 000 - R49 999
	R50 000 - R69 999
	> R70 000

9. Household size (the amount of household family members)

10. In what geographical region did you predominantly grow up in?

	Rural
	Urban

Section 2: Sheep Meat (lamb and mutton)

11. Are you the primary food shopper in your household?

	Yes
	No

12. Are you the primary meat shopper in your household?

	Yes
	No

13. How often do you purchase lamb or mutton meat?

	Every day
	3 - 4 times per week
	1 - 2 times per week
	At least once a month
	Less than once a month
	Only on special occasions

14. How often do you consume lamb or mutton meat?

	Every day
	3 - 4 times per week
	1 - 2 times per week
	At least once a month
	Less than once a month
	Only on special occasions

15. What is your perception of the age difference between lamb and mutton meat?

Lamb age	
Mutton age	

16. **What would your choice be in the two different age categories regarding the different meat cuts? (Please write "lamb" or "mutton").**

Loin	
Leg of lamb/mutton	
Stew meat cuts	

17. **What would your choice be in the two different age categories regarding the following sensory characteristics? (Please write "lamb" or "mutton").**

Flavour	
Tenderness	
Juiciness	

18. **Which lamb or mutton meat cuts do you prefer?** *(Mark the **three** most valued cuts)*

	Shoulder
	Chop
	Rack
	Leg
	Loin
	Rib
	Sirloin
	Breast
	Shank
	Neck
	Flank
	Rump

19. **Which factors do you consider as most important when consuming lamb or mutton meat?** *(Mark the **two** most valued factors)*

	Tenderness
	Juiciness
	Flavour
	Fat content/Marbling
	Colour

Appendix D: Scoresheets

Practice round scoresheet

Panellist ID No:	
Instructions: Please taste the given *droëwors* sample and indicate your bid amount (willingness to pay for the whole 80 g packet) in the space provided below.	
Bid Amount:	**R**

Example of the stew meat sample scoresheet

Panellist ID No:	**Sample code:**
Instructions: Please taste the given meat sample, then place an **(X)** mark on the point in the scale which best describes your feeling. Thereafter, please indicate your bid amount for this sample in the space provided below.	MI10

Sensory Score	**Flavour**	**Juiciness**	**Tenderness**	**Overall liking**
(9) Like extremely				
(8) Like very much				
(7) Like moderately				
(6) Like slightly				
(5) Neither like nor dislike				
(4) Dislike slightly				
(3) Dislike moderately				
(2) Dislike very much				
(1) Dislike extremely				
Bid Amount:	**R**			

Example of the loin sample scoresheet

Panellist ID No:	**Sample code:**
Instructions: Please taste the given meat sample, then place an **(X)** mark on the point in the scale which best describes your feeling. Thereafter, please indicate your bid amount for this sample in the space provided below.	LO10

Sensory Score	**Flavour**	**Juiciness**	**Tenderness**	**Overall liking**
(9) Like extremely				
(8) Like very much				
(7) Like moderately				
(6) Like slightly				
(5) Neither like nor dislike				
(4) Dislike slightly				
(3) Dislike moderately				
(2) Dislike very much				
(1) Dislike extremely				
Bid Amount:	**R**			

Example of the leg sample scoresheet

Panellist ID No:	**Sample code:**

Instructions:

LE10

Please taste the given meat sample, then place an **(X)** mark on the point in the scale which best describes your feeling.

Thereafter, please indicate your bid amount for this sample in the space provided below.

Sensory Score	**Flavour**	**Juiciness**	**Tenderness**	**Overall liking**
(9) Like extremely				
(8) Like very much				
(7) Like moderately				
(6) Like slightly				
(5) Neither like nor dislike				
(4) Dislike slightly				
(3) Dislike moderately				
(2) Dislike very much				
(1) Dislike extremely				
Bid Amount:	**R**			

Appendix E: Auction bids

Practice round

Position	ID number	Bid amount
1	LEA0610	50
2	MAA2803	46
3	CHI2004	45
4	TER1004	39
5	ANJ0909	38
6	AND2202	35
7	JOH1210	35
8	JOH2310	35
9	MAR0713	35
10	MAR2308	35
11	MAR2603	35
12	MAY1104	35
13	NCA2502	35
14	WAY6709	35
15	WIL0412	35
16	JOH2405	30
17	KOS2808	30
18	RAC1802	30
19	ROL1802	30
20	SIM0608	30
21	STE0402	30
22	LIN3103	28
23	PUN2802	28
24	ALF0911	25
25	ANN2509	25
26	DAN0510	25
27	DES2011	25
28	DIR2708	25
29	GLO2702	25
30	LIN1201	25
31	LOU0905	25
32	ELM2710	23
33	DAL2803	22
34	BOK3010	20
35	EDM1407	20
36	HAN1007	20
37	JOH0904	20
38	MER2611	20
39	THE1904	20
40	ALW1105	15
41	ANN2812	15
42	MEL0506	15

Note: The random position drawn is n=16 (first column) with the purchase price of R30. All participants who bid a higher price than R30 will win the auction (from position 15 marked) and have to purchase the product at the randomly drawn purchase price (R30).

Phase 1

Binding sample: 536

Position	ID number	Bid amount
1	WAY6709	90
2	ELM2710	86
3	GLO2702	85
4	JOH1210	80
5	LIN3103	75
6	TER1004	75
7	ALF0911	70
8	BOK3010	70
9	DAN0510	70
10	HAN1007	70
11	LEA0610	70
12	PUN2802	70
13	ROL1802	70
14	STE0402	70
15	MAA2803	67
16	MAR0713	66
17	ANJ0909	65
18	ANN2509	65
19	ANN2812	65
20	JOH2310	65
21	JOH2405	65
22	LIN1201	65
23	LOU0905	65
24	MAY1104	65
25	MER2611	65
26	THE1904	65
27	NCA2502	63
28	ALW1105	60
29	AND2202	60
30	DAL2803	60
31	DIR2708	60
32	EDM1407	60
33	JOH0904	60
34	KOS2808	60
35	MAR2308	60
36	MAR2603	60
37	RAC1802	60
38	DES2011	55
39	SIM0608	55
40	VIL0412	55
41	MEL0506	45
42	CHI2004	40

Note: The random position drawn is n=5(first column) with the purchase price of R75. All participants who bid a higher price than R75 will win the auction (from position 4 marked) and have to purchase the product at the randomly drawn purchase price (R75).

Phase 2

Binding round: Round 1; Binding sample: 645

Position	ID number	Bid amount
1	MAA2803	118
2	JOH1210	105
3	DAN0510	95
4	HAN1007	95
5	MEL0506	95
6	JOH2310	94
7	VIL0412	93
8	ALF0911	92
9	ANJ0909	92
10	PUN2802	92
11	MAR0713	91
12	DES2011	90
13	LEA0610	90
14	LIN1201	90
15	MAR2308	90
16	RAC1802	90
17	THE1904	90
18	ANN2812	88
19	NCA2502	88
20	STE0402	88
21	BOK3010	85
22	LIN3103	85
23	DIR2708	83
24	JOH0904	83
25	ANN2509	80
26	EDM1407	80
27	ELM2710	80
28	JOH2405	80
29	KOS2808	80
30	MAY1104	80
31	MER2611	80
32	ROL1802	80
33	SIM0608	80
34	TER1004	80
35	AND2202	75
36	MAR2603	75
37	CHI2004	70
38	DAL2803	70
39	ALW1105	65
40	LOU0905	65
41	WAY6709	45
42	GLO2702	40

Note: The random position drawn is n=7(first column) with the purchase price of R93. All participants who bid a higher price than R93 will win the auction (from position 6 marked) and have to purchase the product at the randomly drawn purchase price (R93).

Phase 3

Binding round: Round 2; Binding sample: 536

Position	ID number	Bid amount
1	VIL0412	130
2	AND2202	110
3	MAA2803	107
4	ANN2509	105
5	JOH0904	105
6	CHI2004	100
7	EDM1407	100
8	JOH2310	100
9	KOS2808	100
10	LIN1201	100
11	STE0402	100
12	ALF0911	99
13	BOK3010	98
14	MAR0713	98
15	MAR2603	98
16	NCA2502	98
17	ANN2812	95
18	DAN0510	95
19	DIR2708	95
20	ELM2710	95
21	LOU0905	95
22	MAY1104	95
23	PUN2802	95
24	RAC1802	95
25	ROL1802	95
26	TER1004	95
27	THE1904	95
28	ALW1105	90
29	ANJ0909	90
30	DAL2803	90
31	JOH2405	90
32	LEA0610	90
33	LIN3103	90
34	MAR2308	90
35	MER2611	90
36	SIM0608	90
37	HAN1007	85
38	DES2011	80
39	JOH1210	75
40	MEL0506	70
41	GLO2702	60
42	WAY6709	60

Note: The random position drawn is n=3(first column) with the purchase price of R107. All participants who bid a higher price than R107 will win the auction (from position 2 marked) and have to purchase the product at the randomly drawn purchase price (R107).

Appendix F: Auction photographs

Auditorium setting.

Participants completing pre-auction survey.

A participant reading through the written information sheet.

Auction monitor explaining the experimental procedure.

Sensory assessment of the first meat sample by a participant.

Helpers sorting auction bids.

Auction round ID numbers and purchase price are revealed by the auction monitor.

Auction round winners purchasing the reference product with their R200 notes.

Chef Mariette Crafford presenting information on the cooking methods used with the team of assistant chefs.