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Regional, Socioeconomic and Behavioural- Impacts on Consumer Acceptability of Beef in Northern Ireland, Republic of Ireland and Great Britain

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Abstract

This study was commissioned to assess if there are regional differences in the acceptability of beef between consumers from Northern Ireland (NI), Republic of Ireland (ROI) and Great Britain (GB). Palatability traits were affected by socioeconomic and behavioural factors such as preferred cooking endpoint, animal welfare, value, health aspects of beef product, ease of preparation as well as consumption frequency for specific cuts. "Willingness to pay" (WTP) was influenced by income, preferred cooking endpoint, value of beef product, ease of preparation and consumption frequency for frying steak.

Results showed that GB consumers scored higher for the same striploin steak compared to NI and ROI consumers. This may be due to differences in the motivation for beef choice and/or consumption habits. GB consumers were less concerned about the healthiness of beef product and beef origin. In addition, a higher consumption frequency for rump was reported in GB, which may explain the higher sensory scores observed among GB consumers for striploins.

Keywords: Consumers; beef; eating quality; sensory evaluation; palatability

Declaration of interest: none.

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1. Introduction

Beef is an important component of the diet in Northern Ireland (NI), Republic of Ireland (ROI) and Great Britain (GB) (FAO, 2010; Westhoek et al., 2011). It is also an expensive item in the customer's shopping basket. Nevertheless, there is evidence of a high variability of eating quality and this could cause to consumer disappointment and dissatisfaction (Farmer et al., 2017). This inconsistency of eating quality in beef presents a challenge to the beef industry (Polkinghorne & Thompson, 2010).

Historically, the ROI and NI have marketed a considerable proportion of their beef to the highly populated regions of GB. For this reason, the response to beef of consumers in GB relative to those in ROI and NI is of considerable commercial relevance to the ROI/NI industries. While these regions are very close geographically, their culture, purchasing and dietary habits do vary and this could affect consumers' perceptions of beef. The similarities and differences between consumers in such locations, and the socioeconomic basis of any differences, have not previously been examined. This study aims to elucidate the differences between consumers from these regions on their sensory scores, MSA grade boundaries, importance of palatability attributes and WTP. The role of socio-demographic factors on sensory scores and WTP in NI, ROI and GB was also studied.

2. Literature on Consumer Responses to Beef

Eating quality attributes such as tenderness, juiciness and flavour stand out as the strongest quality attributes in beef (Brunsø, Bredahl, Grunert, & Scholderer, 2005), whereas appearance, process-related characteristics or healthiness are equally important in forming quality expectations (Banović, Grunert, Barreira, & Fontes, 2009). Consumers demand beef that is nutritious, safe and of consistent eating quality (Verbeke et al., 2010b). Henchion, McCarthy, and Resconi (2017) reviewed 15 studies to differentiate between "search", "experience" and "credence" attributes, and found that, generally, consumers judge more readily on attributes in evidence on the pack and they identified that origin (a credence attribute), price (search attribute) and brands (search attribute) were the top three attributes. Nevertheless, the "experience" attributes, flavour, freshness and texture were the main "ranked five, eight and ten, respectively. It has been reported that consumers are willing to

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pay for premium quality beef products if the quality can be assured (Lyford et al., 2010). Therefore, it is important that the beef industry produces a product with consistent eating quality.

The evaluation of a complex product such as beef by untrained consumers presents particular challenges. The questions presented to consumers must be sufficiently simple to allow them to understand and score the products easily and quickly. A number of methods have been reported in the literature discrete choice modelling has been extensively used in agriculture and food economics to elicit consumer preferences of beef (Loureiro & Umberger, 2007; Van Wezemael, Caputo, Nayga, Chryssochoidis, & Verbeke, 2014). However, the choice complexity, increase in random error, the way in which the choice are presented to consumers are the limitations of discrete choice modelling (Hanley, Mourato, & Wright, 2001; Mazzotta & Opaluch, 1995; Swait & Adamowicz, 1996). A number of new methods have been developed to collect descriptive data using naïve consumers, such as check-all-that-apply analysis and temporal dominance of sensation (Ares & Jaeger, 2013; Hutchings, Foster, Grigor, Bronlund, & Morgenstern, 2014). Training is required to familiarise consumers with the technique and the process of selecting attributes (Ares et al., 2017). Therefore, these methods are not suitable for the analysis of large numbers of treatments using multiple groups of panellists.

In an endeavour to fulfil consumer demands, a standardised beef grading system called "Meat Standards Australia" (MSA) was developed to predict eating quality using a "Palatability Assured at Critical Control Points" (PACCP) approach (Polkinghorne et al., 1999; Polkinghorne, 2006). The development of MSA was based on extensive consumer tests. A robust and effective protocol was developed by Watson, Gee, Polkinghorne, and Porter (2008a) to facilitate consumer testing under the MSA system. A combined satisfaction score, termed the MQ4 score, was calculated by combining four sensory variables assessed by consumers, including *tenderness* (*TE*), *juiciness* (*JU*), *flavour liking* (*FL*) and *overall liking* (*OL*). Beef muscles were assigned into four grades according to their MQ4 score, including unsatisfactory (ungraded), satisfactory everyday quality (3*), better than everyday quality (4*) or premium quality (5*) (Watson, Gee, Polkinghorne, & Porter, 2008b).

Beef is consumed in many countries and this raises the question of whether consumer perceptions are the same across borders. Previous papers have discussed the validity of implementation of the MSA system more than seven countries (Bonny et al., 2017; Farmer et

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al., 2009a; Farmer et al., 2010b; Hocquette, Legrand, Jurie, Pethick, & Micol, 2011; Hwang, Polkinghorne, Lee, & Thompson, 2008; Legrand, Hocquette, Polkinghorne, & Pethick, 2012; Polkinghorne, Nishimura, Neath, & Watson, 2011), and it has been found to be internationally effective. It was found that the relationship between individual attribute scores and the satisfaction score varied a little between countries, suggesting that the weightings placed on the different attributes may vary. Likewise, the MQ4 boundaries between the different satisfaction grades can also differ. The MQ4 formula has changed over time in Australia and is currently 0.3 *TE*+ 0.1 *JU*+ 0.3 *FL*+ 0.3 *OL*, with grade boundaries 41, 64 and 77. MQ4 score, in itself increased to 46 for the lower 3-stars grade to avoid unsatisfactory experience (Polkinghorne, Thompson, Watson, Gee, & Porter, 2008). In Northern Ireland, the formula for MQ4 was 0.2 *TE*+ 0.1 *JU*+ 0.4 *FL* +03 *OL*, with cut off scores set to 38, 60 and 77(Farmer et al., 2010a).

Socio-demographic factors can influence beef choices and personal preferences (Thompson, Pleasants, & Pethick, 2005). These may include culture, age, gender, occupation, income, beef appreciation and consumption habits. Previous work suggested that gender, age and number of adults in a household significantly ($P<0.05$) affect juiciness score in grilled sheep meat (Thompson et al., 2005). Bonny et al. (2017) conducted studies on 19,000 consumers and found that gender, importance of beef in the diet, preference on "doneness" had small effects on sensory scores. In contrast, Hwang et al. (2008) found that socio-demographic factors only have minor effects on sensory scores for Korean and Australian beef consumers. Interestingly, studies found negative relationship between consumer age and willingness to pay (Bonny et al., 2017; Lusk, Fox, Schroeder, Mintert, & Koohmaraie, 2001; Lyford et al., 2010). None of these studies have investigated or compared the impact of region or socio-demographic status on the palatability scores attributed by consumers across the British Isles. The MSA protocol chosen for this study provides mechanism for determining the socio-economic background and attitudes to beef of the consumers tested.

3. Materials and Methods

3.1. Source of beef

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Beef striploins (72 in total), sourced from three types of animals (bulls, steers, old cows), from continental breed and dairy breeds and processed using two hanging methods (straight hung and tenderstretch) were selected to provide a range of poor to excellent eating quality. The average age of continental steers, dairy steers, continental bulls and dairy bulls were 25 months, 24 months, 14.6 months and 19 months, respectively. The age of dairy and continental old cows ranged from 35 months to 188 months. These animal groups were selected from different sources to give a range of eating qualities. All striploins were sourced from Northern Ireland or Republic of Ireland. Three sets of samples were collected from anterior, middle and posterior positions in each striploin. All samples were aged for 21 days at 4°C before being transferred to a commercial freezer and held at -20°C.

2.2. Consumer Panels

The panels were held at the Sensory Evaluation Units at the Agri-Food Bioscience Institute (Belfast), University College Cork and University of Reading to represent the consumers in Northern Ireland (NI), Republic of Ireland (ROI) and Great Britain (GB). The same protocol was adopted (see below) and the facilities were broadly similar. A total of 360 consumers participated in the panels, with 120 consumers from each of NI, ROI, and GB. Each group of 20 consumers per session was invited to a central location to participate in the consumer panels. To qualify, suitable candidates needed to consume beef regularly and be aged 18 or above. Consumers in Belfast were recruited in groups of 20 through charity groups, societies and local groups. Consumers in Cork and Reading were recruited individually through databases, local forums, social webpages, university societies and posters.

An adaptation of MSA protocol was used for these consumer panels (Polkinghorne et al., 2008; Polkinghorne, 2006) as these methods have been found to be robust and practical for large numbers of consumers, and comparable across locations and panel groups. Samples were thawed at 4°C for 24 hours prior to the consumer panel. The grill was switched on 45 minutes before the session start and the temperature was set to 180°C. In all cases, the steaks were grilled using the same clam grill (S-143, SILEXIA UK. Ltd, York, United Kingdom). The grill was conditioned for 4 minutes using scrap meat before cooking the samples. Samples (ca. 50 x 50 x 25mm) were grilled following MSA protocol (Polkinghorne et al., 2008; Polkinghorne, 2006) to an internal temperature of 72°C (well done). Ten samples were

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cooked in each round, which were cut in half and served to 20 consumers. Internal temperature was recorded and a small sample was retained from each steak for microbiological assessment, if required.

Consumers received seven samples of uniform size but varying qualities. The first sample was a "starter" sample derived from a striploin that was expected to be of ordinary quality. The results from this sample were not included in the statistical analysis. All consumers then received portions of six beef samples from each gender x hang treatment, either from dairy or continental breeds, allocated using a Latin square design to minimise the potential order effects (Hwang et al., 2008; Thompson et al., 2005). Each set of samples (as defined in Section 2.1) was assessed by 10 consumers from each region, distributed across sessions by a latin square design. Water and cream crackers (Jacobs cream cracker, United Biscuits UK Ltd, Leicestershire, United Kingdom) were provided for participants to serve as palate cleansers.

3.3. Questionnaire Design

A questionnaire was designed using Biosystems "FIZZ Paper" (Biosystems, Dijon, France). Consumers were asked to provide information in a socio-demographic survey prior to tasting (supplementary material). The grading system was explained and consumers were then asked how much they would pay for unsatisfactory, satisfactory everyday quality, better than everyday quality and premium quality grades beef in local currency on a continuous line scale. During tasting, consumers were instructed to rate the palatability traits on a line scale (0= low intensity/liking; 100= high intensity/liking) for *aroma liking* (***AL***), *tenderness (**TE**), juiciness (**JU**), flavour liking (**FL**)* and *overall liking (**OL**)*. They were also asked to assign a quality grade as one of the following: unsatisfactory, satisfactory everyday quality, better than everyday quality or premium quality.

3.4. Statistical analysis

A chi-square test was performed to determine the differences in socio-demographic groups between the three regions. In addition to the scores provided by the consumers, a weighted

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eating quality score, MQ4 score, was calculated for each sample using the Australian MSA model (0.3 TE+ 0.1 JU+ 0.3 FL+ 0.3 OL). Data were analysed using linear mixed model (LMM) methodology with factors of interest fitted as fixed (sometimes called treatment) effects and nuisance factors such as consumer, taste session and animal fitted as random effects using the estimation method of residual maximum likelihood (REML) (Ahrens, 1974; Robinson, 1987). The REML algorithm estimates the treatment effects and variance components in a linear mixed model i.e. a linear model with both fixed and random effects. Like regression analysis, REML can be used to analyse unbalanced data sets, but, unlike regression, it can account for more than one source of variation in the data, providing an estimate of the variance components associated with the random terms in the model (Gilmour, Thompson, & Cullis, 1995). It was deemed appropriate to fit consumer, taste session and animal as random effects as we were not primarily interested in these effects, but rather in accounting for them via the modelling process. Additionally it is appropriate to consider these as random terms as it is fair to assume that they are a random selection from the underlying populations of interest.. Linear discriminant analysis was first conducted on four variables (TE, JU, FL, OL) to derive MQ4* formulae. A second linear discrimination analysis was conducted on three variables (TE, JU, FL). Adoption of this approach gives a formula for MQ3*. To maintain the stability of the equation, Watson, Gee, Polkinghorne & Porter (2008b) suggested taking an average of the two formulae as described earlier to form a modified MSA formulae for NI, ROI and GB. Pearson's correlation test was conducted to determine the association between consumers' palatability traits. All statistical analysis was conducted using GenStat (GenStat 16.2.0.11713, VSN International Ltd, Hemel Hempstead, United Kingdom).

4. Results and Discussion

The effect of region, socio-demographic factors and consumer behaviours on palatability scores, willingness to pay are discussed in the following sections.

4.1. Effects of region on palatability scores

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A comparison between consumers from NI, ROI and GB for palatability traits is shown in Table 1. This shows that consumers from different regions attributed the same samples of striploin beef with significantly different mean sensory scores for *aroma liking* ($P<0.01$), *tenderness* ($P<0.001$), *juiciness* ($P<0.01$), *flavour liking* ($P<0.05$), *overall liking* ($P<0.05$) and MQ4 ($P<0.01$). Consumers from GB gave higher mean scores for palatability traits for the same steak samples than consumers from NI and ROI. The differences for MQ4 and tenderness were 4.8 and 6.4 points on a 100 points line scale. This is a positive finding for Irish and Northern Irish beef exporters to the UK. As expected, treatment had significant ($P<0.001$) impacts on all palatability scores, confirming that consumers had received samples with a wide range of eating quality. Overall liking, flavour liking and MQ4 scores for tenderstretch bulls (T2), straight hung steers (T3) and tenderstretch steers (T4) were significantly ($P<0.001$) higher than other treatments (Table 1). Aroma liking scores ($P<0.01$) were also significantly different between treatments, suggesting that consumers were able to differentiate treatments before consumption and based only on aroma. Further analysis of the effects of breed type, gender and hanging method will be reported elsewhere (Chong et al., 2018). Interestingly, there was no significant interaction between region and treatment for any palatability scores, showing that consumers from these three regions liked the same beef, even though the mean scores in GB were higher than those from NI and ROI.

Many other studies have discovered that consumers from different countries responded differently to beef. For example, a comparison of multiple studies conducted in France, Australia, Poland, Republic of Ireland and Northern Ireland showed that countries significantly affected ($P<0.0001$) all the palatability traits (Bonny et al., 2017). Differences between Australian and Korean consumers were also reported by Hwang et al. (2008) in grilled and barbequed samples, which showed that Korean consumers gave lower sensory scores compared to Australian consumers. Neely et al. (1998) also reported significant ($P<0.01$) differences for tenderness, juiciness, flavour intensity, flavour desirability and overall liking for cut and city interaction in the United States of America.

To determine whether consumers from the three regions perceived differences in MSA boundaries, discriminant analysis was conducted. As shown in Table 2, the differences in boundary scores between the three regions were minimal. They also agreed closely with those reported previously for NI (Farmer et al., 2009a), but were somewhat lower than those reported for other regions. This may suggest that consumers from these three regions were a

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little easier to satisfy than those from other countries. However, differences were expected as all the beef in this trial was sirloin, while that used in the other trials listed in Table 2 included a wide range of muscles and qualities. It might have been expected that the narrower range of qualities would have generated a higher boundary between unsatisfactory and satisfactory, but this has not proved to be the case. These results support the assertion by Watson et al. (2008b) that the boundaries vary slightly from one panel to another, but that the overall relationship is generally in agreement.

The MQ4 formula is an indication of the weighting placed on tenderness, juiciness and flavour liking by consumers when they give a satisfaction score. The results (Table 3) show that the weightings for NI and ROI are similar to those reported previously for France, USA and NI, but that GB consumers give a higher weighting for juiciness, more like that reported for Japan. Watson et al. (2008b) suggested that the formulae can vary from one panel to another and in practice, due to correlations between attributes, small changes in weightings have only small effects on MQ4. Such correlations were also observed for the data reported herein (Table 4). As expected from a previous study (Corbin et al., 2015), the results indicated that all correlations among palatability traits were significant (P <0.001). The weighting of FL was generally similar to that for TE (Table 3) suggesting that FL was at least as important as TE for all three regions. This aligns with the findings by (Oliver et al., 2006), who reported that the regression coefficient with overall liking was often higher for flavour liking than for tenderness.

4.2. Effect of region on willingness to pay (WTP)

Table 5 shows the price that consumers were willing to pay for the four quality grades per kilo of steak. The price ranged from £6.90 (€8.20)/kg for unsatisfactory to £22.10 (€25.90)/kg for premium quality. Interestingly, region had significant (P<0.001) effects on WTP for "unsatisfactory" and "premium" beef only, with GB consumers apparently willing to pay less for unsatisfactory beef and ROI consumers willing to pay less for "premium" beef.

Consumers' willingness to pay has been compared across countries by expressing it as a proportion of the price the consumer is willing to pay for "unsatisfactory" to "premium" quality grade compared to "satisfactory everyday quality" (P-WTP). A comparison of this

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ratio from this study is presented in Table 5. The results were broadly similar for these three regions, and close to those reported previously in NI (Bonny et al., 2017).

A study comprising results from 6718 consumers showed that Japanese consumers had the highest P-WTP for premium beef, followed by consumers from United States of America with Australian, Northern Irish and Irish consumers showing lowest P-WTP for "premium" beef (Lyford et al., 2010). In addition, Bonny et al. (2017) reported that country (Poland, France, NI, ROI) had significant impact on P-WTP with Northern Irish consumers expressing less willingness to pay extra for premium beef than those from France and Poland. These findings aligned with our results, where the P-WTP in NI, ROI and GB was lower compared to other countries. In contrast, the previous findings for ROI showed that consumers were only willing to pay €3 difference between "unsatisfactory" to "premium" beef, with the least P-WTP compared to other countries including NI (Bonny et al., 2017). This was not replicated by our results, as our data showed this difference to be around €15 and that the ROI P-WTP for all categories was very similar to that for NI and GB. However, the studies reported by Bonny et al. (2017) covered a wide range of muscles and cooking methods while this study focused on grilled striploin. The difference might also reflect changes in consumer altitude, as the NI data reported by Bonny et al. (2017) was collected in 2003-2007 while the data in this study was collected in 2016.

In general, the findings reported herein agree well with the general trend reported elsewhere (Polkinghorne, 2006) that consumers say they will pay half of the price of satisfactory every day quality for unsatisfactory beef, and 1.5 to 2 times as much for premium quality.

4.3. Effects of socio-demographic factors on palatability traits and WTP

Of the eleven socio-economic questions asked of the 360 consumers, three gave significant effects on sensory scores and/or willingness to pay. These are presented in Table 6, while data that was not significant are reported in Table SM2 (supplementary material). Socio-demographic factors had very limited impact on sensory scores or WTP. For example, age, gender and occupation had no significant effects on either sensory scores or WTP. Thus, although there was some differences in age and occupation between the three regions (Table SM3, supplementary material), as these factors gave little or no effect on sensory perception or WTP, they did not explain the observed differences in scores. In agreement with our

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results, Hwang et al. (2008) found no significant link between occupation and palatability traits in Australian and Korean consumers. Other studies have reported reduced sensory acuity in older consumers, which lowered the attribute scores (Baugreet, Hamill, Kerry, & McCarthy, 2017) and that male consumers scored beef approximately 2% higher than female consumers (Gomes, Pflanzer, Cruz, de Felício, & Bolini, 2014). These results were not confirmed in this study.

Income had no significant effect on palatability traits (Table 6). In contrast, a previous study showed that a lower income group in ROI gave grilled beef significantly higher scores (P<0.05) than consumers from higher income households (McCarthy, Henchion, White, Brandon, & Allen, 2017). However, income did affect WTP and consumers with the highest income were willing to pay £15, £19 and £23 for "satisfactory", "better than everyday" and "premium" beef while consumers with lower incomes were only willing to pay £13, £17 and £23. This concurred with an Irish study, which reported that consumers in higher social classes (retired and employed) were willing to pay more (Cowan, Riordan, & McCarthy, 2000). Household composition had small effects on sensory score and WTP. Presence or absence of children significantly (P<0.05) increased flavour liking score (Table 6), while households with one or two adults had higher WTP for unsatisfactory product. These effects were not consistent across sensory attributes or WTP bands. Some previous research showed that the number of adults in the household is directly proportional to the ratings of importance of price (Reicks et al., 2011), while, Bonny et al. (2017) found that number of adults and number of children in the household had no effect on WTP and the effect on palatability traits were very small.

4.4. Consumer habits

The relationship between preferred "doneness" and palatability traits is presented in Table 7. Consumers with a preference for "blue" to "rare" cooked beef scored tenderness and overall liking significantly lower compared than consumers with a preference for "medium" to "well-done" steak. This matches our expectation as all the samples were presented as "well-done" steak. Furthermore, consumers who preferred less "doneness" had higher WTP for premium quality beef compared to those who preferred higher "doneness". However, there is no difference between the three regions in their preference for different cooking end-points

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(Table 8), so this does not explain the different sensory scores between regions. It is interesting that consumers in all three regions preferred their beef cooked to "medium rare", "medium" or "medium well" (Table 8), which contrasts with previous results from 2003 (Farmer et al., 2009b), when more than 50% of consumers in Northern Ireland preferred their steak "well-done". This suggests that over a period of 14 years, consumers' preferences in NI have shifted from "well-done" towards "medium".

Consumer-perceived "most important attributes" and "beef appreciation" had no effect on sensory scores or WTP (Table 7). Thus, although more consumers in GB selected flavour as the "most important attribute" for beef quality (Table 7), this did not explain the differences observed in sensory scores between regions.

Consumer purchase habits had no effect on sensory scores and little effect on WTP (Table 7) but were highly significantly different ($P<0.001$) between the three regions (Table 8). A higher proportion of consumers in GB purchased beef from supermarkets while more consumers in NI purchased beef from other locations, probably due to the lower availability of alternative sources in GB. Consumers may expect better quality beef when they purchase from a farm shop or local butcher possibly explaining a higher WTP for "better than everyday quality" (Table 8).

4.5. Motivations for beef choice

Consumers who are concerned about the healthiness of beef scored higher for many of the sensory attributes (Table 9). The results in Table 10 revealed that there were significantly fewer ($P<0.01$) health-conscious consumers in GB compared to NI and ROI, with 30% of GB consumers regarding the health aspect of beef product as "not or little important" when they purchased beef, so this may partly explain the observed difference between GB and ROI/NI consumers. This was surprising as it has been reported that, although British and German consumers recognised beef as a source of iron and protein, they believed that beef should not be in the diet on a daily basis consumers (Verbeke, Perez-Cueto, Barcellos, Krystallis, & Grunert, 2010a).

Consumers for whom animal welfare is important scored higher for most sensory attributes (Table 10). Value conscious consumers also scored higher for palatability traits and had

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lower WTP for "better than everyday" and "premium" beef (Table 10). Neither animal welfare nor value differed in importance between the three regions. Most consumers agreed that past experience was an important motivator for purchasing beef (Table SM4, supplementary material). This factor also affected consumers' palatability traits, with significant higher (P<0.05) scores for tenderness and MQ4 scores (Table 10). A previous study showed that the willingness to repurchase related to high degree of eating consistency (Harrington, 1994).

Surprisingly, consumers who rated "ease of preparation" as a very important factor scored significantly higher for most palatability traits except *juiciness* and were willing to pay less for "better than everyday" and "premium beef" (Table 9). Desire for foods that require minimal preparation is most probably caused by time pressures faced by current generation (Grunert, 2006). The distributions of the importance level of how easy to prepare the beef were broadly similar in three regions (Table SM4, supplementary material).

Consumers had significantly different (P<0.05) opinions on how important they felt it was to know how to cook beef. More consumers from ROI and GB believed that it was a very important factor influencing their beef choices (Table 10). Some studies have demonstrated that consumers sometimes use country of origin as an attribute to evaluate product quality (Hong & Wyer, 1990; Maheswaran, 1994). The evidence in this study indicated that NI and ROI consumers cared more about the beef source compared to GB consumers (Table 10). However, neither of these factors had any significant effect on palatability traits or WTP (Table SM5, supplementary material).

4.6. Consumption frequency for different types of beef products

The consumption frequency of different cuts had some significant effects on consumers' sensory scores and WTP, as presented in Table 11. The most pronounced impact was that consumers who consumed mince most frequently gave higher sensory scores than other consumers when they tasted striploins (Table 11). Minced beef is generally the cheapest beef to purchase and this may explain why consumers who consumed mince regularly scored higher when they tasted higher quality meat in the study. Results showed that mince and lean mince were regularly consumed by consumers in all three regions (Table SM6, supplementary material).

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Consumers from different regions had different consumption habits for some muscles (Table 11), although mince, lean mince, fillet, rib eye and frying steak did not differ (Table SM6, supplementary material). More consumers in GB regularly ate rump (P<0.001) and topside (P<0.01) than other regions while consumers from NI ate silverside and brisket more regularly than ROI consumers. Previous studies showed that 53% of roast topside and 25% of grilled rump were graded as unsatisfactory (Farmer et al., 2016). Therefore, the authors speculate that GB consumers gave higher satisfaction scores when they tasted striploin steaks (Table 1) because these consumers habitually consumed lower quality beef. This speculation was further confirmed by results (Table 11), indicating that consumers with higher consumption frequency of rump scored significantly higher in flavour liking for striploin beef samples.

5. Conclusion

This study provides important insights into the similarities and differences between NI, ROI and GB consumers regarding their perceptions of beef. Region had significant impacts on overall palatability scores and willingness to pay (WTP). GB consumers gave significantly higher scores for all acceptability traits compared to NI and ROI consumers eating the same beef striploin samples. However, there was no significant difference between regions on which samples consumers preferred. GB and ROI consumers had higher WTP for premium beef compared to ROI consumers. Beef source and healthiness of beef product were less important factors to the GB consumers than those from ROI or NI. Socioeconomic and behavioural factors affecting palatability traits included preferred cooking "doneness", consideration of beef as a healthy choice, animal welfare, value, ease of preparation and consumption frequency of specific cuts. WTP was influenced by income, importance of value, ease of preparation, preferred "doneness" as well as consumption frequency of frying steak. Higher consumption frequencies of lower quality cuts, such as rump or topside in GB may explain why higher scores for palatability traits were observed from GB consumers when they tasted striploin steaks. These findings will inform the ROI and NI beef industries marketing meat to other regions, suggesting that differences in purchasing and eating habits and standards need to be taken into account, but that differences in quality are recognised equally in all regions.

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Table 1

Mean scores for palatability traits across regions, treatments and subgroups.

	Palatability traits					
	AL	***TE***	***JU***	***FL***	***OL***	**MQ4**
Region						
NI	55.9[a]	55.9[a]	53.2[a]	54.3[ab]	55.6[a]	55.2[a]
ROI	57.4[a]	57.4[a]	51.6[a]	50.8[a]	55.7[a]	54.9[a]
GB	62.3[b]	62.3[b]	56.8[b]	55.3[b]	59.6[b]	59.7[b]
SEM	1.76	1.76	1.57	1.77	1.64	1.58
P	<0.001	<0.001	0.003	0.033	0.023	0.004
Treatment						
T1	58.2[ab]	53.9[b]	51.9[ab]	54.8[b]	55.1[b]	54.3[b]
T2	60.7[bc]	60.8[bc]	57.4[bc]	61.1[c]	61.8[c]	60.9[c]
T3	60.1[bc]	63.1[c]	59.0[bc]	62.3[c]	62.8[c]	62.4[c]
T4	62.4[c]	65.6[c]	60.2[c]	64.5[c]	65.3[c]	64.7[c]
T5	54.1[a]	36.3[a]	44.6[a]	47.5[a]	44.8[a]	43.1[a]
T6	55.8[a]	43.5[a]	47.6[a]	51.6[ab]	49.7[ab]	48.2[ab]
SEM	2.04	3.82	3.79	2.93	3.24	3.23
P	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Interaction						
Region x Treatment	0.180	0.125	0.079	0.453	0.322	0.202

a, b: Numbers in the same column which do not share a common superscript are significantly different.
AL: aroma liking, ***TE***: tenderness, ***JU***: juiciness, ***FL***: flavour liking, ***OL***: overall liking, NI: Northern Ireland, ROI: Republic of Ireland, GB: Great Britain, T1: straight hung bulls, T2: tenderstretch bulls, T3: straight hung steers, T4: tenderstretch steers, T5: straight hung cows, T6: tenderstretch cows.
P: probability, SEM: standard error of mean.

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Table 2

Adjusted MSA boundaries for grilled samples between unsatisfactory, satisfactory everyday better than everyday and premium qualities.

Region	Boundary		
	Unsatisfactory/ Satisfactory everyday quality	Satisfactory everyday quality/ Better than everyday quality	Better than everyday quality/ Premium quality
NI	36.0	57.5	76.5
ROI	35.0	58.0	76.5
GB	37.0	58.5	76.5
Other studies			
NI [a]	38.0	60.0	77.0
Japan [b]	40.4	66.8	83.1
France [c]	38.0	61.0	80.0
United States [d]	41.0	65.0	82.0

NI: Northern Ireland, ROI: Republic of Ireland, GB: Great Britain.

[a] Farmer et al. (2009a), [b] Polkinghorne, Nishimura, Neath & Watson (2011), [c] Legrand, Hocquette, Polkinghorne & Pethick (2012), [d] Smith, Tatum & Belk (2008).

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Table 3

Weightings for final MQ4 model in NI, ROI, GB and other countries (grilled samples).

	Palatability traits			
Region	***TE***	***JU***	***FL***	***OL***
NI	0.39	0.04	0.27	0.31
ROI	0.31	0.03	0.31	0.36
GB	0.23	0.21	0.28	0.28
Other studies				
Japan [a]	0.30	0.20	0.24	0.26
France [b]	0.31	0.04	0.30	0.36
United States [c]	0.30	0.10	0.30	0.30
NI [d]	0.29	0.05	0.40	0.27

TE: tenderness, ***JU***: juiciness, ***FL***: flavour liking, ***OL***: overall liking, NI: Northern Ireland, ROI: Republic of Ireland, GB: Great Britain.
[a] Polkinghorne, Nishimura, Neath & Watson (2011), [b] Legrand, Hocquette, Polkinghorne & Pethick (2012), [c] Hocquette et al. (2014), [d] Farmer et al. (2009).

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Table 4

Pearson's correlation coefficients among consumer palatability traits and MQ4 score.

	Palatability traits			
Trait	***TE***	***JU***	***FL***	***OL***
JU	0.78***	-		
FL	0.84***	0.85***	-	
OL	0.91***	0.88***	0.95***	-
MQ4	0.95***	0.89***	0.95***	0.99***

TE: tenderness, ***JU***: juiciness, ***FL***: flavour liking, ***OL***: overall liking.
*** Correlation coefficient differs from 0 (P<0.001).

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Table 5

Willingness to pay for products at different grades.

Quality Grade	Grade of product			
	Unsatisfactory	**Satisfactory everyday**	**Better than everyday**	**Premium**
Region				
NI, £/kg (€/kg)	7.71[b] (9.07)	14.08 (16.56)	18.22 (21.44)	22.05[b] (25.94)
*ROI, £/kg (€/kg)	8.03[b] (9.44)	13.46 (15.84)	17.22 (20.26)	20.71[a] (24.36)
GB, £/kg (€/kg)	6.93[a] (8.15)	13.98 (16.45)	17.71 (20.84)	21.99[b] (25.87)
SEM, £/kg	0.289	0.491	0.539	0.591
P	<0.001	0.444	0.193	0.041
Ratio (P-WTP)				
NI	0.55	1.00	1.29	1.57
ROI	0.60	1.00	1.28	1.54
GB	0.50	1.00	1.27	1.58

a, b, c, d: Numbers which do not share a common superscript are significantly difference.
P-WTP: Proportion relative to satisfactory everyday quality, NI: Northern Ireland, ROI: Republic of Ireland, GB: Great Britain, *P*: probability, SEM: standard error of mean.
* €1= £0.85. Local currencies were used in each region, Euro (€) in ROI and Pound (£) in NI and GB.

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Table 6

Significant effects of socio-demographic on mean scores of palatability traits and willingness to pay.

	Palatability traits (0-100 scale)						WTP (£)			
	AL	***TE***	***JU***	***FL***	***OL***	**MQ4**	Unsatisfactory	Satisfactory everyday	Better than everyday	Premium
Income										
Below £25,000	57.2[ab]	54.7	53.4	57.2	56.8	56.0	7.52	13.27[a]	17.08[a]	21.14[a]
£25,000- £50,000	60.1[b]	54.3	54.7	57.0	57.0	55.9	7.50	13.77[a]	17.70[a]	21.39[a]
£50,000- £75,000	60.3[b]	53.4	52.7	57.9	57.0	55.8	7.50	13.76[a]	17.64[a]	21.91[ab]
Above £75,000	53.8[a]	52.8	51.5	55.7	55.2	54.3	8.08	15.80[b]	19.78[b]	23.48[b]
SEM	2.306	2.08	2.33	2.18	2.09	1.96	0.374	0.628	0.687	0.760
P	0.041	0.709	0.494	0.818	0.856	0.811	0.409	0.004	0.006	0.039
Children										
None	57.6	53.7	53.4	56.1	56.1	55.1	7.58	14.00	17.91	21.75
Yes	61.2	54.5	53.9	59.4	58.3	57.0	7.46	13.37	17.17	21.16
SEM	1.61	1.45	1.63	1.49	1.44	1.36	0.261	0.444	0.485	0.533
P	0.026	0.601	0.778	0.029	0.137	0.161	0.695	0.177	0.15	0.285
Number of adults										
Less than 2	58.3	53.7	53.2	56.8	56.1	55.3	7.76	13.79	17.58	21.40
More than 2	59.0	54.0	53.8	57.1	57.4	55.9	7.26	13.90	17.92	21.98
SEM	1.58	1.41	1.58	1.47	1.41	1.32	0.252	0.436	0.478	0.523
P	0.657	0.757	0.676	0.742	0.269	0.540	0.029	0.833	0.447	0.279

a, b, : Numbers in the same column which do not share a common superscript are significantly difference. ***AL:*** aroma liking, ***TE***: tenderness, ***JU***: juiciness, ***FL***: flavour liking, ***OL***: overall liking, WTP: Willingness to pay, ***P***: probability, SEM.: standard error of mean.

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Table 7

Effects of consumers' habits on mean scores of palatability traits and willingness to pay (WTP).

	Palatability traits (0-100 scale)						WTP (£)			
	AL	***TE***	***JU***	***FL***	***OL***	***MQ4***	Unsatisfactory	Satisfactory everyday	Better than everyday	Premium
Preferred Doneness										
Blue+ Rare	55.2	48.1^{a}	47.8	54.0	50.7^{a}	50.6	7.30	13.31	17.53	23.40^{c}
Medium Rare	58.3	52.8^{ab}	53.4	56.2	55.3^{ab}	54.6	7.45	13.85	17.85	22.15^{bc}
Medium	57.8	54.3^{b}	53.5	57.6	57.4^{b}	56.1	7.94	14.26	17.79	21.66^{bc}
Medium Well	59.6	56.3^{b}	55.2	57.5	58.2^{b}	57.1	7.37	13.64	17.71	21.35^{ab}
Well done	60.6	54.6^{b}	54.0	58.4	58.2^{b}	56.7	7.53	13.38	16.89	19.90^{a}
SEM	2.551	2.24	2.56	2.37	2.26	2.12	0.413	0.697	0.765	0.833
P	0.422	0.022	0.273	0.599	0.047	0.091	0.447	0.65	0.548	0.008
Most important attribute										
Tenderness	58.7	54.1	53.4	56.6	56.1	55.4	7.37	13.90	17.99	21.84
Juiciness	53.1	47.5	49.8	50.7	51.3	49.8	7.37	13.90	17.99	21.84
Flavour	58.5	54.0	53.3	57.4	57.1	55.9	7.64	13.70	17.41	21.41
SEM	3.959	3.55	3.98	3.68	3.56	3.33	0.631	1.087	1.185	1.313
P	0.961	0.666	0.923	0.814	0.718	0.833	0.205	0.343	0.255	0.729
Beef appreciation										
S1	57.4	54.9	53.2	57.2	57.1	56.1	7.53	13.91	17.83	22.05
S2	59.2	53.2	53.8	57.4	56.5	55.5	7.43	13.65	17.59	21.35
S3 and S4	58.5	53.5	53.5	55.7	56.1	54.9	7.97	14.35	18.00	21.29
SEM	1.994	1.78	2.01	1.85	1.79	1.67	0.321	0.548	0.600	0.656
P	0.640	0.402	0.942	0.600	0.806	0.718	0.371	0.572	0.813	0.267
Purchase habit										
Supermarket	58.3	58.6	53.9	54.1	57.3	56.5	7.59	13.78	17.42	21.42
Other	58.6	58.3	52.9	51.5	56.3	56.0	7.54	14.54	18.74	22.47
SEM	1.692	1.69	1.52	1.70	1.58	1.52	0.274	0.463	0.504	0.553
P	0.947	0.947	0.711	0.242	0.592	0.920	0.858	0.292	0.018	0.104

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a, b, : Numbers in the same column which do not share a common superscript are significantly difference. ***AL:*** aroma liking, ***TE***: tenderness, ***JU***: juiciness, ***FL***: flavour liking, ***OL***: overall liking, WTP: Willingness to pay, *P*: probability, SEM.: standard error of mean.
S1: I enjoy red meat, it's an important part of my diet. S2: I like red meat well enough, it's a regular part of my diet. S3: I do eat some red meat although truthfully it wouldn't worry me if I didn't. S4: I rarely or never eat red meat.

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Table 8

Demographic data and consumer habits in NI, ROI and GB (number of consumers).

	Region			χ^2	*P*
	NI	**ROI**	**GB**		
Preferred "Doneness"					
Blue+ Rare	6	17	10	11.84	0.158
Medium Rare	24	29	34		
Medium	36	26	35		
Medium Well	32	25	25		
Well done	22	23	16		
Most important attributes					
Tenderness	54	51	41	11.14	0.025
Juiciness	1	8	12		
Flavour	65	60	67		
Frequency of consumption					
S1	51	50	48	3.27	0.513
S2	46	54	56		
S3 and S4	23	15	16		
Purchase habit					
Supermarket	49	75	102	46.33	<0.001
Others	70	45	20		

NI: Northern Ireland, ROI: Republic of Ireland, GB: Great Britain. χ^2: chi-square test, *P*: probability.
S1: I enjoy red meat, it's an important part of my diet. S2: I like red meat well enough, it's a regular part of my diet. S3: I do eat some red meat although truthfully it wouldn't worry me if I didn't. S4: I rarely or never eat red meat.

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Table 9

Significant effects on mean palatability traits and WTP for motivation for beef choice.

		Palatability traits (0-100 scale)						WTP (£)			
Factor	Importance level	***AL***	***TE***	***JU***	***FL***	***OL***	***MQ4***	Unsatis-factory	Satis-factory everyday	Better than everyday	Premium
It is a healthy choice.	Not/ Little	56.0	51.5^{a}	52.4	54.4^{a}	54.3^{a}	53.3^{a}	7.60	13.96	18.11	21.91
	Moderate	58.2	53.2^{a}	53.3	56.4^{a}	56.1^{a}	55.0^{a}	7.50	13.76	17.59	21.58
	Very	60.7	56.8^{b}	53.9	60.0^{b}	59.3^{b}	58.2^{b}	7.52	13.70	17.56	21.55
	SEM	1.90	1.68	1.93	1.75	1.70	1.58	0.311	0.529	0.586	0.640
	P	0.083	0.007	0.820	0.013	0.023	0.014	0.886	0.834	0.641	0.928
Animal well cared for.	Not/ Little	56.2	53.8	53.3	56.5^{ab}	55.8^{ab}	55.1^{ab}	7.53	13.55	17.33	21.33
	Moderate	57.8	52.5	52.1	54.9^{a}	55.0^{a}	53.9^{a}	7.66	13.62	17.74	21.60
	Very	60.5	55.7	54.9	59.6^{b}	59.0^{b}	57.8^{b}	7.40	14.16	17.89	21.90
	SEM	1.86	1.67	1.87	1.72	1.67	1.56	0.304	0.520	0.576	0.627
	P	0.078	0.086	0.269	0.008	0.020	0.018	0.629	0.414	0.66	0.623
It is good value.	Not/ Little	56.7	52.5	49.4^{a}	55.3^{ab}	54.6^{a}	53.7^{a}	8.56	14.70	19.47^{b}	23.68^{b}
	Moderate	57.8	52.7	52.5^{ab}	55.3^{a}	54.9^{ab}	54.1^{ab}	7.45	13.97	17.90^{ab}	22.14^{b}
	Very	60.0	55.6	55.4^{b}	59.4^{b}	58.9^{a}	57.7^{a}	7.53	13.52	17.22^{a}	20.68^{a}
	SEM	2.50	2.23	2.51	2.27	2.21	2.06	0.408	0.684	0.757	0.816
	P	0.224	0.063	0.036	0.007	0.006	0.007	0.081	0.179	0.019	<0.001
I enjoyed it last time.	Not/ Little	57.2	53.4^{ab}	52.8	56.5	56.0	55.1^{ab}	7.12	13.49	16.65	20.72
	Moderate	57.2	52.1^{a}	52.0	55.3	55.1	54.0^{a}	7.55	13.59	17.71	21.68
	Very	59.9	55.8^{b}	54.8	58.6	58.0	57.2^{b}	7.65	14.02	17.92	21.84
	SEM	2.21	1.97	2.23	2.04	1.99	1.85	0.359	0.612	0.676	0.741
	P	0.187	0.024	0.190	0.070	0.109	0.041	0.376	0.603	0.304	0.378
It is easy to prepare.	Not/ Little	55.6^{a}	51.3^{a}	50.7	54.2^{a}	53.3^{a}	52.7^{a}	7.59	14.08	18.12^{b}	22.51^{b}
	Moderate	60.0^{b}	54.5^{b}	54.9	58.0^{b}	57.5^{b}	56.5^{b}	7.55	14.06	18.05^{b}	21.80^{ab}
	Very	59.0^{ab}	55.9^{b}	53.6	58.0^{b}	58.7^{b}	57.1^{b}	7.48	13.22	16.83^{a}	20.65^{a}
	SEM	1.85	1.67	1.88	1.71	1.65	1.55	0.302	0.510	0.562	0.618
	P	0.046	0.033	0.073	0.045	0.005	0.014	0.917	0.124	0.024	0.011

a, b, : Numbers in the same column which do not share a common superscript are significantly difference. ***AL:*** aroma liking, ***TE***: tenderness, ***JU***: juiciness, ***FL***: flavour liking, ***OL***: overall liking, WTP: willingness to pay, *P*: probability, SEM: standard error of mean.

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Table 10

Importance level on motivation of beef choice.

Factor	Importance level	Regions			χ^2	*P*
		NI	ROI	GB		
I know how to cook it.	Not/ Little	23	18	27		
	Moderate	60	48	38	12.24	0.016
	Very	34	52	55		
It is a healthy choice.	Not/ Little	19	23	36		
	Moderate	46	56	57	14.02	0.007
	Very	50	39	27		
I know where it comes from.	Not/ Little	10	15	29		
	Moderate	59	44	52	16.57	0.002
	Very	50	58	39		

NI: Northern Ireland, ROI: Republic of Ireland, GB: Great Britain. χ^2: chi-square test, *P*: probability

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Table 11

Effect of frequency of purchase of cuts on mean palatability traits and WTP (significant effects).

		Palatability traits (0-100 scale)						WTP (£)			
Factor	Consumption frequency	***AL***	***TE***	***JU***	***FL***	***OL***	***MQ4***	Unsatisfactory	Satisfactory everyday	Better than everyday	Premium
Frying steak	Never	57.3	52.8	51.5	56.0	54.9	54.2	7.63	13.65^{ab}	17.62^{ab}	21.55
	<2/ month	59.1	54.0	53.8	57.2	56.9	55.8	7.56	14.40^{b}	18.35^{b}	21.92
	≥2/ month	59.8	55.4	55.2	58.3	58.7	57.2	7.45	13.06^{a}	16.82^{a}	21.15
	SEM	1.89	1.70	1.92	1.76	1.71	1.59	0.310	0.520	0.572	0.636
	P	0.492	0.45	0.291	0.57	0.141	0.287	0.856	0.013	0.013	0.418
Mince	Never	55.5	49.4	47.0^{a}	53.6	52.0^{a}	51.2^{a}	7.42	14.08	17.47	22.12
	<2/ month	58.9	55.1	54.9^{b}	57.0	57.2^{b}	56.3^{b}	7.68	14.49	17.96	21.37
	≥2/ month	59.1	54.3	54.2^{b}	57.7	57.3^{b}	56.2^{b}	7.53	13.57	17.72	21.65
	SEM	2.23	1.95	2.21	2.05	1.96	1.83	0.362	0.615	0.677	0.743
	P	0.316	0.072	0.005	0.184	0.042	0.044	0.802	0.178	0.758	0.684
Lean Mince	Never	53.4^{a}	53.4	52.0	53.8	55.3	54.0	7.27	14.94	18.27	21.63
	<2/ month	59.4^{b}	52.6	53.1	55.9	55.3	54.4	7.45	13.82	17.58	21.48
	≥2/ month	59.2^{b}	54.6	53.9	58.2	57.5	56.5	7.62	13.60	17.70	21.72
	SEM	2.19	1.99	2.24	2.04	1.99	1.85	0.360	0.609	0.669	0.735
	P	0.043	0.374	0.642	0.051	0.244	0.180	0.673	0.092	0.612	0.858
Rump	Never	57.4	53.0	51.6	54.7^{a}	54.8	53.9	7.34	13.88	18.01	22.04
	<2/ month	58.3	53.4	53.6	57.6^{ab}	56.8	55.7	7.73	14.20	17.99	21.79
	≥2/ month	62.7	57.4	56.2	61.0^{b}	60.0	59.2	7.11	11.79	16.77	21.79
	SEM	2.79	2.47	2.79	2.57	2.49	2.31	0.449	0.757	0.831	0.908
	P	0.156	0.185	0.116	0.034	0.142	0.079	0.351	0.162	0.657	0.996
Silver-side	Never	56.9^{a}	53.7	52.9	55.8	55.7	54.8	7.41	13.54	17.74	21.50
	<2/ month	59.5^{b}	53.5	53.3	57.8	57.2	55.9	7.75	14.33	18.03	22.16
	≥2/ month	63.5^{b}	54.3	52.8	58.8	56.6	56.2	7.21	12.84	16.45	21.38
	SEM	2.85	2.58	2.90	2.66	2.58	2.41	0.466	0.788	0.863	0.947
	P	0.041	0.768	0.815	0.275	0.588	0.596	0.411	0.212	0.694	0.266

a, b, : Numbers in the same column which do not share a common superscript are significantly difference. ***TE***: tenderness, ***JU***: juiciness, ***FL***: flavour liking, ***OL***: overall liking, <2/ month: less than twice per month, ≥2/ month: twice or more per month WTP: willingness to pay, *P*: probability, SEM: standard error of mean.

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Table 12

Consumption frequency of different muscles.

Muscle	Consumption frequency	Region			χ^2	*P*
		NI	ROI	GB		
Sirloin	Never	5	13	15		
	<2/ month	85	69	81	10.29	0.036
	≥2/ month	28	37	23		
Casserole steak	Never	35	44	23		
	<2/ month	52	50	70	10.53	0.032
	≥2/ month	27	25	27		
Topside	Never	51	63	44		
	<2/ month	49	50	71	16.86	0.002
	≥2/ month	15	5	5		
Silverside	Never	26	77	57		
	<2/ month	59	37	56	66.07	<0.001
	≥2/ month	32	3	7		
Brisket	Never	64	93	63		
	<2/ month	45	22	54	21.84	<0.001
	≥2/ month	5	3	3		
Rump	Never	44	68	20		
	<2/ month	57	47	82	46.41	<0.001
	≥2/ month	14	3	18		

NI: Northern Ireland, ROI: Republic of Ireland, GB: Great Britain, <2/ month: less than twice per month, ≥2/ month: twice or more per month, χ^2: chi-square test, *P*: probability.

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