Meat Science 125 (2017) 128–136

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Compensatory growth in crossbred Aberdeen Angus and Belgian Blue steers: Effects on the colour, shear force and sensory characteristics of *longissimus* muscle

S.M. Keady [a], S.M. Waters [a], R.M. Hamill [b], P.G. Dunne [b], M.G Keane [a], R.I. Richardson [c], D.A. Kenny [a], A.P. Moloney [a,*]

[a] Teagasc, Animal and Grassland Research and Innovation Centre, Grange, Dunsany, Co. Meath, Ireland
[b] Teagasc, Food Research Centre, Ashtown, Dublin 15, Ireland
[c] Division of Farm Animal Science, Department of Clinical Veterinary Science, University of Bristol, Langford, Bristol BS40 5DU, UK

ARTICLE INFO

Article history:
Received 14 July 2016
Received in revised form 24 November 2016
Accepted 25 November 2016
Available online 2 December 2016

Keywords:
Meat quality
Compensatory growth
Sensory analysis

ABSTRACT

The effect of feed restriction (99 days) followed by compensatory growth during a 200 day re-alimentation period on the colour and sensory characteristics of meat from Aberdeen Angus × Holstein-Friesian (AN) and Belgian Blue × Holstein-Friesian (BB) steers was examined. Compensatory growth had no effect on muscle pH and temperature decline, chemical composition, drip loss, fat colour, or juiciness, but increased ($P = 0.009$) Warner-Bratzler shear force and decreased tenderness ($P = 0.08$) and overall liking ($P = 0.09$). Compared to meat from BB steers, meat from AN steers had a higher intramuscular fat concentration and was rated similarly for tenderness, but higher for many of the flavour characteristics examined. While adjustment for intramuscular fat concentration removed some of these differences, genotype-specific flavour differences remained. It is concluded that genotype had greater effects on meat quality than the compensatory growth feeding regime imposed in this study.

1. Introduction

Compensatory growth is the ability of an animal to undergo accelerated growth when offered feed *ad libitum* after a period of restricted feed intake (Hornick, Van Eenaeme, Gérard, Dufrasne, & Istasse, 2000). In grass-based beef production systems, compensatory growth allows the realignment of feed demand from a time when feed is expensive (e.g. winter) to a time when feed is plentiful and cheap (spring/summer). As a result, there is a reduction in the cost of feeding the animal which can contribute to an increase in the profitability of the production system. The literature suggests that compensatory growth is enhanced when the restriction period is relatively short (approximately 3 months) and not too severe (Hornick et al., 2000). The period when compensatory growth is at a maximum is difficult to ascertain since compensatory growth reported in the literature is frequently calculated over the duration of the re-alimentation period. As growth rate generally declines with duration of feeding a high energy ration, for both previously restricted and non-restricted animals (e.g. Hornick, Van Eenaeme, Clinquart, Gerard, & Istasse, 1999), this masks the relative patterns of growth. Nevertheless, the difference in growth rate between previously restricted and non-restricted animals declines with duration of re-alimentation (Nicol & Kitessa, 1995).

There is considerable, but often conflicting, information on the effect of compensatory growth, and its underlying basis, on bovine meat quality, particularly its effect on meat tenderness (Sinclair et al., 2001; Hansen, Therkildsen, & Byrne, 2006; Moloney et al., 2008). Moreover, research relating to the relative effect of compensatory growth on meat quality from breeds of differing maturity reared under a similar production system is limited. The different responses to compensatory growth across the studies cited above seem to reflect, at least in part, intramuscular fat concentration and the capacity of different animals to deposit lipid in muscle. We hypothesised that since early maturing breeds deposit more fat than late maturing breeds at a similar age, compensatory growth would have less of an impact on early maturing breeds.

Therefore, the objective of this study was to examine the effect of compensatory growth on sensory characteristics of *M. longissimus thoracis et lumborum* (LTL) muscle from Aberdeen Angus × Holstein Friesian (AN) and Belgian Blue × Holstein Friesian (BB) steers, representative of early and late maturing genotypes, respectively.

* Corresponding author.
E-mail address: aidan.moloney@teagasc.ie (A.P. Moloney).

http://dx.doi.org/10.1016/j.meatsci.2016.11.020
0309-1740/

2. Materials and methods

All animal procedures were conducted under experimental licence from the Irish Department of Health and Children, in accordance with the Cruelty to Animals Act, 1876 and the European Communities Regulation 2002 and 2005. In addition, ethical approval was granted from the Animal Research Ethics Committee, University College Dublin, Belfield, Dublin, Ireland. Animals were slaughtered in an EU-licensed abattoir, Meadow Meats Rathdowney, Co. Laois, Ireland.

2.1. Animal model and management

Sourcing and rearing of the animals used in the present study were described by Keady (2011). In brief, male Spring-born progeny (n = 46) of Holstein-Friesian dams and sired by either Aberdeen Angus (10 individual sires) or Belgian Blue bulls (9 individual sires) were identified and sourced from Irish commercial herds in Autumn 2009. The calves were castrated using the burdizzo method (Pang et al., 2009) within 1 mo of arrival. They were offered grass silage (228 g dry matter (DM)/kg, 112 g crude protein (CP), 80 g ash, 557 g neutral detergent fibre (NDF), 351 g acid detergent fibre (ADF)/kg DM, DM digestibility 677 g/kg, pH 3.6) *ad libitum* plus 1 kg of concentrates (825 g DM/kg, 121 g CP, 43 g ash, 557 g NDF, 352 g ADF/kg DM) per head per day before commencing the study to allow adjustment to their new environment and recovery from castration. Mean age at the commencement of the study was 362 (SD. 15.5) and 369 (SD 19.4) days for AN and BB steers, respectively. Mean body weights were 295 (SD 30.0) and 287 (SD 48.6) kg for AN and BB, respectively. Within genotype, animals were blocked by weight and randomly assigned to 1 of 2 treatment groups in a 2 (genotypes) × 2 (feeding treatments) factorial design. One group (11 AN and 12 BB) was offered a high energy control diet consisting of the above concentrates *ad libitum* and 10 kg of grass silage per head daily (H-H) throughout the study. The second group (11 AN and 12 BB) was offered an energy restricted diet consisting of grass silage *ad libitum* plus 0.5 kg of concentrate per head per day for 99 days followed by *ad libitum* access to the high energy diet (H-H) until slaughter. Animals were accommodated individually in concrete slatted floor pens and allocated a space allowance of 8 m^2 per animal. Breed and treatment was equally dispersed across the shed. Animals were individually fed their respective diet each morning at 8 am and uneaten feed was weighed and discarded on a daily basis. Fresh water was constantly available.

The initial 99 days was considered the differential feeding period. The subsequent re-alimentation period lasted 200 days with all animals slaughtered on day 299 of the study. The animals were weighed at the start of the study (day 0), the end of the differential feeding period (day 99) and on 2 consecutive days before slaughter (day 299). Animals were also weighed every 2 to 3 weeks at the same time each morning before fresh feed was offered. On the morning of slaughter the steers were transported 130 km to The Meadow Meats commercial slaughter facility in Rathdowney, Co. Laois, Ireland. Animals were slaughtered (Halal ritual procedure) within one hour of arrival. Carcasses were hung by the Achilles tendon and moved to a chill room with an average ambient temperature of 3 °C, within one hour of slaughter. Approximately 8 h *post-mortem*, the chill was set to 0 °C.

2.2. Carcass temperature and pH post-mortem

Starting at 1.5 h *post-mortem*, the temperature of the LTL muscle was recorded by making a scalpel incision between the 10th and 11th rib and inserting a temperature probe (Knick Portamess 913 thermometer, GmbH & Co., Berlin, Germany). The pH of the LTL was measured by insertion of a glass electrode attached to a portable pH meter (Knick Portamess 913 pH meter, GmbH & Co., Berlin, Germany), close to the insertion point of the temperature probe. The pH reading was automatically adjusted for carcass temperature. Temperature and pH were subsequently measured at 3, 4.5.6 and 8 h *post-mortem* and at 48 h *post-mortem*.

2.3. Collection of LTL samples

The right side of each carcass was cold-boned at 24 h *post-mortem*. Three steaks were cut from the LTL each 2.5 cm in thickness, 30 cm distal to the 10th rib. The adhering fat was removed from the steaks and subsequently used for fat colour analysis as described below. The first steak was immediately used for drip loss assessment while the second steak was used for muscle colour assessment. Following this the steak was vacuum packed, aged for 14 days at 2 °C, frozen at −20 °C and subsequently used for Warner-Bratzler shear force (WBSF) assessment. The third steak was vacuum packed, frozen at −20 °C and subsequently chemically analysed as described below. The remaining LTL with subcutaneous fat intact was vacuum packed immediately, aged at 2 °C for 14 days, frozen at −20 °C and forwarded to the Division of Farm Animal Science, University of Bristol for sensory analysis.

2.4. Chemical composition and drip loss from LTL

Intramuscular fat, moisture and protein concentrations were determined in thawed LTL as previously described (Moloney et al., 2008). Drip loss was measured using the hanging bag method (Honikel, 1998).

2.5. Muscle and fat colour

A freshly cut sample of LTL (25 mm) was trimmed of adhering adipose tissue at 48 h *post-mortem*, wrapped with oxygen-permeable PVC film and permitted to bloom in darkness at 4 °C, for 4 h to permit oxygenation of myoglobin. Readings of '*L*' (lightness), '*a*' (redness) and '*b*' (yellowness) values were measured and muscle hue angle ('*H*') and saturation ('*C*') were calculated as $\tan^{-1}(b/a)$ and $[(a)^2 + (b)^2]^{0.5}$, respectively on both the muscle and the trimmed adipose tissue using a Hunterlab UltraScan XE colorimeter (Hunter Associates Laboratory, Inc., Reston, VA, USA). Final conversion of hue angle from radians to degrees was achieved by multiplying $\tan^{-1}$ (b/a) by 180/π (Liu, Scheller, Arp, Schaefer, & Frigg, 1996). The instrument was calibrated prior to measurements using its standard white calibration tile. Four readings were made on non-overlapping areas of each sample using the optical port (2.54 cm) and average values were reported as final readings. Diffuse illumination (D_{65}, 10°) with an 8° viewing angle was used. The spectrocolorimeter was used in reflectance mode and the specular component was excluded.

2.6. Warner-Bratzler shear force and cooking loss

Warner-Bratzler shear force was measured according to the procedure of Shackelford, Koohmaraie, and Savell (1994). In brief, steaks, after 6 months frozen storage, were trimmed of external fat, weighed and cooked in open vacuum pack bags in a circulating water bath (Grant instruments Ltd., UK) set at 72 °C, until their internal temperature reached 70 °C (assessed using a Minitherm H18751 temperature probe, Hanna Instruments Ltd., UK). Steaks were cooled to room temperature, reweighed for determination of cooking loss and tempered at 4 °C overnight. Seven cores (1.25 cm diameter) parallel to the direction of the muscle fibres were collected for each steak and each core was sheared using an Instron Universal testing machine (Model no. 5543, Instron Europe, High Wycombe, Bucks, UK) equipped with a Warner Bratzler shearing device. The crosshead speed was 5 cm/min. The highest and lowest shear force measurements of the 7 means per steak were excluded in the calculation of mean values. For analysis of the data, Instron Series IX Automated Materials Testing System software for Windows (Instron Corporation, Bucks, UK) was employed.