An overview of MSA

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Abstract

Meat Standards Australia (MSA) has identified the Critical Control Points (CCPs) from the production, pre-slaughter, processing and value adding sectors of the beef supply chain and quantified their relative importance using large-scale consumer testing. These CCPs have been used to manage beef palatability in two ways. Firstly, CCPs from the pre-slaughter and processing sectors have been used as mandatory criteria for carcases to be graded. Secondly, other CCPs from the production and processing sectors have been incorporated into a model to predict palatability for individual muscles. The MSA model accuarately predicts eating quality of beef using CCP's from the total beef supply chain.

Introduction

Meat tenderness is a function of production, processing, value adding and cooking method used to prepare the meat for consumption by the consumer. Failure of one or more links in the beef supply chain increases the risk of a poor eating experience for the consumer. A guarantee for eating quality can only be given if the links that most affect tenderness are controlled along the meat production chain.

The Meat Standards Australia (MSA) grading scheme is a "paddock to plate" quality assurance system which manages meat quality along the entire length of the meat production chain. The scheme uses critical control points (CCPs) and to predict the quality of the final product. From the literature and an on-going research program, MSA has identified those CCPs from the production, processing, value adding and cooking sectors of the meat supply chain in Australia that impact on eating quality and combined these into a workable quality assurance, or grading system.

Much of the research undertaken by MSA was not new. The new component was the use of a large-scale consumer testing system that allowed the effects of the CCPs to be quantified using a standard evaluation procedure. This allowed the CCPs to be ranked on their potential impact on palatability and incorporated into a predictive model. Given the variety of meat quality measurements used by scientists around the world, it was not previously possible to integrate results into a general model capable of operating at a commercial level (i.e., a model that predicted palatability using traits that could be measured in a commercial environment). Other prediction models have generally focused on a specific sector of the beef supply chain, whilst MSA incorporated CCPs from production through to cooking the beef.

MSA has had a rapid evolution, initially developing a "carcase pathways" approach whereby carcase grades were defined by a series of threshold parameters which had to be met before the carcase was graded. The need for a cuts-based-grading system was predicated on the need to improve the accuracy of predicting palatability in beef and the need to grade all muscles in the carcase. Analysis of the MSA database showed that the variation in palatability explained by muscles was approximately 60 times greater than that explained by the variation between animals for the same muscle.

Measurement of beef palatability by MSA

At the commencement of MSA the decision was made to use sensory results from consumer testing as the means to describe palatability of beef. Briefly, untrained consumers were used to test a score samples for tenderness, juiciness, flavour and overall acceptability and grade the sample on the following word associations; unsatisfactory, good everyday (3 star), better than everyday (4 star), or premium quality (5 star). The 4 sensory dimensions were combined into a single palatability or meat quality score (MQ4), by weighting tenderness, juiciness, flavour and overall acceptability by 0.4, 0.1, 0.2 and 0.3, respectively. The palatability scores were then used to calculate the optimum boundaries for the grades assigned by the consumers with boundaries between the grades of 45.5 for the ungraded and 3 star categories, 63.5 for 3 for 4 star categories, and 76.5 for the 3 and 5 star categories.

Development of a model to predict palatability

The MSA prediction model was developed using a multiple regression approach whereby input variables from the production, processing and value adding sectors were included in a model to predict palatability of individual muscles for a range of cooking techniques. An important feature of the model approach was that there were now a large number of combinations that could be used to achieve a specified outcome. This was desirable, as consumers are not concerned by how palatability scores are derived, rather, that palatability matches its description.

The initial model was developed using production, processing and sensory data from 12,700 samples contained in the MSA database. The next iteration of the model in February 2000 used data from 23,000 samples. The MSA data base presently contains over 55,000 samples which have been tested by consumers.

Components of the MSA model

The specifications for producers and processors to supply carcases which are eligible for grading by MSA include compliance with a set of conditions aimed at reducing pre-slaughter stress and optimizing processing conditions. Producers need to be registered and must adhere to MSA Cattle Handling Guidelines to minimize stress. They must declare the *Bos indicus* % content of their cattle, and whether the cattle can be classed as milk fed calves. The time of loading must be supplied, the cattle trucked direct to slaughter, not mixed in lairage, and killed the day after dispatch.

Abattoir procedures are audited within a QA system to ensure pH and temperature relationships are within the prescribed window to achieve optimal palatability. To minimise variation in cooling rates carcases must have an even distribution of fat with at least 3mm of fat at the rib site. All carcases must have an ultimate pH below 5.7 and a USDA ossification score below 300. As more samples are tested from older cattle it is intended to extend this limit so that a greater proportion of the Australian domestic cattle kill are eligible for grading.

A sample output from the MSA model is shown in Figure 5a-1. The prediction parameters used in the model include:

- *Bos indicus* %: This is specified on the producer declaration. In addition, hump height is measured at grading and related to carcase weight. Where the hump height is outside a specified range for the declared *Bos indicus* %, a higher *Bos indicus* adjustment is applied. This provides improved accuracy for some adapted *Bos taurus* breeds, such as Belmont Reds. The magnitude of the *Bos indicus* effect varies with muscle (see Table 5a-1).
- Sex: A sex adjustment is applied in two ways. One adjustment is by muscle, with various muscles showing a slight difference between sexes. The second adjustment is applied differentially in conjunction with the ossification score across all muscles. The magnitude of the sex adjustment varies with muscle and is relatively small, being of the order of 2 palatability units.
- Carcase weight: This is used in conjunction with ossification score to estimate the effect of growth rate on palatability. The change in palatability with increased carcase weight differs for each ossification range and tends to decline as ossification increases. An increase in USDA ossification score from 120 to 200 would decrease palatability by approximately 3 palatability units. At this stage a common adjustment is made for all muscles and cooking techniques, although this is under review.
- Milk Fed Veal (MFV): Muscles from calves weaned immediately prior to slaughter receive a higher score than from earlier weaned cattle of equivalent ossification score. The magnitude of the MFV effect varies with muscle and ranges from 0 to 6 palatability units.
- Carcase Hanging Method: This effect is applied on an individual muscle basis, with different values for each muscle and hang combination. Hanging methods are AT (Achilles tendon), TS (Tenderstretch from the ligament), TX (Tenderstretch from the aitch bone) and TC (Tendercut). Differences in palatability between AT and TS carcases are shown in Table 5a-3.
- Marbling: As marbling score and rib fat were positively correlated, both parameters are used to assess the impact of marbling on palatability of individual cuts. An increase in USDA marble score from 250 to 550 (equivalent to an increase from 0 to 3 marble score on the AUSMeat system) results in an increase of 8 palatability units for the striploin. The adjustment made for marbling depends on the muscle.

- Ultimate pH: A small improvement in eating quality occurs as pH declines from the threshold of 5.7 (ca. 1 palatability unit).
- Ageing: The rate of ageing is estimated differently for each muscle within each hanging option. Ageing muscles from 5 to 21 days increases the palatability score by up to 4 palatability units.
- Saleyards: Supply of MSA animals is possible from a saleyard if the facilities have been audited and employ best practise for handling animals. If animals are delivered for slaughter through an accredited saleyard system a 5 point penalty is applied to all cuts.
- Cooking Method: Palatability for individual muscles is predicted for a specific cooking method. Larger muscles generally have several cooking options. Grilling low connective tissue cuts resulted in the highest palatability scores. Roasting low connective cuts gave similar scores to grilling, whereas for the high connective cuts roasting gave higher palatability scores than did grilling. Stir frying and thin slicing gave similar results to grilling for low connective muscles, but relatively high scores in the high connective tissue muscles. The magnitude of the effect of cooking technique on palatability varies with muscle but can be of the order of 30 palatability units.

Production factors that impact on palatability

Between breed effects: Most reported breed differences in beef palatability have centred around the *Bos indicus* breed. This is particularly relevant to Australian production systems where *Bos indicus* derived cattle comprise almost 40% of the Australian cattle herd. A number of researchers (e.g. Hearnshaw et al. 1998) have reported that cattle with high *Bos indicus* content tend to have lower marbling scores and produce less tender and more variable striploin steaks than *Bos taurus* breeds.

hang (AT, TC, TS)	AT
sex (M, F)	M
epbi (est %)	0
hump (cm)	0
cwt	260
uoss	160
MFV? (Y, N)	N
umb	250
d.aged	7
ribfat	12
pHu	5.60
AMC (1a, 1b, ..., 6)	1b
Saleyard? (Y, N)	N
calculated wam	0.72

cut	muscle	d.aged	GRL	RST	SFR	TSL	SC1	SC2	CRN
spinalis	SPN081		74 4	66 4	74 4	75 4			
tenderloin	TDR034				74 4				
tenderloin	TDR062		78 5	76 4	80 5				
cube roll	CUB045		62 3	62 3	62 3	64 4			
striploin	STR045a		56 3	54 3	58 3	58 3			
striploin	STR045p		53 3	53 3	56 3	57 3			
oyster blade	OYS036		63 3	61 3	66 4	69 4			
blade	BLD095				44 x				
blade	BLD096		53 3	57 3	59 3	63 3	52 3	56 3	
chucktender	CTR085			49 3	50 3	57 3	51 3	54 3	
rump	RMP131		50 3	59 3	57 3	58 3			
rump	RMP231		54 3	62 3	63 3	68 4			
rump	RMP005				66 4	69 4			
rump	RMP032				63 3				
rump	RMP087				60 3				
knuckle	KNU066		48 3	60 3	56 3	61 3	37 x	46 3	
knuckle	KNU098				54 3	59 3	46 3	55 3	
knuckle	KNU099		36 x	58 3	45 x	56 3	41 x	50 3	
knuckle	KNU100				62 3	64 4	51 3	56 3	
outside flat	OUT005			42 x	45 x	53 3	41 x	51 3	52 3
outside flat	OUT029				56 3	62 3	50 3	52 3	
eye round	EYE075		41 x	51 3	48 3	50 3	43 x	48 3	41 x
topside	TOP001		41 x		50 3	56 3	41 x	43 x	
topside	TOP033		34 x		52 3	57 3	50 3	55 3	
topside	TOP073		35 x	44 x	43 x	56 3	32 x	46 3	
chuck	CHK068**				49 3	49 3			
chuck	CHK074				61 3	66 4			
chuck	CHK078			56 3	58 3	60 3	57 3	63 3	
chuck	CHK081				59 3				
chuck	CHK082**				53 3				
thin-flank	TFL051				60 3		57 3	61 3	
thin-flank	TFL052				64 4				
thin-flank	TFL064				63 3		54 3	58 3	
rib-blade	RIB041				51 3				
brisket	BRI056				40 x	51 3	39 x	48 3	28 x
brisket	BRI057				38 x	50 3	36 x	51 3	
shin	FQshin						46 3	54 3	
shin	HQshin						54 3	59 3	
intercostal	INT037				56 3				

Figure 5a-1. A sample output from the MSA cuts based model model, showing the inputs used to predict palatability (hanging technique, sex, estimated *Bos indicus* content, hump height, carcase weight, ossification score, milk fed vealer classification, USDA marbling score, days aged, rib fat depth, ultimate pH, AUSMeat muscle colour and selling method) and the outputs which comprise predicted palatability scores and star rating (ungraded, 3, 4 or 5 star grade) by individual muscle and cooking technique. Those cells which are blank represent muscle/cooking techniques combinations that have not been tested.

Most research on the *Bos indicus* effect has been undertaken using the striploin cut. MSA examined the interaction between *Bos indicus* content and cut palatability in an experiment where animals ranged in *Bos indicus* content from 0 to 100% (Thompson, Polkinghorne, Hearnshaw and Ferguson, 1999a). Table 5a-1 shows the regression coefficient for the palatability score of different muscles as a function of percentage *Bos indicus* content after ageing for 14 days. These results clearly demonstrate a *Bos indicus* x muscle interaction, with a decline in palatability with increased % *Bos indicus* content most evident for the muscles surrounding the spinal column (i.e. *m. longissimus* and *psoas* which make up the cube roll, striploin and tenderloin cuts). These results indicated that it would not be appropriate to incorporate a single *Bos indicus* adjustment across all muscles, as the magnitude of the *Bos indicus* effect was muscle dependent.

Growth path effects: Rapid growth over the lifetime of the animal is often cited by industry as resulting in more tender and palatable beef. Oddy et al. (2001) concluded that there was evidence that variation in growth rate could impact on the structure and cross-linking of the collagen matrix and also the proteolytic activity and potential rate of glycolysis of the myofibre component of the muscle. However, the literature is divided on the importance of the effect of growth rate on palatability, with some studies reporting no difference in tenderness or palatability due to growth rate, whilst others have reported a positive association.

The early results from MSA found that, in commercial cattle, there was a weak but positive correlation between palatability score and growth rate (r=0.23), where growth rate was calculated from a ratio of estimated live weight gain and age was estimated by ossification score (Thompson et al 1999a). In the subsequent development of the cuts-based-grading model, palatability score was adjusted for carcase weight nested within ossification score (Thompson et al. 1999a) to provide a more stable adjustment. Whilst the contribution of growth path to final palatability was not large, it was essentially additive to the impact of other CCPs identified in the model.

More recently, a detailed analysis of the Cooperative Research Centre for Cattle and Beef Quality (Beef CRC)/MSA database has been reported by Perry, et al. (2002). The cattle comprised both temperate and tropically adapted breeds finished to a range of slaughter weights on different finishing systems. The data showed a positive relationship between growth rate and palatability. Within a group of animals an increase in growth rate from 0.6 kg/day to 1.0 kg/day resulted in an increase in palatability of approximately 4 units, which is similar to the magnitude of the growth path response described in the MSA model. Even though the growth rate effect is relatively small compared with other CCPs it is important and remains a critical control point that impacts on the production sector of the beef supply chain.

Hormonal growth promotants (HGPs): Hormonal growth promotants are widely used in the Australian beef industry as a means of increasing productivity in both the grass- and grain-fed sectors. However, whilst there are

Table 5a-1. Regression coefficients for the effect of *Bos indicus* content on the MSA palatability score of different muscles, ranked in order of the magnitude of the effect after adjustment for cooking, hanging, US marbling and ossification scores and their interactions. (Thompson et al. 1999a).

Primal Cut	Muscle	Regression coeff (b)	se of b	Significance
Tenderloin	*m. psoas major*	-0.09	0.020	P<0.0001
Cube roll	*m. longissimus thoracis*	-0.08	0.021	P<0.0001
Striploin	*m. longissimus lumborum*	-0.08	0.020	P<0.0001
Brisket	*m. pectoralis profundus*	-0.05	0.038	ns
Spinalis	*m. spinalis dorsi*	-0.05	0.036	ns
Eye Round	*m. semitendinosus*	-0.04	0.022	P<0.10
Knuckle	*m. rectus femoris*	-0.03	0.019	P<0.10
Rump	*m. gluteus medius*	-0.03	0.020	ns
Blade	*m. triceps brachii*	-0.02	0.020	ns
Topside	*m. semimembranosus*	-0.01	0.018	ns
Oyster blade	*m. infraspinatous*	-0.01	0.026	ns
Outside flat	*m. biceps femoris*	0.01	0.018	ns

Table 5a-2. Predicted MSA palatability scores from grilled and roasted samples from 4 primal cuts from HGP and control animals after ageing for 5 or 21 days (B. McIntyre, unpublished data).

Cut	Position	5 days aged		21 days aged		
		HGP	Control	HGP	Control	Av se
Striploin (*m. longissimus dorsi*)	Anterior	44.6	54.4	61.6	67.1	*2.2*
	Posterior	38.0	51.2	51.8	56.3	*2.3*
Rump *(combined muscles)*		55.6	62.5	62.4	64.6	*2.0*
Oyster Blade *(m. infraspinatous)*		65.9	66.6	66.7	66.6	*2.0*
Blade (*m. triceps brachii)*		54.4	53.3	59.1	60.2	*1.9*

clear benefits in terms of liveweight gain and efficiency, a number of studies have reported that HGP implants were responsible for reductions in marbling scores and an increased incidence of dark cutters. There is also a trend for HGP treatment to increase meat toughness, although to date the results have been variable, Published data on HGP effects generally refer to the striploin and have not included evaluations of other muscles.

HGP's were not initially included as a predictor in the MSA model, although recent results from both US studies and Australian studies suggest that this should be reviewed. Recent results from the Beef CRC/MSA research program (B.M. McIntyre, *unpublished data*) investigated the effect of a strong HGP implant (Revalor-S and –H) on palatability of samples from a variety of muscles. The experiment used a total of 80 Angus yearlings which were finished in a domestic feedlot. Half the steers and heifers were implanted with Revalor-S and Revalor-H, respectively. Animals were slaughtered 60 and 70 days later, whilst still within the payout period for the implants, and the striploin, rump, blade and oyster blade cuts collected for both objective and sensory evaluation. Samples were aged for 5 and 21 days prior to testing, as grills or roasted samples, by consumer taste panels.

The rump muscles comprised the *m. gluteus medius* and the proximal portion of the *biceps femoris* which is included in the rump cut.

To date a total of 577 samples have been sensory tested. This comprised 70% of the striploin samples and between 50 and 60% of the rump, oyster blade, and blade muscles. Despite the imbalance in sample numbers there are some clear trends. The striploin showed the largest HGP effect, with the HGP treated striploins having a 10 point lower palatability score than the controls at 5 days of ageing (Table 5a-2). The magnitude of this HGP effect in the striploin decreased to about 5 palatability units after 21 days ageing. The HGP effect was also evident in the rump muscles, although the magnitude of the effect was less than in the striploin. An intriguing result was the clear interaction of the HGP treatment with muscle, with little evidence of the HGP effect in the blade and oyster blade muscles.

It is an MSA priority to quantify the magnitude of various HGP implants on palatability, along with guidelines for their use in terms of repeated implantation and time of slaughter relative to the payout period of the implant. When incorporated into the MSA model the HGP effect will simply quantify the magnitude of the effect in terms of palatability. The extent to which HGPs are used will depend upon the value placed by producers on the penalty for palatability relative to the advantages of increased weight gain and feed efficiency. It is likely that the size of the palatability penalties will vary considerably between markets. As the magnitude of the HGP effects decreased with ageing there is an opportunity in some markets to age the product for sufficient time to minimise the HGP effect. Other alternatives may include accelerating the ageing effect by tenderstretching HGP implanted carcases.

Management of animals in lairage

The MSA criteria for supplying cattle are focused on minimising stress on farm, during transport, and in lairage, and therefore minimising depletion of muscle glycogen reserves prior to slaughter. To achieve an ultimate pH ca. 5.5 in the post-slaughter muscle there needs to be at least 57 *u*moles/g of glycogen in the muscle pre-slaughter to form sufficient lactic acid to lower pH. If glycogen reserves have been depleted below this threshold then an elevated ultimate pH will result and the meat will have a dark colour, which is typically referred to as dark cutting or dark firm dry (DFD) meat. As ultimate pH increases the meat appears to be less juicy, lacks visual appeal and has reduced shelf life. Up to a pH of 6.0, dark cutting meat is also tougher. MSA chose a maximum ultimate pH of 5.7, primarily because of the impact on palatability, but also due to the effect of high pH on degree of doneness, consumer appeal and shelf life.

Stress in a number of forms will deplete glycogen reserves. The effect of transport on glycogen mobilization and ultimate pH post-slaughter is not well documented and tends to vary with the type of animal, nutritional status and the conditions during transport .

In Australia almost half of all prime cattle are marketed through saleyards. This method of selling is more popular in the southern states and also with small lots of cattle. Initially MSA required direct consignment of cattle to the abattoir in an effort to minimise stress and the subsequent depletion of glycogen reserves. A comparison between direct consignment and best practice saleyard selling showed a small penalty in terms of palatability (D.M. Ferguson, *unpublished data*). The best practice saleyard option required animals to be well handled, not mixed, have water available and be slaughtered the day after dispatch from the farm. Based on these results MSA has introduced a saleyard option with a 5 point palatability penalty, relative to direct consignment, for all muscles.

Mixing has been shown to cause mobilization of glycogen and should be avoided at all costs. Certainly, the data for bulls showed mixing results in high levels of dark cutting. For animals which are consigned direct to the abattoir mixing is seldom a problem, although the same cannot be said of saleyard selling.

Current research activities of the Beef CRC are aimed at both enhancing the adaptability of cattle to specific stressors and developing alternative pre-slaughter management strategies to minimise stress.

Optimising the slaughter process for palatability

pH/temperature window: The concept of the pH/temperature window originated from earlier research that showed that myofibrillar shortening occurred when pre-rigor muscle was held at either low or high temperatures. The MSA pH/temperature window requires that electrical inputs during processing be managed to achieve a pH/temperature relationship of greater than pH 6 for muscle temperatures greater than 35°C, and a pH of less than 6 for muscle temperatures less than 12°C (see Figure 5a-2).

When the MSA pH/temperature window was implemented as part of the abattoir audit it was found that many abattoirs were effectively over-stimulating, with carcases clearly entering the heat shortening region (i.e. achieving pH 6 at temperatures greater than 35°C). This was due in part to other electrical inputs being installed in the slaughter chain (e.g. immobilisers and rigidity probes) which, along with electrical stimulation, accelerate glycolytic rate. It is clear that differences between abattoirs in the positioning of the stimulator, effectiveness of contact electrodes, and speed of the chain make it impossible to recommend a uniform protocol for stimulation. The approach taken by MSA is to regularly audit individual abattoirs and then adjust the electrical inputs to match the window specifications.

Alternative carcase suspension: Tenderstretching is done by suspending the side by the pelvis as it comes off the slaughter chain, thereby placing increased tension on the major leg and loin muscles before the muscles pass through rigor. The magnitude of the tenderstretch effect in the MSA model was reported by Ferguson et al. (1999). Their results (see Table 5a-3) demonstrated that the palatability of most hindquarter muscles was improved following tenderstretching. Exceptions included the *m. poas major* which was subjected to less tension pre-rigor in the

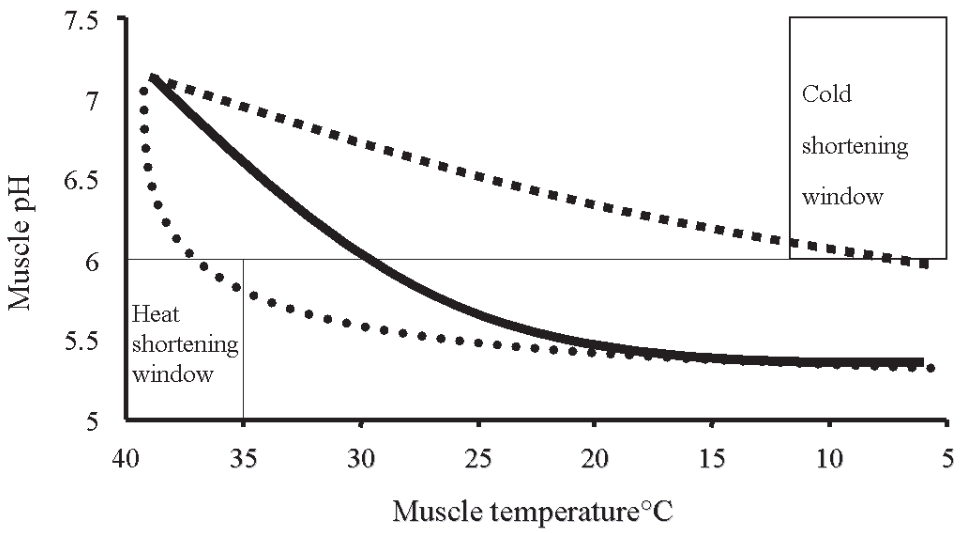

Figure 5a-2. The pH/temperature window used by MSA to optimise the decline in pH relative to the temperature of the muscle. The solid line represents an optimal rate of decline, the dashed line a cold shortening, and the dotted line, a heat shortening scenario.

tenderstretched compared with the normally hung side. Also the eye round (*m. semitendinosus)* was stretched to a similar degree in both the tenderstretched and normally hung sides and therefore showed no difference in palatability. Since this report the tenderstretch effect in the MSA model has been extended to more muscles and cooking techniques.

Table 5a-3. Palatability scores for muscles from electrically stimulated tenderstretched and achilles hung sides after adjustment for cooking, hanging, US marbling and ossification scores and their interactions (Ferguson et al. 1999).

Muscle	Tender Stretch	Achilles	Sign
Forequarter			
Pectoralis profundus	32	35	ns
Triceps brachii	55	56	ns
Infraspinatous	61	62	ns
Longissimus thoracis	65	63	P<0.05
Spinalis dorsi	75	76	ns
Hindquarter			
Longissimus lumborum	61	55	P<0.001
Psoas major	71	74	P<0.01
Gluteus medius	64	57	P<0.001
Semimembranosus	45	38	P<0.001
Biceps femoris	50	47	P<0.001
Semitendinosus	48	47	ns
Rectus femoris	50	48	P<0.001

Tenderstretching obviously provides a very cheap and effective means of managing palatability in beef and is being adopted widely by the Australian industry. The disadvantages of tenderstretching in terms of increased labour (to both tenderstretch the sides as they enter the chiller and to rehang them by the achilles tendon when exiting the chiller for boning) and decreased chiller capacity are a small price to pay for the increased palatability. The smaller tenderstretching effect in highly palatable sides is offset by the added insurance against problems in processing.

Other post-slaughter factors that impact on palatability

Marbling: Although marbling is generally an integral part of any beef grading scheme the literature suggests that it has only a minor association with palatability. Many markets have large premiums for increased levels of marbling and therefore in many carcase grading schemes it is given a very high weighting. The MSA data base has quantified the relationship between marbling score recorded on the striploin and palatability in a range of cuts.

The MSA model showed that the contribution of marbling to palatability was not high, but as this factor tends to be additive to other chiller assessment, processing, and production effects the small increase in score may be sufficient to lift the palatability score into the next grade.

Ageing: Ageing refers to the improvement in palatability that occurs as meat is held post-mortem. Ageing rates for individual muscles are higher for the low connective cuts relative to high connective cuts. From 5 days the ageing rate for muscle from the hindquarter and loin of a tenderstretch side are approximately 66% of that in the normally hung side. Given that MSA testing has shown that hindquarter cuts from tenderstretch sides were more palatable at the commencement of the ageing period and had a lower ageing rate, the palatability of muscles from the hindquarter of tenderstretch and normally hung sides would converge with extended ageing.

The accuracy of the MSA model

The ability of the MSA cuts based model to accurately describe palatability grade has been tested using the MSA data base. Over 19,000 cut x cook combinations were available in the data base, after discarding those samples which did not comply with the basic criteria (i.e. had a fat depth less than 3mm or pH > 5.7 or ossification score > 300).

Table 5a-4 shows that the model correctly classified between 50 to 70% of the samples, with 95 to 97% of the predicted scores being within one grade of their consumer rating. If a muscle was predicted by the cuts based model to be ‘ungraded’ then there was ca. a 70% chance that this agreed with the consumer panels. If the model was incorrect, it was generally only 1 grade out, i.e. if the model said it was “ungraded” then there was only ca. a 30% chance it was a “3 star”, but essentially little chance it was a “4 star” or “5 star”. Similarly for muscles that graded “3” or “4 star”, the model was correct about 50% of the time and again, if it was wrong, it was only by one grade. At the top and bottom grades the accuracy was of the order of 60 to 70%. This is an order of accuracy greater than is possible by just using carcase measurements of fat depth, carcase weight, marbling and dentition measured in the chiller (Hearnshaw, et al. 1995).

Table 5a-4. The ability of the MSA cuts based model to correctly classify samples into consumer grades. The bolded cells represent the percentage of samples which were graded correctly according to the consumer taste panel results.

	Grade given by Consumer panel				
Predicted grade using the MSA model	Ungraded	3 star	4 star	5 star	Total
Ungraded	**68**	29	3	0	100
3 star	24	**50**	23	4	100
4 star	3	25	**49**	23	100
5 star	0	5	32	**63**	100

Conclusion

The MSA grading system is a quality assurance system capable of managing palatability. CCPs which impact on palatability have been quantified using large scale consumer taste panels. For the Australian production system *Bos indicus* is an important CCP. Whilst the magnitude of the growth rate effect on palatability is smaller, it is additive to breed. HGP implantation is not currently incorporated into the MSA scheme, although it can have a substantial impact on palatability and its incorporation into the model is being reviewed. Pre-slaughter and processing effects can have a large impact on palatability and the MSA system has made compliance with these CCPs mandatory. Other post-slaughter CCPs include tenderstretching, marbling and ageing which all have a significant impact on palatability. These CCPs are used as inputs into a model to predict palatability. The model provides a multitude of pathways to achieve a defined quality outcome. The rationale behind this is that, as long as handling the animal/ carcase along the beef supply chain meets welfare and food safety standards, the consumer is not concerned by the means by which a muscle achieved its palatability score, rather that palatability matched the description.

Acknowledgements

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References

Ferguson, D., Thompson, J., and Polkinghorne, R., (1999). Meat Standards Australia, A 'PACCP' based beef grading scheme for consumers. 3) PACCP requirements which apply to carcass processing. *45th Int. Con. Meat Sci. & Tech.* Yokohama, Japan. 45: 18-19.

Hearnshaw, H., Arthur, P.F., Stephenson, P.D., Dibley, K., Ferguson, D., Thompson, J.M., O'Halloran, J., Morris, S. and Woodhead, A. (1998). Meat quality of Angus, Braham and Piedmontese-sired progeny: Results from the first calf crop. *Proceedings of the Sxith World Congress on Genetic Applied to Livestock Production.* 25: 165-168.

Hearnshaw, H. Shorthose, W.R., Melville, G., Rymill, S., Thompson, J.M., Arthur, P.F.and Stephenson, P.D. (1995). Are carcass grades a useful indication of consumer assessment of eating quality of beef? *Meat 95.* CSIRO, Brisbane.

Oddy VH, Harper GS, Greenwood PL and McDonagh MB (2001) Nutritional and developmental effects on the intrinsic properties of muscles as they relate to the eating quality of beef. *Australian Journal of Experimental Agriculture,* **41**, 921-942.

Perry D. Thompson, J.M., Reverter, A. and Johnston, D.J. (2002). Effect of growth rate on palatability in beef cattle. In: *48th International Congress for Meat Science and Technology, Rome, Italy* (in press).

Polkinghorne, R. Watson, R., Porter, M. Gee, A., Scott, J. and Thompson, J. (1999). Meat Standards Australia, A 'PACCP' based beef grading scheme for consumers. 1) The use of consumer scores to set grade standards. In: *45th International Congress of Meat Science and Technology, Yokohama, Japan* **45**:14-15.

Thompson, J., Polkinghorne, R., Hearnshaw, H., and Ferguson, D. (1999). Meat Standards Australia, A 'PACCP' based beef grading scheme for consumers. 2) PACCP requirements which apply to the production sector. In: *45th International Congress of Meat Sciences and Technology, Yokohama, Japan* 45:16-17.