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Effect of a grazing period prior to finishing on a high concentrate diet on meat quality from bulls and steers

L. Moran [a,*], M.G. O'Sullivan [b], J.P. Kerry [b], B. Picard [c], M. McGee [d], E.G. O'Riordan [d], A.P. Moloney [d]

[a] Teagasc, Food Research Centre, Ashtown, Dublin, 15, Ireland
[b] University College Cork, School of Food and Nutritional Sciences, Cork, Ireland
[c] INRA & VetAgro Sup., Recherches sur les Herbivores, Theix, 63122 Saint-Genès-Champanelle, France
[d] Teagasc, Animal & Grassland Research and Innovation Centre, Grange, Dunsany, Co.Meath, Ireland

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ABSTRACT

Bulls and steers (n = 60) were assigned to a pre-finishing grazing period and subsequently finished on concentrates or offered concentrates without grazing until slaughter (19 months). Colour and pH of *longissimus thoracis* were measured (48 h post-slaughter), and samples collected for proximate composition, collagen, sarcomere length, muscle fibre and enzymatic profile analysis. Steaks for texture, cook loss and sensory were aged (14 days). Castration increased intramuscular fat content, cook loss and myosin isoforms IIa and I proportions, and decreased IIx proportion ($P < 0.05$). Steer meat was positively correlated to overall tenderness, texture and acceptability ($P < 0.05$). The presence of a pre-finishing grazing period decreased intramuscular fat and increased the proportion of IIa compared with animals on concentrates, while no differences were found in sensory. Muscle colour, collagen, sarcomere length and instrumental texture were not modified by diet or castration. In conclusion, beef sensory characteristics were unaffected by diet, whereas castration resulted in a small improvement; however all the treatments produced an acceptable product.

1. Introduction

Male beef production in Ireland is typically based on steers grazing at pasture in summer and then housed and offered grass silage and supplementary cereal concentrates during the winter with slaughter at 24 months of age or greater (Drennan & McGee, 2009). Current production systems for bulls generally entail a post-weaning indoor finishing period on *ad libitum* concentrates (Drennan & Fallon, 1998) or high digestibility grass silage plus supplementary concentrates, and slaughter between 12 and 16 months of age with insufficient carcass fat cover being the primary market limitation. However numerous studies highlight the advantages, in terms of growth rate and feed efficiency of using bulls in comparison with steers for beef production (Jones, Price, Berg, & Hardin, 1981; O'Riordan, Crosson, & McGee, 2011). To exploit these biological advantages, while increasing the profitability of bull production there is interest in the inclusion of a grazing period in order to decrease the cost of production (O'Riordan & O'Kiely, 1996), as feedstuff provision accounts for a major proportion of total costs in most cattle production systems and grazed grass is the cheapest feedstuff in temperate climates (Finneran et al., 2011).

Consequently, the most suitable alternative is the use of older animals. For seasonal, spring-calving grass-based systems, bulls must be slaughtered prior to the indoor winter period for the main herd (October/November), due to housing facility constraints; this corresponds to an age of approximately 19 months. The use of this novel less intensive, forage-based system for older animals seems to be a suitable option for bull production in terms of performance and profitability.

However, as 90% of Irish beef is exported within higher value EU markets a key challenge is to maintain Ireland's premium position within these outlets. Meat quality is influenced by multiple interacting factors including castration and diet (Wood et al., 1999), and the effect of a change in these factors within a beef production system should be careful analysed. Some authors have reported lower tenderness, juiciness (Chrystall, 1994) and flavour (Melton, 1990) in meat from cattle finished on forages compared with intensive grain-fed systems, however beef from forage-fed cattle has been found to be as acceptable as that from grain-fed cattle after the inclusion of a short-length grain based finishing period (Cerdeño, Vieira, Serrano, Lavín, & Mantecón, 2006; Vestergaard, Therkildsen, et al., 2000). Similarly, several studies indicate that beef from steers is more tender than beef from bulls, however in many studies comparisons were made at a similar weight at slaughter instead of similar age (Jones, Harries, Robertson, & Akers, 1964). Other studies, however, report only slight differences between castrated and entire animals, and not of a scale that would influence the acceptability of beef by the untrained consumer (Morgan, Wheeler, Koohmaraie, Savell, & Crouse, 1993; Wierbicki, Cahill, Kunkle, & Deatherage, 1953). Finally, bull meat has been reported to be leaner than steer beef

* Corresponding author.
E-mail address: Lara.Moran@teagasc.ie (L. Moran).

(Fritsche & Steinhart, 1998; Kang, Lee, & Lee, 2009), thus meeting increasing consumer demands for quality lean meat (Van Wezemael, Caputo, Nayga, Chryssochoidis, & Verbeke, 2014).

Within this context, the objective of the present study was to assess meat quality characteristics and sensory acceptability from 19 month old suckler bulls and steers, from contrasting production systems, a conventional indoor concentrate system and a modified lower cost system that included a pre-finishing grazing period.

2. Material and methods

2.1. Animals and diets

Spring-born late-maturing breed (Limousin and Charolais) sired suckler male cattle (n = 60) *ca.* 8 months old (369 kg live weight, s.d 27.3 kg), were balanced within breed, weight and age and randomly assigned to one of four treatment groups in a 2 (steer or bull) × 2 production systems differing in the pre-finishing diet factorial arrangement of treatments. All animals were accommodated in replicated pens or batch (3 pens per treatment, 5 animals per pen) and this distribution of animals was maintained throughout the experiment. The castration of the animals (n = 30) was undertaken at 9 months of age, two weeks before the start of the trial.

In winter, the animals were maintained indoors and offered a moderate nutritive value grass silage (dry matter (DM) digestibility (DMD) 688 g/kg) *ad libitum* plus 3 kg concentrate (862 g/kg rolled barley, 60 g/kg soya bean meal, 50 g/kg molasses and 28 g/kg minerals/vitamins). At the end of the winter, half of the animals were turned-out to rotationally graze on a perennial ryegrass dominant sward (GC), while the other half stayed indoors and were offered a barley-based concentrate (same formulation as above) plus grass silage (DMD 677 g/kg) *ad libitum* (CC), for 98 days. All groups were then housed and finished on a barley-based concentrate diet (same formulation and allowance as above) for 76 days. Slaughter was undertaken in 3 balanced groups (n = 20) on 3 consecutive weeks at an average age of ~19 months. Specific details about the production system are described in McMenamin et al. (2015). The study was carried out under license from the Irish Government Department of Health and Children and all procedures used complied with national regulations concerning experimentation on farm animals.

2.2. Slaughter, sampling procedures, pH and colour

On the day of slaughter the animals were transported approximately 30 km to a commercial slaughter plant and slaughtered immediately after arrival by bolt stunning followed by exsanguination from the jugular vein. Electrical stimulation was not applied and carcasses were hanged by the Achilles tendon. The slaughter and dressing procedures were in accordance with the Regulations (EC) No. 1099/2009 and No. 853/2004. Approximately 30 min after slaughter, carcasses were placed in a chill set at 9 °C and ambient temperature was monitored (1 h = 11.5 °C, 3 h = 12.57 °C, 6 h = 11.3 °C). After approximately 10 h the chill temperature was reduced to 0 °C.

The pH and temperature of the *longissimus thoracis* muscle (LT) at the 10th rib were recorded in the left side carcass at 1 h, 3 h 6 h and 48 h *post mortem*, with a portable pH meter with temperature compensation (Model WP-80 (pH/ORP/T meter), TPS Pty, Ltd. Springwood, Queens land, Australia.) and a glass pH probe (Glass electrode: model EC-2010-06, Refex Sensors Ltd. Westport, Ireland.) using a scalpel incision for each measurement as described by Pearce et al. (2010). The pH meter was (re)calibrated at ambient temperature intermittently throughout each measurement period. Within the first hour post-mortem, two samples (5 g) of the LT were collected at the 9th rib, immediately frozen in liquid N_2, and maintained on dry ice until storage at −80 °C for muscle fibre and enzymatic analysis.

After approximately 48 h in the chill carcasses were moved to the deboning hall (4 °C) and subcutaneous fat colour was measured at two different locations (rib and rump) to give a more representative estimate of the overall subcutaneous fat colour across the carcass, while colour of the LT was measured at the 5th/6th rib interface, 1 h after cutting and exposure to oxygen. In both cases, colour was measured as Hunter lab values using a portable spectrophotometer (Miniscan EZ, HunterLab, Reston, Virginia, USA). The cube roll (CR; commercial cut that begins between the 5th and 6th rib and ends between the 10th and 11th rib) was then removed, vacuum packed and transported to Teagasc, Food Research Centre, Ashtown, Dublin. One steak, 2.5 cm thick, was stored at −20 °C for composition, sarcomere length and collagen determination. The remainder of the CR was wet-aged for 12 additional days (4 °C) to reach a total of 14 days of ageing (wet ageing is the normal ageing in the Irish beef industry), thereafter CR was sliced (2.5 cm thick steaks) for sensory evaluation, cook loss and instrumental texture analysis. All samples were then vacuum packed and frozen at −20 °C for subsequent analysis.

2.3. Chemical composition, collagen and sarcomere length analysis

Steaks for proximate analysis, were thawed, trimmed of external fat and connective tissue, and the trimmed muscle was blended (R101, Robot Coupe SA, France). The intramuscular fat content (IF) of each sample was determined using a bench-top nuclear magnetic resonance (NMR) instrument (SMART Trac Fat Analyser; CEM Corporation, Matthews, NC, USA). Approximately 3.5 g of each sample were initially dried using the SMART Trac microwave drying oven and the moisture content of each sample was recorded. Afterwards, the SMART Trac NMR system utilizes NMR and directly measures fat content utilizing the signal-to-mass ratio. Each sample was analysed in duplicate (AOAC, 2000b).

Protein was determined in duplicate using a LECO protein analyser based on the Dumas method (Model FP-428, Leco Corporation, St. Joseph, MI, USA) following AOAC (2000a). Soluble and insoluble collagen concentrations were calculated from the hydroxyproline concentration measured by the method of Kolar (1989) modified by Voutila, Mullen, Ruusunen, Troy, and Puolanne (2007). Sarcomere length was determined in triplicate samples by laser diffraction using the method described by Cross, West, and Dutson (1981).

2.4. Metabolic enzyme activities and muscle fibre type proportions

Glycolytic enzyme activities [phosphofructokinase (PFK, EC 2.7.1.11), lactate dehydrogenase (LDH, EC 1.1.1.27)] and oxidative enzyme activities [isocitrate dehydrogenase (ICDH, EC 1.1.1.42), citrate synthase (CS, EC 4.1.3.7) and cytochrome *c* oxidase (COX, EC 1.9.3.1)] were quantified spectrophotometrically in LT samples using the methods described by Jurie, Ortigues-Marty, Picard, Micol, and Hocquette (2006). The PFK, LDH activities were measured by following the disappearance of nicotinamide adenine dinucleotide, reduced form (NADH) at 340 nm, and ICDH activity was measured by following the reduction of nicotinamide adenine dinucleotide phosphate (NADP) at 340 nm. PFK activity was determined according to Beutler (1971), LDH activity according to Ansay, Laurent, and Roupain (1974), and ICDH activity following Briand, Talmant, Briand, Monin, and Durand (1981). CS activity was determined by measuring the rate of initial reaction at 412 nm by means of the DTNB [5,5′-dithiobis-(2-nitrobenzoic acid)] method as described by Shepherd and Garland (1969). COX activity was determined according to Smith and Conrad (1956) with 20 μl of homogenate in 1 ml of a reaction mixture that contained 90 μM reduced cytochrome *c* as substrate and 50 mM potassium phosphate (pH 7.4). The oxidation of cytochrome *c* was measured spectrophotometrically at 550 nm. The velocity was calculated from $V = k \times [S]$, in which the first order constant k was determined in the assay and [S] was set at 90 μM. All enzyme activities were measured at 25 °C, performed in