EFFECT OF ELECTRICAL STIMULATION, AGE OF THE ANIMAL AND EXTREME AGEING ON TENDERNESS AND WATER HOLDING CAPACITY OF BEEF LOIN MUSCLES

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Abstract – Consumers have indicated tenderness to be the most important attribute regarding meat quality. In this trial seven age/diet groups were used namely, pasture finished A (0 tooth), AB (1 - 2 teeth), B (4 teeth), B (6 teeth), C (8 teeth) and feedlot finished A (0 tooth) and AB (1 - 2 teeth). Within each age/diet two *post mortem* ageing groups (14 and 45 days) were specified. In addition 6 carcasses from every age group were electrically stimulated and 6 were not. Loin steaks from animals with 8 permanent incisors had poorer sensory tenderness scores than steaks from animals with 0 to 6 permanent incisors, irrespective of ageing or electrical stimulation. Both electrical stimulation and prolonged ageing contributed to tenderness development. It was concluded that loin cuts of C-age animals should still be separated from the 0 to 6 teeth animals in marketing.

Key Words – age classes, extreme ageing, tenderness

I. INTRODUCTION

Provided the consumer regards a product as safe, nutritious and affordable, palatability is the main factor which would result in a repeat purchase of a meat product. Flavour, juiciness and tenderness influence the palatability of meat. Among these three traits, tenderness has always been ranked as the most important [1] and it has been shown that consumers can distinguish between tough and tender meat [2] and are also willing to pay a premium for meat which is guaranteed to be tender [3]. Although various countries or production systems rely on grading or classification systems to account for variation in tenderness, meat tenderness is simply influenced by too many factors to rely only on animal age, ossification, marbling, colour or other grading traits alone [4].

Namibia exports trimmed deboned vacuum-packed hind quarter cuts to the EU and South Africa. Warm carcasses are classified according to dentition into 4 age groups, A, AB, B and C in accordance with the classification system used in South Africa [5]. In contrast, the deboned meat is exported in two quality grades namely Prime and Super. Super includes cuts of age groups A through to B, while cuts of age group C are marketed as Prime. Two ageing regimes apply to the two export markets so that meat going to South Africa is aged for 14 days, while meat exported to the EU could age for 3 months. The chilling procedure follows a conditioning phase when initial room temperatures run at ~8°C for about eight to nine hours, before the temperature is reduced to 3 - 3.5°C. The option of applying electrical stimulation is under discussion since it is argued that cuts from older animals and/or the extended ageing regime will not benefit from this procedure.

Under the conditions described, the risk of inconsistent meat tenderness could be high due to the mixing of age groups within one quality grade. Extended *post mortem* ageing (vs. the shorter ageing of 14 days) may or may not alleviate this effect. Secondly, electrical stimulation in combination with variation in age, carcass size and fatness, and the specific chilling regime, could be another reason for variation [6].

Not many trials have been performed where ageing time was extended beyond 21 - 28 days. In addition, apart from the limited research done on extremes in animal age on beef quality, no reports were found on the interaction between extreme ageing and animal age. In the present trial, due to the circumstances of the production system, 14 and 45 days ageing were investigated.

II. MATERIALS AND METHODS

All animals were slaughtered at Meatco Corporation of Namibia (Ltd) abattoir in Windhoek, Namibia, according to EU approved methods for export. Seven age groups/diet were used namely, pasture finished A (0 tooth), AB (1 - 2 teeth), B (4 teeth), B (6 teeth), C (8 teeth) and feedlot finished A (0 tooth) and AB (1 - 2 teeth). Six carcasses per age group were electrically stimulated for 45 seconds (ES) (150V, 17Hz, 5ms pulse width; Jarvis Products Corporation RSA (Pty) Ltd) and the remaining 6 were not electrically stimulated (NES). *M. longissimus* (LT) samples of the left carcass sides were vacuum-packed and aged for 14 days and those of the right side for 45 days. Samples were stored frozen (-20°C) to measure Warner Bratzler shear force (WBSF), water holding capacity (WHC) and sensory evaluation.

All samples were processed into steaks of 30 mm each, vacuum-packed again and thawed at 3°C before preparation for WBSF and sensory analyses. Steaks were oven broiled at 170°C to an internal temperature of 70°C [7].

WBSF was performed on 8 x 12.5 mm (diameter) cores by a Warner Bratzler shear device mounted on a Universal Instron apparatus (Model 4301, Instron Ltd, Buckinghamshire, England; cross head speed = 200 mm/min). For sensory analysis cubes of meat, wrapped in coded aluminium foil were presented to the 10 trained panelists to evaluate overall tenderness on a score of 1 (extremely tough) to 8 (extremely tender).

WHC of samples was determined using the filter paper press method. A meat sample weighing 400-600mg was placed on a filter paper, sandwiched between translucent plastic plates, and pressed at 35kg/cm^2 for 1 min. The meat area and liquid area were measured by a VIA system (BX40, CC12 video camera, Olympus, Tokyo, Japan). The ratio between liquid and meat area was used to determine WHC [8].

Data for WBSF, sensory analysis and WHC were subjected to analysis of variance for a split-plot design (GenStat® VSN International, Hemel Hempstead, UK [9]) with the different age/diet scenarios (pasture finished A, AB, B4, B6, C and feedlot finished A and AB) as whole plots and the two stimulation sub-treatments (ES and NES) and the two ageing periods (14 and 45 days *post mortem*) as sub plots. Means for the interactions between the whole plot and sub-plots were separated using Fisher's protected t-test least significant difference (LSD) at the 5% level [10].

Table 1: Effect of electrical stimulation, age/diet and *post mortem* ageing on tenderness (WBSF), overall tenderness (sensory) and water holding capacity (WHC).

	WBSF (kg)	Sensory	WHC
Elec. stim:			
NES	4.0	5.4^a	0.43^a
ES	3.7	5.7^b	0.40^b
SEM	0.1210	0.1123	0.0057
Age/diet:			
A-pasture	3.6	5.9^{bc}	0.41^{abc}
A-feedlot	3.8	6.1^c	0.40^{ab}
AB-pasture	4.0	5.6^{bc}	0.44^c
AB-feedlot	4.0	6.0^{bc}	0.39^a
B4-pasture	3.7	5.5^b	0.42^{abc}
B6-pasture	3.6	5.7^{bc}	0.39^a
C-pasture	4.2	4.5^a	0.42^{abc}
SEM	0.2264	0.2100	0.0106
Ageing:			
14 days	4.3^b	5.5^a	0.39^a
45 days	3.4^a	5.7^b	0.44^b
SEM	0.0490	0.0562	0.0044

^{a,b,c}*Means in the same column and treatment category with different superscripts differ significantly ($P<0.05$).*

III. RESULTS AND DISCUSSION

Electrically stimulated samples scored higher for sensory tenderness ($P < 0.001$) irrespective of age/diet or duration of *post mortem* ageing (Table 1). WBSF showed the same trend, but was not significant ($P = 0.061$).

Even though the conservative chilling regime (initial chilling at 8°C for 8-9 h) reduces the risk of cold induced toughening of meat, Strydom *et al*. [6] showed that the correct application of ES also speeds up the ageing process and enhances tenderness through other mechanisms even when cold shortening is not at risk. It was however surprising that ES had a positive effect on tenderness on all age/diet groups, which could suggest that ES contributed to tenderness by disrupting the connective tissue structure of the muscle as well [11].

The effect of age/diet scenario on overall tenderness was significant ($P < 0.001$) with the C-age loins having lower scores than the other age groups and being 1 unit lower on average than the B-4 age group samples, which had the second lowest mean score. Although some variation for WBSF occurred among the 7 age/diet groups, the differences were not significant. Heat stability of intramuscular collagen has been shown to increase with animal age [12] which is probably the reason for the lower tenderness scores of the C-age group.

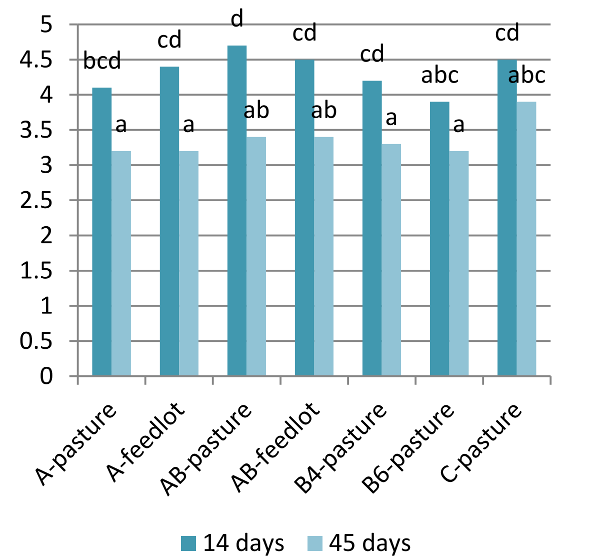
Heat stability of intramuscular collagen may also have been increased by the C-age group's decreased growth rate [13] or by the weight increase and loss over different seasons of their life. The lack of age related changes in the other age groups is consistent with the work of Pflanzer & Felicio [14] who reported no LT differences in sensory tenderness or WBSF for Nelore cattle having 2 to 6 permanent incisors although the effect of age could have been confounded by the better condition of older animals. In their work Shorthose & Harris [15] reported consistently tougher loins for older cattle when variation in myofibrilar toughness was eliminated by electrical stimulation.

Research done on the effect of ageing of beef for relatively short durations is abundant, but works on the effect of extreme ageing periods are not. Monson *et al*. [16] compared different breeds over ageing times from 1 - 35 days. They found that tenderness increased significantly (by one unit or more) between 1 and 14 days but then tended to stabilize over the following 20 days. This suggests that most of the effect of ageing was completed by 14 days, while the present results showed a continued improvement beyond 14 days for all age groups according to both WBSF and overall tenderness scores ($P < 0.001$). WBSF improved by almost 1 kg between 14 and 45 days of ageing. If a 4kg shear value was accepted as a benchmark for consumer acceptability [3], then 35% of the samples were acceptable after 14 days *post mortem* ageing, which increased to 80% after 45 days ageing. The small but significant difference in tenderness score mean value suggests a higher frequency of tenderness scores closer to 8 for longer aged samples, meaning less risk of failure.

There was an interaction between *post mortem* ageing and age/diet which approached significance for WBSF (P = 0.084, Figure 1). AB-pasture carcasses had the least tender loins at 14 days but responded to ageing the best of all the groups (1.3kg improvement). In contrast, the C-pasture group had the second highest shear force at 14 days and only improved by 0.6 kg after a further 30 days ageing. The B6-pasture group did also not respond to ageing in the same way as the other groups (0.7kg), although the shear force (14 days) was among the lowest of the 7 groups.

There was no specific pattern with regard to highest and lowest values among age groups which

Figure 1. The interaction between age/diet and ageing for WBSF.



[a,b,c]Bars with different superscripts differ significantly ($P<0.05$).

was not expected. According to work by Crosley *et al*. [17], shear force values of the loin muscles of different age groups aged for 7 days varied by almost 20 Newton (2 kg) among age groups. In the present trial only the oldest group showed a clear difference in tenderness from the rest of the age groups and even after 45 days of ageing the sensory panel still scored this group significantly lower.

Electrical stimulation significantly improved WHC ($P < 0.001$). While the opposite was expected, Li *et al*. [18] found that low voltage ES had no negative effect on WHC. A possible explanation for the improvement in WHC could be that ES creates conditions favourable for calpain activity (pH decline and decreases the activation of the inhibitor calpastatin) which are similar to the conditions necessary for desmin degradation. Rapid proteolysis of intermediate filament proteins like desmin has been associated with improved WHC [19]. Age/diet had a significant effect on WHC, but no particular pattern could be determined. With regard to *post mortem* ageing, higher values of WHC ratio implies that the longer aged samples had less expressible moisture which is in agreement with Boakye and Mittal [20] who found that WHC improved up to 16 days ageing but then declined as muscle structure started to break down and water was lost as purge.

IV. CONCLUSION

The risk of grouping cuts of animals with animals having less than 6 permanent incisors into 1 quality group seems to be low based on shear force and sensory tenderness measurements of the loin muscle. Palatability of loins under these conditions should not be extrapolated to all cuts of the hind quarter (silverside, topside, thick flank) since the effect of connective tissue heat stability could have a more pronounced effect on eating quality than in the case of the loin. Both extended ageing, beyond 14 days, and electrical stimulation should further reduce the risk of experiencing a tough steak.

ACKNOWLEDGEMENTS

Analytical Services Laboratory staff of ARC-API, Irene. Red Meat Research and Development Trust of South Africa (RMRDT) and Technology and Human Resources for Industry Programme of the Department of Trade and Industry, South Africa for funding.

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