PE7.34 Prediction of eating quality using the meat standards Australia system for northern Ireland beef and consumers 344.00

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***Abstract*— A study was conducted to evaluate the effectiveness of the Meat Standards Australia (MSA) beef grading model at predicting eating quality for Northern Ireland (NI) beef and NI consumers. These results indicate that the MSA system predicted the quality of NI beef effectively for most muscles, with the exception of knuckle (*M. rectus femoris*). For NI consumers the prediction of eating using the MSA model appeared to be mainly based upon tenderness. There is evidence that flavour was more important for NI consumers than for Australian consumers. Further studies will report the effectiveness of the MSA model over a wider range of treatments.**

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***Index Terms*—beef, sensory, eating quality**

I. INTRODUCTION

Beef is a natural product and there can be considerable variation in its eating quality. This can be influenced by many factors, including genetics, diet, sex, husbandry, handling and stress, electrical stimulation, chilling rate, hanging method, ageing, packaging, the cut or muscle and cooking. The impact of unpredictable eating quality together with the lack of time and experience for home cooking may contribute to a sometimes disappointing eating experience.

The "Meat Standards Australia" (MSA) system has been developed as a quality assurance system for the eating quality of beef. The extensive research underpinning the development of this system [1, 2] identified the critical control points affecting eating quality and used consumer panels to quantify the impact of each factor (and interactions between them) on eating quality. This consumer sensory data was used to develop a model to predict the final eating quality for a particular muscle and cooking method from information recorded for each animal pre- and post-slaughter.

This system has been implemented commercially for 37% of the domestic beef slaughtered in Australia (AU) [3]. In some cases the system is used to provide a single grade of quality assured "MSA beef", while in other cases, it is used to differentiate between several different grades of beef [4]. It is claimed that, following the implementation of MSA, perceptions of beef quality improved amongst consumers and per capita consumption of beef also increased, despite increases in the retail price of beef [3].

The factors of key importance for eating quality in the MSA beef grading model include: muscle, position within muscle, hanging method, *% Bos indicus* breed, use of hormonal growth promoters, marbling, maturity (as estimated by ossification), carcase weight, rib fat cover, meat colour, ultimate pH, ageing and cooking method [1]. In addition, participating meat plants have to meet requirements to minimize handling stress and to ensure that the electrical stimulation/chilling regime will allow an appropriate pH decline against temperature.

Some of these factors, especially *% Bos indicus* breed and use of growth promoters, do not apply in the UK or in other EU countries. In addition, the impact of maturity will be much smaller, due to the absence of drought stress and differences in production practices. Nevertheless, with the removal of restrictions on slaughtering beef animals for food at over 30 months of age in the UK, beef from older animals does now enter the food chain. The MSA system does not predict eating quality for bulls or beef cooked "well-done" and the impact of dairy beef was not investigated**.** Despite these differences, many of the factors impacting on eating quality in Australia, especially in the southern states where European breeds are the norm, are common to Northern Ireland and Europe.

This preliminary study was conducted to evaluate the effectiveness of the standard MSA model at predicting eating quality for Northern Ireland (NI)

beef and for NI consumers eating "medium" and "well-done" beef. A range of cuts and treatments were selected to give a wide range of qualities of beef. Future publications will investigate the use of MSA to predict quality for a range of other factors including dairy beef and bulls.

II. MATERIALS AND METHODS

Source of beef

Twenty four NI cattle and twenty AU cattle were slaughtered and the meat sampled as described by Farmer *et al.* [5]. Carcase information, namely breed, sex, hot standard carcase weight was recorded. MSA grading measurements of hump height, ossification, rib fat, marbling, meat colour, fat colour, ultimate pH and temperature were recorded after quartering.

Labelled primal joints were boned out, vacuum packed prior to being prepared for consumer panels as described by Farmer *et al.* [5]. All samples were aged for 7 days post-slaughter prior to blast freezing. The muscles evaluated were: striploin (*M. longissimus dorsi)*, anterior, mid and posterior portions (STR045A, STR045M, STR045P), rump heart and rump heart eye *(M. gluteus medius;* RMP131, RMP231*)*, knuckle *(M. rectus femoris and M. vastus lateralis;* KNU066, KNU099*)*, and topside (*M. semimembranosus,* TOP073*)*. The alpha/numeric codes are those used as a description system for MSA identification of specific muscle portions.

Consumer panels

Consumer panels in Australia and Northern Ireland assessed beef as follows: AU meat eaten by AU consumers, cooked "medium" (AU/AU/MED), AU meat eaten by NI consumers, cooked "medium" (AU/NI/MED), NI meat eaten by NI consumers, cooked "medium" (NI/NI/MED) and NI meat eaten by NI consumers, cooked "well-done" (NI/NI/WD). Beef was assessed grilled and roasted, as described by Farmer *et al.* [5]. Roast joints were cooked in a fan assisted electric oven. Those samples allocated to 'medium' and 'well done' degree of doneness endpoint were cooked to internal temperature of 70^{o}C and 80^{o}C, respectively. Grilled steaks were cooked on a Silex grill set to 200^{o}C for 5 minutes 45 secs for "medium", and 215^{o}C for 6 minutes 45 secs for "well-done".

Steaks or roast from each cut/muscle from each animal were sampled by 10 consumers [5]. Consumers scored portions for tenderness (TE), juiciness (JU), flavour liking (FL) and overall liking (OL) by placing a mark on a 100 mm line scale. Additionally, they were asked to assign a quality rating to each sample: "unsatisfactory", "satisfactory everyday quality", "better than everyday quality" or "premium quality". In Australia, a clipped mean was determined for each sensory attribute after discarding the top and bottom pairs of responses. In this work, the mean of all responses was used. A comparison of these methods showed no difference and thereafter they are treated as the same score.

Data analysis

Discriminant analysis was used to determine coefficients for the relationship between satisfaction grade and the sensory scores. These coefficients, to predict satisfaction grade from the sensory scores, were scaled so that they summed to 1. This was repeated leaving out the variable overall liking. A second discriminant analysis was carried out between satisfaction grades and MQ4 (as derived by equation (a) below). The results from this analysis allowed the meat samples to be graded as unsatisfactory, 3*, 4* or 5*.

The predicted MQ4 score (MQ4pred) was obtained for each muscle and position within muscle using the MSA model. This was compared with the MQ4 score determined experimentally by comparing the mean residuals.

Linear regression analysis was used to assess the relationship between each of the measures of eating quality determined by consumer panels and MQ4pred, while testing for differences due to country of origin of the beef, country of residence of the consumer and "doneness".

III. RESULTS AND DISCUSSION

As part of the development of the MSA model, the relationship of the satisfaction grade to the four sensory scores and to the first three only was determined using discriminant analysis [6]. An approximate average of the factors from the three term and four term equations was taken to give the MSA working equation (a) for palatability on a scale of 0-100:

$$\textbf{(a) MQ4 = 0.4*TE + 0.1*JU + 0.2*FL + 0.3*OL}$$

The MSA boundaries between "unsatisfactory", "satisfactory everyday quality" (3 star), "better than everyday quality" (4 star) and "premium quality" (5 star) were found to be ca. 42, 65 and 78, respectively [6].

MQ4 as a measure of eating quality for NI consumers

Examination of the data for NI panellists eating NI beef allowed the boundaries and coefficients for

the MQ4 equation to be compared between the NI consumers and those forming the basis of the Australian MSA system. Discriminant analysis gave coefficients relating satisfaction to the attributes as shown in Table 1. Using the 3 and 4 variable discriminant functions approximately 63% and 65% of the samples were correctly allocated to their satisfaction rating.

Table 1. Coefficients for contribution to satisfaction scores of tenderness, juiciness, flavour liking with and without overall liking for NI consumers

	TE	**JU**	**FL**	**OL**
4 attributes	0.23	0.02	0.22	0.53
3 attributes	0.35	0.08	0.57	

The observed differences between the three attribute and the four attribute coefficients were in accord with those reported by Watson *et al.* [6]. These authors also found that the inclusion of overall liking generated a large coefficient for this attribute and reduced the coefficients for the more specific attributes, but found that overall liking assisted in the predictive power of the equation. The three-attribute coefficients (Table 1) suggest that, over the wide range of qualities of beef tested, flavour liking was at least as important as tenderness for the NI consumers and possibly more so. This contrasted with the findings for AU consumers. Watson *et al.* [6] reported an example of the three attribute equation to be: MQ3 = 0.53*TE + 0.17*JU + 0.30*FL, indicating that tenderness has the greatest impact on the satisfaction rating [6]. These findings also question the long-held view that tenderness is the most important aspect of eating quality for beef and are supported by Oliver *et al.* [7] who reported that, for German, Spanish and British consumers, the regression coefficients for the prediction of the overall acceptability were at least as high for flavour as for tenderness, and often considerably higher. More recent analysis of Australian, Korean and Japanese data has also supported a re-evaluation of the coefficients used in the MSA model in which flavour and tenderness have similar weightings (Polkinghorne R *personal communication*).

One might speculate that this greater importance of flavour reflects the customary cooking of beef to "well-done" in NI. The associated longer cooking times will allow more flavour development than would occur in medium-cooked beef. However, only small differences in coefficients for flavour were found for "well-done" and "medium" cooked beef: 0.54 and 0.59, respectively, for the 3 attribute coefficients. Furthermore, the data reported by Oliver *et al.* [7] were all on beef cooked to the same internal temperature (72^{o}C).

The boundaries derived for the NI consumers between "unsatisfactory", "satisfactory everyday quality" (3 star), "better than everyday quality" (4 star) and "premium quality" (5 star) were found to be 38, 60 and 77. These were slightly lower than those reported by Watson *et al.* [6] for Australian beef. This may suggest that the NI consumers were a little more easily satisfied than those in Australia. Watson *et al.* [6] reported that these boundaries varied a little from taste panel to taste panel, but that there was general agreement in terms of the form of this relationship. It would appear that NI consumers fit this general pattern.

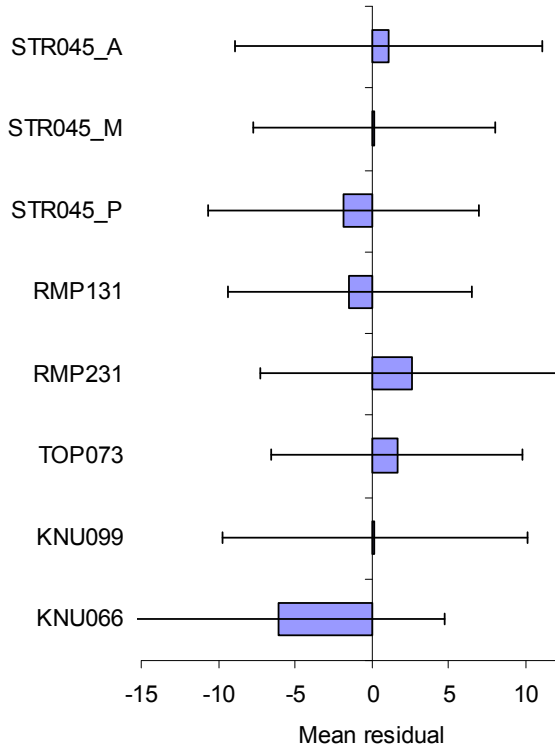
An equation specific to the NI consumer responses was tested but the exact formulation of this equation made only small differences to the accuracy of prediction of eating quality, presumably due to high correlations between sensory variables (not shown). For consistency, the MSA system has been evaluated using the Australian equation (a) for MQ4.

Accuracy and precision of prediction

The Australian MSA model provides a predicted MQ4 score (MQ4pred) from the factors recorded for each carcase. One measure of the success of the MSA system for the meat used in this experiment was to determine the residual differences between the calculated MQ4 score (MQ4calc) derived from equation (a) and MQ4pred from the MSA model. The mean residuals are presented for each muscle/position in Figure 1.

The results in Figure 1 showed that, on average, the MSA model predicted the MQ4 score accurately (± 3 on a 0-100 scale) for all the muscles/positions tested except for the knuckle (KNU066). This agreed with findings that knuckle from the NI group of animals was judged differently to those from Australia [5]. The standard deviations of the residuals are 10 or less, indicating that the precision of prediction was reasonable. This suggested that, if a particular muscle or cut was predicted to have a MQ4 score of 60, then about 67% will lie between 50 and 70, subject to the systematic error described above. Only about 17% will lie below a score of 50. Most of these residuals are similar to the results of Watson [8] when the accuracy of the MSA model was tested for Australian consumers. In terms of meat eating quality prediction, this was very acceptable.

Figure 1. Residuals (MQ4calc – MQ4pred) for muscles from NI animals (error bars show standard deviations)



These results represent only the first of a number of trials using the MSA system and a greater number of animals, cuts and factors have since been assessed to determine the full effectiveness of MSA for NI consumers. Nevertheless, these initial findings suggest that the MSA system has the potential to predict eating quality for NI consumers and European beef.

Differences in prediction due to meat country of origin/country of residence of consumers/doneness

In order to compare the ability of MSA to predict the MQ4 for NI and Australian consumers and for "medium" and "well-done" beef, a regression analysis was conducted between MQ4pred and each of the attributes determined by consumer panels, for each of the composite treatments (Table 2).

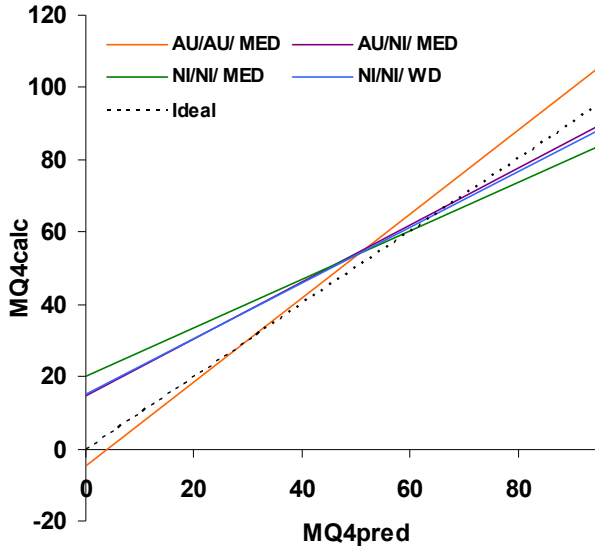
Table 2 shows the gradient and intercept for each of the regression lines obtained. In each case, the relationship was described by distinct lines for the different treatments (e.g., Figure 2). In all cases, all three lines for NI consumers were very similar, irrespective of meat eaten or extent of cooking, and these differed from those for the AU consumers. Overall, the MQ4 estimated from the MSA model explained variability in tenderness (42% variance) and MQ4calc (36%) better than overall liking (31%), flavour (25%) or juiciness (18%).

Table 2. Linear regression analysis (intercept *a* and gradient *b)* between MQ4pred and individual consumer sensory scores.

Treatment[#]		TE	JU	FL	OL	MQ4 calc
AU/AU / MED	**b**	**1.41**	**0.86**	**0.89**	**1.11**	**1.16**
	a	-16.7	6.1	11.1	-2.1	-4.5
AU/NI/ MED	**b**	**1.08**	**0.47**	**0.55**	**0.66**	**0.79**
	a	-0.4	29.7	27.2	20.8	14.5
NI/NI/ MED	**b**	**0.93**	**0.39**	**0.45**	**0.56**	**0.67**
	a	6.5	34.3	31.7	25.5	20.0
NI/NI/ WD	**b**	**1.05**	**0.45**	**0.56**	**0.66**	**0.77**
	a	0.1	29.1	27.3	21.8	14.9
Significance		***	***	***	***	***
Variance explained (%)		42.4	18.4	25.3	30.7	36.3

[#] *Composite treatments: meat country of origin/country of residence of consumers/doneness*

Figure 2. Relationship between MQ4calc and MQ4pred by regression analysis



The ideal prediction of MQ4calc by MQ4pred would be represented by a gradient of 1.0 and an intercept of zero. These relationships suggest that, in this experiment, the MSA model predicted more accurately for AU consumers at lower scores and for NI consumers at higher scores (Figure 2). However, MQ4pred gave an accurate prediction of tenderness for all NI consumers, whether consuming AU or NI beef, and whether "medium" or "well-done".

IV. CONCLUSION

As an initial study, these results indicate that the MSA grading model predicted the eating quality of the NI beef with good accuracy and reasonable precision for most muscles, with the exception of knuckle (*M. rectus femoris*). This prediction of eating quality appears to be largely a function of tenderness for NI consumers but gives a more general prediction of eating quality for AU consumers. Further studies will report the effectiveness of the MSA model over a wider range of treatments.

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