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Composition and quality differences between the longissimus and infraspinatus muscles for several groups of pasture-finished cattle

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Abstract

Samples of longissimus (LT) and infraspinatus (IS) muscles from five contrasting groups of pasture-finished cattle ($n = 7$/group) were assessed for quality and composition characteristics in order to determine whether features of pasture-finished beef reported previously apply across different muscles and different classes of cattle. The cattle were not raised together or slaughtered at the same time. Wagyu-cross steers had the highest intramuscular fat levels, particularly in the LT, followed by Angus steers, Charolais-cross steers and Belgian Blue-cross steers, with the lowest levels for Friesian bulls. Relative to the LT, the IS muscle had longer sarcomeres, higher cooking losses, higher concentrations of vitamin E, and lower myofibrillar fragmentation indexes, while its ultimate pH was slightly higher but less variable. Beef from Wagyu-cross steers had the highest chroma values and the lowest shear values, while Friesian bull beef was darkest and least tender. Intramuscular fatty acid composition and concentrations of bioactive compounds such as coenzyme Q_{10} and carnosine, were similar to those reported previously for cattle finished on New Zealand pastures although taurine levels were lower. Generally concentrations of bioactive compounds differed more between muscles and groups than between cattle finished on pasture or grain as reported previously.
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1. Introduction

The range of beef quality characteristics of concern to consumers has broadened over recent years, from being restricted mainly to aspects of appearance and palatability (flavour, tenderness, and juiciness) of the product, to include several other aspects including nutritive value, whether or not it contains compounds with useful bioactive properties, and, to some extent, the farming system involved in its production (Bernues, Olaizola, & Corcoran, 2003; European Commission, 2005).

For lean beef (i.e. beef with all visible fat except intramuscular fat removed), it is generally accepted that the nutritive value is consistently high (Biesalski, 2005), but research has shown that some important aspects vary significantly between muscles and within the same muscle from animals finished on different diets. Thus, New Zealand studies have shown that levels of vitamin D3 and 25-hydroxyvitamin D3 vary significantly between different cuts of beef (Purchas, Zou, Pearce, & Jackson, 2007), and that levels of several beneficial fatty acids, including the CLAs and their precursor, and the omega-3 group, are higher in intramuscular lipid of cattle finished on pasture than of those finished on high-grain diets (Purchas, Knight, & Busboom, 2005). The latter effect has been widely reported elsewhere as well, as has the fact that vitamin E levels are higher in beef from pasture-finished cattle, although this difference can be rectified if vitamin E supplements are included in feedlot rations (Kerry, Buckley, & Morrissey, 2000).

Compounds present in beef with potential bioactive properties, including taurine (Huxtable, 1992), carnosine

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(Decker & Mei, 1996), coenzyme Q_{10} (Overvad et al., 1999) and creatine (Snow & Murphy, 2003), have also been shown to vary significantly between muscles, and in the case of coenzyme Q_{10}, carnosine, and taurine for one study, to be at higher concentrations in beef from pasture-finished cattle (Purchas & Busboom, 2005). Functions of these compounds in the human body have been outlined by Purchas, Rutherfurd, Pearce, Vather, and Wilkinson (2004), but whether the quantities in typical servings of beef are sufficient to have measurable bioactive effects has not been determined.

It is not known whether the desirable features of pasture-finished beef outlined above will apply to all types of cattle or to all muscles. Therefore, the objective of the current study was to determine the extent to which concentrations of selected nutrients, fatty acids, and bioactives varied between two muscles from contrasting groups of cattle, all of which had been finished on pasture in New Zealand.

2. Materials and methods

2.1. Animals and sample collection

The five groups of seven cattle from which samples of the LT and IS muscles were taken were:

1. Angus steers (Ang) aged about 4 years (all had six permanent incisors erupted) with an average carcass weight of 405.7 kg (SD = 19.7), as an example of a traditional beef breed.
2. Belgian Blue × Angus steers (BBX) aged about 30 months with a mean carcass weight of 329.1 kg (SD = 16.9), as an example of cattle that excel with regard to low levels of fatness and high muscularity (Hanset, 1982). It was not known how many of the so-called double-muscling *mh* genes these cattle had, but it is well known that such genes are present at a high frequency in the Belgian Blue breed (Grobet et al., 1997).
3. Friesian bulls (FrBu) aged about 27 months with a mean carcass weight of 336.6 kg (SD = 22.9), as an example of a class of cattle from the dairy industry that is widely used for beef production.
4. Charolais × (Hereford × Friesian) steers (ChX) aged about 20 months with a mean carcass weight of 296.9 kg (SD = 3.9), as an example of a relatively late-maturing and fast growing cross.
5. Wagyu × Friesian steers (3/4 or 7/8 Wagyu) (WaX) aged about 4 years with a mean carcass weight of 392.2 kg (SD = 19.7), as an example of cattle with a reputation for producing high levels of intramuscular fat (Smith et al., 2006).

All cattle were raised and finished on pasture, but each group was from a different farm so breed composition was completely confounded with farm. They were slaughtered and processed at commercial meat plants according to normal practice. In the case of the WaX group, samples of 1–1.5 kg of the LT muscle from the cube roll (in the region of ribs 8–12) and the thickest part of the IS muscle from the oyster-blade cut were collected at the time of boning 3 days *post-mortem*. The samples were then aged at 1–3 °C until day 9 *post-mortem* when they were frozen at −20 °C until processed. For the other four groups, samples of a similar size from the same two muscles were taken from the right side of each carcass within 2 h of slaughter and were stored at 8 °C until 24 h *post-mortem*, at which time they were chilled to 1–3 °C and aged until day 9 *post-mortem* when they were frozen at −20 °C. Thus all samples were treated similarly except that those from the WaX group were collected at the time of boning rather than within 2 h *post-mortem*.

2.2. Sample processing and meat quality assessment

Processing the samples followed the procedures reported by Purchas, Burnham, and Morris (2002) with regard to characteristics related to meat quality, which, briefly, included the measurement of:

1. Ultimate pH on an homogenate of 2–2.5 g of muscle in 10 mL of 150 mM KCL.
2. Water-holding capacity using a filter-paper press method expressed as the wetted area per unit weight of sample ($cm^2\ g^{-1}$).
3. Sarcomere length by laser diffraction.
4. Warner–Bratzler shear force using a square blade as a measure of tenderness based on 12 shears of cores with a 13 × 13 mm cross section taken from 25 mm steaks cooked in a 70 °C water bath for 90 min.
5. Compression measurements on samples cooked in the same way using a 10 × 10 mm plunger to compress a 10 mm-thick sample by 8 mm using two cycles at 100 mm min^{-1} (TA.TX-Plus instrument, Texture Technologies, Scarsdale, New York).
6. Myofibrillar fragmentation index using a filtration method (a stainless steel mesh with 231 μm gaps).
7. Colour as L^*, a^*, and b^* values of samples exposed to air for >20 min using a Minolta Chromameter (CR-200) with an 8 mm aperture.

At the time of preparing samples for meat quality assessments, approximately 200 g of finely diced and mixed internal muscle samples from both the LT and IS muscles were prepared and frozen for subsequent analytical measurements.

2.3. Analytical measurements

The proportions of iron as haem iron and non-haem iron were assessed as described by Purchas, Simcock, Knight, and Wilkinson (2003). Haem iron was assessed using the colorimetric method of Hornsey (1956), and non-haem iron was assayed colorimetrically using the ferrozine method after removal of haem iron by trichloro-

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