



Consumer assessment, in Ireland and the United Kingdom, of the impact of the method of suspension of carcasses from dairy-origin bulls and steers, on the sensory characteristics of the *longissimus* muscle

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Abstract

The objective was to compare the assessment of beef produced in Ireland from a 19-month bull or a 24-month steer dairy beef production system by consumers in Ireland (Cork) and the United Kingdom (Belfast and Reading). Carcass sides were suspended by the Achilles tendon or by the pelvic bone and 21-d aged longissimus muscle assessed using Meat Standards Australia protocols. Carcass weight and classification were similar for bulls and steers. Consumers in Belfast and Cork rated aroma liking, tenderness, juiciness, overall liking and the composite meat quality score (MQ4) similarly, but lower ($P < 0.05$) than consumers in Reading. Consumers in Belfast and Cork rated flavour liking similarly as did consumers in Cork and Reading, but consumers in Reading rated flavour liking higher ($P < 0.05$) than consumers in Belfast. Muscle from steers had higher scores for aroma liking, flavour liking, overall liking and MQ4 scores than bulls ($P < 0.05$). On average, pelvic suspension increased ($P < 0.05$) the scores for aroma liking and flavour liking compared with conventional suspension but increased ($P < 0.05$) tenderness, juiciness, overall liking and MQ4 scores only in bulls. Consumers in Reading rated striploin from the traditional Achilles tendon-suspended steers similarly to striploin from pelvic-suspended bulls (MQ4 score of 71.8 and 68.2, respectively). Beef from the latter system could replace the traditional steer beef in this market, thereby benefiting the beef producer and the environment.

Keywords

Bulls • carcass suspension • consumers • steer

Introduction

In 2020, 46% of the beef exported from the Republic of Ireland went to the United Kingdom, including Northern Ireland (Bord Bia, 2021). Meeting the requirements of consumers is critical to maintaining this market. This market is also important for dairy-origin male cattle where bulls slaughtered at under 16 months of age and steers slaughtered at 24 months of age are preferred (AHDB, 2020). However, Murphy *et al.* (2017, 2018) demonstrated that producing dairy-origin bulls in a grass-based production system and slaughtering at 19 months of age was more profitable than either an under-16-months-of-age production system or the traditional 24-month steer production system. In addition, a 19-month bull production system had lower greenhouse gas emissions compared with the 24-month steer production system, mainly due to the younger age at slaughter (Murphy *et al.* 2017, 2018). The lack of enthusiasm by beef processors for 19-month dairy bull beef

may be based in part on a perception of inferior eating quality compared with dairy steer beef. This perception is supported by Nian *et al.* (2018) who reported higher Warner Bratzler shear force, an instrumental measurement of toughness, in the *longissimus* muscle from 19-month dairy bulls compared with 21-month dairy steers, and by Moran *et al.* (2021) who made a similar observation in a comparison of 19-month dairy bulls and 24-month dairy steers. Traditionally, beef carcasses are suspended by the Achilles tendon. However, pelvic suspension uses the obturator foramen of the aitch bone to suspend the carcass, thereby improving meat tenderness in a muscle-dependent manner (Hostetler *et al.*, 1975). Application of this suspension method to the bulls and steers in Moran *et al.* (2021) resulted in 14-d aged *longissimus* muscle from Achilles tendon-suspended steers being rated similarly by Irish naïve sensory panellists as that from pelvic

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bone-suspended bulls. Should this observation be confirmed by consumers in the target United Kingdom market, it would assist in the marketing of dairy-origin bull beef from the more profitable production system.

The objective of this study was therefore to compare the sensory characteristics as assessed by consumers in Ireland and the United Kingdom of dairy-origin bull and steer beef from carcasses that were suspended from the Achilles tendon or from the pelvic bone.

Materials and methods

The animals chosen for this study were a subset from the larger dairy beef production study described by Murphy *et al.* (2018). In brief, spring-born Holstein-Friesian male calves were randomly assigned to remain as bulls (B, $n = 15$) or to be castrated (S, $n = 15$; castrated at 202 ± 9 d of age), turned out to pasture for the summer, housed during winter (offered grass silage *ad libitum* plus 1.5 kg concentrate DM/head daily) and returned to pasture in March. Bulls were slaughtered at 19 months (586 ± 9 d of age) after finishing indoors on a concentrates and straw ration offered *ad libitum* for 100 d, while steers were housed in November, offered grass silage *ad libitum* plus 5 kg of concentrate DM/head daily and slaughtered in February at 24 months (733 ± 8 d) of age. The slaughter procedure was described by Moran *et al.* (2021). Electrical stimulation was not applied and within 1 h post slaughter the carcasses were split into two sides from the backbone. One side was suspended using the Achilles tendon and the other side using the obturator foramen of the pelvic bone (aitch bone). The suspension method was assigned randomly to each side of each carcass. Both sides were immediately placed in a chill set at 9°C . After approximately 10 h, the chill temperature was reduced to 0°C .

At 48 h post mortem, the *longissimus thoracis* muscle (posterior to the 10th rib) was removed from both sides from six animals chosen at random from each treatment group, vacuum packaged, transported to the laboratory and placed in a chill ($3 \pm 1^{\circ}\text{C}$) for a total of 21 d post mortem and then frozen (-20°C). Samples of *longissimus thoracis* muscle (between the 10th and 11th ribs) were also collected for measurement of pH (Moran *et al.*, 2021) and then stored at -20°C for subsequent proximate analysis and analysis of collagen concentration and crosslinks as described by Moran *et al.* (2021).

The details of sample preparation prior to consumer assessment are given in Chong *et al.* (2020). In brief, the frozen striploins were sliced into 25-mm steaks (25 mm) using a bandsaw and transported to the Agri-Food Bioscience Institute (AFBI) in a polystyrene box with ice packs (journey time 5 h). The frozen steaks were partially thawed for 30 min, cut into smaller samples ($\sim 50 \times 50 \times 25 \text{ mm}^3$) and transferred

to a commercial freezer. Specific samples were identified and coded for analysis using Meat Standards Australia (MSA) protocols (Watson *et al.*, 2008) and transported frozen to each location.

The consumer analysis based on MSA protocols is described in detail in Chong *et al.* (2019). In brief, the consumer panels were conducted at AFBI (Belfast), University College Cork and University of Reading to represent the consumers in Northern Ireland, Republic of Ireland and Great Britain, respectively. The same protocol was adopted, the facilities were broadly similar and the consumer panels were conducted as close in time as was practicable. A total of 360 consumers participated in the panels, with 120 consumers from each location. Each group of 20 consumers per session was invited to a central location to participate in the consumer analysis.

In all cases, the steaks were grilled using the same clam grill (S-143, SILEXIA UK. Ltd, York, United Kingdom). Samples were thawed at 4°C for 24 h prior to assessment. Samples (ca. $50 \times 50 \times 25 \text{ mm}^3$) were grilled to an internal temperature of 72°C (well done). Ten samples were cooked in each round, which were cut in half and served to 20 consumers. Consumers were presented with seven samples with 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. A section of each striploin 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. Consumers rated the palatability traits of aroma liking, tenderness, juiciness, flavour liking and overall liking on 100-mm line scales verbally anchored at 0 (0 = low intensity/liking) and 100 (100 = high intensity/liking). In the MSA system, the two highest and two lowest scores are removed “clipped” for each sample. In the present dataset, the s.e.d. was consistently higher for the clipped results compared with unclipped results, and there was little change in the mean values (data not shown). The unclipped data were therefore used. Thus the 10 individual scores were averaged to generate the mean sensory scores for each palatability trait prior to analysis.

Statistical analysis

In addition to the scores provided by the consumers, a weighted eating quality score, MQ4 score, was calculated for each sample using the MSA model (0.3 tenderness + 0.1 juiciness + 0.3 flavour liking + 0.3 overall liking). Data were subjected to linear mixed-model analysis using the random effect model variance component (REML) estimation method of GenStat (GenStat 16.2.0.11713, VSN International Ltd, Hemel Hempstead, United Kingdom). The location of

consumers, sex and suspension method and their interactions were considered as fixed effects, and the sides within the animal were random effects.

Results

The characteristics of the animals and their muscle selected for consumer analysis are summarised in Table 1. Bulls grew faster ($P < 0.05$) than steers but pre-slaughter live weight, carcass weight and carcass classification were similar for bulls and steers. The ultimate pH and the concentration of collagen crosslinks were similar for bulls and steers, but bulls had a higher ($P < 0.05$) collagen concentration and tended ($P = 0.11$) to have a lower intramuscular fat concentration than steers.

The mean consumer sensory scores are summarised in Table 2. There was no location by gender by suspension method or location by gender interactions for any of the sensory variables examined. Consumers in Belfast and Cork rated aroma liking, tenderness, juiciness, overall liking and the MQ4 score similarly, but lower ($P < 0.05$) than consumers in Reading. Consumers in Belfast and Cork rated flavour liking similarly as did consumers in Cork and Reading, but consumers in Reading rated flavour liking higher ($P < 0.05$) than consumers in Belfast. Muscle from steers had higher scores for aroma liking, flavour liking, overall liking and MQ4 scores than bulls ($P < 0.05$). Pelvic suspension increased the scores for aroma liking and flavour liking

compared with conventional suspension ($P < 0.05$). There was an interaction ($P < 0.05$) between gender and hanging such that pelvic suspension increased tenderness and juiciness in *longissimus thoracis* from bulls but not in steers (Table 3). There was also a tendency ($P < 0.07$) for an interaction between gender and hanging such that the increase in overall liking and MQ4 scores due to aitch bone hanging were greater for bulls than steers (Table 3).

Discussion

The United Kingdom is an important market for beef from the Irish dairy herd and the most common production system is steers slaughtered at 24 months of age. Consumers in the United Kingdom are therefore accustomed to this type of beef. A bull production system with animals slaughtered at 19 months of age is a more profitable dairy beef production system for the producer and is more environmentally “friendly” (Murphy *et al.*, 2018). There is a resistance among beef processors to accept these animals based in part on the perception that bull beef is of inferior quality when compared with the more conventional dairy steer beef. If strategies could be identified that would enhance the eating quality of 19-month-old dairy bull beef, this could provide an opportunity for these animals to enter the United Kingdom market at a similar premium price as 24-month steer beef. One relatively easy strategy is

Table 1: Growth and characteristics of the carcass and *longissimus* muscle of Holstein-Friesian male cattle slaughtered as bulls at 19 months or steers at 24 months of age

	Bulls	Steers	s.e.d	Significance
Age (d)	588	732	4.95	***
Live weight (kg)	606	611	24.8	
Carcass weight (kg)	318	303	12.4	
ADG (kg/d)	0.90	0.79	0.034	*
FDG (kg/d)	2.15	0.95	0.139	***
Conformation score ¹	5.40	4.17	0.668	
Fatness score ¹	7.80	8.00	0.322	
Muscle pH ²	5.54	5.52	0.014	
Composition (g/kg)				
Fat	53	75	12.6	(0.11)
Moisture	719	697	8.1	*
Protein	222	222	3.2	
Collagen	9.1	6.6	0.05	***
Collagen crosslinks (nM pyridinoline/g DM)	16.0	12.1	2.84	

ADG, average daily gain from the beginning of the study; FDG, average daily gain during the finishing phase.

¹Conformation and fatness measured on a 15-point scale.

²At 10th rib, 48 h post mortem.

Table 2: Sensory scores of consumers in three locations for *longissimus* muscle from Holstein-Friesian male cattle slaughtered as bulls at 19 months and steers at 24 months of age and whose carcasses were suspended from the Achilles tendon or pelvic bone (aitch)

		Sensory		Attribute			
		Aroma liking	Tenderness ¹	Juiciness ¹	Flavour liking	Overall liking ¹	MQ4 ¹
Location²	Belfast	58.1 ^a	58.1 ^a	59.1 ^a	60.3 ^a	59.0 ^a	59.1 ^a
	Cork	61.3 ^a	59.1 ^a	59.5 ^a	62.7 ^{a,b}	62.6 ^a	61.3 ^a
	Reading	66.1 ^b	66.5 ^b	63.9 ^b	66.7 ^b	67.9 ^b	66.7 ^b
	s.e.d.	1.92	2.27	1.78	2.08	2.06	1.85
	Significance	**	**	*	*	***	**
Gender	Bulls	59.0	52.7	52.5	56.6	55.7	54.8
	Steers	64.6	69.7	69.1	69.9	70.6	70.0
	s.e.d.	2.09	2.81	2.77	2.02	2.12	2.21
	Significance	*	***	***	***	***	***
Suspension	Achilles	59.6	58.2	58.4	60.5	60.5	59.6
	Aitch	64.1	64.3	63.2	66.0	66.0	65.2
	s.e.d.	1.56	1.92	1.60	2.02	2.12	1.87
	Significance	**	**	*	*	*	*

¹Gender by suspension interaction (Table 3).

²Means within location with a different superscript differ significantly ($P < 0.05$).

Table 3: Gender by suspension method interactions for sensory scores for *longissimus* muscle from Holstein-Friesian male cattle slaughtered as bulls at 19 months and steers at 24 months of age and whose carcasses were suspended from the Achilles tendon or pelvic bone (aitch)¹

Gender (G)	Bull		Steer		s.e.d.	Significance
	Achilles	Aitch	Achilles	Aitch		
Suspension (S)						
Tenderness	47.3 ^a	58.2 ^b	69.1 ^c	70.4 ^c	3.18	*
Juiciness	47.9 ^a	57.1 ^b	68.9 ^c	69.4 ^c	2.89	*
Overall liking	50.9 ^a	60.6 ^b	70.0 ^c	71.2 ^c	3.00	0.07
MQ4	49.9 ^a	59.7 ^b	69.3 ^c	70.6 ^c	2.81	0.06

¹Means within a row with a different superscript differ significantly ($P < 0.05$).

to exploit the reported advantages with respect to tenderness, in particular, from hanging the carcass by the pelvic bone “aitch bone” rather than the more traditional Achilles tendon or “straight hanging”.

The primary objective of this study was to compare this strategy in the most relevant market for dairy-origin beef, that is, the United Kingdom. There is a paucity of information on the behaviour of consumers in the United Kingdom compared with those in Ireland. In an Irish research context, most sensory analysis of beef is carried out by Irish trained panellists or Irish consumers. It is important to understand whether the results obtained in this situation transfer to the more relevant export markets for Irish beef. A project under the Sensory Food Network Ireland programme provided an opportunity to explore this issue by supplying relevant

samples to the large sample set being examined in that project. The MSA grading system has been developed to predict beef eating quality based on large-scale consumer data (Watson *et al.*, 2008). This robust protocol was used, with minor adaptations, as it facilitates comparison of consumer behaviour across the diverse locations/countries where it has been applied.

The production and economic data, the predicted environmental impact and data on the colour and meat quality characteristics of the dairy-origin animals of which the samples in the current study are a subset have been reported (Murphy *et al.*, 2018; Moran *et al.*, 2021). Relevant carcass data for the latter are presented for reference.

That beef from steers was rated more highly for the sensory characteristics examined than beef from bulls is consistent

with the analysis by Bonny *et al.* (2016) of a database from studies where the MSA protocol was used. In the present study, while bulls were younger at slaughter than steers, their lower ratings for the sensory variables measured likely reflect their lower intramuscular fat and higher collagen concentrations and collagen crosslinks (Mezgebo *et al.*, 2019). Park *et al.* (2008), who used the MSA protocol, observed that pelvic bone suspension enhanced the sensory characteristics of steers. This was not observed in the present study and likely reflects the difference in the duration of post-mortem ageing of samples prior to assessment: 21 d in the present study and 7 d in the study by Park *et al.* (2008). Indeed, in this study, tenderness of bull beef was enhanced by aitch bone hanging while tenderness of steer beef was not, and this halved the sensory difference between bull and steer beef. We are not aware of a comparison using the MSA protocol of carcass suspension methods applied to bulls. However, Sorheim *et al.* (2001) reported an improvement in tenderness, measured by trained assessors, of striploin from 16- to 19-month bulls due to pelvic suspension, which was subsequently confirmed, using an instrumental measure of tenderness, by Ahnstrom *et al.* (2012).

Preferences of consumers in different beef markets are subject to a myriad of social and cultural influences (Chong *et al.*, 2019). For example, a comparison of multiple studies conducted in France, Australia, Poland, Republic of Ireland and Northern Ireland using the MSA protocol showed that the location of the consumers significantly affected all the palatability traits (Bonny *et al.*, 2017). Similarly, Realini *et al.*

(2009) reported that when offered Uruguayan beef from several finishing rations, there were differences between consumers in France, Spain, Germany and the United Kingdom and that the differences were influenced by the finishing diet of the cattle. That consumers from Cork and Belfast responded similarly to the beef provided likely reflects the similar production systems and beef available for consumption in Northern Ireland and the Republic of Ireland. Chong *et al.* (2019) examined the socioeconomic and behavioural impacts on the choices made by the consumers in the present study. They suggested that the higher frequency of consumption of lower quality cuts, such as rump or topside, may explain the higher scores for palatability traits given by consumers in Reading. From a marketing perspective, a key finding from the present study is that consumers in Reading gave a similar composite eating quality score (MQ4) to striploin from the traditional, Achilles-suspended steers and striploin from pelvic-suspended bulls. This was not the case in Cork and Belfast (Figure 1). This reflected the similar overall liking score given by Reading consumers for both sources of striploin (73 and 70 for Achilles-suspended steers and pelvic-suspended bulls, respectively). These findings indicate that beef from this bull production system could replace the traditional dairy-origin steer beef in this region of the United Kingdom, thereby benefiting the beef producer and the environment. It is recognised that this comment applies only to the striploin commercial beef cut. A further larger-scale study encompassing other commercial beef cuts and other regions of the United Kingdom is needed to support this finding.

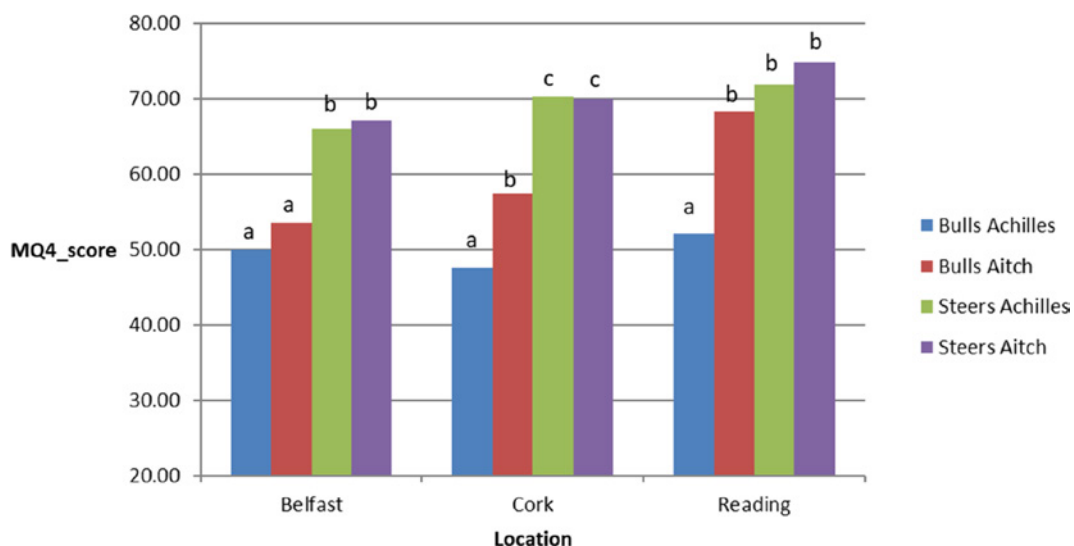


Figure 1. Weighted eating quality score (MQ) of consumers in three locations for the *longissimus* muscle from Holstein-Friesian male cattle slaughtered as bulls at 19 months and steers at 24 months of age and whose carcasses were suspended from the Achilles tendon or pelvic bone (aitch). Means with a different superscript differ significantly ($P < 0.05$).

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