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Predicting beef eating quality

Key external stakeholders:

Beef processors, retailers

Practical implications for stakeholders:

Beef processors could use the Meat Standards Australia (MSA) grading system to sort individual cuts into eating quality classes priced accordingly. Such a guarantee of expected eating quality could increase the share of the market particularly at the premium end. For optimum eating quality boning should not be carried out on the day after slaughter. Processors and retailers need to consider the negative effects of MAP on eating quality.

Main results:

- The MSA palatability grading scheme uses a predictive model to assess the eating quality of individual cuts from each carcass and assigns them to a quality class
- Although the model was developed in Australia using Australian consumers our research showed that it worked equally well for Irish beef and Irish consumers
- The model was tested over a wide range of carcass types and for three cooking methods (grill, roast and thin slice) with over 1600 consumers tasting over 1100 samples
- Factors of particular importance to the Irish beef industry (breed, sex, electrical stimulation, aitch-bone hanging, prolonged ageing) were accounted for by the model
- Boning at 24 v 48 hours post mortem had a small negative effect on eating quality and this was not accounted for by the model
- PiVac, a novel method of avoiding cold shortening of hot boned beef (Tenderbound) produced meat of equal quality to cold boning
- High resolution imaging using hyperspectral imaging can predict eating quality attributes with a high degree of accuracy
- High oxygen MAP promotes lipid oxidation leading to off-flavours and protein oxidation leading to less tender meat
- Irish consumers preferred meat from MAP packs with 50% oxygen despite a high level of lipid oxidation

Opportunity / Benefit:

Irish beef processors could use the MSA system to sort beef into quality classes and supply the market with beef of guaranteed quality.

Collaborating Institutions:

UCC and UCD

Contact Paul Allen Email: paul.allen@teagasc.ie

Teagasc project team: Dr Paul Allen (PI), Dr Karen Brandon, Anna White, Dr Maeve Henchion and Dr Sinead mcCarthy

External collaborators: Prof. DaWen Sun and Dr Patrick Jackman (UCD), Dr Joe Kerry, Dr Michael O'Sullivan and Patricia Zakrys (UCC)

1. Project background:

Previous research has shown that the eating quality of Irish beef is variable. This agreed with major studies carried out in Australia and USA. In those two countries there is some attempt at assessing likely eating quality as part of the carcass grading, but the EUROP carcass grading scheme is not attempt related to palatability. Meat and Livestock Australia addressed the problem of declining beef sales due to inconsistent palatability by devising a grading system that predicts the eating quality of the main beef cuts from individual carcasses cooked by a number of different methods. The inputs for the model are all the live animal and post slaughter factors that are known to affect palatability. The effects of these factors were assessed by around 65,000 consumers who scored samples for tenderness, juiciness, flavour and overall liking. These were combined into a Meat Quality Score (MQS) using appropriate weightings, and cut off points have been determined for four quality categories, denoted by stars. The system has proven to be successful in Australia, as evidenced by the number of carcasses graded the MSA system increasing each year and consumers being willing to pay a premium for graded cuts. Adoption of the MSA system or something similar by the Irish beef industry could improve consumer confidence in the eating quality of Irish beef and increase exports. The model can also be used as a management tool to optimise eating quality and as a training tool to demonstrate to producers how to improve eating quality.

Packaging method is a factor known to affect eating quality that is not included in the model. High oxygen modified atmosphere packaging (MAP) which is now widely used to preserve the attractive bright red colour retail cuts of beef has been shown to adversely affect the flavour and tenderness. In collaboration with UCC studies were carried out to determine the optimum MAP packaging conditions for Irish beef.

An alternative to the palatability at critical control points (PACCP) approach to predicting eating quality that was adopted by MSA is to take non-invasive measurements that are correlated with eating quality. Hyperspectral Imaging (HI) is a technology that shows potential in this regard. A study was carried out in collaboration with UCD to determine whether HI could predict eating quality traits and intramuscular fat.

2. Questions addressed by the project:

The MSA model for predicting palatability is based on a large dataset of Australian beef samples tasted by Australian consumers. It allows the Australian beef industry to market beef cuts with an expected eating quality grade – 3-star, 4-star and 5-star. If this model were suitable for application by the Irish beef industry it would enable then to market beef of more consistent quality. The main question addressed by the project is whether the MSA model would be as accurate at predicting the eating quality assessments made by Irish consumers for Irish beef. A secondary question is whether the main processing factors commonly used in Irish factories are accurately accounted for by the model. If the latter were not the case then a modified model could be considered for Ireland.

In relation to MAP packaging the issues addressed were firstly the optimum percentage of oxygen to maximise eating quality as assessed by Irish consumers and secondly the effect of meat to head space ratio on the eating quality and shelf life.

In relation to HI the issues addressed were how accurately could HI predict eating quality traits and intramuscular fat and what was the best approach to building the predictive models.

3. The experimental studies:

Firstly, a trial was carried out in collaboration with MSA to determine the performance of the model on Irish beef and Irish consumers compared to Australian beef and Australian consumers. Samples from 18 carcasses were taken from a relatively homogenous group of heifers and a similar set of samples were selected in Australia and shipped to Teagasc Ashtown. Duplicates of the latter set were scored by Australian consumers. Irish consumers scored both the Irish and Australian samples. Samples were grilled, roasted or cooked by Yakiniku method (thin slice). The resulting MQS scores were compared with the model predictions and the Irish and Australian scores were compared with each other.

Secondly, samples were collected from a more variable group of carcasses to test the performance of the model over a wider range. These samples were cooked and presented to Irish consumers.

Finally, a series of experiments were conducted to test the model for a number of factors known to be

Contact Paul Allen Email: paul.allen@teagasc.ie

important for the Irish industry. These included breed, sex, high and low voltage stimulation, aitch bone hanging, boning time and ageing time (maturation). These samples were also presented to Irish consumers and their scores were compared with predictions from the model.

4. Main results:

The overall conclusion from the comparative trial was that the model fits Irish beef and Irish consumers at least as well as it fits the Australian beef and consumers for which it was developed. There were some small differences in the relative importance of tenderness and flavour to Irish and Australian consumers.

The model also worked quite well for the variable sample and accounted for the factors of low voltage electrical stimulation (LVES) and ageing time (14 v 28 days) with good accuracy.

How well the model accounted the effects of high voltage electrical stimulation (HVES), breed and sex was tested with cattle from the Teagasc herd at Johnstown Castle. Overall the mean deviations from the model were small for both sexes, both breeds and for HVES and non-stimulated carcases. The only significant sex effect on the eating quality was a higher satisfaction rating for the eye of round sample from heifers compared to steers while the only significant breed effect was a higher score for Charolais eye of round samples than for Aberdeen Angus samples. HVES samples tended to score higher than non-stimulated samples though these differences were significant only for the striploin.

The effect of carcass suspension technique in conjunction with LVES was tested in another experiment. Overall the model was a good fit for both hanging methods with and without stimulation with small mean deviations from the model for all groups. Accuracy was significantly better for aitch bone hung samples, with Achilles tendon hung samples having mean deviations greater than 10 units. Aitch bone hung samples had lower (more tender) average Warner Bratzler Shear Force (WBSF) 14 day values, indicating the tenderising effect of this hanging method on some muscles.

The effect of boning time on eating quality and how this was accounted for by the model was studied. The MSA model assumes that samples are boned out after rigor has been fully resolved which may not be the case on the day after slaughter when boning is often done. The model significantly overestimated the eating quality of 24-hour boned samples suggesting that rigor resolution was had not been completed at this time. Hot (1 hour) and warm (4 hour) boning were also studied. Both hot and warm boning resulted in the mean actual scores for grilled striploin and roasted topside samples being lower than predicted by the model. This is not surprising as the model was developed for cold boning and it is known that removing cuts prior to rigor results in shortening and consequent toughening. These results suggest that the model is not appropriate for hot-boned and warm-boned samples.

Tightly wrapping hot-boned muscles using the PiVac machine has been shown to avoid the negative effect of hot-boning on tenderness. How well the model worked for such samples was tested. The model fitted PiVac samples as well as it did control samples. Mean deviations were small for both groups and both cuts (striploin and topside) indicating no biases. The absolute differences were smaller for PiVac striploin samples suggesting a better fit to the model. This may have arisen because the PiVac system has been shown to reduce variability in tenderness.

Much beef is now sold in high oxygen modified atmosphere packaging (MAP). Recent studies have shown that this may decrease tenderness due to oxidation of the proteases and adversely affect the flavour due to lipid oxidation. The effect of varying the oxygen content of MAP packs on the eating quality of beef steaks was studied in collaboration with UCC. Sensory panels preferred steaks stored in 50% oxygen (0 to 80% studied). This result was more or less repeated with a larger consumer test, which showed a preference for steaks stored in 40% oxygen. TBARS tests confirmed that lipid oxidation had occurred in these steaks suggesting that Irish consumers prefer some degree of rancidity. Protein oxidation and consequent reduced tenderness was also confirmed in these samples suggesting that the flavour effect overrides the tenderness effect.

In collaboration with UCD a novel image analysis system for predicting beef palatability was developed. Using a range of data and image analysis approaches, models to predict the eating quality attributes and WBSF values with a high degree of accuracy have been developed. This could be used alone or to augment the MSA model predictions.

Contact Paul Allen Email: paul.allen@teagasc.ie

5. Opportunity/Benefit:

Irish beef processors could use the MSA grading system or a version of it optimised for Irish beef to sort cuts according to their expected eating quality. Markets could then be supplied with beef of more consistent eating quality which could be sold to consumers with an eating quality guarantee. This could help the industry to maintain or even grow their share of the premium markets for beef.

6. Dissemination:

Main publications:

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4. Zakrys-Waliwander, P I; O'Sullivan, M G; Walsh, H; Allen, P; Kerry, J P. (2011). Sensory comparison of commercial low and high oxygen modified atmosphere packed sirloin beef steaks. *Meat Science,* 88.1: 198-202.
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6. Jackman, P., Sun, D.-W., Allen, P. and Downey, G. (2008). Prediction of beef eating quality from colour, marbling and wavelet texture features. *Meat Science,* **80(4)**, 1273-1281.
7. Jackman, P., Sun, D. W. and Allen, P. (2009). Comparison of the predictive power of beef surface wavelet texture features at high and low magnification. *Meat Science*, **82(3)**, 353-356.
8. Jackman, P., Sun, D-W and Allen, P. (2009). Comparison of various wavelet texture features to predict beef palatability. *Meat Science,* **83(1),** 82-87.
9. ElMasry, G; Da-Wen, Sun; Allen, P. (2012). Near-infrared hyperspectral imaging for predicting colour, pH and tenderness of fresh beef. *Journal of Food Engineering,* 110.1: 127-140.
10. Jackman, P; Da-Wen, Sun; Allen, P. (2011). Recent advances in the use of computer vision technology in the quality assessment of fresh meats. *Trends in Food Science & Technology*, 22.4: 185-197.
11. ElMasry, G; Sun, D-W and **Allen, P.** (2011). Non-destructive determination of water-holding capacity in fresh beef by using NIR hyperspectral imaging. Food Research International 44. 9: 2624-2633.
12. Jackman, P; Sun, DaWen; **Allen, P**. (2010). Prediction of beef palatability from colour, marbling and surface texture features of *longissimus dorsi*. Journal of Food Engineering 96. 1: 151-165.
13. Jackman, P., Sun, D.-W., **Allen, P**., Brandon, K. and White, A. (2010). Correlation of consumer assessment of longissimus dorsi beef palatability with image colour, marbling and surface texture features. Meat Science 84, 3: 564-568.
14. Jackman, P., Sun, D. W. and **Allen, P**. (2009). Comparison of the predictive power of beef surface wavelet texture features at high and low magnification. Meat Science vol. 82, no. 3, p. 353-356.
15. Jackman, P., Sun, D.-W. and **Allen, P**. (2009). Automatic segmentation of beef longissimus dorsi muscle and marbling by an adaptable algorithm. (2009d). Meat Science 83(2): 187-194.
16. Jackman, P., Sun, D.-W. and **Allen, P**. (2009). Comparison of various wavelet texture features to predict beef palatability. (2009c). Meat Science 83(1): 82-87.
17. Jackman, P., Sun, D.-W., Du, C.-J. and **Allen, P.** (2009). Prediction of beef eating quality from colour, marbling and wavelet texture features using homogeneous carcass treatment. *Pattern Recognition,* **42**(5): 751-763.

7. Compiled by: Dr Paul Allen, Food Chemistry and Technology Department, Teagasc Food Research Centre, Ashtown, Dublin 15

paul.allen@teagasc.ie

Contact Paul Allen Email: paul.allen@teagasc.ie