EFFECT OF ELECTRICAL STIMULATION ON CONSUMER ACCEPTANCE OF MUTTON FROM CLASS-AB SHEEP CARCASSES

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DEDICATION

To Daniël-Joe who was three months old when I started my studies
and who does not know life without it.
To Chris for your love and support.
To Mother for your encouragement and example.

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SUMMARY

Background

The inconsistency in the eating quality of meats, predominantly tenderness, is probably the most important problem faced by the meat industry worldwide. Consumers consider tenderness to be the single most important component of meat quality. An alternative for increasing meat tenderness and/or preventing cold shortening may exist in the form of electrical stimulation of the carcass shortly following slaughter. Other advantages of electrical stimulation such as increased shelf life, bright red colour and decreased bacterial growth are all quality characteristics demanded by consumers.

Objective

The objective of this research was to study the effect of electrical stimulation on consumer acceptance of, preference for and consumption intent regarding mutton of the recently introduced AB-class sheep carcasses.

Methods

A total of 22 wethers of between 45 and 50 kg live weight were selected from a homogenous group of Dorpers. Carcasses were divided in two groups, of which one group was electrically stimulated (0.4amp/h for 45sec; ES) and the other group was not electrically stimulated (NES). The left *M. longissimus dorsi* samples of both groups were oven-roasted and total cooking losses were determined. A consumer panel rated the degree of acceptance of each cooked mutton sample regarding juiciness, tenderness and flavour. Overall acceptance was calculated. A preference test and food action rating test were also conducted.

Results

Results of the hedonic tests indicated that consumer acceptance regarding juiciness, tenderness, flavour and overall acceptability of mutton samples were not significantly influenced by the electrical stimulation. Samples from both the ES and NES treatments were highly acceptable to the consumers. No significant differences in preference were obtained. The present results suggest that electrical stimulation does not have a significant influence on consumer acceptance or preference for the AB-class mutton. Shear force values of the electrically stimulated and non-stimulated samples also showed no significant numerical differences. The variation within shear force values of the electrically stimulated group of samples was, however, less than within the non-stimulated group, indicating that electrical stimulation can successfully be applied to lessen variation in tenderness within class-AB. Consumption intent towards both samples was scored very high, which revealed a positive attitude towards both the electrically stimulated and non-electrically stimulated class-AB mutton samples. No significant difference in the % cooking losses was observed between the ES and NES samples.

Conclusion

Electrical stimulation can be applied successfully to limit variation in tenderness of mutton within class-AB sheep carcasses. The class-AB mutton is of a very high quality and is highly accepted by consumers.

Key words

Electrical stimulation, class-AB sheep, mutton, tenderness, consumer acceptance.

OPSOMMING

Agtergrond

Die variasie in die eetkwaliteit van vleis, veral sagtheid, blyk die grootste probleem in die vleisindustrie te wees. Sagtheid is die belangrikste kwaliteitseienskap vir verbruikers. Elektriese stimulering van karkasse kan as alternatiewe metode gebruik word om die taaiheid van vleis a.g.v koelkrimping van die spierweefsel kort na die slagting te voorkom. Addisionele voordele van elektiese stimulering wat ook verbruikersvereistes is, is 'n verlengde rakleeftyd, helder rooi kleur en verlaagde bakteriële groei.

Doel

Die doel van die studie was om die effek van elektriese stimulering (ES) op verbruikersaanvaarbaarheid van die vleis van die AB-klas skaap te ondersoek.

Metode

'n Totaal van 22 hammels tussen 45 en 50 kg lewende massa is geselekteer vanuit 'n groep homogene Dorpers. Die karkasse is in twee groepe verdeel waarvan die een groep elektries gestimuleer (0.4amp/h vir 45 sek; ES) is. Die linker *M. longissimus dorsi* van beide groepe is ge-oondrooster en totale gaarmaakverliese is bepaal. 'n Verbruikerspaneel het elke gaar skaapvleismonster geëvalueer ten opsigte van die graad van aanvaarbaarheid van die sappigheid, sagtheid en smaak. Algehele aanvaarbaarheid is daarna bereken. 'n Voorkeur- en reaksieskattingstoets van elk van die twee groepe is ook bereken. .

Resultate en bespreking

Resultate van die hedoniese toetse het aangedui dat elektriese stimulering geen betekenisvolle effek op die aanvaarbaarheid van die sappigheid, sagtheid, smaak of totale aanvaarbaarheid van die skaapvleismonsters gehad het nie. Beide die gestimuleerde en nie-gestimuleerde vleismonsters was vir die verbruikers hoogs aanvaarbaar. Daar was ook geen betekenisvolle verskil in die voorkeur vir 'n spesifieke monster nie. Die huidige resultate bewys dat elektriese stimulering nie 'n betekenisvolle invloed op die verbruiker se aanvaarbaarheid van en die voorkeur vir die AB-klas skaap het nie. Snyweerstandresultate van die elektries gestimuleerde (ES) groep en die nie-elektries gestimuleerde (NES) groep het geen numeries betekenisvolle verskille opgelewer nie. Die variasie tussen die snyweerstandwaardes binne die elektries gestimuleerde groep was egter laer as binne die nie-gestimuleerde groep. Hierdie resultate dui

dus daarop dat elektriese stimulering van die AB-klas skaapkarkasse sal bydra tot meer konstante kwaliteit en verminderde variasie in sagtheid binne die AB-klas. Die mate waartoe die verbruikers bereid was om beide vleismonsters te eet was baie hoog en dit dui dus op 'n positiewe houding teenoor beide die elektries gestimulleerde en nie-gestimuleerde AB-klas skaapvleismonsters. Resultate dui ook daarop dat die verbruikers nie 'n spesifieke voorkeur vir 'n bepaalde skaapvleismonster gehad het nie. Geen betekenisvolle verskille in die gaarmaakverliese van die elektries gestimuleerde en nie-elektries gestimuleerde skaapvleismonsters is verkry nie.

Gevolgtrekking

Elektriese stimulering kan suksesvol aangewend word om moontlike variasies in die sagtheid van die AB-klas skaap te verminder. Die AB-klas skaap is van baie hoë gehalte en is ook hoogs aanvaarbaar vir die verbruiker.

Sleutelterme

Elektriese stimulering, AB-klas skaap, skaapvleis, sagtheid, verbruikersaanvaarbaarheid.

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LIST OF ABBREVIATIONS

ES: electrically stimulated

NES: non-electrically stimulated

HVES: high voltage electrical stimulation

LVES: low voltage electrical stimulation

PM: post mortem

WBSF: Warner Bratzler shear force

V: volts

CHAPTER 1

INTRODUCTION

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INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

The aim of this chapter is to motivate the actuality and relevance of this research to the ongoing debate regarding the quality and acceptability of the recently introduced class-AB mutton. This study was motivated by the need to determine consumer acceptance of the meat from the recently introduced class-AB mutton into the current South African meat classification system, in order to accommodate the large proportion of good quality carcasses from sheep with one or two permanent incisors. During the past years the Food Science Research Group in the School for Physiology, Nutrition and Consumer Sciences from the Potchefstroom University for Christian Higher Education (PU for CHE), together with the Department of Animal and Wildlife Sciences from the University of Pretoria, have researched numerous factors that influence the sensory characteristics of mutton, such as the influence of different diets on meat and carcass fat composition and fatty acid composition.

The relationship between meat science, consumer studies, sensory evaluation of products as well as the current trend towards the production of more "natural" products presented the unique opportunity to address current concerns regarding meat quality. Access to a representative group of consumers and national and international established networks and colleagues, facilitated a new direction in research, namely the effect of electrical stimulation on the consumer acceptance of mutton from class-AB sheep carcasses. This study comprised of the evaluation of the acceptability of electrically stimulated and non-stimulated samples by using a consumer panel and the objective measurement of the samples' shear force values.

As will be pointed out in this chapter, inconsistencies in the eating quality of meat, predominantly tenderness, is probably the most important problem faced by the meat industry as well as the most important requirement insisted on by the consumer (Morgan, 1998:10; Webb, 1998:1).
After a general motivation for the research, an in-depth discussion on electrical stimulation, the class-AB sheep carcass and consumer expectations of meat quality will set the background against which the advantages of electrical stimulation as a possible solution to lessen inconsistencies in meat tenderness will be described in a literature study (Chapter 2). The

structure of the manuscript will be explained, followed by the author and co-authors' contributions to the manuscript.

1.1.1 Electrical stimulation and its effects on meat tenderness

Meat toughness is the result of the combined effects of two intrinsic factors in muscle, namely the connective tissue and muscle fibre. Connective tissue includes collagen (which is inextensible and non-branching) and elastin (branching, elastic and yellow in colour). Animal age, muscle type, gender and rate of collagen synthesis are the main factors influencing collagen characteristics in meat. Variation in collagen characteristics (increased cross-link formation, heat stability and insolubility in older animals) and increased collagen concentration are responsible for the toughening of meat as animals age (Webb, 1998:3). Postmortem myofibrillar toughness is the net result of two opposing processes, namely rigor mortis (toughening process) and the natural tenderising process. The binding of myosin to actin is associated with an increase in toughness, depending on the number of cross-bridges formed.

Tenderness is generally improved by slow chilling, electrical stimulation, ageing methods and calcium injection. Together with ageing, electrical stimulation contributes to the improved tenderness of meat, much more so than genotype or feeding (Epley, 2002:3). A consistent method for increasing the tenderness to a more acceptable level would transform mutton carcasses into a product that is highly acceptable for the consumer (Ockerman et al., 2001:184). Electrical stimulation can improve tenderness with approximately 10% and is particularly effective for carcasses that are inherently less tender. Electrical stimulation enhances meat colour, improves tenderness and blood yield, and also decreases back breaks in carcasses during hide removal. Low-voltage electrical stimulation is currently used to prevent cold-induced shortening of muscles from lean carcasses (Morgan, 1998:16), thus reducing the variation in tenderness within a specific group.

Electrical stimulation promotes the activity of endogenous proteolytic enzymes, including calpain. The increased calpain activity is due to a depolarisation of the cell membrane that causes the release of calcium into the cell, activating calcium-dependent proteases (Kerth et al., 1999:2951). Increased carcass temperature due to the electrical stimulation stimulates the dilation of veins, improving the maximal bleeding of the carcass (Menday, 1979:5).

1.1.2 Consumer perception and expectations of meat quality

Accepting a food is a dynamic process in which the relationship between the food and the consumer changes from one moment to the next and depends on the situation in which the consumer consumes the food. The determinants of acceptability can be categorised as the sensory characteristics of the food, the physiological state of the consumer, the socio-psychological context of consumption and the effects of learning on all these categories (Booth, 1981:64). Consumer perception regarding meat quality differs between age groups, with time and between ethnic groups. Meat tenderness is the single most important component of meat quality for the consumer (Webb, 1998:1). Consumers appear to pay more for guaranteed tenderness (Morgan, 1998:10) and have new expectations regarding meat quality due to safety concerns, technological progress in the meat industry and movement towards the buying of more natural products (Monin, 1998: S231). The class-AB sheep carcass (p32-33) is definitely a possible answer to the raising need, seeing that lambs can be left on the field for a longer period, produce an additional shearing and have an increased carcass weight. The meat obtained from this method will still be of a high quality and highly acceptable to consumers (De Bruyn, 2002:2). Variations in tenderness within the group can be reduced by electrical stimulation, ensuring consistent meat quality and consumer satisfaction. Consumers' eating satisfaction results from desirable flavour, juiciness and tenderness combined (Morgan, 1998: 11-14; Webb, 1998:1). Objective measurement of meat tenderness can never mimic the complex and multifaceted actions that occur during biting and chewing (Perry, 2002:1). Consumer expectations, perceptions and acceptance must therefore be the driving force behind improving meat quality.

1.2 HYPOTHESIS

The meat from the electrically stimulated class-AB sheep carcasses will differ significantly in acceptance by consumers, will be preferred to and will be consumed more often than the meat from non-stimulated carcasses.

1.3 AIM AND OBJECTIVE

The aim and objective of this mini-dissertation are:

Aim: To investigate the effect of electrical stimulation on the consumer acceptance of, preference for and consumption intent of mutton from class-AB sheep carcasses.

Objective: a.) To compare the following by means of consumer panel evaluation:

- acceptance of juiciness, tenderness and flavour,
- preference for,
- and intended consumption of meat from the electrically stimulated and non-stimulated class-AB sheep carcasses.

b.) To compare shear force values obtained between ES and NES samples.

c.) To determine variation in cooking loss between ES and NES samples.

1.4 STRUCTURE OF THIS MINI-DISSERTATION

This mini-dissertation is presented in article format. The experimental work included consumer assessment of the acceptance of sensory attributes and objective measurement of meat tenderness. This introductory chapter motivates the necessity of the research effort, outlines the objectives of the study and explains the structure. Chapter 2 gives an overview of the literature considered important for the interpretation of data from the collected information. Chapter 3 consists of a manuscript on the effect of electrical stimulation on the consumer acceptance of mutton from class-AB sheep carcasses (submitted for publication in the South African Journal of Animal Sciences). The questionnaire used in this study is presented as Addendum A at the end of the mini-dissertation. Please note that the relevant references in Chapter 3 are provided at the end of the chapter according to the instructions of the specific journal to which the manuscript was submitted. The references used in the unpublished Chapters 1 and 2 are provided according to the mandatory style stipulated by the PU for CHE.

1.5 AUTHORS' CONTRIBUTIONS

The contribution of each researcher involved in the study is given in Table 1. Also included in this section is a statement from the co-authors confirming their individual role in the study and giving their permission that the article may form part of this mini-dissertation.

Table 1: Names and role descriptions of people involved in the study of the effect of electrical stimulation on consumer acceptance of mutton from class-AB sheep carcasses

Name	**Role in the study**
Mrs Mariana Davel	Co-responsible for planning and execution of the study, as well as literature searches and preparation of the manuscript.
Prof. MJC Bosman Ph.D (Food Scientist)	Supervisor. Co-responsible for design, planning, approval of final protocol, adaptation of questionnaires, compilation of the data and execution of the total study. Supervised the writing of the manuscript.
Prof. EC Webb	Co-supervisor. Co-responsible for design, approval of final protocol and determination of shear force values. Responsible for obtaining of experimental sheep carcasses. Supervised the writing of the script.
Mrs Elize Pienaar	Supervised the preparation and serving of the meat samples as well as determination of cooking losses.
4th Year students (Food)	Assisted in the preparation of the samples for the taste panel sessions as well as recruitment of consumers.

The following is a statement from the co-authors confirming their individual role in the study and giving their permission that the article may form part of the manuscript.

I declare that I have approved the above mentioned article, that my role in the study, as indicated above, is representative of my actual contribution and that I hereby give my consent that it may be published as part of the mini-dissertation of Mrs M Davel for the degree Magister Consumer Science.

Prof MJC Bosman

Prof EC Webb

1.6 REFERENCES

1. BOOTH, D.A. 1981. Momentary acceptance of particular foods and processes that change it. (In J. Solms & R.L. Hall (eds), Criteria of food acceptance. 6th edition. Zurich. Foster verslag).
2. DE BRUYN, J. 2002. Proposal: Alternative description of AB-Mutton.(Original copy in possession of the author).
3. EPLEY, J.E. 2002. Meat tenderness. [Web:] http://www. extension. umn.edu/distribution /nutrition /DJ0856.html. [Date used: 13 October 2002].
4. KERTH, C.R., CAIN, T.L., JACKSON, S.P., RAMSEY, C.B. & MILLER, M.F. 1999. Electrical stimulation effects on tenderness of five muscles from Hampshire rambouillet crossbred lambs with callipyge phenotype. *Journal of Animal Science*, 77: 2951-2955
5. MENDAY, K. 1979. Elektriese stimulering van vleis. *Community Health in SA*. 5-7. March.
6. MONIN, G. 1998. Recent methods for predicting quality of whole meat. *Meat Science*, 49:S231-243.
7. MORGAN, J.B. 1998. Influence of extrinsic factors on meat tenderness. (*In* ZILMAX® Meat quality symposium, Gallagher Estates Midrand: South Africa. *p.10-22.)*
8. OCKERMAN, H.W., YANAR, M. & YETIM, H. 2001. The effects of electrical stimulation on sensory and instron textural measurements of mutton tissue. Ohio State University. Bulletin. Research and reviews: meat. Special circular 183-02. [Web:] http://www.ohioline.osu.edu/sc183/sc_14a.html. [Date of access: 10 Oct. 2002] (Abstract from Internet)
9. PERRY, D. 2002. Laboratories, taste panels and palatibility. [Web]: http://www.beef.crc.org.au/Publications/Latest_Publications/feeder2002/Session6/6f.html. [Date of access: 7 October 2002].
10. WEBB, E.C. 1998. Intrinsic factors influencing meat tenderness in commercial beef production. (In ZILMAX® Meat quality symposium, Gallagher Estates Midrand: South Africa. p.1-8.).

CHAPTER 2

LITERATURE REVIEW

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LITERATURE REVIEW

2.1 INTRODUCTION

The inconsistency in the eating quality of meats, predominantly tenderness, is probably the most important problem faced by the meat industry worldwide. Consumers consider tenderness to be the single most important component of meat quality (Morgan, 1998:10; Webb, 1998:1). An alternative for increasing meat tenderness and/or preventing cold shortening may exist in the form of electrical stimulation of the carcass shortly following slaughter (Savell et al., 1977:702). Other advantages of electrical stimulation, such as increased shelf life, bright red colour and decreased bacterial growth, are all quality characteristics demanded by consumers (Menday, 1979:7). Red meat consumption has decreased dramatically over the past 30 years. Numerous factors have contributed to this phenomenon e.g. economical factors (increased red meat prices), consumer perceptions (red meat versus white meat) and misconceptions regarding the market, e.g. grading system of red meat (Poonyth et al., 2001:427-8). In the current South African Red Meat Classification System, consumers have the perception that Class-A carcasses yield the best quality meat and may therefore have a higher price (Bray et al., 1989:303; Webb, 1998:1). The demand and associated marketing of more "natural" animal products are increasing daily. This demand will entail the exclusion of any synthetic growth stimulants (hormones and feed additives) and will expose animals to a more natural (free-range) environment. An important consequence of this shift in animal production is in many instances the production of somewhat older animals, compared to those produced in more intensive systems (De Bruyn, 2002:1). The introduction of the class-AB in the Beef, Lamb & Mutton Carcass Classification System is a good example of adaptation to changes in the market. It is, however, necessary to inform consumers of the quality characteristics of the class-AB mutton and to investigate options such as electrical stimulation of carcasses to minimise inconsistencies in the tenderness of the class-AB mutton to assure consistent quality and guaranteed tenderness.

2.2 FOOD QUALITY

Food quality is a complex concept that is frequently measured using objective indices related to the nutritional, microbiological or physiochemical characteristics of the food or in terms of the opinions of designated experts. However, when food quality is defined in terms of "degree of excellence" none of these measures serves as adequate indices of food quality. It can be argued that food quality is a consumer-based perceptual/evaluative construct that is relative to person, place and time (Cardello, 1995:163).

Food quality can be considered as both the best defined and the least well defined concept in the food industry. The difference depends upon who is defining it and the level at which it is measured. Food scientists represent only a small percentage of people concerned with food quality. The majority are consumers – the people whose definition of food quality drives the economy of the global food industry (Cardello, 1995:163).

According to Clark (quoted by Cardello, 1995:163), the notion that food quality must be defined and measured from the consumer's perceptive can be traced to the earliest attempts to establish a scientific discipline related to food. In volume 1 of *The Food Journal*, published in 1870, there appeared a paper by H. Clarke, in which the basic proposition was put forth that food quality is a relative concept that is inappropriate for evaluation by anyone other than the average consumer of that food. As underlined by many authors, the consumer expectations and perceptions must drive quality improvement. Such a consumer-oriented approach is in accordance with the ISO definition of quality (ISO, 1992) "quality represents the totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs". To motivate a consumer, quality must be supported by a specific concrete benefit for the consumer. Food quality is not an inherent characteristic of the food but it is closely allied with the concept of acceptability (Cardello, 1995:164; Issanchou, 1996: S5).

2.2.1 Consumers' perceptions and expectation of food quality

When focusing on the perceived quality by the consumer, the first question is: " Who is this consumer?" Many people have different role patterns and cannot be categorised in one type of behaviour. Perceived quality is thus dependent on a person but also on the context, i.e. on the circumstances in which food and consumer interact (Issanchou, 1996: S6).

Consumers only respond to what they see and taste. They know very little, if anything, about the process by which food comes to them (Kahar, 2002:1). Consumer research, which involves consulting the consuming public about their preferences and investigating acceptable traits, is one way of analysing a product. But this method tells the scientist little, because people express their preferences for and their impressions of certain food attributes differently (Issanchou, 1996: S6; Kahar, 2002:1).

Perceived quality is determined by many factors, which can be categorised in different dimensions. Sensory properties contribute to a product's aesthetics, shelf life, conformance, performance and reliability (Civille, 1991:57). For Molnar (1995:185) their sensory qualities, safety, nutritional value and convenience determine the quality of food products. Molnar's model is, however, based on consulting experts and not consumers' judgements. Issanchou (1996:S7) distinguished between two types of quality attributes, experience quality attributes (including convenience, freshness and sensory characteristics) and credence quality attributes (including health, naturalness and wholesomeness that cannot be experienced directly).

The overall quality evaluation is hypothesised to be based upon the perceptions of the product with regard to the quality attributes. According to Issanchou (1996:S7), personal and situational variables influence the formation of perceived quality judgements. A product is thus valued in comparison with other products and price must be considered as a key element in this value evaluation. It can thus be stated that perceived quality depends on the person, product and situation and all three aspects are changing continuously for a given population over time.

2.2.2 Consumers as sensory panellists

The importance of meat quality is crucial, as meat consumption tends to decline in many Western countries. Changes in the perception of meat quality can take place rapidly, e.g. those related to product safety and pathogens, whereas attitudes based on ethical and moral evaluations evolve slowly. Consumers' expectations appear to be a paradox for the producer. There is also a clear lack of consumer-oriented communication from the meat producers and the food industry. Communication could help to decrease the uncertainty concerning meat. Reducing uncertainty is a key point because consumers experience different consequences of making a wrong choice, especially health and financial consequences (Issanchou, 1996: S16). It is obvious that the meat industry is changing from being a traditionally production-led industry to being a consumer-driven industry. This implies that methodologies developed in consumer science will have to be more widely used than is currently the case.

Consumer panel testing provides valuable feedback, particularly where large numbers of samples are involved (Claire et al., 1993:7). Consumer taste panels are commonly used for sensory assessment of palatability, which is a function of assessment of the acceptance of tenderness, juiciness and flavour/aroma (Perry, 2002:1). The consumer is an individual who regularly consumes the product and generally has a positive disposition towards the product (Goldman, 1994b: 822).

Training a panel is expensive and time-consuming and requires considerable commitment from the potential panel members, who must be available for training and for the duration of any investigation. The alternative approach is to ask consumers to judge types of food, which they eat themselves. Previous studies have considered consumer sensory appraisal work in two broad groups: food given to prepare at home or samples evaluated under controlled conditions in a sensory appraisal laboratory (Claire et al., 1993:7). The results obtained from consumer panels are trustworthy because the consumer cannot be influenced in opinion and there is no variation in response because a sample is only evaluated once and not over a period of time (Claire et al., 1993:7; Goldman, 1994a: 103). Preference tests focus on the choice of one item over another. It does not indicate whether any of the products are liked or disliked. Acceptance tests indicate how well a product is liked by consumers. A hedonic scale is used to indicate degrees of unacceptability to acceptability or dislike to like. From relative acceptance scores one can infer preference. The sample with the highest score is preferred (Meilgaard et al., 1990:150-151; Thompson, 1988:77). These tests may appear identical, but it is possible for a consumer to show a strong preference for a sample but not to consume it frequently (Penfield & Campbell, 1990:70).

Where large numbers of samples are to be evaluated quickly, there are considerable advantages to consumer testing under controlled sensory laboratory conditions using hedonic rating scales. The major advantages of hedonic scales are simplicity, their suitability for use by a wide range of participants and the speed with which a large number of samples can be assessed (Claire et al., 1993:7).

While sensory evaluations may be moving in the direction of more demanding and sophisticated approaches of situations, consumer panel testing retains its relevance in a number of situations, particularly where large numbers of samples must be tested (Claire et al., 1993:8).

2.3 MEAT QUALITY

Consumers of meat have always been concerned with the safety and sensory quality of food, in particular meat. In the present century new expectations arise and are still growing. Purchasers of any product expect an optimal quality/price relation and consistency in quality. These growing expectations have led to increased demands for

- technological quality due to industrialisation in the meat industry,
- guarantees for safety and eating quality and
- authenticity.

The meat industry is therefore continuously in search of new techniques to improve meat quality (Monin, 1998:S231).

The free market system not only gives farmers a better opportunity to market their products but also expects of them to continuously deliver high quality products. The products should produce the highest edible yield and be of superior quality. It is, however, important that the farmer, market and retail organisations work together to assure that all crucial control points are maintained to keep the carcass quality high (Morgan, 1998:20). Total quality management should be applied from the production to the delivery of the end product on the consumer's plate (Morgan, 1998: 10).

Meat quality needs to be defined so as to fully appreciate the needs of the consumer. Appearance, palatability, nutritive values, processability and shelf life contribute greatly to meat quality (Webb et al., 1994: 45). The current Red Meat Classification System can be confusing to the consumer, producer, supplier and retailer. They have the perception that a class-A carcass produces the best quality meat and can therefore have a higher price (Meaker, 1995:1). Although meat colour is a poor indicator of eating quality, most consumers make purchase decisions based on display colour. Consumers discriminate against meat that is not red and bright, considering it to be old or of poor quality (Young et al., 1999: 47).

Interesting results were obtained in a study completed by Glitsch (2000:177), who found that consumer perception of meat quality consists of two phases namely the stage prior to the actual purchase (experiences, habits) and the stage after the purchase while eating the meat (sensory evaluation, experiences).

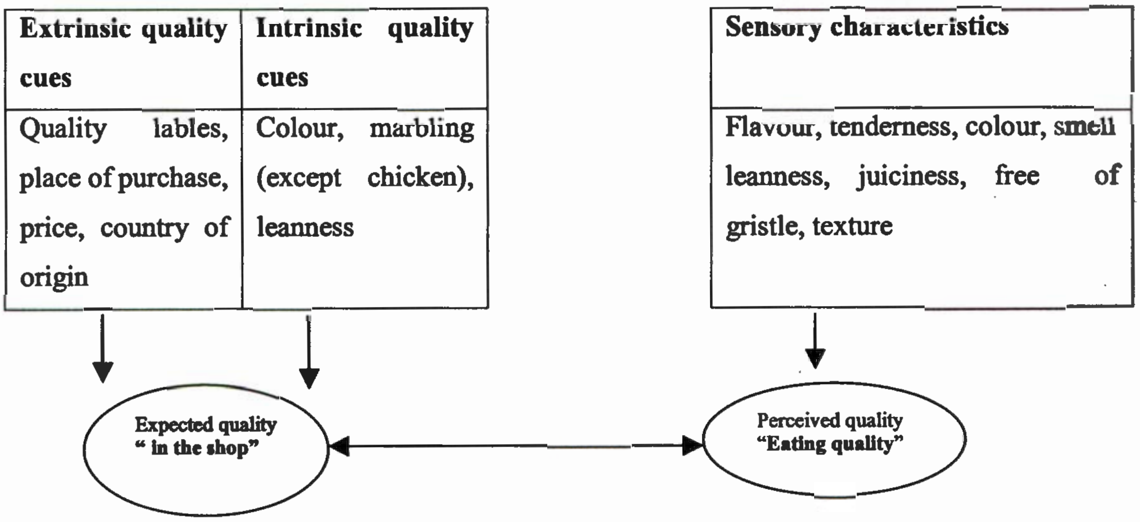

Figure 1. Consumer's perception of fresh meat quality (Glitsch, 2000:185)

According to Figure 1, consumers' perceptions of fresh meat quality are influenced by the expected quality (extrinsic and intrinsic quality cues) and perceived quality (sensory characteristics) (Glitsch, 2000:185). Among meat characteristics which can be used for assessing meat quality in the shop for the first stage, "price" was distinctly considered to be the least helpful quality indicator. "Place of purchase" was one of the most important quality cues, while among the intrinsic factors "colour" was the most important factor. In the phase of quality evaluation after purchase, flavour was one of the most significant quality characteristics, while "leanness, texture and free of gristle" were of minor importance (Cassal, 2000:193-4).

Inconsistency in meat tenderness at the consumer level has been identified as one of the major problems facing the entire meat industry. The importance of meat tenderness to consumers and the meat industry is the reason that retail meat cuts are priced according to the expected tenderness level. Consumers' eating satisfaction results from desirable flavour, juiciness and tenderness combined. One must, however, keep in mind that twice as much variation exists in meat tenderness, when compared to the variation of juiciness and flavour (Morgan, 1998: 11-14).

Palatability of meat and consumer taste preferences are based on three components: acceptability of juiciness, tenderness and flavour (Umberger et al., 2000:2). In a study done by Schultz & Wahl (1981:97), the relative importance of appearance, flavour and texture to the perceived quality of meat when eaten, was investigated. Consumers were asked to value appearance, flavour and texture according to importance. Results indicated that texture was globally rated more important to men than women. A significant increase of importance ascribed to flavour with increasing of age was noted. It also appeared that young people gave little priority to sensory criteria, whereas older respondents declared sensory factors very important for meat quality. Results also indicated that texture, especially tenderness and juiciness, has a substantial effect on the acceptability of cuts of meat.

2.4 FACTORS INFLUENCING MEAT QUALITY WITH SPECIAL REFERENCE TO TENDERNESS

Meat tenderness can be measured or estimated either objectively (in a laboratory using an instrument) or subjectively (sensory analysis e.g. taste panel). Tenderness assessment by laboratory instruments can, not mimic the complex and multifaceted actions that occur during biting and chewing. Objective measurements attempt to use a number of instrumental methods that closely correlate with one or more of these actions. Shear force measurements measure the toughness caused by both the muscle fibres and connective tissue (Perry, 2002: 1).

Food quality in a product may be regarded as the degree of excellence of a product. Each consumer's needs, previous experiences and expectations will influence the perception of food quality. Red meat consumption has decreased dramatically over the past 30 years. Numerous factors have contributed to this phenomenon, e.g. economical factors (increased red meat prices), consumer perceptions (red meat vs white meat) and misconceptions in the market (grading system of red meat). In the current South African Red Meat Classification System, consumers have the perception that A-grade carcasses produce the best quality meat and can therefore have a higher price.

Consumer demand for more "natural" animal products is increasing daily. This demand will entail the exclusion of any synthetic growth stimulants (hormones, feed additives etc.) and will expose animals to a more natural (free-range) environment. An important consequence of this shift in animal production is in many instances the production of somewhat older animals, compared to those produced in more intensive systems. In light of these changes, it is important that available marketing tools, e.g. the SA Carcass Classification System, support the shift in production systems and customer demands. The introduction of the class-AB in the Beef and Lamb & Mutton Carcass Classification System is a good example of adaptation to changes in the market.

Meat quality is a function of production, processing, value adding and cooking methods used to prepare the meat for consumption by the consumer. Failure of one or more links in the meat supply chain increases the risk of a poor eating experience for the consumer. A guarantee for eating quality can only be given if the factors that affect tenderness the most are controlled in the production chain (Thompson, 2002:295). Meat toughness is the result of the combined effect of connective tissue and muscle fibres. Both the connective tissue and the muscle fibres are responsible for physiological functioning and ultimately muscle contraction. Connective tissue components include collagen (inextensible and non-branching) and elastin (branching and elastic) (Webb, 1998:1-2). Myofibrillar toughening is the result of the binding of the main contractile proteins (myosin and actin), resulting in a rigor complex. The binding of actin to myosin is associated with an increase in toughness. The strength of the myosin/actin complex appears to be variable in rigor and this may affect tenderness. Post-mortem changes in skeletal muscles may improve meat tenderness. The post-mortem activation of calpains is initiated by an increase in the concentration of available activating ions (calcium). Activated calpains may form a complex with calpastatin, particularly at a high pH, and temporarily reduce any proteolysis. If there is a significant proportion of calpain when inactivation occurs, less tenderisation will occur, resulting in tough meat (Webb, 1998:5-7).

Factors influencing meat quality are:

2.4.1 Age and species

Meat of older animals tends to be more tough (less tender) with the accruement of permanent incisors. This is one of the reasons why the classification system is based on the number of incisors (Schönfeldt et al., 1993:381). Beef is usually the most variable in tenderness, followed by lamb, pork and veal. The tenderness variation between species is due primarily to the chronological age of the animal at the time of slaughter. Beef is normally processed at 20 months of age, lamb at 8 months, pork at 5 months and veal at 2 months. The decrease in tenderness with increasing age is due to the changing chemical constitution of collagen (gristle), the connective tissue protein found in meat. Collagen becomes more complex and stronger with advancing age and is thus more resistant to tenderisation from moist heat cooking (Epley, 2002:2; Webb, 1998:2). It is thus the changes in collagen characteristics, rather than collagen concentration, that are responsible for the toughening of meat as animals age (Webb, 1998:2).

2.4.2 Genotype

The heritability of tenderness in meat is approximately 45%, which means that 45% of the observed variation in tenderness of cooked meat is due to the genetics of the animal from which the meat comes (Epley, 2002:1-2). However, difference in genotype should not be used alone as an indicator of quality meat. Incorrect slaughtering, cooling and preparation methods can attribute to poor quality meat.

2.4.3 Type of muscle

Within any species, there is considerable variation in tenderness among muscles. The amount of connective tissue present is due to the function of the muscle in the live animal. The pH decline is faster in fast twitch glycolytic muscles, compared to slow twitch muscles. The fore shank will therefore have more connective tissue than the tender loin. The amount of stretch of the muscle is another factor influencing tenderness. Stretching of the muscles takes place when the carcass is being chilled. This stretching is due to the weight of the carcass and prevents shortening of the muscle (Epley, 2002:3; Webb, 1998:5).

Skeletal muscles are composed of different fiber types, which are classified according to contraction characteristics and predominant metabolism of the fibres. Both these characteristics are involved in rigor mortis development and may be involved in its acceleration by electrical stimulation and muscle tensioning to tenderise meat (Walker et al., 1996:1118). The *M. longissimus dorsi* is significant in terms of its high value as a cut of meat and is generally used as a test muscle. However, it does not give the greatest response to stress. The shoulder muscles (*M. triceps brachii* and *infra spinatus*) generally have a higher ultimate pH than the loin and it is also more affected by stress situations (Bray et al., 1989:65). Deviations in the ultimate pH of meat may also result in two unfavourable conditions, namely PSE (pale, soft and exudative meat) and DFD (dark, firm and dry meat) (Webb, 1998:4). The development of PSE is usually attributed to an increased post mortem glycolitic rate. In muscles which developed DFD the muscle glycogen is already depleated before slaughter. This gives substrate for post-mortem glycolysis and the ultimate pH becomes higher than normal (Webb, 1998:4). Irreversible anaerobic glycolysis which occurs when oxygen is permanently removed from the muscle at death is the sequence of chemical steps by which glycogen is converted to lactic acid. Exercise immediately before slaughter diminishes the reserves of glycogen in the muscle and the conversion of glycogen to lactic acid will continue until a pH is reached where enzymes effecting the breakdown become inactivated. In the typical mammalian muscles this pH is about 5.4-5.5 (Lawrie, 1998:67). The extent of tenderisation is critically dependant upon the net proteolysis resulting from both the activity and inactivation of mainly µ-calpain. Calpain activity is pH and temperature sensitive and increases about five-fold from pH 5.5 to 7.0. Inactivation occurs mainly at high temperatures, almost independently of pH. High or low temperature will lead to a preferential rate of inactivation of calpain and will be accompanied by muscle shortening (Webb, 1998:6-7).

1.4.4 Feeding

Animals in feedlots are removed from field grazing at an earlier stage and will have more tender meat than animals kept grazing in the field (Bosman et al., 1994:25; Epley, 2002:2). This is due to the fact that the muscles of animals in feedlots are still actively growing and will result in more tender meat with less yellow fat.

1.4.5 Pre-slaughter stress conditions

All stressing conditions, such as bruising, bathing etc., should be limited before slaughtering. Bruising reduces the total carcass yield and stress reduces the quality and shelf life of the meat. Stressing, unnecessary handling and long waiting periods in the abattoirs may increase the presence of dark, firm and dry meat (Viljoen et al., 2002:181). Hygienic slaughtering, processing and storage can enhance shelf life. Stressful conditions, e.g. undernutrition, pre-slaughter wash and depleted muscle glycogen reserves before slaughter, increase the ultimate pH of meat and result in low residual levels of glucose. This causes changes in protein structures and chemical composition that influence meat colour, flavour, tenderness, water-holding capacity and storage life (Bray et al., 1989:59; Geesink et al., 2001(b):265).

Developments in the meat industry may have increased the incidence of pre-slaughter stress. The meat industry has become centralised into fewer, larger plants and animals have to be transported over greater distances. The larger plants often operate at higher speeds than smaller plants. The need to move and process animals rapidly may increase stress in the period immediately before slaughter (Geesink et al., 2001(b):265).

Apart from the toughening effect of stress on the ultimate pH, a toughening effect independent of ultimate pH has been observed in a study done by Geesink et al. (2001(b):266). In addition, this effect was more pronounced when low-voltage electrical stimulation was used to immobilise the animals, suggesting an interaction between stress and electrical stimulation. Stress treatment increased the percentage of muscle with a high ultimate pH associated with undesirable tenderness and colour characteristics (see p.17) (Geesink et al., 2001(b):267).

2.4.6 Electrical stimulation

Together with ageing, electrical stimulation contributes to the tenderness of meat, much more so than genotype or feeding (Epley, 2002:3). If the muscles still contain energy and are cooled immediately after slaughter, meat becomes tough. The advantage of electrical stimulation is that after two days electrically stimulated meat will have the same tenderness as non-electrically stimulated meat after ten days ageing (Menday, 1979:5). Savell et al.(1981:1781) reported that electrical stimulation appears to increase the tenderness of meat if its initial tenderness would be unacceptable but it does not appear to affect the tenderness of meat if its initial tenderness level would be acceptable. The effect of electrical stimulation on tenderness improvement is not consistent throughout the carcass. In a study done by Savell et al. (1977:704) results indicated that electrical stimulation resulted in substantial improvements in tenderness in the loin region (*longissimus muscle*) while sporadic results in tenderness were observed for the leg region (*M. biceps femoris*). This may be related to the connective tissue content of these muscles. On average the electrical stimulation lowered the variability in tenderness ratings. Electrical stimulation will accelerate the post- mortem ageing of meat but the actual ageing time reduction and extent of ultimate tenderisation appear to be affected by inherent tenderness of the meat (Savell et al., 1981:1781).

2.4.7 Ageing

On completion of rigor mortis, changes take place in meat, resulting in more tender meat. Post- mortem ageing of meat is probably the most widely used tenderising process in the meat industry (Savell et al., 1981:1777). This holding of meat in a cooler is referred to as the ageing period. Lamb and pork are rarely aged, as a lack of tenderness is not encountered because of the relatively young age of the animals when slaughtered (Epley, 2002:4). Even if the animals/carcasses have been treated correctly before, during and after slaughtering, it is still very important that the processing and distribution of the meat should be of a high standard.

Consumers' acceptance of meat quality is also influenced by convenience, animal welfare, safety, intrinsic quality cues, extrinsic factors and sensoric factors (Geesink et al., 2001b:265; Issanchou, 1996: S10-12; Lister, 1995:3; Verbeke et al., 1999:77).

2.5 ELECTRICAL STIMULATION

A consistent method for increasing the tenderness to a more acceptable level would transform mutton carcasses into a product that might be marketed through retail channels, allowing for increased flexibility in merchandising (Ockerman et al., 2001:184). Post-mortem technologies that enhance the tenderness of meat are economically important to both the processor and producer. As consumer satisfaction increases, sales are likely to increase. Electrical stimulation has provided positive results for improving meat tenderness.

Methods of handling carcasses immediately post-mortem have been shown to affect the ultimate tenderness of meat. The most common problem associated with prerigor meat is "cold shortening," which can be controlled by physical restraint or the use of high temperature conditioning during the development of rigor mortis. Although these procedures have been shown to improve tenderness, there are production time problems with the use of high temperature conditioning and changes in carcass shape with the use of non-conventional carcass suspension, which have deterred industry application of either method (Savell et al., 1977:702).

An alternative for increasing tenderness and/or preventing cold shortening may exist in the form of electrical stimulation of the carcass shortly following slaughter. Electrical stimulation would not disrupt product flow through a plant, requires little time and does not affect the appearance of the carcass (Savell et al., 1977:702). Post-mortem electrical stimulation has received considerable attention as a tool to improve meat quality traits such as tenderness, flavour, lean colour, marbling set-up and reduce dark, coarse-band formation (Lee et al., 2000:786).

Electrical stimulation was originally used to prevent the toughening effect of cold shortening and to provide an additional tenderising effect (Geesink et al., 2001a:145; Lee et al., 2000:786). Electrical stimulation has been used to tenderise meat in the red meat industry for more than 20 years (Li et al., 1994:223). It has also been reported to be an effective method for improving meat tenderness in beef, lamb and goat carcasses (Kerth et al., 1999:2951; Savell et al., 1977:706; Savell et al., 1978:1609). The orthodox meaning is that electrical stimulation only accelerates post-mortem changes (Menday, 1979:5). Although the mechanism by which electrical stimulation improves tenderness has not been elucidated, postulations include the reduction in cold shortening and increased activity of acid proteases (Savell et al., 1977:705).

2.5.1 History of electrical stimulation

The use of electricity to increase meat tenderness is not new: Benjamin Franklin had already suggested its use for that purpose in 1749. In a biography of Franklin, it was reported that "killing turkeys electrically, with the pleasant side effect that it made them uncommonly tender, was the first practical application that had been found for electrical stimulation" (Lopez & Herbert, 1975:7).

According to Lemisch (1961:51), Franklin stated the following in a letter in 1773 to two French scientists:

"It has been observed that lightning, by rarefying and reducing into vapour the moisture contained in solid wood in an oak, has forcibly separated its fibres and broken it into small splinters. Is it not then improbable, that the same subtle matter, passing through the bodies of animals with rapidity, should possess sufficient force to produce an effect nearly similar? The flesh of animals, fresh killed in the usual matter, is firm, hard and not in a very eatable state, because the particles adhere too forcibly to each other. At a certain period, the cohesion is weakened, and, in its progress toward putrefaction, which tends to produce a total separation, the flesh becomes more tender or is in a state most proper to be used as our food.

Experience alone will inform us on the requisite proportions (of electricity) for animals of different forms and ages."

Harsham and Deatherage issued patents for the electrical stimulation process in 1951. No reports of the research studies upon which those patents were based, were ever published in scientific or popular literature (Smith, 1985:123). Scientists at Texas A & M University (TAMU) developed a process for tenderisation of carcasses that was ultimately called "Texas A & M Tenderstretch". Despite extensive research documenting its effectiveness in increasing the tenderness of beef and lamb, the Tenderstretch process was not implemented by packers in the United States. It was the use of the Tenderstretch process in Australia and New Zealand to prevent toughness in rapidly processed (chilling and/or freezing) lamb carcasses that led to TAMU investigations of electrical stimulation (Smith, 1985:122). The first report of scientific research on electrical stimulation and meat tenderness in New Zealand was released in 1973. Research on electrical stimulation and meat tenderness was initiated at the University of Florida and at Texas A & M University (TAMU) in 1975 and the first report of scientific research was published in 1976 (Smith, 1985:123). TAMU studies of electrical stimulation involved field research and the development and implementation of specifics for commercial use. The main advancements made by the scientists were the identification of the proper voltage, impulse duration and number of impulses needed to achieve the desired changes in tenderness and meat quality indicators. The most useful results were those that allowed identification of locations on the kill floor for possible installation of the electrical stimulator in an in-line, hand operated system for all carcasses (Smith, 1985:126).

2.5.2 Principles of electrical stimulation

- Physiology of electrical stimulation

  The most common post- mortem change is the reduction in muscle pH together with the conversion of muscle glycogen (energy) to lactic acid (Menday,1979:5). At a critical pH level and while the carcass is still warm due to the electrical stimulation, lysosomes in the muscle tissue burst and release enzymes. These enzymes are capable of breaking down macromolecules such as proteins and connective tissue (Menday, 1979:5).

  The increased carcass temperature (due to the electrical stimulation) is also associated with increased enzyme activity.

  Electrical stimulation can promote the activity of endogenous proteolytic enzymes, including µ-calpain, that are instrumental in promoting the ageing effect. The increased calpain activity may be due to a depolarisation of the cell membrane that causes a release of calcium into the cell, which then activates calcium-dependent proteases (Kerth et al., 1999:2951).

  The increased temperature of the thermal receptors in the carcass stimulates the widening of veins and improves the conditions for maximal bleeding of the carcass after slaughtering. The quick post-mortem changes lead to the stiffening of the muscles while the higher muscle temperatures prevent cold shrinkage, which normally leads to tough meat (Menday, 1979:5).

Post-mortem electrical stimulation has received considerable attention in the improvement of the meat quality traits like tenderness, flavour, lean colour, marbling set-up and reduced dark, coarse-band formation (Savell et al., 1979:911). There are three popular theories to explain how electrical stimulation improves tenderness: (1) the rapid decline of available ATP, which accelerates rigor onset before chilling, may reduce the effects of cold shortening, (2) the rapid reduction in pH while carcass temperatures are high may provide favourable conditions for the naturally occurring lysosomal enzymes (Unruth et al., 1986:282) and (3) the physical tissue disruption may also improve tenderness. One mechanism alone is not responsible for the beneficial effects of electrical stimulation. There is considerable evidence that increased tenderness results from a combination of relatively low pH and high temperature during the early post-mortem period (Savell et al., 1978:1606; Unruth et al., 1986:282).

- Inconsistencies in results with electrical stimulation

Conversely, the voltage, frequency, duration of ES and the method of application are important factors influencing the degree of tenderisation (Lee et al., 2000:786). According to Li et al. (1994:223), inconsistencies in results obtained in studies on electrical stimulation may have resulted from (1) different experimental procedures such as applying electrical stimulation before or after scalding, and with or without specific environments, and different ageing methods, (2) different electrical parameters such as voltage, frequency, duty cycle and wave form, (3) different tenderness analysis procedures such as the shear force device or technique used and (4) variations in physiological properties such as genotype and body weight (Li et al., 1994: 223).

- Low-voltage vs high-voltage electrical stimulation

Concern has arisen in some circles regarding the relative effectiveness of low-voltage and high-voltage electrical stimulation. Research has shown that low-voltage electrical stimulation is similar to high-voltage electrical stimulation in terms of its effects on carcass quality traits, but that low-voltage electrical stimulation is not as effective as high-voltage electrical stimulation in improving tenderness (Smith, 1985:148). High-voltage electrical stimulation (HVES, 300V-1000V) has been applied to achieve a very rapid pH decline that results in a more desirable lean colour and improved marbling scores (Lee et al., 2000:786). Many researchers have also demonstrated a similar effect from low-voltage electrical stimulation (LVES, ca 30V) on pH decline and improvement of quality (Bouton et al., 1980:146; Eikelenboom et al., 1985:249; Hopkins et al., 2000:362). In many cases low-voltage stimulation of lamb carcasses has not significantly reduced the shear force of cooked meat compared to that of non-stimulated meat. It is speculated by Hopkins et al. (2000:362) that the response to low-voltage electrical stimulation was determined by the history of the animal rather than the processing conditions. Low-voltage electrical stimulation may be more desirable under commercial conditions due to its practicality and safety of application (Geesink et al., 2001a:145; Lee et al., 2000:786).

Results from a study done by Polidori et al. (1999:179) indicated that the use of a low-voltage electrical stimulation (28V, 60 Hz) accelerated the glycolytic process, resulting in a significant fall in pH during the first 6 h post-mortem. Tenderness was also significantly increased. Results in a study done by Geesink et al. (2001(a):146) indicated that even low electrical input during immobilisation could adequately stimulate carcasses and avoid cold shortening. According to Aalhus et al. (2000:51), low-voltage electrical stimulation accelerates the rate of pH decline, which results in brighter red coloured meat. Results from a study done by Hopkins et al. (2000:364) indicated that low-voltage stimulation does not significantly improve tenderness but caused pH to drop significantly faster than in the control samples. The lamb industry must investigate and adopt methods that reduce the variability in quality.

Table 1: Comparison of studies done to determine the effect of electrical stimulation on meat quality

	Eikelenboom et al., 1985	Aalhus et al., 2000	Birkhold & Sams, 1993	Bouton et al., 1980	Hopkins et al., 2000
LVES	85V	21V		45V	45V
HVES	300V		440V vs 820V	1100V	
PH	pH decline in both samples insignificant	Decline	Significant reduction in pH 1h/PM	Lower value for 1100V than 45V	Faster drop in ES than in NES carcasses
Temperature	Increased in ES carcasses	Drop in temperature			
Sarcomere length	Shorter in control than ES samples	20% shorter in control than ES samples	Shorter in control than ES samples	Shortest in control samples	No significant difference
Shear force values	Lower in stimulated samples	Lower in stimulated samples	Lower in stimulated samples	No significant differences.	No significant effect
Cooking loss	Increase in ES samples			Significant increase in ES samples	No significant losses
Consumer panels (tenderness scores)	HVES & LVES higher than control samples	Higher for LVES than control samples		Lower for 1100V than for 110V	
Preference	Higher for ES samples than control	Higher for LVES than control			
Conclusion	No significant diffences in HVES/ LVES meat quality	ES reduced proportion of meat rated as tough, improved red colour	ES tenderised meat causing myofibrillar fragmentation	HVES is a bigger risk than LVES. Tenderness increased with LVES	Animal history influences meat tenderness

LVES – low-voltage electrical stimulation, HVES – high-voltage electrical stimulation, ES – electrical stimulation, NES- non-electrically stimulated, PM – post- mortem, h – hour, V- volt

Results in the above summary indicate numerous studies done to indicate the effect of various rates of electrical stimulation on meat quality and consumer perceptions of that. Electrical stimulation varied between 21V – 1100V. The drop in pH was significantly faster in the ES samples than in the NES samples (Hopkins et al., 2000:365). Sarcomere lengths were significantly shorter in NES samples. This underlines the results obtained through the Warner-Bratzler measurements, indicating that ES has a definite positive effect on the tenderness of meat. The results of consumer feedback in the above studies, indicate that tenderness scores were significantly lower for high-voltage ES (HVES) than for low-voltage ES (LVES). Control samples (NES) scored lower than the LVES. It should be noted that other pre- and post-mortem factors also affect meat tenderness. It is not clear if the ageing periods in the above experiments were the same, and how the age of the animals in the different experiments differed? Neither is it clear which muscles were used.

2.5.3 Effect of electrical stimulation on meat

- Tenderness

Tenderness, juiciness and flavour are components of meat palatability. Although juiciness and flavour normally do not vary a great deal, tenderness can vary considerably from one meat cut to another (Epley, 2002:1) Tenderness is most probably the most important quality parameter affecting consumer acceptance. Tenderness has been defined as the initial impression of softness (Casey et al., 1990:190).

In its original application in New Zealand electrical stimulation was used to prevent meat from becoming tough. In the United States, electrical stimulation was (and still is) used to make meat more tender. If a lamb muscle with inherently "tough" muscle is split and one side (side A) is treated by the use of the New Zealand process (stimulated with a single impulse of high voltage low-ampere electricity, then rapidly chilled and frozen) and the other side (side B) is treated in the manner identified by the TAMU research group (stimulated by use of repetitive electrical impulses of intermediate voltage and intermediate ampere, then conventionally chilled), muscle from side A will still be "tough" whereas muscle from side B will be "tender" (Smith, 1985: 128; Smith et al., 1980:5).

Shear force value is a measure of meat tenderness and is one of the most important factors in determining meat quality. A reduction in shear force and control of the variation in shear force are two of the main concerns in terms of the tenderisation of meat using electrical stimulation (Li et al., 1994:223). As reported by West (1982:5) electrical stimulation decreased shear force and brought borderline acceptability in tenderness within an acceptable range of tenderness.

The inherent tenderness of meat affects its response, in terms of tenderisation, to electrical stimulation. The reductions in shear force for treated samples were generally large when control samples (from untreated sides) had high shear force requirements and small when control samples (from untreated sides) had low shear force requirements, suggesting that electrical stimulation is of greatest benefit for carcasses that would produce less tender meat if untreated (Savell et al., 1977:706). This supports the hypothesis that lamb is generally regarded as tender, while mutton (meat from AB-, B- and C-class carcasses) could be less tender.

Savell et al. (1977:706) stated that the increase in tenderness observed in meat from electrically stimulated carcasses appears to be different for different animals. Carcasses that would otherwise produce tough meat benefited greatly from electrical stimulation, while those carcasses that would otherwise produce tender meat did not benefit from electrical stimulation. Electrical stimulation appears to be most effective for improving the tenderness of the *longissimus dorsi muscle*, partially effective in improving the tenderness of some muscle of the sirloin and relatively ineffective for improving the tenderness of almost all of the muscle of the chuck (Smith, 1985:138).

Electrical stimulation can also be employed to reduce breed differences in tenderness of the *M. longissimus* (Ferguson et al., 2000:267). Cuts of meat from ram lambs have been shown to be slightly tougher than similar cuts from wethers, as determined by Warner-Bratzler shear values and sensory panel scores (Mendenhall & Ercanbrack, 1979:1064).

- Post-mortem glycolysis

  Post-mortem shortening of muscles toughens lamb if carcasses are chilled or frozen in a pre-rigor state. To prevent this toughening, carcasses are held at about 15 °C until pre-rigor changes are near completion. This "conditioning" procedure introduces an undesirable delay in processing. Storage facilities with environmental controls must be provided, carcass weight loss through evaporation is increased and microbial growth is encouraged (Carse, 1973:163). This is a costly practise in terms of labour, space and refrigeration (Walker et al., 1996:1118). Because it is expensive to hold carcasses for the ageing period, post-mortem electrical stimulation has been investigated as a means to reduce the toughness (Birkhold & Sams, 1993:578). ES facilitates the conversion of glycogen to lactate, which results in a decrease in muscle pH required for the normal conversion of muscle to meat.

- pH

  In a study done by Geesink et al. (2001(b):267) results indicated that electrical stimulation accelerated the pH-decline to the extent that the pH of stimulated muscles was significantly lower than the non-stimulated muscle up to 24 hours post-mortem. Similar results were obtained in a study done by Hopkins et al. (2000:364). Stress treatment resulted in a significant increase in pH post-mortem, which persisted as a trend up to 48 hours post-mortem. This result indicates that the stress treatment caused some depletion of muscle glycogen stores, resulting in a decreased lactic acid production post-mortem (Geesink et al., 2001(b): 267; Menday, 1979:5).

Meat pH results show a cumulative effect of stressors. Individually the stressors did not have a significant effect, but combined they enhanced the pH response. The importance of the increase in pH relates to its association with eating qualities and storage life of meat. Tenderness increased subsequently with the normal decrease in muscle pH (Bray et al., 1989:65).

- Protease activity and calpastin activity

Bovine carcasses are usually electrically stimulated to increase tenderness and the process has been hypothesised to increase the activity of proteolytic enzymes (protease). The calcium-dependent proteases, known as calpains, play a key role in the tenderisation process. These enzymes may degrade structural proteins in muscle cells and cause fractures and breaks in muscle fibres, thus enhancing meat tenderness (Ho et al., 1996:1563; Morton et al., 1997:71). The post mortem activation of calpains is initiated by an increase in the concentration of available activating ions (calcium). Activated calpains may form a complex with their inhibitor (calpastatin), particularly at a high pH and temporarily reduce any proteolysis (Webb, 1998:6).

Electrical stimulation results in a general reduction in calpastin activity, suggesting that it accelerates proteolysis (Ferguson et al., 2000:267). The strong correlation between calpastatin and the rate of tenderisation indicates that the calpain system is closely linked to the proteolytic breakdown of myofibrillar proteins (Morton et al., 1999:71). Early post-mortem electrical stimulation is used to increase meat tenderness and promotes the activity of some endogenous proteolytic enzymes, including μ-calpain (Ho et al., 1996:1563).

In a study done by Polidori et al, (1999:180) it was shown that electrical stimulation accelerated the glycolytic process, resulting in a significant reduction in adenosine triphosphate (ATP) content in the muscle (Polidori et al., 1999:179).

- Breed differences

Breed differences in shear force values were reduced by electrical stimulation. The lowering in shear force following ageing was smaller for stimulated carcasses, compared to the controls. This tends to reinforce the premise that electrical stimulation accelerates proteolysis (Ferguson et al., 2000:268).

2.5 4 Advantages of electrical stimulation

- "Free Iron"

  It is speculated by Menday, (1979:7) that the electrical stimulation of carcasses stimulates the binding of free iron in the blood. This will lead to sufficient removal of iron during the bleeding period. Research in the USA indicated that consumers prefer meat with a lower iron-to-zink relation. Increased shelf life is predictable due to less iron, because the deterioration process is accelerated by iron-oxidation, which leads to the discolouring of meat during storage.

- Colouring

  Another advantage of electrical stimulation is that the bleeding process is accelerated. This prevents the discolouration of the neck muscle, which is very common in most carcasses (Menday, 1979:7).

- Bacterial growth

  According to Menday, (1979:5) bacterial growth is lower in mediums with a low iron content. Bloody and coloured meat therefore creates the ideal medium for bacterial growth. Electrical stimulation can therefore be used to prevent this situation.

- Shelf life

  In a study done in the USA and Australia it was shown that the shelf life of electrically stimulated meat is longer than meat which was not stimulated. The study also indicated that the colour of electrically stimulated meat cuts stayed acceptable for a day longer than for non-stimulated meat (Menday, 1979:7).

- Tenderness

  Electrical stimulation can improve tenderness with approximately 25% and is particularly effective for carcasses that are inherently less tender or with little finish and low amounts of marbling (Morgan, 1998:15).

2.6 CLASSIFICATION OF RED MEAT

The carcass grading system, which had been in use in South African abattoirs since 1985, was replaced by a carcass classification system on 26 June 1992 (South Africa, 1992: Agriculture Product Standards Act, 1990 (Act No. 119 of 1990)). Carcass grading implies that carcasses are graded in order of merit, from the most preferred to the least preferred grades. This system assumes that all buyers have the same preferences and needs in terms of carcass characteristics (SA Department of Agriculture, 2002). Where records are absent, the ages of cattle and sheep are commonly estimated by examining their teeth. Teeth are considered erupted when it has broken through the gum. The age at which animals have attained a particular pair of permanent incisors can be defined as the number of days from birth to the time when both incisors making up a pair have cut the gum (Matika et al., 2002:2).

A classification system provides a sound basis for:

- meat traders to describe their specific requirements in simple terms when purchasing carcasses;
- utilisation in the market to indicate variety with a view to optimum consumer satisfaction;
- utilisation to determine price differences; and
- fixing selling price.

(SAMIC, 1998; SA Department of Agriculture. 2002)

Table 2: South African Classification Characteristics of Beef, Lamb, Sheep and Goat Meat (SAMIC, 1998)

AGE	CLASS	CONFORMATION	CLASS
0 Teeth	A	Very flat	1
1 – 2 Teeth	AB	Flat	2
3 – 6 Teeth	B	Medium	3
More than 6 teeth	C	Round	4
		Very round	5
FATNESS	**CLASS**	**DAMAGE**	**CLASS**
No fat	0	Slight	1
Very lean	1	Moderate	2
Lean	2	Severe	3
Medium	3		
Fat	4	**SEX**	
Overfat	5	Only for bull and ram carcasses in the AB, B and C groups.	
Excessively overfat	6		

Table 3: Average age classes of sheep (Clayes & Rogers, 2001:6)

Classification	Age	Average age
A	<11 months	6 months
AB	11-21 months	16 months
B	21-36 months	30 months
C	>36 months	6 years

Although these ages indicate that animals that yield AB-carcasses could be about 10 months older than those that yield A-carcasses, in some instances the differences could only be one month. It is therefore important to inform the customer that the AB-carcasses are not coming from old/culled animals, but from production animals that will in most instances only be a few months older than the normal A-age animals. (De Bruyn, 2002:1).

2.6.1 Classification of sheep carcasses

- Classification based on dentition
    - 20 temporary teeth
    - 32 permanent teeth at maturity
    - pairs of incisor teeth on the lower jaw

- upper incisors missing
- cartilaginous (hard) dental pad on upper jaw.

- Classification based on the age of sheep

Table 4: Classification according to the age and dentition of sheep (Clayes & Rogers, 2002: 1; Matika et al., 2002:3)

Age	Dentition	Definition
Lamb	4 pairs of incisors	Lamb:Young sheep under 12 months of age, no permanent incisors in wear
1 year	Middle pair of incisors	Hogget/Yearling: Animal between 1 & 2 years in age, no more than two permanent incisors in wear.
2 years	2nd pair of permanent incisors	Mutton: Two or more permanent incisors in wear.
3 years	3rd pair of permanent incisors	
4 years	4th pair of permanent incisors	
5 years	All permanent incisors close together	
6 years	Incisors begin spreading apart	
7-8 years	Some incisors broken	
10-12 years	All incisors missing	

In Australia a sheep ceases to be a lamb as soon as the eruption of its first permanent incisor teeth is evident. The timing of teeth eruption is highly variable and can range from 10 – 18 months of age. After teeth eruption, the carcass is classified as hogget and the price paid is substantially less than that for lamb (Bray et al., 1989:303). A study done by the Department of Agriculture in Western Australia indicated that the average duration of teeth eruption was 27.4 days. Allowing sheep with partially erupted teeth to be classified as lambs could therefore provide producers with a four week period in which to market their sheep. Overall the Australian results indicated that meat from young sheep with partially erupted teeth was unlikely to be inferior in eating quality to the meat currently classified as lamb (Department of Agriculture – Western Australia, 2001:1).

2.6.2 Class-AB Sheep

From the above information a definition of the class-AB would be sheep at the age of 11 – 21 months (average age 16 months) with only 1 – 2 permanent incisors present. Although sheep is one of the most significant red meat sources in most countries, the native sheep breeds in developing countries are usually small and grow slowly (Ockerman et al., 2001:183; South African Department of Agriculture, 2002).

The sheep producers aim to raise sheep that produce heavier carcasses for a higher income. Therefore, old sheep are generally the animals slaughtered in developing countries. As living standards increase, consumers are demanding better/higher quality (more tender) meat. There are many factors that influence the meat quality of sheep (Sanudo & Alfonso, 1998:30), including tenderness and mutton flavour (Ockerman et al., 2001:183).

In the United States of America sheep numbers have decreased from nearly 30 million head in the 1960's to 7 million head in 2000. Total production of lamb and mutton has not declined as sharply, because of an increase in lamb carcass weight. From 1960 to 2000, the weight of the average lamb carcass increased from 22kg to 31kg. This change in carcass size is in part the result of improved feed management and an increase in mature size due to direct genetic selection and the use of large terminal sire breeds. Studies of consumer preferences indicate a lamb product with reduced fat and less intense flavour would be more appealing (Cockett & Snowder, 2001: S1).

The results of research conducted by Tatum et al. (1978: 144) showed that the eating preferences of consumers were consistently in favour of meat from younger animals, due to more tender meat. It is well known that advanced chronological age and/or increased physiological maturity are usually associated with toughness of mutton and also mutton flavour (Ockerman et al., 2001:183). As a consequence of age-associated problems with tenderness, the majority of old ewes are commonly sold at a low price or the tissue is used in comminated meat (Ockerman et al., 2001:183).

2.7 CONSUMPTION OF RED MEAT IN SOUTH AFRICA

The South African economy faced various economic adjustments over the past two decades. As a result, the structure and patterns of consumption have changed significantly (Poonyth et al., 2001:426; Traintis, 1995:459). According to Poonyth et al. (2001:436) the red meat industry needs to commit resources to research and develop innovative and consumer friendly items, as well as to recognise the fact that consumers place a higher value on their time and that the demand for food that requires less preparation time will increase. Price and quality will influence the consumer's choice (McIlveen & Buchanan, 2001: 286).

Per capita consumption of beef and veal has drastically decreased from 23.95kg in 1965/66 to 12.32kg in 1999/2000 (approximately 50% reduction). The *per capita* consumption of lamb reflects a similar pattern, namely a decrease from 7,6kg in 1965/66 to 3,8kg in 1999/2000. On the other hand, the *per capita* consumption of pork remained constant at 3kg over the same period. Aggregate *per capita* consumption of white meat, however, increased from 2,98kg in 1965/66 to 22.91kg in 1999/2000 (Poonyth et al., 2001: 427-8). This indicates a significant shift in meat consumption patterns.

The sheep carcass is a more expensive cost item, due to its slower growth rate, lower reproduction rate and production under natural conditions. According to Venter and Horsthemke, (1999:723) generic marketing is most effective when the product is consumed by the masses at low prices and when consumers buy the product for the need of filling or nutritional value. (Venter & Horsthemke, 1999:723). If current growth in export and domestic markets continues, additional meat needs to be produced. Due to the shortage of available land the answer is not to have more sheep, but to produce heavier carcasses (http://lambplan.une.edu.au /mcpt /newsletter /dd14/14.htm 29/11/02). Genetic selection for increased lamb carcass weight has reduced the decline in the total production of lamb (http://www.oznet.ksu.edu/meatscience/column/lamb. 14/11/02).

In the meat industry the pressure for closer relationship or supply chain management derives from the needs of supermarkets for quality, consistency, reliability of supply and to ensure safety. The perishability of meat also contributes to the need for closer relationship in the value chain (Venter & Horsthemke, 1999:724-5). Technical excellence and innovation are becoming more important to producers who want to supply food stores with quality products.

According to Bruwer (2002), 80% of all animals slaughtered in South Africa are from the A-class, whereas only 5% of the slaughtered animals are from the AB-class. This underlines the trend in consumer demand for more tender meat as well as their misperception that meat other than the A-class will be tough and of lower quality. This trend is not only due to consumer demand, but also to factors associated with the production system on the farm, e.g weaning, breeding programmes and the availability of grazing.

Table 5: Percentage of animals slaughtered in each meat class in South Africa (Bruwer, 2002)

Class	%
A-class	80%
AB-class	5%
B-class	7%
C-class	8%

The class-AB makes provision for animals to be raised on veld to a marketable fat cover, because in young animals (no incisors) an acceptable fat cover is not achieved on most veld types without supplemental feeding (SA Department of Agriculture, 2002).

2.8 CONCLUSION

From the literature review it is clear that meat quality, more specifically tenderness, is influenced by numerous factors. The evaluation of meat tenderness is complex due to the fact that objective measurements can give a value, but cannot give an explanation for the value, e.g. the meat : fat ratio in the carcass. Subjective measurement with consumer panels may give a more honest opinion.

Tenderness is one of the most important quality parameters affecting consumer acceptance. The problem of consumer dissatisfaction regarding meat products will only be solved when the problem of unacceptable variation in meat tenderness is solved. Research on the tenderness of electrically stimulated and non-stimulated meat indicates that the shear force values tend to be lower in electrically stimulated meat. Electrical stimulation can thus be used to reduce the percentage of meat in a population that would be unacceptable in terms of tenderness without electrical stimulation and thereby reducing inherited differences.

Consumers and the meat industry demand continuous high quality products. Electrical stimulation of meat can be used to obtain and maintain high quality products. Good quality meat must, however, be used to obtain the highest quality, but electrical stimulation can contribute to reduce minor differences, due to genotype and the influence of pre-slaughter stress conditions.

The misconceptions amongst consumers that meat from the AB-class is of a lesser quality compared to the class-A, needs to be rectified. This can only be done through more intensive research on the class-AB, improved marketing strategies of the class-AB and educating the consumer on the advantages of the class-AB. Available information indicates that the class- AB sheep carcasses are of a very high quality regarding taste, tenderness and flavour. The class-AB also conforms to the most important consumer demands regarding tenderness, flavour, affordable prices, safety and the demand towards more "organic/natural/free-range" products.

Electrical stimulation can be used as a tool to improve tenderness and decrease tenderness differences of the class-AB mutton. The effect of electrical stimulation on meat has numerous other advantages, such as increased shelf life and improved colour. These advantages are all quality characteristics demanded by consumers.

2.9 REFERENCES

1. AALHUS, J.L., LARSEN, I.L., DUBESKI, P.L. & JEREMIAH, L.E. 2000. Improved beef tenderness using a modified on-line carcass suspension method with, or without low voltage electrical stimulation. *Canadian Journal of Animal Science*, 80(1): 47-51. March.
2. BIRKHOLD, S.G. & SAMS, A.R. 1993. Fragmentation, tenderness and post-mortem metabolism of early-harvested broiler breast fillets from carcasses treated with electrical stimulation and muscle tensioning. *Poultry Science*, 72: 577-582.
3. BOSMAN, M.J.C., WEBB, E.C., CASEY, N.H., VAN AADRT, A.M. & SILVIS, N. 1994. Die invloed van hoë- en medium-energiediete in verpilde vorm op die eet- en vetkwaliteit asook gaarmaakverliese van lamsvleis van verskillende rasse. *Tydskrif vir Dieetkunde en Huishoudkunde*, 22(1): 19-25.
4. BOUTON, P.E., HARRIS, P.V. & SHAW, F.D. 1980. Electrical stimulation of beef sides. *Meat Science*, 4:145-155.
5. BRAY, A.R., GRAAFHUIS, A.E. & CHRYSTALL, B.B. 1989. The cumulative effect of nutritional, shearing and preslaughter washing stresses on the quality of lamb meat. *Meat Science*, 25: 59-67.
6. BRAY, A.R., MURRAY, R.N. & SAVELLE, D.J. 1989. Proceedings of the NZ Soc. Animal. Prod. 49:303-306 (Abstract).
7. BRUWER, G. 2002. Discussion with author. (Information in possession of author).
8. CARDELLO, A.V. 1995. Food quality: Relativity, context and consumer expectations. *Food Quality and Preference*, 6: 163-170.
9. CARSE, W.A. 1973. Meat quality and the acceleration of post-mortem glycolysis by electrical stimulation. *Journal of Food Technology*, 8: 163-166.
10. CASEY, N.H., SWANEPOEL, J., DE BRUYN, J.F. & NAUDE, R.T. 1990. Meat studies of indigenous Southern African cattle. II. Textural evaluation of ribcut samples from carcasses of Afrikaner, Nguni and Pedi bulls fed intensively. *Suid Afrikaanse Tydskrif vir Veekunde*, 20(4): 188-192.
11. CASSAL, C.E. 2000. Consumers perceptions of fresh meat. *British Food Journal*, 102: 158-194.
12. CIVILLE, G.V. 1991. Food quality: Consumer acceptance and sensory attributes. *Journal of Food Quality*, 14(1): 1-8.
13. CLAIRE, E.A., ALAN, H.H., HINKS, C.E. & DOREEN, A.P. 1993. Consumers as sensory panellists. *British Food Journal:* 95(8), 7-8.

14. CLAYES,C.C. & ROGERS, S.B. 2002. Sheep facts. [Web:] http://www.cals.ncsu.edu /an_sci/ extension /animal/4youth/sheep/sheepfacts.htm. [Date of access: 18 July 2002].

15. COCKETT, E. & SNOWDER,G.D. 2001. Genetic influences on carcass merrit of sheep. *Journal of Animal Science*, 79(S1): S1-S5.

16. DE BRUYN, J. 2002. Proposal: Alternative description of AB-Mutton.(Original copy in posession of the author).

17. DEPARTMENT of Agriculture see UNITED STATES OF AMERICA. Department of Agriculture.

18. EIKELENBOOM, G., SMULDERS, F.M.J. & RUDERUS, H. 1985. The effect of high- and low-voltage electrical stimulation on beef quality. In Lawrie, R.A. Meat Science.Barking Essex, Eng.: Applied Science publishers. Vol, 15: 247-254.

19. EPLEY, J.E. 2002. Meat tenderness. [Web:] http://www.extension.umn.edu/distribution /nutrition/DJ0856.html. [Date used: 13 October 2002].

20. FERGUSON, D.M., JIANG, S.T., HEARNSHAW, H., RYMILL, S.R. & THOMPSON, J.M. 2000. Effect of electrical stimulation on protease activity and tenderness of M. longissimus from cattle with different proportions of Bos indicus content. *Meat Science*, 55(3): 265-272, July. http://ohioline.osu.edu/sc183/sc183_14a.html [Date of access: 8 July 2002].

21. GEESINK, G.H., MAREKO, M.H.D., MORTON, J.D. & BICKERSTAFFE, R. 2001a. Electrical stimulation- when more is less. *Meat Science*, 57(2): 145-151, Feb.

22. GEESINK, G.H., MAREKO, M.H.D., MORTON, J.D. & BICKERSTAFFE, R. 2001b. Effects of stress and high voltage electrical stimulation on tenderness of lamb m. longissimus. *Meat Science*, 57(3): 265-271, March.

23. GLITSCH, K. 2000. Consumer perceptions of fresh meat quality: cross-national comparison. *British Food Journal*, 102(3): 177-194.

24. GOLDMAN, A. 1994a. Predicting product performance in the marketplace by immediate- and extended-use sensory testing. *Food Technology*, Oct. p103-106.

25. GOLDMAN, A. 1994b. Gaining the competitive edge: sensory science in the marketplace. *Cereal Foods World*, 39(11):822-825.

26. HO, C.Y., STROMER, M.H. & ROBSON, R.M. 1996. Effect of electrical stimulation on post-mortem titn, nebulin, desmin and troponin-T degradation and ultrastructural changes in bovine longissimus muscle. *Journal of Animal Science*, 74: 1563-1575.

27. HOPKINS, D.L., LITTLEFIELD, P.J. & THOMPSON, J.M. 2000.The effect of low voltage stimulation under controlled conditions on the tenderness of three muscles in lamb carcasses. *Asian-Australian Journal of Animal Sciences*, B: S362-S365.

28. ISSANCHOU, S. 1996. Consumer expectations and perceptions of meat and meat product quality. *Meat Science*, 43(S5): S5-S19.

29. KAHAR, K. 2002. Educating the taste buds. [Web:] http://www.uoguelph.ca /research/mtg /preview98/page6.html [Date of access:10 Oct. 2002].

30. KERTH, C.R., CAIN, T.L., JACKSON, S.P. RAMSEY, C.B. & MILLER, M.F. 1999. Electrical stimulation effects on tenderness of five muscles from Hampshire rambouillet crossbred lambs with callipyge phenotype. *Journal of Animal Science*, 77: 2951-2955.

31. LAWS see South Africa.

32. LEE, S., POLIDORI, P., KAUFMANN, R.G. & KIM, B.C. 2000. Low-voltage electrical stimulation effects on proteolysis and lamb tenderness. *Journal of Food Science*, 65(5): 786-791.

33. LEMISCH, L.J. 1961. Benjamin Franklin: The autobiography and other writings, 1st edition. New American Library of World literature: New York. 236p.

34. LI, Y., SIEBENMORGEN, T.J., GRIFFIS, C.L., WOLFE, R.E., DAKE, R.L. & WEBB, J.E. 1994. Tenderness and its variation of broiler breast meat harvested from electrically stimulated carcasses. *American Society of Agricultural Engineers*, 37(1):223-225.

35. LISTER, D. 1995. Influence of animal welfare on consumer acceptance of quality. 41st International Congress of Meat Science and Technology. San Antonio, Texas, Aug 20-25.

36. LOPEZ, C.A. & HERBERT, E.W. 1975. The private Franklin, the man and his family, 1st Ed. W.W. Norton and Co: New York. 144p.

37. MATIKA, O., SIBANDA, R. & BEFFA, M. 2002 Eruption of permanent incisors in indigenous goats and sheep. www.fao.org. [date of access: 18 July 2002]

38. McILVEEN, H. & BUCHANAN, J. 2001. The impact of sensory factors on beef purchase and consumption. *Nutrition & Food Science*,31(6): 286-292.

39. MEAKER, H.J. 1995. Memorandum ter motivering vir die insluiting van 2-tand karkasse binne die A-klassifiseringstelsel. Vleisklassifikasie werkswinkel, 24 April 1995.

40. MENDAY, K. 1979. Elektriese stimulering van vleis. *Community Health in SA*. 5-7. March.

41. MENDENHALL, V.T. & ERCANBRACK, K.E. 1979. Influence of carcass, weight, sex and breed on consumer acceptance of lamb. *Journal of Food Science*, 44: 1064-1066.

42. MEILGAARD, M., CIVILLE, G.V. & CARR, B.T. 1990. Sensory evaluation techniques.CRC Press Inc. Boca Raton: Florida. 271p.

43. MOLNAR, P.J. 1995. Food quality model. *Food Quality and Preferance*, 6:185-191.

44. MONIN, G. 1998. Recent methods for predicting quality of whole meat. *Meat Sciene*, 49:S231-243.

45. MORGAN, J.B. 1998. Influence of extrinsic factors on meat tenderness. (*In* ZILMAX® Meat quality symposium, Gallagher Estates Midrand: South Africa. *p.10-22.)*

46. MORTON, J.D., BICKERSTAFFE, R., KENT, M.P., DRANSFIELD, E. & KEELEY, G.M. 1999. Calpain-calpastatin and toughness in *M. longissimus* from electrically stimulated lamb and beef carcasses. *Meat Science*, 52(1): 71-79, May.

47. OCKERMAN, H.W., YANAR, M. & YETIM, H. 2001. The effects of electrical stimulation on sensory and instron textural measurements of mutton tissue. Ohio State University. Bulletin. Research and reviews: meat. Special circular 183-02. [Web:] http://ohioline.osu.edu/sc183/sc_14a.html [Date of access: 10 Oct. 2002] (Abstract from Internet)

48. PENFIELD, M.P. & CAMPBELL, A.M. 1990. Experimental food science. New York: Academic press. 541p.

49. PERRY, D. 2002. Laboratries, taste panels and palatibility. [Web]: http://www.beef.crc.org.au/Publications/Latest_Publications/feeder2002/Session6/6f.html. [Date of access: 7 October 2002].

50. POLIDORI, P., LEE, S., KAUFFMAN, R.G. & MARSH, B.B. 1999. Low-voltage electrical stimulation of lamb carcasses: effects on meat quality. *Meat Science*, 53(3): 179-182, Nov.

51. POONYTH, D., HASSAN, R. & KIRSTEN, J.F. 2001. Random coefficients analysis of changes in meat consumption preferences in South Africa. *Agrekon*,40(3): 426-437. September.

52. SANUDO, C.A.S. & ALFONSO, M. 1998. Small ruminant production systems and factors affecting lamb quality. *Meat Science*, 49:29-64(Suppl.1).

53. SAVELL, J.W. DUTSON, T.R. SMITH, G.C. & CARPENTER, Z.L. 1978. Structural changes in electrically stimulated beef muscle. *Journal of Food Science*, 43(5): 1606 –1609.

54. SAVELL, J.W., McKEITH, F.K. & SMITH, G.C. 1981. Reducing postmortem ageing time of beef with electrical stimulation. *Journal of Food Science*, 46: 1777.

55. SAVELL, J.W., SMITH, G.C., CARPENTER, Z.L. & PARRISH, F.C. 1979. Influence of electrical stimulation on certain characteristics of heavy-weight beef carcasses. *Journal of Food Science*, 44: 911.

56. SAVELL, J.W., SMITH, G.C., DUTSON, T.R & CARPENTER, Z.L. & SUTER, D.A. 1977. Effect of electrical stimulation on palatability of beef, lamb and goat meat. *Journal of Food Science:*42(3): 702-706.

57. SAVELL, J.W., SMITH, G.C., DUTSON, T.R & CARPENTER, Z.L. 1980. Industry application of electrical stimulation in the United States. Proc. 26th Eur. Meet. Meat Res. Workers, Colorado Springs, 2, K-2.

58. SCHÖNFELDT, H.C., NAUDE, R.T., BOK, W., VAN HEERDEN, S.M. & SOWDEN, L. 1993. Cooking- and juiceiness-related quality characteristics of goat and sheep meat. *Meat Science*,15: 381-393.

59. SCHULTZ, H.G. & WAHL, O.L. 1981. Criteria for food acceptance. Foster- Verlag A.G. Zurich. p90-97.

60. SMITH, G.C. 1985. Effects of electrical stimulation on meat quality, color, grade, heat ring and palatability. *Advances in Meat Qquality*, 1: 121-158.

61. SMITH, GC, SAVELL, JW, DUTSON, TR, HOSTETLER, RL, TERRELL, RN, MURPHEY CE & CARPENTER, ZL. 1980. Effects of electrical stimulation on beef, pork, lamb and goat meat. Proc. 26th Eur. Meet. Meat res. Workers, Colorado Springs, 2,H-5

62. SOUTH AFRICA. 1992. Agricultural Product Standards Act, no 119 of 1990.

63. SOUTH AFRICA. Department of Agriculture. 2002. The beef carcass classification system. [Web:] http://agriculture.kzntl.gov.za/production_guidelines/beef_basics/carcass_classification system.pdf. [Date of access: 7 October 2002].

64. SOUTH AFRICAN MEAT INDUSTRY COMPANY (SAMIC). 1998. Classification of red meat. Feb.

65. TATUM, J.D., SMITH, G.C. & CARPENTER, Z.L. 1978. Blade tenderization of steer, cow and bull beef. *Journal of Food Science,* 45: 144-145.

66. THOMSON, M.H. 1988. Food acceptability. Elsevier applied science: London. 502p.

67. THOMPSON, J. 2002. Managing meat tenderness, Meat Science, 62: 295-308.

68. TRAINTIS, S.G. 1995. Changes in income, behaviour and tastes. *The South African Journal of Economics*, 63(3): 459-470.

69. UMBERGER, W.J., FEUZ, D.M., CALKINS, C.R. & KILLINGER, K.M. 2000. Consumer preferences and willingness to pay for flavour in beef. Intrnational food and Agribusiness Management Association Meetings, Chicago. 24-25 June. P 1-17.

70. UNITED STATES OF AMERICA. Department of Agriculture. Food and safety inspection service. 2000. Focus on: Lamb...from the farm to the table. [Web]. http://www.fsis.usda.gov/OA/pubs/focuslamb.htm. [Date of access: 13 November 2002].

71. UNRUTH, J.A., KASTNER, C.L., KROPF, D.H., DIKEMAN, M.E. & HUNT, M.C. 1986. Effects of low-voltage electrical stimulation during exsanguination on meat quality and display colour stability. *Meat Science*, 18: 281-293.

72. VENTER, R.H. & HORSTHEMKE, O. 1999. Analysis of the competitive nature of the Southern African sheep meat value chain. *Agrekon*, 38(4): 716-725, Dec.

73. VERBEKE, W., VAN OECKEL, M.J., WARNANTS, N., VIANE, J. & BOUCQUE, Ch.V. 1999. Consumer perception, facts and possibilities to improve acceptability of health and sensory characteristics of pork. *Meat Science*, 53:77-99.

74. VILJOEN, H.F., DE KOCK, H.L. & WEBB, E.C. 2002. Consumer acceptability of dark, firm and dry (DFD) and normal pH beef steaks. *Meat Science,* 61: 181-185.

75. WALKER, L.T., BIRKHOLD, S.G., KANG, I.S., HIRSCHLER, E. M. & SAMS, A.R. 1996. The effect of post-mortem electrical stimulation and muscle tensioning in two broiler muscles. *Poultry Science*, 75:1118-1120.

76. WEBB, E.C. 1998. Intrinsic factors influencing meat tenderness in commercial beef production. (*In* ZILMAX® Meat quality symposium, Gallagher Estates Midrand: South Africa. *p.1-8.)*

77. WEBB, E.C., BOSMAN, M.J.C. & CASEY, H.N. 1994. Dietary influences on subcutaneous fatty acid profiles and sensory characteistics of Dorper and SA Mutton Merino wethers. *The South African Journal of Food Science and Nutrition*, 6(2): 45-49.

78. WEST, RL. 1982. Commercial application of electrical stimulation in the United States. Proc. Int.Symp. Meat Science. Technol. Lincoln, NB,1982, Nat., Live Stock and Meat Board, Chicago, 1-23.

79. WESTERN AUSTRALIA. DEPARTMENT OF AGRICULTURE. 2001. Investigating teeth erruption and eating quality. *Journal of Agriculture*, 42:1-3. Oct.

80. YOUNG, O.A., PRIOLI, A., SIMMONS, N.J. & WEST, J. 1999. Effects of rigor attainment temperature on meat blooming and colour display. *Meat Science*, 52(1): 47-56.

CHAPTER 3

Effect of electrical stimulation on consumer acceptance of mutton from class-AB sheep carcasses

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Abstract

The inconsistency in the eating quality of meats, predominantly tenderness, is probably the most critical problem faced by the meat industry worldwide. Consumers consider tenderness to be the single most important component of meat quality. An alternative for increasing meat tenderness may exist in the form of electrical stimulation of the carcass shortly following slaughter. The aim of this research was to study the effect of electrical stimulation on the consumer acceptance of, preference for and consumption intent regarding mutton of the recently introduced class-AB sheep carcasses. A total of 22 wethers of class-AB, weighing between 45 and 50 kg, were selected from a homogenous group of Dorpers. Carcasses were divided in two groups, of which one group was electrically stimulated (0.4amp/h for 45sec) and the other group was not electrically stimulated. Samples of the left *M. longissimus thoracis et lumborum* of both groups were oven roasted and a consumer panel evaluated the acceptability of the mutton regarding certain sensory characteristics. Three consumer sensory tests, namely the hedonic rating of the acceptability of each sensory attribute, a preference test and a food action rating test, were conducted in sequence. The acceptability of the juiciness, tenderness, flavour and overall acceptability were not significantly influenced by the electrical stimulation of carcasses. Samples from both the electrically stimulated and non-stimulated carcasses were highly acceptable to consumers. No significant differences in preference or % cooking losses were obtained. The present results indicate that electrical stimulation of class-AB carcasses does not have a significant influence on the consumer's acceptance of, nor consumption intent towards the class-AB mutton. The consumers revealed a positive attitude by declaring their intention to eat samples from both electrically stimulated and non-electrically stimulated carcasses once a week. Moreover, the variation in shear force values of meat samples from the electrically stimulated group was less compared to that of the non-stimulated group, indicating that electrical stimulation can successfully be applied to reduce the variation in tenderness within the class-AB mutton.

Key words: Class AB-mutton, electrical stimulation, consumer acceptance, tenderness.
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Introduction

Meat quality is a complex concept that is frequently measured using objective indices related to the nutritional, microbiological or physiological characteristics (Cardello, 1995). As emphasised by many authors, the consumer expectations and perceptions must drive improvement in meat quality. According to Cardello (1995), the notion that meat quality must be defined and measured from the consumer's perception can be traced to the 1870's when H. Clark indicated that meat quality is a relative concept that is inappropriate for evaluation by anyone other than the average consumer. Factors influencing perceived meat quality are intrinsic quality cues, convenience, safety and acceptability of sensory characteristics (Schultz & Wahl, 1981; Umberger *et al.*, 2000). Meat tenderness can be measured objectively (using instruments) or subjectively (sensory analysis e.g. taste panel). Tenderness assessment by laboratory instruments can, however, not mimic the complex and multifaceted actions that occur during biting and chewing (Perry, 2002).

Red meat consumption has decreased dramatically over the past 30 years. Numerous factors have contributed to this phenomenon e.g. economical factors (increased red meat prices), consumer perceptions (red meat vs. white meat) and misconceptions in the market (grading system of red meat) (Poonyth *et al.*, 2001). In the current South African red meat classification system, consumers have the perception that class-A carcasses produce the best quality meat and can therefore have a higher price. The introduction of the class-AB in the Beef and Lamb & Mutton Carcass Classification System must be used to highlight the unique qualities of the class-AB sheep carcass. The demand and associated marketing of more "natural" animal products are increasing daily. From an animal production perspective, this strategy will entail excluding the use of synthetic growth stimulants, anti-microbial feed additives and exposing animals to a more free-range environment. An important consequence of this shift in animal production is in many instances the production of somewhat older animals, compared to those produced in more intensive systems (De Bruyn, 2002). The class-AB mutton carcass can definitely be used as an answer to the increasing need, seeing that lambs can be left on the field for a longer period, produce an additional shearing and have an increased carcass weight. The quality of meat obtained from this method will still be of a high standard and acceptable to consumers (De Bruyn, 2002).

Electrical stimulation can be used to reduce the percentage of meat in a population that would otherwise have been unacceptable in tenderness (Lee *et al.*, 2000). Inherent differences can thus be reduced. Apart from the tenderising effect of electrical stimulation on meat, numerous other advantages such as an increased shelf life, bright red colour and reduced bacterial growth are obtained (Menday, 1979). Consumers and the meat industry demand consistent, high quality products. Electrical stimulation of meat can be used to obtain and maintain high quality products. Good quality meat must, however, be used to obtain the highest quality, but electrical stimulation can contribute to reduce minor differences, e.g. between genotypes and the influence of pre-slaughter stress conditions (Bray *et al.*, 1989; Geesink *et al.*, 2001; Viljoen *et al.*, 2002).

In Table 1 a summary is provided of the results obtained in numerous studies on the effect of various rates of electrical stimulation on meat quality and consumer perceptions. Electrical stimulation varied between 21V – 1100V. The drop in pH was significantly faster in the ES samples than in the NES samples (Hopkins *et al.*, 2000). Sarcomere lengths were significantly shorter in NES samples. The results obtained from Warner-Bratzler measurements, indicate that ES has a positive effect on the tenderness of meat. Evaluating consumer feedback in the above studies, results indicate that scores were significantly lower for high-voltage ES (HVES) than for low-voltage ES (LVES). Control samples (NES) scored lower than the LVES.

Table 1 Comparison of studies done to determine the effect of electrical stimulation on meat characteristics

	Eikelboom *et al.*, 1985	**Aalhus *et al.*, 2000**	**Birkhold & Sams, 1993**	**Bouton *et al.*, 1980**	**Hopkins *et al.*, 2000**
LVES	85V	21V		45V	45V
HVES	300V		440V vs. 820V	1100V	
pH	PH decline in both samples Insignificant	Decline	Significant reduction in pH 1h/PM	Lower value for 1100V than 45V	Faster drop in ES than in NES carcasses
Temperature	Increased in ES carcasses	Drop in temperature			
Sarcomere length	Shorter in control than ES samples	20% shorter in control than ES samples	Shorter in control than ES samples	Shortest in control samples	No significant difference
Shear force values	Lower in stimulated samples	Lower in stimulated samples	Lower in stimulated samples	No significant differences.	No significant effect
Cooking loss	Increase in ES samples			Significant increase in ES samples	No significant losses
Consumer panels (tenderness scores)	HVES & LVES higher than control samples	Higher for LVES than control samples		Lower for 1100V than for 110V	
Preference	Higher for ES samples than control	Higher for LVES than control			
Conclusion	No significant diffences in HVES/ LVES meat quality	ES reduced proportion of meat rated as tough, improved red colour	ES tenderise meat causing myofibrillar fragmentation	HVES is more unsafe than LVES. LVES increased tenderness.	Animal history influences meat tenderness

LVES – low-voltage electrical stimulation, HVES – high-voltage electrical stimulation, ES – electrical stimulation, NES- non-electrically stimulated, PM – post- mortem, h – hour, V- volt

It should be noted that other pre- and post-mortem factors also affect meat tenderness. It is not clear if the ageing periods in the above experiments were the same, to what extend the age of animals in different experiments differed and which types of muscle were used.

The present study reports on the effect of electrical stimulation versus non-electrical stimulation on the tenderness of meat as well as the consumer's acceptance of the sensory characteristics of class-AB mutton.

Materials and methods

Experimental design

A total of twenty-two wethers of between 45 and 50 kg live weight (two permanent incisors to yield class-AB carcasses with similar fatness scores) were selected from a homogenous group of Dorpers and slaughtered at a commercial abattoir according normal procedures. The carcasses were randomly allocated to two treatments, namely, electrically stimulated (ES) and non-electrical stimulated (NES). Carcasses were clearly marked to indicate ES or NES. Hence, 11 wethers were subjected to the ES procedure and 11 wethers to the NES procedure immediately post-mortem. The carcasses in the ES treatment were electrically stimulated with an alternating current (ca. 20 V, 45 Hz, 45 s), eviscerated and chilled for 24 h at 2°C. The initial carcass temperature and pH at the beginning of cold storage were respectively ca. 30°C and 6.8, which decreased to an average carcass temperature of 3°C and pH of 5.8 within 12 hours post-mortem. The *m.longissimus thoracis et lumborum* were split medially, vacuum packed and frozen at –30°C, pending sensory evaluation. The left *m.longissimus lumborum* samples were oven roasted at 160°C until an internal temperature of 73°C was reached. Total cooking loss was determined according to standard procedure (Webb, Bosman & Casey, 1994). A consumer sensory panel evaluated the samples regarding acceptability of juiciness, tenderness and flavour (Webb, Bosman & Casey, 1997). Overall acceptance was calculated as the average of the attribute scores. Cooked samples were stored overnight in a refrigerator. The following day core samples were removed (2.54cm diameter, cut with the grain) and tenderness tested on an Instron Model 1011 equipped with a Warner-Bratzler shear blade. Five shear force measurements (N) were made on each core sample, by shearing across the grain of the meat. The higher the reading recorded, the greater the shear force required to cut through the meat and therefore the tougher the meat.

Consumer panel

The target population was defined as actual consumers of mutton, male and female, ages varying between 21 to 40+ years. The level of education varied from lower than grade 12 to tertiary education. Consumers took part in the consumer test conducted at a central location. One ES sample and one NES sample were given to the panellists to compare the acceptability of juiciness, tenderness and flavour. A preference test and food action rating test was also conducted. Results from each panel member were captured on a questionnaire and later statistically analysed. Section A on the questionnaire was designed to obtain demographic information about gender, age and level of education. Section B was the score sheet for the sensory consumer tests.

Consumer sensory tests

Three sensory tests were conducted in sequence. In the first test subjects had to taste and rate the degree of acceptance for each given mutton sample independently on juiciness, tenderness and flavour. A 5-point hedonic scale was used (1= extremely unacceptable; 5 = extremely acceptable) (Bosman *et al.*, 1997). Overall acceptance was calculated from the attribute acceptance scores. The subjects were also asked to indicate whether they preferred one specific meat sample to the other and if so, which one. Consumption intent was determined by using a 5-point food action rating scale, with response categories ranging from "never eating it" (1); to "will eat it only when no other food is available" (2); to "will eat it occasionally (once per month)" (3); to "will eat it often (once per week)" (4) and "eating it every day" (5).

Statistical analysis

Demographic data of subjects was analysed using descriptive statistics. T-tests ($p \leq 0.05$) were applied to the hedonic attribute scores for each meat sample, using SAS (1992). Non-parametric tests were used for the variable consumption intent (evaluated on a food action rating scale), which did not have equal distances between the different categories on the scale. Significant differences in medians within groups were determined by using the Wilcoxon matched pairs test, and significant differences by using the Mann-

Whitney U test. A chi-square test would have been performed if the results for preference were significantly different.

Results and discussion
Consumer panel

As indicated in Table 2 the consumer panel consisted of 229 actual consumers of mutton, of which 43% were male and 57% female consumers. Nearly 40% of the consumers were between 21 and 30 years of age; only 20% were between 31 and 40 years and almost 40% were older than 40 years. Almost 70% of them had training after school, while the rest had only training up to grade 12.

Table 2 Description of consumer panel (n=229)

	Gender			
Age	**Male**	**Female**	**Total**	**% of Total**
21 – 30 years	43	51	94	41
31 – 40 years	16	30	46	20
>40 years	39	50	89	39
Total	99	130	229	100
	43%	57%	100	

Acceptance, preference and intended consumption

As indicated by the results in Table 3, electrical stimulation had no effect on any of the sensory acceptance criteria evaluated by the consumer panel ($p>0.5$). Consumers rated both the ES and NES samples between 4-5 on the hedonic scale, indicating that both ES and NES samples are highly acceptable for consumers. Results indicated that there was no statistically significant preference amongst the consumers participating in this study towards the ES or NES class-AB mutton samples. According to Figure 1, the ES and NES samples were preferred by an equal percentage of consumers (38%), while 24% did not prefer any one to the other. According to the Wilcoxon matched pair test, there was no significant difference ($p = 0.889$) between the consumers' consumption intent towards the ES and NES class-AB mutton samples. Most of the consumers revealed a positive attitude towards both samples by declaring their intent to eat both samples once a week.

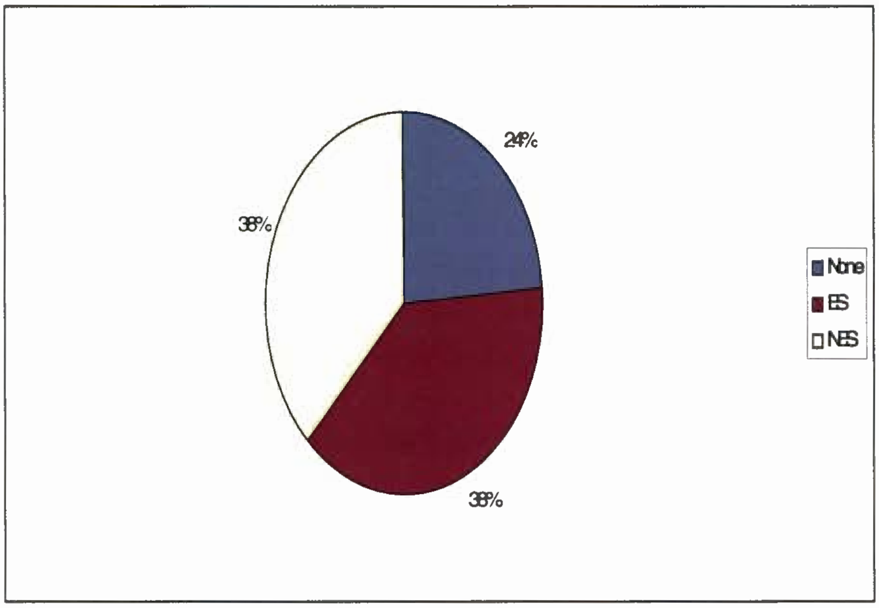

Figure 1 Consumer preference of electrically stimulated (ES) and non-stimulated (NES) class-AB mutton samples.

Table 3 Mean (± s.d.) values for the acceptance of sensory attributes, shear force values and % total cooking losses of *M longissimus dorsi et lumborum* samples from ES and NES class-AB sheep carcasses.

Parameter	NES	ES	p-value
Sensory acceptance#			
Juiciness	4.2 ± 0.74	4.1 ± 0.80	0.335
Tenderness	4.1 ± 0.84	4.1 ± 0.79	0.765
Flavour	4.0 ± 0.83	3.9 ± 0.78	0.591
Overall acceptance	4.1± 0.65	4.1 ± 0.64	0.372
Shear force value (Newton)	37.7 ± 10.57	32.6 ± 5.04	0.168
Total cooking loss (%)	20.2 ± 2.54	18.1 ± 2.78	0.078

#Hedonic scale: 1 = extremely unacceptable
5 = extremely acceptable

Shear force evaluation

Shear force value is a measure of meat tenderness, which is one of the most important factors that determine meat quality. A reduction in shear force values and control of the variation in shear values are two of the main concerns in tenderisation of meat using electrical stimulation (Li *et al.*,1994). As indicated in Table 3, results obtained from the Instron Warner Bratzler shear force compression test indicated that there were no significant differences between the ES and NES samples at the $p<0.05$ level. The variance between the standard deviations, however, indicated that the variation in the tenderness within ES samples were significantly less than within the NES samples ($p=0.028$). These results indicate that ES does have a positive effect on reducing the variation in meat tenderness and thus overall meat quality. Because the meat samples used in this study were all relatively tender as measured by the Warner-Bratzler instrument, low-voltage electrical stimulation did not significantly improve the tenderness of the muscles studied (Epley, 2002; Webb, 1998). The type of muscle used in this study, LTL, is, however, known for its tenderness and would not have been significantly influenced by ES. It is possible that the tenderness of other muscles will be affected more positively by ES, e.g. shoulder muscles (Bray et *al.*, 1989:65).

Cooking loss

As indicated in Table 3, no significant differences regarding the % total cooking losses were found between electrically stimulated and non-stimulated samples ($p<0.05$). It can therefore be assumed that electrical stimulation does not have a significant influence on total cooking loss. Increased cooking losses are associated with increased slaughter weight and carcass fatness, particularly if the fat contains large proportions of unsaturated fatty acids (Webb *et al.*, 1994).

Conclusion

From the results obtained it is concluded that there was no significant difference between consumer acceptance of juiciness, tenderness, flavour and overall acceptability of the ES and NES samples from the class-AB mutton. Both samples were highly acceptable and consumers indicated that both the ES and NES class-AB mutton samples would be consumed weekly. Although shear force values indicated no significant differences between the ES and NES samples, variances between the standard deviations indicated that the variation in the tenderness within ES samples were significantly less than within the NES samples. ES can thus be applied in older animals or within the same group to reduce the possible variations in tenderness due to factors such as age, animal history, slaughtering conditions and nutrition as well as increase shelf life, reduce bacterial growth and enhance the red colour of meat, thus increasing the number of good quality carcasses available for consumption. ES can be applied successfully to reduce the variation within the class-AB mutton group. Other post-mortem treatments should be investigated for their effectiveness in combination with electrical stimulation in improving the tenderness of the AB-class, limiting variation of tenderness within the group and assuring consistent meat quality.

It is important to continue researching the role of the consumers' pre-conceptions, particularly in relation to their perception of product quality and the likely impact that this will have on future purchase and consumption behaviour (Kerth, 1999; McIlveen & Buchanan, 2001). The misperception amongst consumers regarding the quality of class-AB mutton can be addressed by using scientific results to prove the high quality of meat in this specific class.

Acknowledgement

The authors acknowledge the technical assistance rendered by Mrs E. Pienaar, 4th -year students at Potchefstroom University for CHE, students from the University of Pretoria, all the consumers participating in the taste panels, LAW Wholesale Meat Suppliers (Groblershoop, Northern Cape) and the Potchefstroom University for financial support.

References

Aalhus, J.L., Larsen, I.L., Dubeski, P.L. & Jeremiah, L.E. 2000., Improved beef tenderness using a modified on-line carcass suspension method with, or without low voltage electrical stimulation. Can. J. Anim. Sci.80(1), 47-51. March.

Birkhold, S.G. & Sams, A.R. 1993., Fragmentation, tenderness and post-mortem metabolism of early-harvested broiler breast fillets from carcasses treated with electrical stimulation and muscle tensioning. Poult. Sci. 72, 577-582.

Bosman, M.J.C., Van Aardt, A.M., Vorster H.H. & Drewnowski, A. 1997., Dietitian's attitude towards fat substitutes and the acceptability of high-fibre muffins containing Simplesse®. S. Afr.J. Food Sci. & Nutr. 9(2),61-68.

Bouton, P.E., Harris, P.V. & Shaw, F.D. 1980., Electrical stimulation of beef sides. In Lawrie, R.A. Meat Science. Barking Essex, Eng.: Applied Science publishers. Vol 4, 145-155.

Bray, A.R., Graafhuis, A.E. & Chrystall, B.B. 1989., The cumulative effect of nutritional, shearing and preslaughter washing stresses on the quality of lamb meat. Meat Sci. 25, 59-67.

Cardello, A.V. 1995., Food quality: Relativity, context and consumer expectations. Food Quality and Preference, 6: 163-170.

De Bruyn, J. 2002., Proposal: Alternative description of AB-Mutton.(Original copy in posession of the author).

Eikelenboom, G., Smulders, F.M.J. & Ruderus, H. 1985., The effect of high-and low-voltage electrical stimulation on beef quality. In Lawrie, R.A. Meat Science. Barking Essex, Eng.: Applied Science publishers. Vol, 15: 247-254.

Geesink, G.H., Mareko, M.H.D., Morton, J.D. & Bickerstaffe, R. 2001., Effects of stress and high voltage electrical stimulation on tenderness of lamb m. longissimus. Meat Sci. 57(3), 265-271, March. 1996.

Epley, J.E., 2002. Meat tenderness. [Web:] http://www.extension.umn.edu/distribution/nutrition/J0856.html. [Date used: 13 October 2002].

Hopkins, D.L., Littlefield, P.J. & Thompson, J.M. 2000., The effect of low voltage stimulation under controlled conditions on the tenderness of three muscles in lamb carcasses. Asian-Aus. *J.Anim.Sci.* B, S362-S365.

Kerth, C.R., Cain, T.L., Jackson, S.P., Ramsey, C.B. & Miller, M.F. 1999., Electrical stimulation effects on tenderness of five muscles from Hampshire, Rambouillet crossbred lambs with the Callipyge phenotype. J.Anim Sci, 77: 2951-2955.

Lee, S., Polidori, P., Kaufmann, R.G. & Kim, B.C. 2000., Low-voltage electrical stimulation effects on proteolysis and lamb tenderness. J. Food Sci. 65(5), 786-791.

Li, Y., Siebenmorgen, T.J., Griffis, C.L., Wolfe, R.E., Dake, R.L. & Webb, J.E. 1994., Tenderness and its variation of broiler breast meat harvested from electrically stimulated carcasses. Am. Soc.Agri.Eng. 37(1),223-225.

McIlveen, H. & Buchanan, J. 2001., The impact of sensory factors on beef purchase and consumption. Nutr. & Food Sci.31(6), 286-292.

Menday, K. 1979., Elektriese stimulering van vleis. Comm. Health in SA. 5-7. March.

Perry, D. 2002., Laboratries, taste panels and palatibility. [Web]: http://www.beef.crc.org.au/Publications/Latest_Publications/feeder2002/Session6/6f.html [Date of access: 7 October 2002].

Poonyth, D., Hassan, R. & Kirsten, J.F. 2001., Random coefficients analysis of changes in meat consumption preferences in South Africa. Agrekon, 40(3), 426-437. September.

SAS Institute INC., 1992., SAS user's guide: Statistics. SAS Institute Inc., Cary, N.C.

Schultz, H.G. & Wahl, O.L. 1981., Criteria for food acceptance. Foster- Verlag A.G. Zurich, 90-97.

Umberger, W.J., Feuz, D.M., Calkins, C.R. & Killinger, K.M. 2000., Consumer preferences and willingness to pay for flavour in beef. Intrnational food and Agribusiness Management Association Meetings, Chicago. 24-25 June, 1-17.
Viljoen, H.F., De Kock, H.L. & Webb, E.C. 2002., Consumer acceptability of dark, firm and dry (DFD) and normal pH beef steaks. Meat Sci. 61, 181-185.
Webb, E.C. 1998., Intrinsic factors influencing meat tenderness in commercial beef production. (In ZILMAX® Meat quality symposium, Gallagher Estates Midrand: South Africa. p.1-8.).
Webb, E.C., Bosman, M.J.C. & Casey, N.H. 1997. Influence of dietary presentation on the composition of fatty acids and sensory characteristics of meat from wethers. S. Afr. J. Food Sci. & Nutr. 9(2): 69-76.
Webb, E.C., Bosman, M.J.C. & Casey, H.N. 1994., Dietary influences on subcutaneous fatty acid profiles and sensory characteistics of Dorper and SA Mutton Merino wethers. S. Afr. J. Food Sci. & Nutr. 6(2): 45-49.

CHAPTER 4

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 4

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 INTRODUCTION

In this final chapter, a summary of the main findings from the study in this mini-dissertation will be presented. Since the results are discussed, interpreted, elucidated and compared to the relevant literature in the preceding chapters, only general conclusions will be made. This will be followed by general recommendations regarding the study.

4.2 SUMMARY OF MAIN FINDINGS

- With reference to the main objective, the results indicated that both the electrically stimulated (ES) and non-stimulated (NES) mutton samples from the class-AB carcasses were highly acceptable to the consumers regarding juiciness, tenderness, flavour and overall acceptance. The consumers did not prefer the ES samples to NES samples and also revealed a positive attitude to both samples by declaring their intention to eat both samples once a week.

- Meat from the class-AB mutton carcasses is highly acceptable to consumers. The introduction of the class-AB sheep appears to be justified, due to the limited variation in the acceptance of sensory characteristics and tenderness of the meat samples, regardless of the electrical stimulation of the carcasses.

- According to these findings the hypothesis was rejected that the meat from the electrically stimulated class-AB sheep would be significantly different in terms of acceptance and preference by consumers and that it would be consumed more often by consumers than those from non-stimulated carcasses.

- Although shear force values indicated no significant differences between the ES ans NES samples, the variance between the standard deviations, indicated however that the variation in tenderness within the ES samples was significantly less than within the NES samples.

- There were also no statistically significant differences in the % cooking losses between the electrically stimulated and non-stimulated meat samples from the class-AB carcasses.

4.3 CONCLUSIONS

Post-mortem electrical stimulation has received considerable attention as a tool to improve meat quality traits such as tenderness, flavour, lean colour and marbling set-up and to reduce dark, coarse-band formation. Electrical stimulation improves meat tenderness by reducing ATP (conversion of muscle glycogen to lactic acid), rapid reduction of meat pH, increasing the carcass temperature and the physical disruption of the tissue.

Tenderness is one of the most important quality parameters affecting consumer acceptance. The problem of consumer dissatisfaction regarding meat products will only be solved when the problem of unacceptable variation in meat tenderness is solved. Although research on the shear force measurement of electrically stimulated and non-stimulated meat did not indicate that the shear force values decrease due to electrical stimulation of the meat, electrical stimulation can be used to reduce the percentage of meat in a population that would be unacceptable in tenderness without electrical stimulation. In that way inherited differences would be reduced.

Consumers and the meat industry demand continuous high quality products. Electrical stimulation of meat can be used to obtain and maintain high quality products. Good quality meat must be used to obtain the highest quality, but electrical stimulation can contribute to reduce minor differences, due to age, genotype and influence of pre-slaughter stress conditions.

The misconceptions among consumers that meat from the class-AB is of lesser quality than class-A, needs to be rectified. This can only be done through more intensive research of the class-AB sheep and educating the consumer on the advantages of the class-AB. Information available indicates that the class-AB sheep carcasses are of a very high quality regarding juiciness, tenderness and flavour. The class-AB also conforms to most important consumer demands as well as new trends in the market.

Electrical stimulation can be used as a tool to decrease variances in tenderness of the class-AB mutton and plays an important role in improving the quality characteristics of the class-AB mutton carcasses, and can successfully be used to limit these inconsistencies in meat quality.

4.4 RECOMMENDATIONS

- Marketing "older" beef products (e.g. class-AB) to the customer does not imply a name change. A class-A and class-AB products are both sold as beef. With sheep, the name of class-AB products changes from lamb to mutton with the eruption of the first incisors. Despite the fact that the meat quality of the class-A and class-AB products may be almost the same, consumers will discriminate against the product if the name "Mutton" is used for the class-AB product. This misperception can be overcome by highlighting the unique qualities of the class-AB mutton regarding juiciness, tenderness and flavour and by informing the customer that the class-AB is the best quality mutton and that it is only slightly inferior to lamb in tenderness.

- It is important to continue researching the role of consumers' preconceptions, particularly in relation to their perception of product quality and the likely impact that this will have on future purchase and consumption behaviour.

- The misperception among consumers regarding the quality of AB-class mutton can be addressed by using scientific results to substantiate the meat quality of this specific class.

- Future studies are recommended to research the possible variation in meat tenderness within the total class-AB mutton carcass spectrum. It can be assumed that age variation will be present within the class-AB mutton, due to the variation in age and number of permanent incisors within the group.

- In a follow-up study the shear force values and acceptability of sensory characteristics of class-AB mutton should be compared to that of class-A lamb.

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27 February 2002

RECRUITING OF CONSUMERS FOR THE SENSORY EVALUATION OF THE ACCEPTABILITY OF MUTTON

The subject group Food Science, Master and final year students are currently busy with a research project regarding the effect of electrical stimulation of sheep carcasses on the acceptability and meat quality of the meat (mutton).

The aim of the study is to make recommendations regarding the necessity of electrical stimulation on meat quality and sensory acceptability of the sheep meat (mutton) as motivation for inclusion of such processes as part of the after slaughtering procedures on sheep carcasses.

We need 200 consumers of mutton, 18 for each session, to take part in the study from each of the following age groups, i.e. between 20-30 years, 31-40 and above 40 years. The taste sessions will take only 10 minutes.

Dates and times of taste sessions

	Dates	Time	Time	Time	
1.	Wed 10 Apr	1.1 09:30	1.2 10:30	1.3 15:00	Students – fully booked
2.	Wed 17 Apr	1.2 09:30	2.2 10:30	2.3 -15:00	3 sessions x 18 each
3.	Thur 18 Apr	3.1 09:30	3.2 11:30	3.3 15:00	3 sessions x 18 each
4.	Wed 24 Apr	4.1 09:30	4.2 11:30	4.3 15:00	3 sessions x 18 each
5.	Thur 25 Apr	5.1 09:30	5.2 11:30	5.3 15:00	3 sessions x 18 each

If you are willing to take part in the study will you please telephone one of the following numbers, or send an e-mail to book for a session.

Prof MJC Bosman	299 2474	vgemjcb@puknet.puk.ac.za
Mrs E Pienaar	299 2474	vgeep@puknet.puk.ac.za
The secretary	299 2470	(only if no answer at 2474)

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27 Februarie 2002

WERWING VAN VERBRUIKERS VIR DIE SINTUIGLIKE EVALUERING VAN DIE AANVAARBAARHEID VAN SKAAPVLEIS

Die vakgroep Voedsel,Nagraadse en Finalejaar Voedsel studente is tans besig met 'n navorsingprojek in verband met die effek van elektriese stimulering van skaapkarkasse op die aanvaarbaarheid en kwaliteit van die vleis.

Die doel van hierdie studie is om aanbevelings in verband met die noodsaaklikheid van elektriese stimulering vir hoë vleiskwaliteit te maak ter motivering vir insluiting van sodanige prosesse as deel van naslagtingsprosedures.

Ons benodig 200 verbruikers, 18 per sessie, pertinent bekend met skaapvleis, uit elk van die volgende ouderdomsgroepe, om aan hierdie studie deel te neem naamlik tussen 20-30 jr; 31-40 jr en bo 40 jr. Die proesessies sal slegs 10 minute duur.

Datums en tye vir proesessies:

	Datums	Tyd	Tyd	Tyd	
1.	Wo 10 Apr	1.1 -------	1.2 -------	1.3 -------	1 sessie x 18 (1.1 en 1.2 vol)
2.	Wo 17 Apr	1.2 09:30	2.2 10:30	2.3 15:00	3 sessies x 18 benodig
3.	Do 18 April	3.1 09:30	3.2 11:30	3.3 15:00	3 sessies x 18 benodig
4.	Wo 24 April	4.1 09:30	4.2 11:30	4.3 15:00	3 sessies x 18 benodig
5.	Do 25 April	5.1 09:30	5.2 11:30	5.3 15:00	3 sessies x 18 benodig

Indien u bereid is om aan hierdie studie deel te neem, sal u asseblief een van die ondergenoemde persone skakel of 'n e-pos stuur om vir 'n sessie te bespreek.

Prof MJC Bosman 299 2474 vgemjcb@puknet.puk.ac.za

Mev E Pienaar 299 2474 vgeep@puknet.puk.ac.za

Die sekretaresse 299 2470 (slegs indien geen antwoord by 2474)

CONSUMER QUESTIONNAIRE: STRICTLY CONFIDENTIAL

QUESTIONNAIRE NO.			
SESSION NO.			
TREATMENT CODE.			
SHEEP NO.			

*** Mark the appropriate square with a cross (X)**

SECTION A

DEMOGRAPHIC INFORMATION

1. GENDER

For office use only

Male	1	
Female	2	

2. AGE

Between 21 and 30 years	1	
Between 31 and 40 years	2	
Older than 40 years	3	

4. EDUCATIONAL QUALIFICATION

Matric / Grade 12	1	
Degree / Diploma	2	

SECTION B

SENSORY EVALUATION OF THE ACCEPTABILITY OF MEAT SAMPLES WITH RESPECT TO VARIOUS CRITERIA

- **Evaluate the acceptability of the meat samples (in the specified order) with respect to the given criteria by marking the appropriate square with a cross.**

		EXTENT OF ACCEPTABILITY					Office use	
Criteria	Meat sample codes	5 Extremely acceptable	4 Acceptable	3 Neutral	2 Not accept-able	1 Extremely unaccept-able	Code	
Juiciness	1							
	2							
	3							
Tenderness	1							
	2							
	3							
Flavour	1							
	2							
	3							

- **You have now evaluated all the samples for acceptability according to certain criteria**

	Yes	No	Office use
Is one of the samples in total more acceptable than the others?			
If Yes, which one? Write down the code in the square.			

- **Please indicate how often you will be willing to eat each of the meat samples. Choose only one option under each code.**

		Sample code 305		510
5. I will eat it very often (every day).	5			
4. I will eat it often (1x/week).	4			
3. I will eat it occasionally (1x/month).	3			
2. I will only eat it when no other food is available.	2			
1. I will never eat it.	1			

Codes

305		510

VERBRUIKERSVRAELYS: STRENG VERTROULIK

VRAELYS NO.	
SESSIE NO.	
BEHANDELINGSKODE	
SKAAP NO.	

*** Merk die toepaslike blok met 'n kruisie (X)**

AFDELING A

DEMOGRAFIESE GEGEWENS

1. GESLAG

Slegs vir kantoor gebruik

Manlik	1	
Vroulik	2	

2. OUDERDOM

Tussen 21 en 30 jaar	1	
Tussen 31 en 40 jaar	2	
Ouer as 40 jaar	3	

4. OPVOEDKUNDIGE KWALIFIKASIE

Matriek / Graad 12	1	
Graad / Diploma	2	

AFDELING B

SINTUIGLIKE EVALUERING VAN DIE AANVAARBAARHEID VAN VLEISMONSTERS TEN OPSIGTE VAN VERSKILLENDE KRITERIA

- **Evalueer die aanvaarbaarheid van die vleismonsters (in volgorde soos aangedui) ten opsigte van genoemde kriteria deur 'n kruisie in die toepaslike blokkie te maak.**

		MATE VAN AANVAARBAARHEID					Kantoorgebruik	
Kriteria	Vleismonster kodes	5 Besonder aanvaarbaar	4 Aanvaarbaar	3 Neutraal	2 Nie aanvaarbaar	1 Glad nie aanvaarbaar	Kode	
Sappigheid	1							
	2							
	3							
Sagtheid	1							
	2							
	3							
Smaak	1							
	2							
	3							

- **U het nou al die monsters vir aanvaarbaarheid volgens sekere kriteria geëvalueer.**

	Ja	Nee	
Is een van die monsters vir u in totaal meer aanvaarbaar as die ander?			
Indien Ja, watter een? Skryf kode in die blokkie neer.			

- **Dui asseblief aan hoe dikwels u bereid sal wees om elk van die vleismonsters te eet.**
  Merk slegs een blokkie teenoor elke monsterkode.

		Monsterkode			Kodes		
		305		510	305		510
5. Ek sal dit baie dikwels eet (elke dag)..	5						
4. Ek sal dit dikwels eet (1x/week).	4						
3. Ek sal dit af en toe eet (1x/maand).	3						
2. Ek sal dit slegs eet indien daar geen ander voedsel beskikbaar is nie.	2						
1. Ek sal dit nooit eet nie.	1						

SESSION : [ ] CONSUMERS: [ ]

Sheep 510 [NES] Animal no [ ]

Mass raw (x) = ... g
Mass cooked (y) = ... g
Mass loss (x-y): .... g

% mass loss = ... %

Cooking time: .... min

Time **INTO** oven ....
Time **OUT** oven ....

Stand: 10 min
Cut: 1 min
Serve: ....

SESSION : [ ] CONSUMERS: [ ]

Sheep 305 [ES] Animal no [ ]

Mass raw (x) = ... g
Mass cooked (y) = ... g
Mass loss (x-y): .... g

% mass loss = ... %

Cooking time: .... min

Time **INTO** oven ....
Time **OUT** oven ....

Stand: 10 min
Cut: 1 min
Serve: ....