

Effect of electrical stimulation of carcasses from Dorper sheep with two permanent incisors on the consumer acceptance of mutton

M. Davel¹, M.J.C. Bosman¹ and E.C. Webb^{2#}

¹School of Physiology, Nutrition & Consumer Sciences, Potchefstroom University for CHE, Private Bag X6001, Potchefstroom 2520, South Africa

²Department of Animal & Wildlife Sciences, University of Pretoria, Pretoria 0002, South Africa

Abstract

The inconsistency in the eating quality characteristics 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 method 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 (carcasses from sheep with one to two permanent incisors) in South Africa. A total of 22 wethers of class-AB, weighing between 45 and 50 kg, was selected from a homogeneous group of Dorpers. Carcasses were divided into two groups, one was electrically stimulated (0.4 amp/h for 45 sec) and the other group not 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 percentage cooking losses were obtained. The present results indicate that electrical stimulation of class-AB carcasses did not have a significant influence on the consumer's acceptance of, nor consumption intent towards the class-AB mutton. This study shows that 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.

Keywords: Class AB-mutton, electrical stimulation, consumer acceptance, tenderness

[#]Corresponding author. E-mail: ecwebb@postino.up.ac.za

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 consumers' 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 cannot, however, 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 South Africa meat quality is managed by means of a meat classification system based on animal age, carcass fat content and conformation. Age classes in sheep include A (no permanent incisors), AB (1 to

2 permanent incisors), B (3 tot 6 permanent incisors) and C (more than 6 permanent incisors). Consumers have the perception that class-A carcasses produce the best quality meat and can therefore realise 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 marketing and associated demand for 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 physiologically older animals, compared to those produced in more intensive systems (De Bruyn, 2002). Class-AB mutton carcasses can be used to help meet the consumer requirement, seeing that lambs can be finished for a longer period, produce an additional wool clip and have a higher carcass weight. The meat obtained from this production system will still be of a high quality 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). Electrical stimulation of sheep carcasses can be used to improve meat tenderness particularly in underweight or leaner carcasses where cold shortening is often a problem.

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.

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

	Eikelboom <i>et al.</i> , 1985	Aalhus <i>et al.</i> , 2000	Birkhold & Sams, 1993	Bouton <i>et al.</i> , 1980	Hopkins <i>et al.</i> , 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 differences 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 – electrically stimulation, NES- non-electrically stimulated, PM – post- mortem, h – hour, V- volt

Electrical stimulation varied between 21 V – 1100 V. The drop in pH was significantly faster in the electrically stimulated (ES) samples than in the non-electrically stimulated (NES) samples (Hopkins *et al.*, 2000). These researchers found that sarcomere lengths were significantly shorter in NES samples. The results obtained from Warner-Bratzler shear force measurements indicate that ES has a tenderising effect in meat. Evaluating consumer feedback in the above studies, results indicate that meat was more tender in the high-voltage ES (HVES) treatment than the low-voltage ES (LVES) treatment. Control samples (NES) were less tender compared to the LVES.

It should be noted that numerous 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 extent 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

A total of 22 wethers of between 45 and 50 kg live weight (two permanent incisors to yield class-AB carcasses with similar fatness codes) was selected from a homogenous group of Dorper sheep. The sheep were stunned electrically and slaughtered by severing the jugular veins, and then dressed down hanging from the rail in a commercial abattoir. The carcasses were randomly allocated to two treatments, namely ES and 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* was 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 *et al.*, 1994). An untrained consumer sensory panel evaluated the samples regarding acceptability of juiciness, tenderness and flavour (Webb *et al.*, 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 (2.54 cm 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.

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 secondary school to tertiary education. Panellists 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 were also conducted. Results from each panel member were captured on a questionnaire and later analysed statistically. 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.

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” (0 - 1); to “will eat it only when no other food is available” (> 1 < 2); to “will eat it occasionally (once per month)” (> 2 < 3); to “will eat it often (once per week)” (> 3 < 4) and “eating it every day” (4 - 5).

Demographic data of subjects were analysed using descriptive statistics. The t-test ($P \leq 0.05$) was applied to the hedonic attribute scores for each meat sample, using Statistica® (1999 edition, StaSoft Inc, Tulsa, USA). 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 (SAS, 1992). A chi-square test would have been performed if the results for preference were significantly different.

Results and Discussion

The consumer panel consisted of 229 consumers of mutton, of which 43% were male and 57% female (Table 2). 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 tertiary training, while the rest had secondary school education up to grade 12.

Table 2 Gender and age distribution of consumer panel (n=229)

Age	Gender		Total	% of Total
	Male	Female		
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	

Electrical stimulation had no effect ($P > 0.5$) on any of the sensory acceptance criteria evaluated by the consumer panel (Table 3). Consumers rated both the ES and NES samples between 4-5 on the hedonic scale, indicating that both ES and NES samples were highly acceptable for consumers. The ES and NES samples were preferred by an equal percentage of consumers (38%), while 24% did not prefer any one to the other (Figure 1). According to the Wilcoxon matched pair test, there was no significant difference ($P = 0.889$) between the consumers' 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.

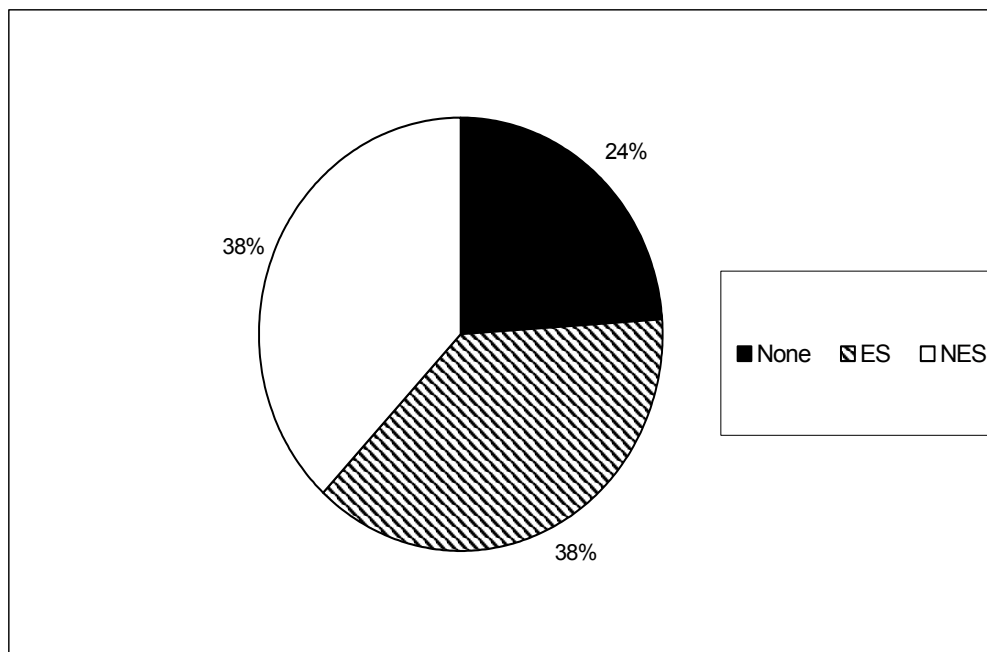


Figure 1 Consumer preference of electrically stimulated (ES) and non-stimulated (NES) class-AB mutton samples

Table 3 Mean (\pm 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 \pm 0.74	4.1 \pm 0.80	0.335
Tenderness	4.1 \pm 0.84	4.1 \pm 0.79	0.765
Flavour	4.0 \pm 0.83	3.9 \pm 0.78	0.591
Overall acceptance	4.1 \pm 0.65	4.1 \pm 0.64	0.372
Shear force value (Newton)	37.7 \pm 10.57	32.6 \pm 5.04	0.168
Total cooking loss (%)	20.2 \pm 2.54	18.1 \pm 2.78	0.078

#Hedonic scale: 0-1 = extremely unacceptable
 4-5 = extremely acceptable

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 ($P > 0.05$). 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. Low-voltage electrical stimulation did not significantly improve the tenderness because the meat samples used in this study were all relatively tender compared to previous studies on similar animals (Webb, 1997; Epley, 2002) as measured by the Warner-Bratzler instrument. 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, e.g. shoulder muscles will be affected more positively by ES (Bray *et al.*, 1989).

No differences ($P > 0.05$) in the percentage total cooking losses were found between ES and NES samples (Table 3). The results indicated that electrical stimulation did not influence the total cooking loss of meat samples. Increased cooking losses are associated with increased slaughter weight and carcass fatness (Webb *et al.*, 1994), but all carcasses in this experiment had the same fat classification code.

Conclusion

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 in the class-AB mutton. All 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 was significantly less than within the NES samples. Thus, ES can be applied to carcasses from older animals to reduce the possible variations in tenderness due to factors such as age, animal history, slaughtering conditions and nutrition. The effect of electrical stimulation in combination with other post-mortem treatments on meat quality of the AB-class should be investigated further. It is also important to continue researching the role of the consumers' preferences, particularly in relation to their perception of product quality and the likely impact that this will have on future purchasing and consumption behaviour (Kerth, 1999; McIlveen & Buchanan, 2001).

Acknowledgement

The authors acknowledge the technical assistance rendered by E. Pienaar, 4th-year students at Potchefstroom University for Christian Higher Education, 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, 47-51.
- 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 *simpless*®. *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: *Meat Science*. Ed. Lawrie, R.A., Barking Essex, England: 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 possession 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: *Meat Science*. Ed. Lawrie, R.A., Barking Essex, England. 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, 265-271.
- 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.* 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, 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, 223-225.
- McIlveen, H. & Buchanan, J., 2001. The impact of sensory factors on beef purchase and consumption. *Nutr. & Food Sci.* 31, 286-292.
- Menday, K., 1979. Elektriese stimulering van vleis. *Community Health in South Africa*. 5-7. March.
- Perry, D., 2002. Laboratories, taste panels and palatability. [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, 426-437.
- SAS, 1992. *Statistical Analysis Systems user's guide* (4th edition). SAS Institute Inc., Cary, North Carolina, USA.
- Schultz, H.G. & Wahl, O.L., 1981. *Criteria for food acceptance*. Foster- Verlag A.G., Zurich. pp. 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. *International 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. pp.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, 69-76.
- Webb, E.C., Bosman, M.J.C. & Casey, H.N., 1994. Dietary influences on subcutaneous fatty acid profiles and sensory characteristics of Dorper and SA Mutton Merino wethers. *S. Afr. J. Food Sci. & Nutr.* 6, 45-49.