PE7.33 Effect of type and extent of cooking on the eating quality of northern Ireland beef 343.00

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***Abstract*— This study examined the impact of doneness, cooking method and country of residence on consumer sensory scores of beef, and whether these factors were influenced by muscle, hanging method or the country of origin of the beef. Differences in sensory scores due to hanging method and muscle were as expected. The effect of cooking method on eating quality depended on the muscle, with striploin and knuckle being preferred grilled and rump and topside preferred roasted. For consumers who preferred their beef cooked to "medium" or "well-done" endpoints, the effects of doneness on sensory scores was generally small. However, "well-done" cooking gave some decreases in juiciness but improved sensory scores for rump.**

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***Index Terms*— beef, consumer sensory scores, eating quality, degree of doneness**

I. Introduction

The effect of the type and extent of cooking arises from a series of complex interactions between the time, level and type of heat input on the components of meat, and the impact of these changes on texture and flavour. The proteins in both the myofibre and connective tissue denature on cooking. The changes in texture of cooked meat with increased temperature are not linear. Cooking meat from medium to well-done will begin to gelatinize the collagenous connective tissue in the muscle, whilst at the same time enhancing hardening and shrinkage of the myofibrils within the muscle cell [1]. Therefore, with increased application of heat the connective tissue component becomes more tender, whilst the myofibre component becomes tougher. In addition, flavour precursors, formed through the enzymic breakdown of meat components, react together during cooking to give the desirable flavour of cooked meat. The time, type and extent of cooking will affect the flavour compounds formed. Therefore, it is likely that sensory scores will be influenced by the degree of doneness and the type of cooking that is used in their preparation.

An initiative in Australia has developed a standardised protocol for the consumer assessment of beef eating quality which underpins the Meat Standards Australia (MSA) beef grading scheme [2-4] and also allows them to determine the relative impact of a wide range of factors on eating quality [5]. The protocol has been used to compare sensory responses from Australian and Korean consumers and potential interactions with processing factors [6-8].

Australian MSA-based taste panels have been conducted with samples cooked to a medium degree of doneness, using volunteer consumers who preferred this cooking endpoint. This reflects a general preference for "medium" cooked beef in Australia (AU) [9]. In contrast, a recent survey of Northern Ireland (NI) consumers showed that more than 50% liked their beef cooked well-done, with less than 15% preferring medium, or lower degrees of doneness (LJ Farmer, *unpublished data*). There is evidence [9] that serving consumers with steak which does not meet their requirements for doneness results in reduced sensory scores, the penalty being higher in overcooked compared to undercooked steaks. Therefore, it was of interest to determine the impact of adapting the MSA protocol to assess "well-done" beef on the sensory responses of Northern Ireland consumers.

The aim of this study was to identify whether consumer scores for a range of beef samples is affected by doneness, cooking method and country of residence of the consumer, and whether these factors would be influenced by muscle, hanging method or the country of origin of the beef.

II. MATERIALS AND METHODS

Source of beef

Eighteen NI cattle were selected on arrival in lairage at a local abattoir to give estimated hot standard carcase weights of between 300 and 400kg. The cattle came from local farms and different groups were kept separate at all times to minimise stress. The animals were mainly continental crossbred steers and were all less than 30 months of age. They were slaughtered within 4 hours of arrival at the abattoir. Slaughter, evisceration and chilling regimes were the normal abattoir practice, except that no electrical inputs were used. Alternate carcase sides were either suspended by the Achilles tendon (AT) or hip hung (tenderstretched; TS) through the ligament.

The rate of pH fall and temperature decline in the striploin was measured (Sentron ISFET pH meter fitted with a Sentron Lancefet pH probe), over a period of six hours post-mortem, with the ultimate pH and temperature being recorded at 24 hours. Post-mortem pH/temperature measurements indicated the carcasses reached rigor (i.e. pH 6) at approximately 28^{o}C with ultimate pHs of between 5.56 and 5.66. All striploins, rumps, topsides and knuckles were labelled with unique reference numbers. At 48 hours, post-mortem carcases were quartered between ribs 9 and 10. The labelled primal joints were boned out, vacuum packed and held at 1°C prior to muscle dissection and sample preparation.

Twenty Aberdeen Angus cross steers were slaughtered in an Australian abattoir shortly after arrival at the abattoir. Seventeen of the 20 carcasses received high voltage electrical stimulation. Hot standard carcase weights ranged between 227 and 356kg. Prior to entry into the chiller alternate sides were either suspended AT or TS through the aitch bone. Measurements and primal collection followed the same procedures as the Northern Ireland slaughter.

Sample preparation

The primals were dissected into individual muscles and trimmed of all fat and connective tissue. Samples for grilling were sliced across the grain into five 25mm steaks, numbered, wrapped individually and vacuum packed. Samples for roasting were prepared as a block (150 x 60 x 60 mm with the long axis parallel to the grain), individually netted and vacuum packed. All samples were aged at 1^{o}C for 7 days post slaughter, blast frozen and stored at -21^{o}C, prior to selection for sensory evaluation panels. The muscles evaluated were: striploin (*M. longissimus dorsi* both anterior and posterior portions), rump heart *(M. gluteus medius)*, knuckle *(M. rectus femoris)*, and topside (*M. semimembranosus)*.

The same procedure was carried out in Australia. A set of frozen roast and grill samples were then exported to Northern Ireland.

Experimental design

Variables included hanging method (Hang), cooking method (Cook), muscle and position within muscle (Cut_Pos) and a composite treatment (Treat) incorporating the origin of the meat, the country of residence of the panelists and the extent of cooking ("Doneness"). These four treatments were AU/AU/MED (AU beef eaten by AU consumers, cooked "medium"), AU/NI/MED (AU beef eaten by NI consumers, cooked "medium"), NI/NI/MED (NI beef eaten by NI consumers, cooked "medium") and NI/NI/WD (NI beef eaten by NI consumers, cooked "well-done").

Consumer panels

Samples for grilling and roasting were defrosted at 1°C over periods of 24 and 48 hours respectively. Cooking protocols follow the general procedure described by Watson et al. [3] and Anon. [10] with cooking times and temperatures adjusted to ensure that the "medium" and "well-done" endpoints were consistently achieved. "Medium" degree of doneness for both grill and roast samples was defined as: pink in the centre after cooking, resting and cut ready for serving. "Well-done" was defined as: no visible pink colour after cooking, resting and cut ready for serving with clear meat fluids.

Roast joints were cooked in a fan assisted electric oven (medium cooked to an internal temperature of 70^{o}C and well-done to 80^{o}C). They were left to stand for 10 minutes before being trimmed of caramelised surfaces and placed in a *bain marie* at 50^{o}C prior to cutting into 10mm slices, using a guide, to serve to 10 consumers.

Grilled steaks were cooked on a Silex grill (200^{o}C for 5 minutes 45 secs for "medium", and 215^{o}C for 6 minutes 45 secs for "well-done"). Samples were left to stand for 3 minutes before halving and serving to 10 consumers.

Consumers in the "well-done" and "medium" doneness panels were volunteers who preferred their beef cooked that way. They were recruited from local voluntary organisations and had no previous experience of sensory evaluation techniques. Each consumer received either seven half steaks or seven slices of roast beef. Samples were allocated to the taste panel sessions using a latin square design where each consumer was presented with a starter sample followed by 6 experimental samples. All samples were evaluated by 10 different consumers. Consumers scored each sample 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”.

Data analysis

The unit for analysis purposes was the mean sensory score for 10 consumers for each sample. 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. A combined measure of eating quality, MQ4, was calculated from the individual linescale scores according to the equation developed in Australia [3]:

$$MQ4 = 0.4*TE + 0.1*JU + 0.2*FL + 0.3*OL$$

A REML random effects model was used to determine the significance of differences due to first, second and third order effects on all measures of eating quality using the statistical software package GenStat (version 11). The model used was a nested design for the random effects with joint nested within side which in turn was nested within animal. The fixed effects are in factorial arrangement with factors considered being Hang, Cut.Pos, Treat and Cook.

III. RESULTS AND DISCUSSION

Significant first order effects of hanging method, cut and position within cut were all subject to second order effects and these are illustrated for the combined MQ4 score in Figures 1 to 4. Only one third order effect was significant (P<0.05), being the effect of hang x treatment x cooking method on juiciness (not shown).

Table 1. Significance of first and second order effects by a REML random effects model on consumer sensory scores.

	Consumer sensory scores					
	TE[#]	JU	FL	OL	MQ4	Satis
Hang (H)	***	***	***	***	***	***
Cut.Pos (P)	***	***	***	***	***	***
Treat (T)	ns	***	ns	ns	ns	***
Cook (C)	***	**	ns	*	***	**
Interactions						
H * P	**	P=0.06	*	**	**	***
H * T	ns	ns	ns	ns	ns	ns
H * C	ns	ns	ns	ns	ns	ns
P * T	***	***	***	***	***	***
P * C	***	***	***	***	***	***
T * C	ns	***	*	**	*	*

[#] *TE = tenderness, JU = juiciness, FL = flavour liking, OL = overall liking; Satis = satisfaction category*

The consumer MQ4 scores highlighted the expected effect of carcass hanging on eating quality of the different muscles (Figure 1). Tenderstretch hanging significantly improved scores for all muscles except the knuckle. When tenderstretched, striploin and rump received significantly (P<0.05) higher scores than knuckle and topside and the anterior of the striploin received higher (P<0.05) scores than the posterior. These differences have been reported previously [7, 11].

Figure 1. Effect of cut and hanging method on MQ4.

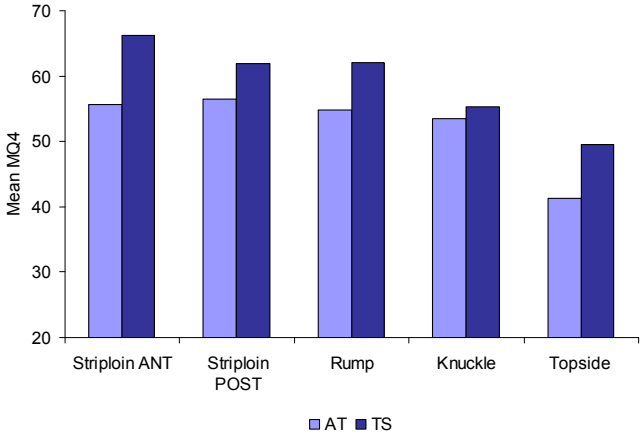


Figure 2 clearly demonstrates that the differences between muscles/cuts interact with cooking method. Rump and topside received significantly (P<0.05) higher MQ4 scores when roasted. In contrast, striploin scored significantly higher when grilled. These results probably reflect the fact that high connective tissue cuts benefit from the considerably longer cooking times associated with roasting which allows a greater degree of

gelatinization of collagenous connective tissue to occur.

There were significant main effects between the composite treatments only for juiciness and satisfaction (Table 1). For these attributes, there was a difference between assessments by consumers from NI and from AU. NI consumers gave slightly higher scores for these traits. This difference was not related to the consumption of the AU beef served "medium" rather than "well-done", as there was no difference between scores given by NI consumers to beef served "medium" or "well-done".

Figure 2. Effect of cut and cooking method on MQ4.

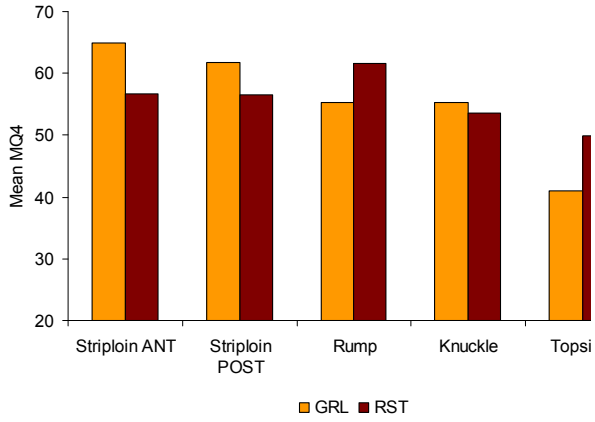
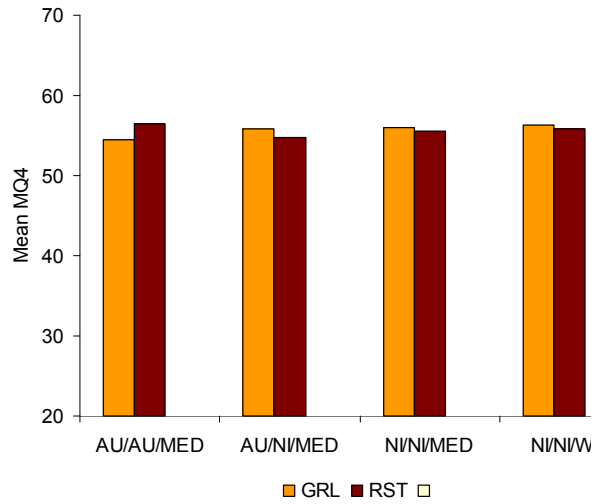


Figure 3. Effect of cooking method and composite treatment on MQ4.

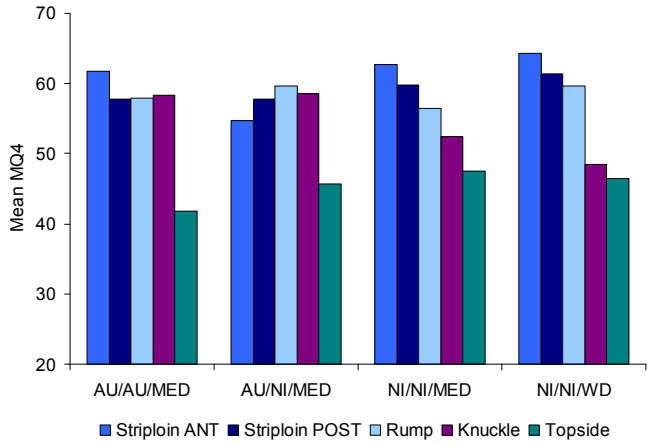


Treatments: meat country of origin/country of residence of consumers/doneness

A very highly significant treatment x cook interaction for juiciness (Table 1) was due to AU and NI consumers responding differently to cooking method. The mean scores over a range of muscles grilled and roasted were the same for AU consumers, while NI consumers gave the grilled beef higher scores for juiciness and overall liking. The effect of these composite treatments on MQ4 was smaller ($P<0.05$, Figure 3).

Comparison of beef sourced from AU and NI (Figure 4) relates only to differences between the groups of animals slaughtered, as country of origin is confounded by genetics, transport, slaughter and chilling conditions. The knuckle from this group of NI animals received lower scores than those from the AU animals, which may have influenced prediction accuracy for this muscle [12].

Figure 4. Effect of cut and composite treatment on MQ4.



Treatments: meat country of origin/country of residence of consumers/doneness

The effect of "doneness" on consumer scores for eating quality was of particular interest. In this study, beef cooked to "medium" (generally preferred by AU consumers) and "well-done" (generally preferred in NI) was presented to consumers who preferred their beef cooked this way. There was a significant treatment x muscle interaction which suggested that knuckle scored significantly lower for most traits when cooked "well-done" while "well-done" rump scored higher than "medium" rump for some traits (Figure 4). With this exception, the "well-done" beef was scored almost the same as "medium" cooked beef for tenderness, overall liking, MQ4 and satisfaction even though it was sometimes scored as less juicy. This suggests that, generally, consumers expecting "medium" or "well-done" beef scored these similarly, which is in agreement with Cox *et al*. [9].

IV. CONCLUSION

Differences in eating quality due to hanging method and muscle were as expected. The effect of cooking method on eating quality depended on the muscle under consideration, with striploin and

knuckle being preferred grilled and rump and topside roasted. The impact of cooking to “medium” or “well-done” on sensory scores, for consumers preferring these cooking endpoints, were generally small, though “well-done” cooking gave some decreases in juiciness and improved the sensory scores for rump.

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