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Abstract

A consumer's decision to purchase beef is strongly linked to its sensory properties and consistent eating quality is one of the most important attributes. Consumer taste panels were held according to the Meat Standards Australia guidelines and consumers scored beef according to its palatability attributes and completed a socio-demographic questionnaire. Consumers were able to distinguish between beef quality on a scale from unsatisfactory to premium with high accuracy. Premium cuts of beef scored significantly higher on all of the scales compared to poorer quality cuts. Men rated grilled beef higher on juiciness and flavour scales compared to women. Being the main purchaser of beef had no impact on rating scores. Overall the results show that consumers can judge eating quality with high accuracy. Further research is needed to determine how best to communicate inherent benefits that are not visible into extrinsic eating quality indicators, to provide the consumer with consistent indications of quality at the point of purchase.

Keywords

Beef, Palatability, Eating Quality; Willingness to pay; Meat Standards Australia

1. Introduction

In Europe consumer confidence in beef and beef products has been affected by health scares and safety scares and more recently due to climate change considerations. This, taken alongside increasing globalisation and increased competitiveness, means that an evidence based and refined strategic vision for the future of the beef industry is needed to maintain and grow this vital industry. The Irish beef industry is export orientated with beef exports for 2015 valued at €2.4 billion, an increase on previous years (Bord Bia, 2017). Meeting consumer expectations and ensuring consistent eating quality will play a pivotal role not only in ensuring the continued success and growth of this export market for Ireland, but also in increasing confidence in all international beef markets.

To secure this continued success, efforts should focus on maintaining consumer confidence in and demand for beef. Food quality is considered to be an important factor in determining food choice such as beef and consumer choice is framed in terms of their perceived quality expectations at point of purchase and actual quality experience after consumption. These quality attributes not only encourage the consumer to purchase the food but also serve to reinforce their choice depending on the experience, after the purchase/consumption of the food (Grunert, 2002, Henchion et al 2014).

Consumers use both intrinsic and extrinsic cues to determine meat quality. Intrinsic cues are the physical internal characteristics of the meat. Some of these cues are not evident to the consumer at the point of purchase, such as eating quality. Other intrinsic cues for beef include colour and fat and many consumers currently select beef according to its colour, preferring bright red (Mannion *et al.*, 2000; Banovic et al 2016), although colour is a poor indicator of palatability (Grunert, 1997; Henchion et al 2014) while fat, which has a negative impact on quality expectations actually has a positive effect on palatability and is perceived differently be men and women (Steenkamp and Van Trijp, 1996; Banovic et al 2016).

Extrinsic cues such as brand name, labels, presentation and price are related to the product but are not physically part of it (Grunet *et al*., 1996). Price has a positive effect on perceived quality, with higher price perceived as better quality which is not always the case (Acebron *et al*., 2000). Although meat is mainly sold unbranded, a brand has been shown to have potential as a cue for both eating quality and health (Bredahl 2004). Therefore the labelling of beef may act as a beneficial extrinsic cue as it has potential to relay and communicate positive intrinsic information in a consumer friendly manner. Such an intrinsic cue would enable consumers to form accurate expectations, which would improve consumer satisfaction as it would reduce the difference between expected quality and experienced quality. Steenkamp and Van Trip (2006) emphasised the importance of providing information at the place of purchase on expected quality. These palatability cues must be consistently accurate in order to reduce perceived risk and gain consumer confidence.

However, to win consumer confidence, eating quality needs to be consistent and of high quality. This is a challenging task due to the nature of beef itself. Beef is biochemically dynamic, hence it is naturally susceptible to variation in palatability which is evident in the market place. This variation in palatability stems from a wide range of factors along the supply chain from farm to fork. For example breed, sex, age at slaughter, the use or not of intervention techniques post-slaughter such as electrical stimulation, hanging techniques and the chilling regime all influence palatability. The selection of beef cut by consumers at point of purchase combined with cooking method also has an effect on variation in palatability and consumer evaluation of the product. Research by Maher *et al*. (2004) found variation in eating quality traits of randomly selected Irish beef. Furthermore, surveys in the USA have shown that consumers have difficulty in selecting beef because they are unsure of its quality (Miller *et al.*, 2001). Controlling this variation is a complex task. Predicting eating quality

before consumption would be beneficial as it would allow for beef to be classified according to quality, hence reducing overall variation.

Currently in Europe beef carcasses are classified according to the Official EU scheme (EC 1208/1981) for conformation and fat cover. These visually assessed characteristics are related to the value of the carcass through their effects on saleable yield and are not related to eating quality (Bonny et al. 2016). In order to improve the consistency of beef eating quality there is a need for a revised grading system which takes into account the palatability of each cut. A system like this has the potential to communicate the beef eating quality as a front of pack type extrinsic cue thereby increasing consumer satisfaction through the reduction in the differences between before and after consumption evaluations (Grunet *et al*., 2004).

The Australian beef industry has pioneered a key initiative called Meat Standards Australia (MSA). This programme adopted consumer testing as a measure by which to evaluate the effectiveness of a grading system and as a tool to develop a detailed understanding of factors which interact to determine the eating quality of individual beef cuts. This system takes a total quality management approach which was suggested as a means of controlling the factors which contribute to the incidence of poor beef quality (Thompson, 2002). Large-scale consumer taste panels were undertaken by MSA to give a detailed understanding of factors which lead to variation in palatability. These factors were labelled 'critical control points' (CCP's) which were then used to predict the palatability of beef cuts using multiple regression analysis. This approach has been labelled 'Palatability Assured Critical Control Points (PACCP)'. The objective of PACCP is to identify and carefully control production and processing factors which have the largest effect on palatability so that it is possible to accurately predict the quality of the final product (Polkinghorne *et al*., 1999). Consumer feedback should guide industry to tease out those parameters which result in inconsistent beef palatability. The PACCP system also leaves scope for the improvement of meat quality rather than prevention of poor meat quality alone. This may lead to increased production of premium quality beef which could be consistently labelled as such. The potential for this type of system was positively evaluated for implementation in Europe (Hocquette et al 2014).

The aim of this research was to apply the PACCP grading system which was developed in Australia to Irish beef in order to determine if Irish consumers could accurately identify good eating quality beef when presented with samples of differing quality. The willingness to pay for guaranteed eating quality was also assessed and consideration was given to developing an extrinsic cue to communicate eating quality.

2. Methods

Consumer taste panels were conducted on sample of 1739 Irish adults. At the outset of each session, consumers were informed of the study and what participation entailed in. Consumers were free to leave the taste panel at any stage of the session if they no longer wished to participate. Consumers were recruited through clubs, societies and charity groups. Suitable candidates had to be 'beef eaters' aged 20 to 60 years. In groups of twenty, consumers (n = 1739 final sample) were invited to a central location to participate in the taste panels.

2.1 Sample preparation

The Irish samples were sourced from 20 Irish heifers, either Limousin crosses or Charolais crosses, with an average carcass weight of 304 kg (range 257-336 kg). These were slaughtered in a single commercial abattoir with minimal electrical stimulation and Achilles tendon hanging. The Australian

samples were sourced from 20 steer of mixed breeds with an average carcass weight of 299 kg (range 283-318 kg). These were slaughtered in a single commercial abattoir with minimal electrical stimulation and Achilles tendon hanging. Relatively homogenous carcasses were selected to minimise variation between samples of the same cut. Six primal cuts (tenderloin, striploin, topside, rump, outside round and blade), selected to provide a range of good to poor quality, were removed from both sets of carcasses and aged for 14 days. Frozen beef samples were prepared for Irish consumers according to the MSA protocols (Polkinghorne, 2006, Watson et al 2008a, Watson et al 2008b). Homogenous carcasses were selected to minimise variation between samples of the same cut. Beef cuts (tenderloin, striploin, topside, outside round, rump and blade) were cooked to medium using two different cooking methods. The first method was grilling, where a clam shell type cooker was used for cooking steak pieces. The second cooking method was yakiniku, which involved cooking small strips of beef on a Korean style cooker resembling a domed hot-plate. The grill method was selected as it was used for cooking steak-like pieces familiar to Irish consumers. The yakiniku cooking method was selected as a method for cooking thin beef strips which may differ in quality attributes to steak-like pieces. These two methods are both included in the MSA cooking protocols.

2.2 Sensory evaluation

Consumers were presented with seven small uniform pieces of beef of varying quality (i.e. from different cuts) for evaluation. The first sample was used as wash-out/control. Consumers were blinded to the quality of the meat cuts and rated each sample on a scale of 1 to 100 for the following palatability attributes; tenderness, juiciness, flavour and overall liking. They were also asked to rank the beef just consumed as one of the following: unsatisfactory, good everyday eating quality, better than everyday eating quality or premium quality. A questionnaire was also completed which obtained information on socio-demographic factors and beef eating preferences.

2.3 Meat Quality Score Calculation

The Irish meat quality score (IMQ) was calculated, using linear discriminant analysis, as a linear function of the scores for the three palatability attributes (tenderness, juiciness, and flavour) and overall liking measured at the taste panels. This was done to see whether the optimised weightings would differ from those used for the Australian Meat Quality score (AMQ). The result sowed that Irish consumers gave a lower weighting to tenderness and a higher weighting to flavour liking than Australian consumers.

IMQ = 0.2*tenderness score + 0.1*juiciness score + 0.4*flavour liking score + 0.3*overall liking score. This differed from the meat quality score optimised for Australian consumer responses (AMQ) which was:

AMQ = 0.4*tenderness score + 0.1*juiciness score + 0.2*flavour liking score + 0.3*overall liking score.

2.4 Statistics

All statistical analyses were carried out using SPSS Version 18 (Chicago, IL, USA). The mean and standard deviation were calculated for the beef attributes of tenderness, juiciness, flavour, overall eating quality and MQ for each cooking method (yakiniku and grill). Independent t-tests and one-way analyses of variance (ANOVA) were used to determine significant differences in the different attributes across a number of socio-demographic and beef preference categories. When significant differences were identified using ANOVA, Scheffe post hoc tests were used to identify where these differences were.

3. Results

Results for the three palatability attributes, overall liking and MQ scores are presented across demographic factors and by grill and yakiniku cooking type in Tables 1a and 1b respectively. There were no significant differences in tenderness or juiciness scores between men and women for beef cooked on the grill. However, males scored grilled steaks significantly ($P<0.01$) higher for flavour and overall liking resulting in higher MQ scores. Females ranked beef cooked on the yakiniku significantly ($P\leq 0.01$) higher for tenderness than males ($P<0.01$) although it did not significantly change the MQ scores. Age had no effect on tenderness scores for either yakiniku or grilled samples. The 20 - 30 age group ranked juiciness significantly higher ($P\geq 0.05$) than the older age categories for both cook types but among the MQ scores only the yakiniku MQ score was significantly higher. Occupation had no effect on tenderness for both cook types but had a significant ($P\leq 0.05$) effect on grill flavour and on all other yakiniku attributes. Household income had no significant effect on beef cooked by the yakiniku method, however tenderness and juiciness were scored significantly ($P\leq 0.05$) higher for grilled samples by consumers from households with an income of less than €20,000, resulting in higher MQ scores.

Insert table 1a and 1b here

The relationship between palatability scores with meat enjoyment and eating frequency, cooking preferences, cut type and satisfaction rating for grilled and yakiniku cooked meat samples are presented in Tables 2a and 2b respectively. There were no significant differences for either cooking method between any of the palatability attributes across beef eating frequency and red meat enjoyment level. Consumers with a preference for beef cooked to rare/medium rare scored all of the attributes except for flavour significantly lower compared to those with a preference for medium to well-done meat for the yakiniku cooking method. For the grilled samples cook level preference only affected juiciness scores with those indicating preference for rare/medium or rare scoring juiciness significantly lower than the other preferences.

Consumers ranked their perceived quality of each beef sample consumed from unsatisfactory to premium eating quality. Mean palatability scores for each of the attributes and the derived AMQ and IMQ scores were calculated for each quality grade as shown in tables 2a and 2b. All of the palatability scores and both MQ scores increased significantly as quality rating point increased ($P<0.001$). Overall liking scores were as low as 26 for unsatisfactory samples and as high as 90 for beef rated as premium quality. A similar range of scores was also observed for the other attributes. When palatability scores were assessed across meat cut type, significant differences were observed for both grill and yakiniku cooking methods ($P\leq 0.05$). Palatability scoring across cuts of better eating quality such as the tenderloin consistently scored significantly higher for all of the attributes compared to the blade and the rump ($P<0.05$) for both cooking types

Insert table 2a and 2b here

Table 3 presents the price that consumers indicated they were willing to pay per kilo of beef for each of the four quality categories. This ranged from approximately €6/kg for unsatisfactory beef up to approximately €19/kg for premium quality beef. Whether the consumer was the main purchaser of beef or not had little impact on the price the consumer was willing to pay. There was also a willingness to pay a significantly higher amount per kilo for the grilled beef compared to the yakiniku cooked beef regardless of quality rating if the consumer was the main purchaser in the household. However, with the exception of better than everyday quality rated beef, there was no difference in willingness to pay between cook types for the non-shoppers.

Insert table 3 here

4. Discussion

In order to develop consumer-led quality extrinsic cues for communicating beef eating quality, it is worthwhile assessing the accuracy of consumers when evaluating beef eating quality as well as the effect of socio-demographic factors on quality evaluation. The findings from this study have very clearly demonstrated that consumers can evaluate with relatively high accuracy, beef eating quality and that socio-demographic factors play a role in this assessment of quality. Similar findings were also observed in a six country study, showing that the MSA system was effective at predicting beef eating quality in European consumers (Bonny *et al.*, 2017a)

Gender had some effect on the palatability traits. Males ranked grilled steaks higher for flavour and overall liking then females, while females ranked tenderness of beef cooked on the yakiniku higher than males. Kubberød *et al*. (2002) found a close relationship between the sensory attributes of meat and consumer attitudes which differ between males and females and supported the hypothesis that the dislike of red meat is more prevalent among females. Although panellists selected in this study were all beef eaters, irrespective of gender, it appears that males still prefer the red meat palatability attributes which are prevalent in the thicker grill steaks as opposed to the thin yakiniku strips which may have reduced red meat attributes, due to their size, such as bloody taste. Similarly, Newcombe *et al.*, (2012) also showed the importance of red meat in the diet of Irish men, whereby there is a strong association between meat consumption and expression of masculinity. There was also a relationship with increasing age and lower attribute scores for juiciness for both cooking methods, while overall likeness decreased with age for the yakiniku cooked meats. This may be a function of the lack of familiarity with the taste associated with contemporary cooking methods such as the yakiniku. However, it has been demonstrated that there is a loss of sensory acuity with increasing age (Baugreet *et al.*, 2017) and this may also be reflected in the findings here.

Lower income households ranked grilled beef as significantly ($P \leq 0.05$) more tender then households in the higher income brackets and households earning below €50,000 ranked grilled beef as significantly ($P \leq 0.05$) juicier (Table 1). As the MQ score is a function of the score of the palatability attributes it was also scored significantly ($P \leq 0.05$) higher for grilled beef by people in the lowest income households. Newman (2001) found that as income increases expenditure on meat increases and that minced beef has a lower income elasticity then beef overall. This suggests that as income increases it is more likely that better quality cuts are consumed. As beef cooked by the yakiniku method is similar to stir-fry beef strips it is likely that 'yakiniku type' beef is more likely to be purchased by consumers in the lower income bracket than higher cost steaks for grilling. Hence consumers in the lower income brackets may perceive grill steaks as a luxury and score them higher for the palatability attributes tenderness and juiciness. Improving value recognition by PACCP implementation could ensure market specific promotion of beef so that consumers from all income categories can be consistently supplied with beef of the quality they expect.

For grilled beef, a consumer's occupation had no significant effect on their perception of all palatability traits with the exception of flavour for grilled beef. However, for yakiniku beef the MQ scores were significantly ($P \leq 0.05$) higher for the professional than the tradesperson/labourer and administration/technical/sales categories. The perceptions that red meat is old fashioned and boring and also difficult and time consuming to prepare were identified by Huston (2000). The yakiniku method of cooking beef may be able to overcome these negative perceptions as cooking beef on a yakiniku grill is different to methods usually used in Ireland. Consumers in the professional category may be more willing to try new, exciting and convenient ways of cooking beef. Newman (2001) found that professional households exhibit expenditure patterns suggestive of a greater desire for convenience compared with other households and they also possess a 'snob' or bourgeoisie'

preference for traditional cuts of meat when they do decide to cook at home. This 'snob' preference may also incorporate the need to try new and exciting cooking methods. Cultural differences have been observed in other countries assessing the MSA approach in overall rating of grilled and yakiniku cooked beef samples. Beef cooked using the yakiniku or similar BBQ methods score higher for overall liking compared to the grilled beef for Korean and Japanese consumers (Thompson *et al.*, 2008, Polkinghorne *et al.,* 2011). This may be attributed to the increased familiarity of these consumers with the cooking methods.

Consumers accurately ranked palatability attributes according to the quality of the beef consumed regardless of cooking type (Table 2). For example 'good everyday eating quality' consistently scored significantly higher ($P \geq 0.05$) for all palatability attributes than 'unsatisfactory'. The tenderloin (fillet) was ranked as being of significantly ($P <= 0.05$) better quality for all palatability attributes when compared to the other cuts. The tenderloin is traditionally the most expensive of the cuts which consumers tasted. A similar study in Poland using the MSA protocols also demonstrated that the tenderloin was perceived as the best cut when evaluated by consumers (Guzek *et al.,* 2015). This further emphasises that consumers can accurately assign palatability attributes and can distinguish between cuts which have differing quality attributes.

Scoring for palatability attributes was not dependent on how frequently the consumer ate beef or how much they enjoyed eating red meat. This is expected since these are objective attributes. Nonetheless, it also suggests that the palatability attributes of beef are distinguishable to a large range of consumers and not just the more frequent 'beef eaters'.

Overall, it can be concluded that in a sensory panel environment, Irish consumers have a good understanding and are consistent in determining the palatability factors which constitute beef quality. This in is contrary to McKinna (1995) who concluded that Australian consumers are confused and do not have extensive knowledge of cuts. Implementation of the MSA approach would be beneficial for Irish consumers as it has the potential to predict quality using consumer feedback. By building on consumers' knowledge of palatability, product differentiation thorough branding or other extrinsic cues may improve value recognition in retail situations. This would help consumers to link after-purchase evaluations with before-purchase extrinsic cues. In addition, consumers in this study were willing to pay nearly twice as much for guaranteed premium eating quality compared to what they are willing to pay for every day eating quality. However, a recently published study with a larger sample of Irish consumers along with other countries did not find a willingness to pay for premium quality beef by Irish consumers (Bonny *et al.,* 2017b). The lack of consensus among the two studies can be attributed to the larger sample size and heterogeneous samples. However, similar or greater differentials to our study have been reported for the Australian, US and Japanese consumers (Lyford *et al.,* 2010). Furthermore, in the USA, when all market factors were considered, consumers were most willing to pay for eating satisfaction, compared to other attributes (Igo *et al.,* 2014).

5. Conclusion

It is vital to increase the consistency of predicting palatability in order to produce a reliable labelling system for beef eating quality. This poses huge challenges for the beef industry; however these challenges may be overcome by the implementation of a whole chain eating quality assurance scheme, such as the PACCP approach used to develop the MSA palatability grading model, and by the demonstration of a clear economic rationale. Rodgers *et al.* (2007) calculated the benefit to cost ratio of implementing the PACCP system in Australia to be in the region of 2.7 to 1. The present study has found that Irish consumers are ideal candidates to benefit from implementation of a system such as PACCP which would guarantee beef eating quality. Similar findings were also seen in France whereby the MSA grading system was shown to be in high agreement with French consumers

(Legrand *et al*., 2013), further supporting the notion for a European wide grading system. Further research should focus on communicating palatability through easy to recognise extrinsic cues such as a labelling system and ensuring these cues accurately and reliably describe the objective eating quality of a particular piece of beef. Meat Standards Australia have developed the star grading system, where beef is graded according to palatability and a front of pack label is used to convey this information to consumers. Given that the consumers in the present study clearly indicated a willingness to pay for premium eating quality, an indicator of eating quality such as the star system used by MSA may also be of benefit in Ireland.

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Table 1a. Mean scores and standard deviations (SD) for tenderness, juiciness, flavour, overall liking, Australian meat quality (AMQ) and Irish meat quality (IMQ) across various demographic categories for beed cooked by the grill cooking method.

			tenderness			juiciness			flavour			overall liking			AMQ			IMQ		
		n	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Grill	male	844	53.2	28.5	ns	54.7	26.1	ns	58.9	24.3	**	57.6	25.7	**	55.8	24.0	*	56.9	23.4	**
	female	1387	52.4	28.9		52.7	27.7		55.4	26.5		54.0	26.9		53.6	25.3		54.2	25.1	
	20-30 years	831	52.8	27.9	ns	56.6	26.4	a	58.8	25.0	a	56.5	25.9	ns	55.5	23.6	ns	56.7	23.3	ns
	31-50 years	809	52.4	29.2		51.2	27.0	b	55.4	26.0	b	54.5	26.7		53.6	25.7		54.2	25.2	
	>50 years	655	53.2	29.0		52.3	27.6	b	55.7	26.1	ab	54.9	26.7		54.1	25.1		54.6	24.8	
	Tradesperson/labourer	237	50.1	30.6	ns	52.0	26.7	ns	54.8	27.0	ab	53.5	27.7	ns	52.2	26.3	ns	53.1	25.6	ns
	Professional	650	53.0	27.9		51.8	26.5		54.2	25.8	b	53.5	26.1		53.3	24.3		53.5	24.1	
	Admin/Technical/sales	753	53.8	28.1		54.4	27.1		59.1	24.9	a	57.4	25.7		56.1	24.2		57.1	23.8	
	Homemaker	347	52.6	30.0		53.4	28.3		54.6	27.0	ab	53.3	27.8		53.4	26.6		53.8	26.2	
	Student/unemployed	287	51.5	28.9		55.8	27.2		59.9	24.5	a	57.7	26.1		55.5	24.0		57.1	23.5	
	below €20,000	224	58.0	28.0	a	57.1	27.7	a	60.5	26.1	ns	59.3	27.0	ns	59.0	24.6	a	59.4	24.5	a
	€20-50,000	898	51.6	29.0	b	54.8	27.5	a	56.1	26.5		54.5	26.9		53.7	25.0	b	54.6	24.8	b
	>€50,000	1144	52.6	28.4	b	51.7	26.4	b	56.5	24.9		55.2	25.9		54.1	24.5	b	54.9	24.0	b

* P<0.05; **P<0.01; ***P<0.001

ns columns within a category not significantly different at P ≥0.05

abc columns within a category with a common superscript are not significantly different at P ≥0.05 using one way ANOVA and Scheffe post hoc test

Table 1b. Mean scores and standard deviations (SD) for tenderness, juiciness, flavour, overall liking, Australian meat quality (AMQ) and Irish meat quality (IMQ) across various demographic categories for beef cooked by the yakiniku cooking method

		tenderness			juiciness			flavour			overall liking			AMQ			IMQ		
	n	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
male	1292	58.0	25.2	**	61.9	22.8	ns	60.5	23.2	ns	60.5	23.3	ns	59.7	21.5	ns	60.2	21.3	ns
female	916	61.1	27.0		62.5	24.2		59.8	25.4		60.3	25.1		60.7	23.9		60.5	23.8	
20-30 years	970	60.0	23.5	ns	64.1	21.5	a	61.3	22.9	ns	62.0	22.3	a	61.3	20.1	ns	61.5	20.3	a
31-50 years	669	59.8	26.8		61.1	24.0	b	59.5	24.4		59.0	25.0	b	59.6	23.7		59.5	23.4	ab
>50 years	598	57.6	29.1		59.9	25.8	b	58.4	25.8		59.1	25.8	ab	58.4	25.0		58.6	24.5	b
Tradesperson/labourer	387	57.2	26.4	ns	60.1	23.8	b	58.3	22.9	ab	58.7	22.9	b	58.0	21.8	b	58.3	21.3	b
Professional	663	61.3	24.6		65.0	22.0	a	62.8	23.7	a	63.5	23.5	a	62.7	21.5	a	62.9	21.6	a
Admin/Technical/sales	698	58.3	26.7		60.3	23.6	b	58.3	23.7	b	58.0	24.0	b	58.4	23.1	b	58.4	22.7	b
Homemaker	273	62.1	27.5		63.3	25.9	ab	61.0	26.8	ab	62.4	25.8	ab	62.1	24.5	ab	61.9	24.5	ab
Student/unemployed	203	56.3	25.5		62.0	22.4	ab	60.2	24.2	ab	59.8	23.7	ab	58.7	21.9	ab	59.5	21.8	ab
below €20,000	235	60.1	26.6	ns	64.4	24.3	ns	61.6	25.1	ns	62.7	24.0	ns	61.5	21.8	ns	61.8	21.7	ns
€20-50,000	957	59.5	26.0		62.7	23.4		61.1	24.4		61.1	24.4		60.5	22.6		60.9	22.6	
>€50,000	958	58.8	25.8		60.9	23.0		58.6	23.5		59.0	23.7		59.0	22.6		59.0	22.3	

* P<0.05; **P<0.01; ***P<0.001

ns columns within a category not significantly different at P ≥0.05

abc columns within a category with a common superscript are not significantly different at P ≥0.05 using one way ANOVA and Scheffe post hoc test

Table 2a. Mean differences and standard deviations (SD) in meat scoring for tenderness, juiciness, flavour, overall liking, Australian meat quality (AMQ) and Irish meat quality (IMQ) across various beef characteristics by the grill cooking method

		tenderness			juiciness			flavour			overall liking			AMQ			IMQ		
	N	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Frequency of beef consumption																			
Daily	14	55.1	31.0	ns	59.5	29.1	ns	70.4	21.8	ns	70.6	23.2	ns	63.3	19.7	ns	66.3	18.9	ns
4-5 times per week	419	52.5	30.4		53.0	27.4		54.2	26.8		53.4	27.6		53.1	26.6		53.5	26.0	
2-3 times per week	1277	53.9	27.9		53.5	26.7		58.0	24.8		56.4	25.7		55.4	24.1		56.2	23.7	
weekly	585	50.5	29.0		53.6	27.7		55.4	26.7		54.0	27.1		52.9	24.9		53.9	24.8	
Red meat enjoyment level																			
Enjoy red meat/important part of my diet	942	52.7	29.5	ns	53.5	27.8	ns	57.2	26.0	ns	55.7	26.6	ns	54.7	25.4	ns	55.5	25.0	ns
like red meat/regular part of my diet	1040	52.5	28.0		53.1	26.5		56.4	25.3		54.9	26.4		54.0	24.5		54.8	24.2	
some red meat/not bothered if didn't eat	291	53.6	28.1		53.8	26.6		56.0	25.6		55.4	25.8		54.8	24.2		55.3	23.9	
rarely never eat red meat	21	55.1	32.8		66.7	28.8		56.0	31.8		59.6	30.5		57.8	18.6		58.0	21.4	
Cooked preference																			
rare/med-rare	343	51.9	28.1	ns	48.3	28.6	b	54.8	24.9	ns	54.0	26.5	ns	52.7	24.8	ns	53.3	24.4	ns
medium	720	52.4	28.0		53.8	26.0	a	57.7	24.8		55.9	25.5		54.8	24.3		55.8	23.9	
med-well	564	51.9	28.8		53.7	26.3	a	55.6	24.9		54.4	25.7		53.6	24.4		54.3	23.8	
well done	654	54.5	29.5		55.5	27.8	a	57.4	27.7		56.3	28.1		55.7	25.5		56.3	25.6	
Rate of quality of beef consumed																			
unsatisfactory	640	26.0	21.3	d	31.0	22.4	d	30.2	18.9	d	26.1	16.9	d	27.4	15.5	d	28.3	15.4	d
good everyday quality	879	49.6	20.0	c	51.1	21.1	c	55.9	17.1	c	54.3	15.7	c	52.4	14.1	c	53.6	13.9	c
better than everyday quality	486	74.1	16.8	b	70.1	17.7	b	74.3	13.9	b	75.5	13.0	b	74.1	11.6	b	74.2	11.4	b
Premium Quality	284	87.2	16.3	a	83.4	18.5	a	89.0	11.4	a	90.3	10.0	a	88.1	10.7	a	88.4	9.9	a
Origin of beef consumed																			
Ireland	1193	52.6	27.8	ns	48.5	26.8	***	55.0	25.1	**	53.7	25.8	**	53.0	23.9	**	53.4	23.7	***
Australian	1101	53.0	29.6		58.8	26.3		58.5	26.2		57.1	27.1		56.0	25.6		57.1	25.1	
Cut of beef consumed																			
blade	347	50.3	24.6	c	55.5	24.8	b	54.9	24.1	bc	53.8	23.9	bc	52.7	21.6	c	53.7	21.8	bc
outside	338	40.7	27.4	d	47.5	24.9	c	49.7	25.1	cd	45.9	25.8	de	44.8	23.3	de	46.6	23.0	de
rump	356	47.6	26.0	c	47.6	24.6	c	53.0	24.0	c	51.3	24.2	dc	49.8	22.1	dc	50.9	22.1	cd
striploin	582	57.7	25.9	b	56.8	27.1	b	59.3	24.4	b	59.1	24.8	b	58.3	22.8	b	58.6	22.8	b
tenderloin	329	81.5	19.6	a	71.5	23.7	a	75.7	21.2	a	77.1	20.6	a	78.0	18.3	a	76.9	19.0	a
topside	344	36.8	25.9	d	40.4	26.3	d	46.8	25.6	d	43.1	25.6	e	41.1	23.3	e	43.1	23.5	e

* P<0.05; **P<0.01; ***P<0.001

ns columns within a category not significantly different at P≥0.05

abcd columns within a category with a different superscript are significantly different at P<0.05 using one way ANOVA and Scheffe post hoc test

Table 2b. Mean differences and standard deviations (SD) in meat scoring for tenderness, juiciness, flavour, overall liking, Australian meat quality (AMQ) and Irish meat quality (IMQ) across various beef characteristics by the yakiniku cooking method

		tenderness			juiciness			flavour			overall liking			AMQ			IMQ		
	N	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Frequency of beef consumption																			
Daily	112	63.3	27.0	ns	64.4	26.1	ns	61.1	27.4	ns	62.1	26.6	ns	61.7	24.1	ns	61.5	24.5	ns
4-5 times per week	419	59.4	25.8		62.1	24.1		61.6	24.6		61.4	24.5		60.7	23.1		61.2	23.1	
2-3 times per week	1162	58.8	26.7		61.3	23.5		58.7	24.2		59.1	24.3		59.1	23.0		59.1	22.7	
weekly	558	59.4	24.7		63.2	22.3		61.5	23.0		61.8	22.7		60.9	21.0		61.3	20.9	
Red meat enjoyment level																			
Enjoy red meat/important part of my diet	1007	58.1	26.6	ns	61.0	24.3	ns	60.0	24.3	ns	60.1	24.2	ns	59.3	23.2	ns	59.8	22.9	ns
like red meat/regular part of my diet	853	60.9	24.9		62.9	22.2		60.2	23.3		60.7	23.3		60.9	21.4		60.8	21.4	
some red meat/not bothered if didn't eat	328	57.6	27.2		62.9	23.8		59.2	25.7		59.2	25.5		59.0	23.3		59.3	23.3	
rarely never eat red meat	21	69.2	20.9		68.2	23.9		65.6	23.9		67.1	25.1		67.8	22.4		67.0	23.1	
Cooked preference																			
rare/med-rare	502	55.7	26.4	b	58.2	23.3	c	58.3	24.1	ns	57.6	24.5	b	57.0	23.0	b	57.6	22.8	b
medium	561	57.8	24.6	ab	60.7	21.6	bc	59.5	22.0		59.3	21.8	ab	58.9	20.7	b	59.2	20.4	ab
med-well	496	62.3	25.4	a	65.3	23.7	a	62.4	24.7		63.3	24.3	a	62.9	22.5	a	62.9	22.5	a
well done	651	60.8	27.2	a	63.6	24.6	ab	59.4	25.4		60.5	25.3	ab	60.6	23.7	ab	60.4	23.5	ab
Rate of quality of beef consumed																			
unsatisfactory	405	31.3	21.4	d	38.1	21.0	d	30.2	16.7	d	28.4	14.5	d	30.9	14.7	d	30.7	14.0	d
good everyday quality	943	53.6	20.8	c	57.6	19.1	c	55.8	17.7	c	55.6	16.6	c	55.0	15.3	c	55.4	14.9	c
better than everyday quality	589	73.7	16.8	b	74.0	15.8	b	73.5	15.5	b	75.5	13.0	b	74.2	12.1	b	74.2	12.1	b
Premium Quality	296	87.4	13.7	a	86.1	13.1	a	88.5	10.2	a	89.5	10.6	a	88.2	9.3	a	88.4	8.9	a
Origin of beef consumed																			
Ireland	1192	58.3	25.9	ns	60.6	23.6	**	58.3	24.2	***	58.7	23.7	**	58.6	22.3	**	58.6	22.2	**
Australian	1050	60.3	26.3		63.7	23.2		61.9	24.1		62.2	24.5		61.5	22.8		61.9	22.6	
Cut of beef consumed																			
blade	351	59.4	24.2	bc	63.3	22.0	b	61.2	22.9	b	61.2	22.6	b	60.7	21.0	b	61.1	21.0	b
outside	321	49.4	26.8	de	57.5	24.0	cd	54.0	24.9	c	53.5	25.0	c	52.3	23.3	c	53.2	23.2	c
rump	356	58.4	24.1	bc	60.4	23.4	bcd	58.8	23.8	bc	59.5	23.8	b	58.9	21.6	b	59.1	21.7	b
striploin	573	59.8	23.8	b	61.3	23.2	bc	58.3	23.2	bc	59.2	22.8	b	59.4	20.7	b	59.1	20.8	b
tenderloin	322	81.8	18.3	a	75.3	20.2	a	75.5	19.9	a	77.1	18.9	a	78.6	16.4	a	77.4	17.1	a
topside	319	46.2	25.4	e	55.0	23.1	d	53.5	24.5	c	52.2	24.1	c	50.2	22.3	c	51.7	22.5	c

* P<0.05; **P<0.01; ***P<0.001

ns columns within a category not significantly different at P ≥0.05

abcd columns within a category with a different superscript are significantly different at P ≥0.05 using one way ANOVA and Scheffe post hoc test

Table 3: Price (€) consumers are willing to pay per kg of beef of different quality categories

		Grill					Yakiniku				
Rated quality of beef sample	**Purchase**	**Mean**	**SD**	**n**	**Min.**	**Max.**	**Mean**	**SD**	**n**	**Min.**	**Max.**
Unsatisfactory	yes	6.2	3.3	413	2	20.0	5.3*	3.0	215	2	14.0
	no	6.0	3.7	205	2	18.0	6.0	3.5	158	2	20.0
Good everyday quality	yes	11.1	4.7	515	4	30	10.2*	4.2	477	4	24
	no	10.9	4.1	348	2	22	10.9	3.9	417	2	22
Better than everyday quality	yes	15.1	5.2	503	4	30	13.9*	5.0	300	6	28
	no	14.6	4.9	338	2	26	14.2*	4.8	268	6	26
Premium Quality	yes	19.4	6.6	188	4	32	17.3*	6.2	164	6	32
	no	19.3	6.0	94	4	32	18.4	6.5	115	8	32

*Indicates significant difference between cook type at $P<0.05$