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MEAT STANDARDS AUSTRALIA, A 'PACCP' BASED BEEF GRADING SCHEME FOR CONSUMERS.
2) PACCP REQUIREMENTS WHICH APPLY TO THE PRODUCTION SECTOR

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Background

Research into the influence of production factors, notably breed, slaughter age and growth path/rate on beef palatability has to date yielded results which invariably demonstrate significant effects. However, the magnitude of the effect is often variable (Shorthose and Harris, 1991). The equivocal nature of the results has made it difficult to rank their relative importance in the context of a beef grading scheme. This is certainly the case with *Bos indicus* content, where most studies have reported a commensurate decrease in beef paplatability with increasing *Bos indicus* content , although the magnitude of the effect tends to vary between studies. In several studies (Wheeler et al. 1990 and Hearnshaw et al. 1998), the results indicate that the magnitude of the breed effect will depend on the post-slaughter management of the carcasses. In these studies, the application of electrical stimulation significantly reduced the breed differences in tenderness. The effect of growth rate on palatability is also variable. In a commercial sense, quantification of growth rate is further complicated by the lack of an accurate measure of age by which to calculate average growth rate. The mechanisms by which the rate and pattern of development during an animal's life affect final meat quality have yet to be fully elucidated. One mechanism proposed by Harper et al. (1997) was that the effect of delayed growth on eating quality was via changes in the connective tissue solubility. Results from the Cattle and Beef Industry Co-operative Research Centre (CRC) tend to support this where the average lifetime growth rate was negatively associated with compression measurements (D. Robinson pers. com.). This paper uses data from several Meat Standards Australia (MSA) experiments to quantify the magnitude of the *Bos indicus* content and lifetime growth rate effects on palatability and how these parameters have been incorporated into the MSA cuts-based eating quality scheme.

Materials and Methods

The MSA database was described briefly by Polkinghorne et al. (1999), and comprises sensory data from 12 muscles, which were derived from carcasses with different production and processing histories. In addition, the muscles have been cooked using four different cooking methods. The analysis of the database has been ongoing since its creation to support the initial carcass pathways system and subsequent changes, and more recently, the development of the cuts-based grading model. Broadly, the data in the database can be grouped into three categories. Category 1 comprises consumer sensory results on 3,500 striploin samples obtained from commercial cattle sources. These cattle were phenotypically graded for *Bos indicus* content and their carcasses were subjected to a number of post-slaughter treatments, including electrical stimulation, alternative hanging methods and ageing periods. In the second category, there are sensory results from approximately 2,000 striploin samples from cattle in the CRC straightbred and crossbred progeny evaluation projects. The design of these projects (Robinson 1995) incorporates pedigreed animals from a number of breeds and crosses which were allocated at weaning to either grain or grass finishing regimes and one of three slaughter weights. The data in this group will ultimately be used to provide estimates of genetic parameters for palatability traits. The third category comprises data from from ten different experiments. The animals were slaughtered in a number of commercial abattoirs. In total, 300 carcasses were used and from these there were 6,500 muscle x cooking method combinations. For all carcasses, one side was tenderstretched, whilst the other was normally hung. Low voltage electrical stimulation was applied in eight of the experiments (1, 2, 3, 6, 7 and 8). In experiments 1 and 2, the cattle ranged in *Bos indicus* content (0-100%), experiment 3 comprised *Bos taurus* steers which grew rapidly and were finished in a feedlot for either 100 or 150 days. A 2 x 2 factorial design, where high voltage stimulation and tenderstretch were overlaid on the sides of two groups of commercial carcasses was used in experiments 4 and 5. In experiment 6, the data set comprised a group of commercial steers that had been grain finished and slaughtered at 320 kg carcass weight. Experiments 7 and 8 comprised a total of 48 animals in which sides from experiment 8 were tenderstretched and rumps and striploins aged for 14 and 28 days prior to consumer testing.

Statistical Analysis

The analysis for the cuts based scheme was undertaken on a step-wise basis. The major analysis used data from category 3 (experiments 1, 2, 3, 4 , 5, 6) and included approximately 285 animals from which 5,545 cuts, aged between 14 and 19 days, were had been consumer tested under a variety of cooking techniques. In addition to the above treatments, the database contained a large number of carcass measurements (>30) which were screened as predictors of palatability. Carcasses with high ultimate pH (>5.7) and muscle colour scores (US lean score >300) were excluded. The final multiple regression model included terms for estimated *Bos indicus* content, hanging method, cut, US marbling score, US ossification score and cooking method. The cut effect significantly interacted with estimated *Bos indicus* content, hanging method, US marbling score and cooking method (P<0.0001). In addition carcass weight nested within US ossification score was highly significant (P<0.0001). For this data set, the model accounted for 50.5% of the variance in CMQ4 score with an RSD of 11 which was further partitioned into measurement error of eight and prediction error of seven units. The proportion of variance accounted for by the model did not improve with the inclusion of abattoir in the model.

The analysis on the effect of ageing of different muscles was restricted to data from experiments 7 and 8 where rumps and striploins were aged for 14 and 28 days. This result showed an improved CMQ4 score at 5 days ageing in the tenderstretched side compared to the normally hung side, although subsequent ageing was slower in the tenderstretch side relative to the normally hung carcass. The final cut-based model includes an ageing effect, which has been derived from limited sensory data. Quantification of the ageing effect in a range of muscles from tenderstretched and normally hung sides is a research priority being addressed by MSA.

Results

Bos indicus content: The MSA carcass pathways had clear thresholds for *Bos indicus* content. This was based primarily on results from the MSA database (ie. Category 1data) which showed that for commercial carcasses classed as having greater than 75% *Bos indicus* content (based on phenotype) the palatability failure rate (ie a CMQ4 score of < 48) was 63%. For carcasses that were classed as having an intermediate *Bos indicus* content (25 to 75%) the palatability failure rate was 31%, whilst for the low *Bos indicus* content (<25%) carcasses the palatability failure rate dropped to 11%. Given that these were commercial cattle it is not possible to conclusively say that this was a true breed effect, or whether the effect was confounded by other environmental effects eg. harsher production environments, pre-slaughter mangement.

Using data from experiments 1 and 2, the effect of *Bos indicus* content on the palatability of different muscles was investigated. Table 2 shows the regression coefficients for *Bos indicus* content by muscle. When *Bos indicus* content was tested as a curvilinear term it was not significant suggesting that a linear term for *Bos indicus* content adequately described the change in palatability. The decline in palatability interacted with muscle, with increased *Bos indicus* content having the largest effect for the *Psoas major* and *longissimus* muscles. For these muscles a *ca.* 10 point decrease in palatability was found over the range of 0 to 100% *Bos indicus* content. Shackelford *et al.* (1995) also suggested that the *Bos indicus* effect for different muscles interacted with cooking technique, although when tested this was not evident in the present data set. These results indicated that a *Bos indicus* effect based on the striploin was not appropriate to apply across all muscles of the carcass, rather the magnitude of the effect was muscle dependent. Further taste panel tests are currently underway to validate the coefficients for a wider range of muscles and to test whether there is an interaction between *Bos indicus* content and ageing rate.

Growth path effects: Although previous studies (Harper *et al.* 1997) indicated the potential importance of growth rate as a predictor of palatability, the difficulty for MSA was that age and liveweight were rarely available for commercial cattle. Given that carcass weight and ossification score were available on all carcasses, a weight for maturity score (WAM) was derived as ((Hot carcass weight/0.53) - 35)/age estimated by ossification in days. For the carcass pathways approach this parameter was included as a threshold value because it had a weak, but positive correlation (0.23) with palatability. Analysis of CRC data where actual age and lifetime growth rate were known, showed that for over 1,300 cattle, the estimated WAM measurement had a positive correlation of 0.7 with actual lifetime growth rate. A more stable way of examining the relationship between ossification score, carcass weight and palatability was to adjust palatability score for carcass weight nested within ossification score.

Conclusion

The MSA scheme has identified *Bos indicus* content and growth path as important Critical Control Points to include in the cuts-based grading scheme. *Bos indicus* content interacts with muscle and this has been incorporated in the model. Further work is being undertaken to investigate the presence of interactions between *Bos indicus* content with ageing rate for the different cuts. Growth path is presently estimated from carcass weight and ossification score, although work is underway to identify more specific periods during backgrounding and finishing which will improve the accuracy in predicting palatability.

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Table 1 The regression coefficients for the effect of *Bos indicus* content on the palatability of samples ranked in order of the magnitude of the effect and after adjustment for cooking, hanging, US marbling and ossification scores and their interactions.

Primal Cut	Muscle	Regression coeff (b)	se of b	Significance
Tenderloin	*Psoas major*	-0.09	0.020	P<0.0001
Cube roll	*Longissimus thoracis*	-0.08	0.021	P<0.0001
Striploin	*Longissimus lumborum*	-0.08	0.020	P<0.0001
Brisket	*Pectoralis profundus*	-0.05	0.038	ns
Spinalis	*Spinalis dorsi*	-0.05	0.036	ns
Eye Round	*Semitendinosus*	-0.04	0.022	P<0.10
Knuckle	*Rectus femoris*	-0.03	0.019	P<0.10
Rump	*Gluteus medius*	-0.03	0.020	ns
Blade	*Triceps brachii*	-0.02	0.020	ns
Topside	*Semimembranosus*	-0.01	0.018	ns
Oyster blade	*Infraspinatous*	-0.01	0.026	ns
Outside flat	*Biceps femoris*	0.01	0.018	ns