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Evaluation of beef eating quality by Irish consumers

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30 **Abstract**

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

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44 **Keywords**

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

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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 by 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 (Grunert *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

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

98
99 Currently in Europe beef carcasses are classified according to the Official EU scheme (EC
100 1208/1981) for conformation and fat cover. These visually assessed characteristics are related to the
101 value of the carcass through their effects on saleable yield and are not related to eating quality
102 (Bonny et al. 2016). In order to improve the consistency of beef eating quality there is a need for a
103 revised grading system which takes into account the palatability of each cut. A system like this has
104 the potential to communicate the beef eating quality as a front of pack type extrinsic cue thereby
105 increasing consumer satisfaction through the reduction in the differences between before and after
106 consumption evaluations (Grunet *et al.*, 2004).

107
108 The Australian beef industry has pioneered a key initiative called Meat Standards Australia (MSA).
109 This programme adopted consumer testing as a measure by which to evaluate the effectiveness of a
110 grading system and as a tool to develop a detailed understanding of factors which interact to
111 determine the eating quality of individual beef cuts. This system takes a total quality management
112 approach which was suggested as a means of controlling the factors which contribute to the
113 incidence of poor beef quality (Thompson, 2002). Large-scale consumer taste panels were
114 undertaken by MSA to give a detailed understanding of factors which lead to variation in
115 palatability. These factors were labelled ‘critical control points’(CCP’s) which were then used to
116 predict the palatability of beef cuts using multiple regression analysis. This approach has been
117 labelled ‘Palatability Assured Critical Control Points (PACCP)’. The objective of PACCP is to
118 identify and carefully control production and processing factors which have the largest effect on
119 palatability so that it is possible to accurately predict the quality of the final product (Polkinghorne *et*
120 *al.*, 1999). Consumer feedback should guide industry to tease out those parameters which result in
121 inconsistent beef palatability. The PACCP system also leaves scope for the improvement of meat
122 quality rather than prevention of poor meat quality alone. This may lead to increased production of
123 premium quality beef which could be consistently labelled as such. The potential for this type of
124 system was positively evaluated for implementation in Europe (Hocquette et al 2014).

125
126 The aim of this research was to apply the PACCP grading system which was developed in Australia
127 to Irish beef in order to determine if Irish consumers could accurately identify good eating quality
128 beef when presented with samples of differing quality. The willingness to pay for guaranteed eating
129 quality was also assessed and consideration was given to developing an extrinsic cue to communicate
130 eating quality.

131 **2. Methods**

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133
134 Consumer taste panels were conducted on sample of 1739 Irish adults. At the outset of each session,
135 consumers were informed of the study and what participation entailed in. Consumers were free to
136 leave the taste panel at any stage of the session if they no longer wished to participate. Consumers
137 were recruited through clubs, societies and charity groups. Suitable candidates had to be ‘beef eaters’
138 aged 20 to 60 years. In groups of twenty, consumers (n = 1739 final sample) were invited to a central
139 location to participate in the taste panels.

140 141 142 *2.1 Sample preparation*

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

146 samples were sourced from 20 steer of mixed breeds with an average carcass weight of 299 kg
147 (range 283-318 kg). These were slaughtered in a single commercial abattoir with minimal electrical
148 stimulation and Achilles tendon hanging. Relatively homogenous carcasses were selected to
149 minimise variation between samples of the same cut. Six primal cuts (tenderloin, striploin, topside,
150 rump, outside round and blade), selected to provide a range of good to poor quality, were removed
151 from both sets of carcasses and aged for 14 days. Frozen beef samples were prepared for Irish
152 consumers according to the MSA protocols (Polkinghorne, 2006, Watson et al 2008a, Watson et al
153 2008b). Homogenous carcasses were selected to minimise variation between samples of the same
154 cut. Beef cuts (tenderloin, striploin, topside, outside round, rump and blade) were cooked to medium
155 using two different cooking methods. The first method was grilling, where a clam shell type cooker
156 was used for cooking steak pieces. The second cooking method was yakiniku, which involved
157 cooking small strips of beef on a Korean style cooker resembling a domed hot-plate. The grill
158 method was selected as it was used for cooking steak-like pieces familiar to Irish consumers. The
159 yakiniku cooking method was selected as a method for cooking thin beef strips which may differ in
160 quality attributes to steak-like pieces. These two methods are both included in the MSA cooking
161 protocols.

162 163 *2.2 Sensory evaluation*

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

171 172 *2.3 Meat Quality Score Calculation*

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

179
180 $IMQ = 0.2 * \text{tenderness score} + 0.1 * \text{juiciness score} + 0.4 * \text{flavour liking score} + 0.3 * \text{overall liking}$
181 score . This differed from the meat quality score optimised for Australian consumer responses (AMQ)
182 which was:
183 $AMQ = 0.4 * \text{tenderness score} + 0.1 * \text{juiciness score} + 0.2 * \text{flavour liking score} + 0.3 * \text{overall liking}$
184 score .

185 186 *2.4 Statistics*

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

194 195 **3. Results**

196 Results for the three palatability attributes, overall liking and MQ scores are presented across
197 demographic factors and by grill and yakiniku cooking type in Tables 1a and 1b respectively. There
198 were no significant differences in tenderness or juiciness scores between men and women for beef
199 cooked on the grill. However, males scored grilled steaks significantly ($P<0.01$) higher for flavour
200 and overall liking resulting in higher MQ scores. Females ranked beef cooked on the yakiniku
201 significantly ($P\leq 0.01$) higher for tenderness than males ($P<0.01$) although it did not significantly
202 change the MQ scores. Age had no effect on tenderness scores for either yakiniku or grilled samples.
203 The 20 - 30 age group ranked juiciness significantly higher ($P\geq 0.05$) than the older age categories
204 for both cook types but among the MQ scores only the yakiniku MQ score was significantly higher.
205 Occupation had no effect on tenderness for both cook types but had a significant ($P\leq 0.05$) effect on
206 grill flavour and on all other yakiniku attributes. Household income had no significant effect on beef
207 cooked by the yakiniku method, however tenderness and juiciness were scored significantly
208 ($P\leq 0.05$) higher for grilled samples by consumers from households with an income of less than
209 €20,000, resulting in higher MQ scores.

210

211 *Insert table 1a and 1b here*

212

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

222

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

233

234 *Insert table 2a and 2b here*

235

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

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245 *Insert table 3 here*

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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 than 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 than 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 than 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'

296 preference for traditional cuts of meat when they do decide to cook at home. This ‘snob’ preference
297 may also incorporate the need to try new and exciting cooking methods. Cultural differences have
298 been observed in other countries assessing the MSA approach in overall rating of grilled and
299 yakiniku cooked beef samples. Beef cooked using the yakiniku or similar BBQ methods score higher
300 for overall liking compared to the grilled beef for Korean and Japanese consumers (Thompson *et al.*,
301 2008, Polkinghorne *et al.*, 2011). This may be attributed to the increased familiarity of these
302 consumers with the cooking methods.

303
304 Consumers accurately ranked palatability attributes according to the quality of the beef consumed
305 regardless of cooking type (Table 2). For example ‘good everyday eating quality’ consistently scored
306 significantly higher ($P \geq 0.05$) for all palatability attributes than ‘unsatisfactory’. The tenderloin
307 (fillet) was ranked as being of significantly ($P \leq 0.05$) better quality for all palatability attributes
308 when compared to the other cuts. The tenderloin is traditionally the most expensive of the cuts which
309 consumers tasted. A similar study in Poland using the MSA protocols also demonstrated that the
310 tenderloin was perceived as the best cut when evaluated by consumers (Guzek *et al.*, 2015). This
311 further emphasises that consumers can accurately assign palatability attributes and can distinguish
312 between cuts which have differing quality attributes.

313
314 Scoring for palatability attributes was not dependent on how frequently the consumer ate beef or how
315 much they enjoyed eating red meat. This is expected since these are objective attributes.
316 Nonetheless, it also suggests that the palatability attributes of beef are distinguishable to a large
317 range of consumers and not just the more frequent ‘beef eaters’.

318
319 Overall, it can be concluded that in a sensory panel environment, Irish consumers have a good
320 understanding and are consistent in determining the palatability factors which constitute beef quality.
321 This is in contrast to McKinna (1995) who concluded that Australian consumers are confused and do
322 not have extensive knowledge of cuts. Implementation of the MSA approach would be beneficial for
323 Irish consumers as it has the potential to predict quality using consumer feedback. By building on
324 consumers’ knowledge of palatability, product differentiation through branding or other extrinsic
325 cues may improve value recognition in retail situations. This would help consumers to link after-
326 purchase evaluations with before-purchase extrinsic cues. In addition, consumers in this study were
327 willing to pay nearly twice as much for guaranteed premium eating quality compared to what they
328 are willing to pay for every day eating quality. However, a recently published study with a larger
329 sample of Irish consumers along with other countries did not find a willingness to pay for premium
330 quality beef by Irish consumers (Bonny *et al.*, 2017b). The lack of consensus among the two studies
331 can be attributed to the larger sample size and heterogeneous samples. However, similar or greater
332 differentials to our study have been reported for the Australian, US and Japanese consumers (Lyford
333 *et al.*, 2010). Furthermore, in the USA, when all market factors were considered, consumers were
334 most willing to pay for eating satisfaction, compared to other attributes (Igo *et al.*, 2014).

335 336 **5. Conclusion**

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

346 (Legrand *et al.*, 2013), further supporting the notion for a European wide grading system. Further
347 research should focus on communicating palatability through easy to recognise extrinsic cues such as
348 a labelling system and ensuring these cues accurately and reliably describe the objective eating
349 quality of a particular piece of beef. Meat Standards Australia have developed the star grading
350 system, where beef is graded according to palatability and a front of pack label is used to convey this
351 information to consumers. Given that the consumers in the present study clearly indicated a
352 willingness to pay for premium eating quality, an indicator of eating quality such as the star system
353 used by MSA may also be of benefit in Ireland.
354

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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 beef cooked by the grill cooking method.

	n	tenderness		juiciness		flavour		overall liking		AMQ		IMQ	
		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

	n	tenderness		juiciness		flavour		overall liking		AMQ		IMQ							
		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	Mean	SD				
<i>Frequency of beef consumption</i>																			
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	
<i>Red meat enjoyment level</i>																			
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	
<i>Cooked preference</i>																			
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	
<i>Rate of quality of beef consumed</i>																			
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
<i>Origin of beef consumed</i>																			
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	
<i>Cut of beef consumed</i>																			
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 $\alpha=0.05$

^{abcd} columns within a category with a different superscript are significantly different at $\alpha=0.05$ 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

	N	tenderness		juiciness		flavour		overall liking		AMQ		IMQ	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Frequency of beef consumption</i>													
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
<i>Red meat enjoyment level</i>													
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
<i>Cooked preference</i>													
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}
<i>Rate of quality of beef consumed</i>													
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
<i>Origin of beef consumed</i>													
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
<i>Cut of beef consumed</i>													
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

Rated quality of beef sample	Purchase	Grill					Yakiniku				
		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 $P < 0.05$