MEAT STANDARDS AUSTRALIA, A 'PACCP' BASED BEEF GRADING SCHEME FOR CONSUMERS. 3) PACCP REQUIREMENTS WHICH APPLY TO CARCASS PROCESSING

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Background

The Meat Standards Australia (MSA) grading scheme is based on a systems approach. Of all the critical control points from production to value-adding, the post-slaughter processing of the carcass can potentially have the largest impact on final eating quality. Consequently, considerable effort has been expended in the development of specifications and control measures that can be reliably used in the abattoir to ensure that eating quality, particularly tenderness is maximised. The focus has centred on minimising the degree of myofibrillar shortening and optimising the degree of proteolysis. However, this is by no means simple, as some of the practices that minimise against myofibrillar shortening (eg. electrical stimulation) may not always be conducive to optimal proteolytic activity. The understanding of this interrelationship is further complicated by the variability in cooling rates between different regions in the carcass. This issue is quite important given the MSA goal of grading a range of cuts/muscles in the carcass, not just the *M. longissimus*. This paper discusses the application of key control variables specific to the post-slaughter management of the carcass, in addition to the chiller assessment criteria, which have been incorporated into the cuts-based prediction model.

Rate of pH Decline and Rigor Temperature

The rate and extent of pH decline and the temperature at rigor are key factors governing the magnitude of myofibrillar contraction (eg O'Halloran *et al.* 1997). Based on these studies, MSA has developed specifications regarding the post-mortem pH/temperature/time relationships. The prescribed pH/temperature "window" is that the muscle commences rigor (defined as pH <6.0) between 12 and 30°C. The adoption of these criteria was preferred, as it allowed flexibility in the choice of whether this specification was achieved through the use of electrical stimulation (low or high voltage), controlled chilling regimes, or a combination of both. Subsequent validation of these specifications indicated that further research aimed at resolving the effects of high rigor temperatures was clearly needed. This need was based on the fact that the current electrical stimulation protocols used in industry , particularly for low voltage stimulation, were resulting in exceptionally fast rates of pH decline and therefore, high rigor temperatures (Butchers *et al.* 1998, Hwang *et al.* 1998). In some instances the increased rates were due to additional electrical inputs in abattoirs utilising immobilisers, either after the knocking box and/or during mechanical hide-pulling. Pre-slaughter management of cattle has also been shown to be implicated (Butchers *et al.* 1998). The results of two electrical stimulation experiments (Hwang *et al.* 1998, 1999) have reinforced the view of Devine *et al.* (1999) that high rigor temperature exerts its influence on myofibrillar tenderness via the tradeoff between the simultaneous increase in myofibrillar shortening and the acceleration and subsequent inhibition of proteolytic (calpains) activity. Further ageing of high rigor temperature muscle resulted in further, albeit smaller improvements in tenderness. However, the results of Hwang *et al.* (1999) have also shown the extent the ageing potential was compromised after 3, 7 and 14 days ageing, where the lowest shear forces were attained for those muscles which had undergone an intermediate rate of pH decline (*ca.* 6.0 at 1.5 hours post-mortem). Based on these results, the MSA protocols for low voltage electrical stimulation, with respect to duration of stimulation and post-mortem time of application are being revised.

Alternative Carcass Suspension

The practice of suspending the side via the pelvis (Tenderstretch) is another effective means of controlling the degree of myofibrillar shortening in a number of muscles (eg. Bouton *et al.* 1973). Extensive re-evaluation of the merits of tenderstretch have now been completed as part of the development of MSA. Thompson *et al.* (1999) provided a summary of the numbers of animals used, main treatments and details of the statistical analysis. Briefly, 258 cattle were slaughtered, all carcasses received electrical stimulation, one side was tenderstretched and 12 muscles were taken for sensory evaluation. The combination of electrical stimulation with and without tenderstretch was examined to ascertain whether or not the two post-slaughter treatments were additive, as shown by Bouton *et al.* (1978).

From the analysis, the results are in agreement with those from previous studies (Hostetler *et al.* 1972, Bouton *et al.* 1973), in that a highly significant (P<0.001) hanging method x muscle interaction was found (Table 1). As expected, there was no effect of tenderstretch on the forequarter muscles with the exception of the *M. longissimus thoracis.* In stark contrast, eating quality was significantly improved by tenderstretch in the majority of the hindquarter muscles. The notable exceptions to this trend were the *Mm. psoas major* and *semitendinosus*. Both of which are stretched in conventionally hung sides and in the case of the *Psoas major* more likely to shorten in the tenderstretched state (Bouton *et al.* 1973). That said, it must be remembered that the carcasses were also electrically stimulated and it could be argued that the degree of shortening should have been negligible. Moreover, this supports the findings of Bouton *et al.* (1978) that the combination of electrical stimulation and tenderstretch are additive in terms of improving eating quality. There are a number of possible reasons for this. For example, cooking losses and sensory juiciness scores are typically higher and lower in tenderstretched (Bouton *et al.* 1973) and electrically stimulated (Bouton *et al.* 1980) sides respectively, relative to the contralateral control sides. Therefore, tenderstretch may help to mitigate against decreased juiciness in electrically stimulated muscle. Another possibility is that unlike electrical stimulation, tenderstretch reduced the adhesion strength between the fibres (Bouton *et al.* 1973) thereby effectively reducing the connective tissue contribution to tenderness. As an alternative means of achieving the benefits of carcass stretching without some of the operational issues other forms of carcass suspension are also under investigation eg. Tendercut.

Table 1: CMQ4 least square differences (standard errors and significance) between electrically stimulated tenderstretched and normally hung (achilles tendon) sides for different muscles

Primal Cut	Muscle	Tenderstretch	Achilles Tendon	SE of the difference	Significance
Forequarter					
Brisket	*Pectoralis profundus*	31.9	34.7	1.7	ns
Blade	*Triceps brachii*	55.3	55.8	1.0	ns
Oyster Blade	*Infraspinatous*	61.3	62.4	1.2	ns
Cube roll	*Longissimus thoracis*	65.2	62.9	1.1	P<0.05
	Spinalis dorsi	74.6	75.6	1.8	ns
Hindquarter					
Striploin	*Longissimus lumborum*	61.2	55.3	0.8	P<0.001
Tenderloin	*Psoas major*	70.9	73.5	1.0	P<0.01
Rump	*Gluteus medius*	63.9	56.9	0.9	P<0.001
Topside	*Semimembranosus*	44.9	37.8	0.8	P<0.001
Outside flat	*Biceps femoris*	50.4	46.7	0.8	P<0.001
Eye round	*Semitendinosus*	48.3	47.3	1.0	ns
Knuckle	*Rectus femoris*	50.3	48.0	0.9	P<0.05

Chiller Assessment Criteria

After chilling, carcasses eligible for MSA grading are quartered and assessed. Ultimate pH is measured along with visual marbling score and meat colour. The USDA marbling and meat colour standards are preferred over the current AUS-MEAT standards as they provide a more continuous scale for assessment. Carcasses with an ultimate pH > 5.7 and a USDA meat colour score > 300 are automatically excluded. Initially, minimal marbling criteria were proposed relative to each grade ie. no minimum for 3 star, traces to slight for 4 star and small or higher for 5 star. This is being reconsidered under the new cuts-based scheme and the relationship between eating quality and marbling has been re-analysed (refer Thompson *et al.* 1999). The results revealed a significant (P<0.001) muscle x marbling score interaction which was primarily relevant for the high value loin muscles. A positive association between marbling score and CMQ4 scores was shown for the *psoas major, longissimus and spinalis*. In these muscles, a change in marbling score from 200 to 500 (*ca.* 4 – 5% intramuscular fat) resulted in a six unit increase in CMQ4 score. Given the composite nature of the CMQ4 score, it is most likely that improvements are associated with enhanced appreciation of juiciness or flavour rather tenderness. Marbling score was generally not associated with the eating quality of the other muscles.

Conclusions

In general, the results continue to reinforce the value in controlling the post-slaughter environment in the interests of maximising eating quality. Electrical stimulation will continue to play a role in Australian abattoirs, however, it is clear that there is a need to revise the protocols, particularly in reference to low voltage stimulation in order to prevent rigor shortening. MSA has facilitated new interest in the practice of tenderstretch. The results also suggested that the combination of electrical stimulation and tenderstretch are additive in terms of the improvement in eating quality for the majority of the hindquarter cuts. In the quest to minimise myofibrillar toughness, the effects these post-slaughter practices, particularly electrical stimulation, have on the ageing process are not fully understood. The interaction between these practices on the rate and extent of biophyical changes during ageing in a range of muscles is a prioirty for future research. Finally, the contribution of marbling to eating quality was specific to the high quality loin muscles. Nevertheless, it still provides a useful means for differentiating eating quality.

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