EFFECT OF CASTRATION AND AGEING TIME ON THE QUALITY OF BEEF FROM MALE DAIRY CATTLE

Y. Nian[1,2], J. P. Kerry[2], R. Prendiville[3] and P. Allen[1,*]

[1] Department of Food Chemistry and Technology, Teagasc Food Research Centre, Ashtown, Dublin 15, Ireland

[2] School of Food and Nutritional Sciences, University College Cork, Cork, Ireland

[3] Department of Livestock Systems Research, Teagasc, Grange, Dunsany, Co Meath, Ireland

[*]Corresponding author email: Paul.Allen@teagasc.ie

Abstract – Bulls have production advantages over steers, however, there is concern about the eating quality of bull beef. This study assessed the physico-chemical characteristics of Holstein-Friesian bull and steer beef from pasture based production systems and slaughtered at 19 and 21 m, respectively. *Longissimus thoracis* (LT) muscles were removed from the cube rolls of 15 bull and 15 steer carcasses. Ultimate pH (pHu), meat colour, chemical composition, collagen content and solubility were evaluated. Warner-Bratzler Shear Force (WBSF) and cook loss were measured after 3, 7, and 14 ageing days. Steer beef had higher redness, yellowness, and chroma values after 24 h blooming, while bull beef had higher pHu and darker muscle. WBSF and cook loss at all ageing days were higher for bull beef, while intramuscular fat (IMF) concentration was higher for steer beef. Bull beef had more insoluble and total collagen, while soluble collagen and collagen solubility were higher for steer beef. This suggests that for young dairy cattle, steer beef would likely have superior eating quality to bull beef. The ageing process improved tenderness for both bull and steer beef and the WBSF of aged bull beef indicates it was acceptably tender after more than 7 d of ageing.

Key Words – Collagen, Colour, IMF, Tenderness

I. INTRODUCTION

The number of male calves from the Irish dairy herd has markedly increased following the abolition of EU milk quotas in 2015. This is a potential new resource for the industry if they can be reared economically to produce meat of acceptable eating quality. Leaving these males intact to develop as bulls may be the most viable option due to their improved growth rate and feed conversion efficiency compared to steers. On average, bulls have 8.4% higher live weight gain, 9.5% heavier carcass weight and 20% greater lean meat yield than steers reared in the same way [1]. Moreover, the lower carbon emissions for bull production systems compared to steers will benefit sustainable farming and the environment [2]. Although the number of bulls reared increased in the last decade, any further growth in bull beef production is constrained by the reluctance of processors to purchase bulls arising from concerns about the consumer acceptability of bull beef. It is known that several meat processing parameters affect meat eating quality, such as the improvement of tenderness by ageing. But little is known about how the ageing process affects beef from bulls and steers from the dairy herd. Thus, this study aims to evaluate the physico-chemical quality characteristics of beef derived from extreme dairy breeds under a specific production system and assess the effect of castration and ageing time on their meat quality traits.

II. MATERIALS AND METHODS

Animals and experimental design

Thirty weaned early spring-born male Holstein-Friesian (HF) dairy calves (10-12 weeks of age) were sourced in 2013. The calves were turned out to pasture and supplemented with 1.5 kg concentrates during the first grazing season (May-Nov). The concentrates consisted of 80% barley, 14% soya bean meal, 4% molasses and 2 minerals. Towards the end of the first grazing season 15 calves were castrated. All calves were then housed and offered good quality grass silage supplemented with 2 kg concentrates during the winter period (Nov-Mar 2014). They were all turned out again and fed grass only for the second grazing season (bulls: Mar-June, and steers: Mar-Sep). Bulls and steers were housed in June and September and finished on pasture plus 5 kg concentrates over a

100 or 60 d period and slaughtered at 19- and 21-months old, respectively.

Sampling procedures

Carcasses were chilled at 4 ºC for 24 h. The LT muscle was removed from the cube roll (ribs 6-10) from the left-hand side of each carcass at 48 h post-mortem. Ultimate pH (pHu) of the LT was measured at 72 h, and the muscle was cut into individual slices (25 mm thick). Colour was measured on the first slice from the 10th rib end and the remainder of the slices were vacuum-packed. Samples for chemical composition and collagen were stored at -20 ºC immediately, while samples for WBSF and cook loss analysis were aged for 3, 7 and 14 d at 4 ºC and then frozen at -20 ºC for further analysis.

Quality measurements

Freshly cut samples were wrapped in oxygen-permeable polyvinylchloride film and left to bloom at 4 ºC for 24 h. Colour measurements were taken using a dual beam spectrophotometer (UltraScan XE, Hunter Lab., VA, USA) through the cling film at 5 locations on each muscle and averaged. CIE L* (lightness); a* (redness) and b* (yellowness) values were recorded. Hue angle ($\tan^{-1}b^*/a^*$)*57.29, and Chroma index $(a^{*2} + b^{*2})^{1/2}$ were calculated.

Moisture and IMF concentrations of thawed minced beef samples were measured using Smart System 5 microwave moisture drying oven and the NMR Smart Trac rapid Fat Analyser, respectively (CEM Corporation, USA).

Warner-Bratzler Shear Force (WBSF) was determined on cores taken from steaks cooked in a water bath at 72 ºC to a core temperature of 70 ºC using an Instron Universal Testing Machine (Models 5543). Cook loss was determined as the difference between the initial weight before cooking and the final weight after cooking and expressed as a percentage of the initial weight.

Collagen samples were freeze dried, defatted and extracted as described by Hill [3]. Final supernatant 100 µL and 3 mg of dry defatted powder (total collagen) were hydrolysed using 2 mL of 6 M HCl under nitrogen atmosphere at 110 °C overnight following the method described by Colgrave et al. [4] with slight modification. 4-hydroxyproline was measured using Ultra-performance Liquid Chromatographic-tandem Mass Spectrometry (UPLC-MS) (Waters Corporation, MA, USA). Insoluble collagen was expressed as the difference between total collagen and soluble collagen, and percentage solubility was calculated as soluble collagen as a percentage of total collagen.

Statistical Analysis

Each measurement was carried out for 30 individual samples with two or three replicates per sample, depending on the analysis. The data were analysed using the GLM procedure of ANOVA from the SAS software [5] with gender as a factor. Multiple comparisons were adjusted by the Tukey-Kramer test with a significance level of $P<0.05$.

III. RESULTS AND DISCUSSION

The pHu of the LT muscle was higher for young bulls than for steers ($P<0.01$) (Table 1). This agreed with Dunne et al. [6] who found that the physical contests between bulls caused glycogen depletion prior to slaughter, thus insufficient lactic acid generation post slaughter. The pHu of both bulls and steers were within the range $5.4 \leq pHu \leq 5.7$ considered normal for beef [7]. No DFD (dark, firm, dry, pHu >5.9) meat was recorded.

Table 1 pHu, colour after 24 h blooming and cook loss at 14 d ageing of LT muscle from HF bulls and steers

	Bull		Steer		P-value
	LSM	S.E.M	LSM	S.E.M	
pHu	5.76^a	0.03	5.62^b	0.03	<0.01
L*	42.7^b	0.54	44.6^a	0.52	<0.05
a*	13.8^b	0.53	19.5^a	0.51	<0.001
b*	11.2^b	0.32	14.2^a	0.31	<0.001
Chroma	17.9^b	0.58	24.2^a	0.56	<0.001
Hue angle	39.3^a	0.67	36.1^b	0.65	<0.01
Cook loss	32.8^a	0.33	29.9^b	0.32	<0.001

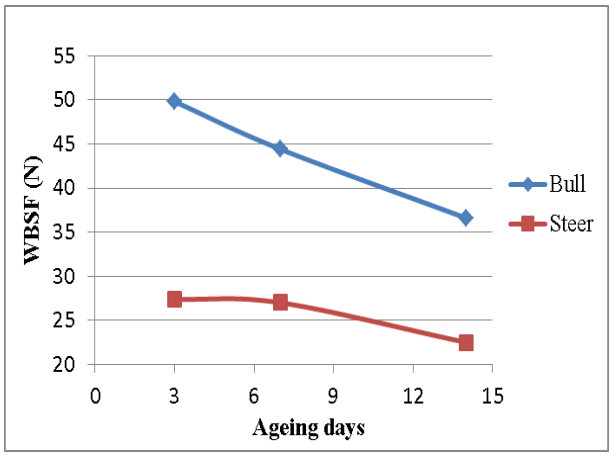
LSM=least square means; S.E.M=standard error of LSM; a,b: Means within a row with different superscripts significantly differ (P<0.05); HF=Holstein-Friesian; pHu=ultimate pH.

After 24 h blooming, bull beef was darker than steer beef (P<0.05), and since the myoglobin content of bulls and steers has been shown to be similar, this was probably due to reduced myofiber disruption, as indicated by the higher pHu [8], and to the lower marbling concentration (Table 2) [9]. Redness, yellowness and chroma were all higher (P<0.001) in steer beef indicating a deeper colour, whereas hue angle was higher in bull beef indicating a less red hue (P<0.01), in line with Dune et al. [6].

The WBSF of bull and steer beef both decreased during ageing with the decline being more marked for bulls, while steer beef was surprisingly tender even after only 3 d of ageing (Figure 1). Based on the beef tenderness categories of Shackelford et al. [10], bull beef after 7 d ageing would be classified as on the borderline between 'tender' and 'intermediate tender' (WBSF between 31.36 and 45.08 N) whereas by 14 d it would be classified as 'tender'. Steer beef was 'very tender' (WBSF < 31.36 N) from day 3 on.

Castration improved tenderness with steer beef being more tender at all ageing days (P<0.001), which agreed with the finding of Zhang et al. [11]. The more tender beef from steers can be partly explained by the lower total collagen, higher collagen solubility and higher IMF concentration compared to bulls (Table 2). The rate and extent of muscle proteolysis during postmortem storage, such as calpain and calpastatin activity could also contribute to the tenderness difference between the sexes [12].

Figure 1 WBSF of LT muscle from HF bulls and steers at different ageing days



Cook loss did not change with ageing for both bull and steer beef (data not shown). Castration had a significant effect on cook loss at all ageing days (data at 3 d and 7 d not shown), being higher for beef from bulls than steers, in agreement with Zhang et al. [11].

Table 2 Chemical composition and collagen traits of LT muscle from HF bulls and steers

	Bull		Steer		P-value
	LSM	S.E.M	LSM	S.E.M	
Moisture (%)	75.1^{a}	0.26	72.1^{b}	0.25	<0.001
IMF (%)	0.49^{b}	0.36	3.84^{a}	0.35	<0.001
SC (mg/g)	0.49^{b}	0.05	0.74^{a}	0.04	<0.001
IC (mg/g)	3.04^{a}	0.19	2.16^{b}	0.13	<0.001
TC (mg/g)	3.53^{a}	0.19	2.90^{b}	0.13	<0.05
CS (%)	14.6^{b}	2.00	25.8^{a}	1.36	<0.001

LSM=least square means; S.E.M=standard error of LSM; a, b: Means within a row with different superscripts significantly differ (P<0.05); HF=Holstein-Friesian; IMF=Intramuscular fat; SC=Soluble collagen; IC=Insoluble collagen; TC=Total collagen; CS=Collagen solubility.

Castration affected the composition of the LT muscle, including an increase in fat (P<0.001) and a concomitant decrease in water content (P<0.001) (Table 2), in agreement with Destefanis et al. [8]. The greater muscle gain and lower fat deposition of bulls compared to steers primarily results from the effects of the androgenic hormones, particularly testosterone, on the reduction of muscle protein degradation [13]. Fat levels between 3% and 7.3% in beef have been considered to be generally acceptable for consumers in terms of visual quality and health concerns [14]. IMF also plays an important role in beef palatability with regard to flavour, tenderness and juiciness [15]. Thus, Steer beef in this study had a satisfactory IMF level, whereas the IMF content of bull beef was much lower than the acceptable level.

Bulls had higher insoluble (P<0.001) and total collagen (P<0.05) contents than steers, while soluble collagen (P<0.001) and collagen solubility (P<0.001) were higher in steers than bulls (Table 2), which indicated that collagen in the LT muscle of bulls had more intermolecular cross-links. The reduced total collagen content in LT muscle in the

castrates has also been reported by Destefanis et al. [8] and Zhang et al. [11], and is probably due to the lack of the anabolic effects of testosterone on collagen synthesis [16].

IV. CONCLUSION

Castration improved pHu, water holding capacity, tenderness, IMF concentration and collagen characteristics of young male dairy cattle. There were also differences in terms of beef colour, with steer beef being lighter with a more intense red colour. Steer beef was tender after only 3 days ageing, while ageing continued to enhance the tenderness of bull beef even up to 14 days. Dairy bulls can produce acceptably tender beef provided it is aged for more than 7 days.

ACKNOWLEDGEMENTS

This work was funded by the Teagasc Walsh Fellowship Scheme. We wish also to acknowledge the Teagasc Johnstown Castle Research Centre for rearing the young dairy bulls and Dawn Meats for slaughtering them.

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