Meat Science 83 (2009) 484–491

Contents lists available at ScienceDirect

Meat Science

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

Effect of finishing and ageing time on quality attributes of loin from the meat of Holstein–Fresian cull cows

Daniel Franco [a,*], Esperanza Bispo [a], Laura González [a], Jose Antonio Vázquez [b], Teresa Moreno [a]

[a] Instituto Gallego de la Calidad Alimentaria (INGACAL), Centro de Investigaciones Agrarias de Mabegondo, Apdo 10 15080 A Coruña, Spain
[b] Grupo de Reciclado y Valorización de Residuos, Instituto de Investigaciones Marinas (IIM-CSIC) Vigo, Spain

ARTICLE INFO

Article history:
Received 2 July 2008
Received in revised form 9 March 2009
Accepted 18 June 2009

Keywords:
Cull dairy cows
Finishing feeding
Meat ageing
Textural properties

ABSTRACT

The effects of finishing time, (T0 = 0, T1 = 30 and T2 = 60 days), on Holstein–Friesian cull cows (n = 18) and *post-mortem* ageing, (1, 7, 14, 21, 35 and 42 days), under vacuum conditions of *Longissimus thoracis* (LT) muscles were investigated. The objective of this research was to study how finishing feeding (based on a commercial concentrate and corn silage), following a pasture period of 90 days, affected carcass and meat quality. Ageing time effect was also evaluated on the main quality attribute of added value pieces, such as "*striploin of ox*" from cull cows. Finishing treatment affected intramuscular fat content (IMF), moisture percentage, water-holding capacity (WHC), colour parameters and shear force of meat at 24 h *post-mortem*, whereas ageing time enhanced meat tenderness, when this was measured by two textural tests, Warner–Braztler (WB) and textural profile analysis (TPA). A minimum shear force was achieved at 7 and 14 days of ageing for T1 and T2, respectively. No differences ($P > 0.05$) could be found in colour parameters from 7 to 42 days. The results show that a finishing time of two months is very beneficial, due to the increase in meat fatness, improved overall carcass quality and luminosity (L^*). Furthermore, 14 ageing days were sufficient to improved tenderness. Ageing time did not have an effect on lipid oxidation ($P > 0.05$) and this leads us to conclude that meat shelf life exceeded 42 days under vacuum conditions'.

1. Introduction

The finishing of cull cows in the dairy herds can be an important activity to raise the profits of a cattle farm. The productive life of these cows is about five years. Then over 50% are culled for various reasons, none of which prevent them from being used for butchering. Finishing these animals increases their weight and improves their condition score and fatty state (Malterre, 1986; Cranwell, Unruh, Brethour, & Simms, 1996), with a subsequent rise in price. This higher value can be very significant for fatty cows when they are sold to the special market of "*entrecote for gourmet*", as happens in the north of Spain. Therefore, this situation can give rise to an important increase in the price per kilogram of the meat carcass. This is due to a qualitative difference between carcasses of animals that are classified as *O* or *P*, with a poor fat content, (CEE, 1991), compared to those ones classified as *R* or *U*, with good fat content (Carballo & Moreno, 2006). The economic interest of finishing cull cows has been studied primarily in beef breeds (Cranwell et al., 1996; Sawyer, Mathis, & Davis, 2004). In Galicia (region of the north of Spain), there is a census of around 500,000 dairy cows (AEG, 2003), that mainly belong to the Holstein–Fresian breed. Therefore, we can estimate that about 50,000 cull cows from dairy and suckler herds are eligible to enter the beef supply chain. To produce "*entrecote for gourmet*" the carcass must have a fatness score of 4 or 5 (fatness scale 1–5) and it cannot be finished off pasture during spring and summer due to a low body condition score. For this reason, the prolongation of finishing should be considered using conserved forages and concentrates. Furthermore, the sirloin, a highly appreciated piece of meat in Spain, is commercialized targeting consumers who exclusively value the sensory characteristics of the meat, in which the ageing process has an important effect. Tenderness is the most appreciated attribute by the consumer (Koohmaraie, 1996) and is affected by ageing. A minimum of tenderness is required to appreciate the flavour adequately. The instrumental measure best related to tenderness is the one obtained using the Warner–Braztler (WB) probe (Boleman et al., 1997). There are other measures of meat texture, such as the hardness or chewiness, measured with a compression probe, using a textural profile analysis (TPA). This test can be more useful in older animals, where connective tissue is more abundant, and which is not altered by ageing (Caine, Aalhus, Best, Dugan, & Jeremiah, 2003). During ageing, we can obtain a satisfactory tenderness and flavour, however, a loss in meat coloration is also likely, changing from bright red to brown, due to the oxidation of the oxymyoglobin to myoglobin. Moreover, there can be damage due to lipid

* Corresponding author. Tel.: +34 988 548277; fax: +34 988 548276.
E-mail address: danielfranco@ceteca.net (D. Franco).

0309-1740/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.meatsci.2009.06.030

oxidation in the intramuscular fat content (IMF). Both types of oxidation are intimately related and are responsible for the appearance of smells and strange flavours of fat (Kanner & Harel, 1985) that can cause rejection by the consumer. These alterations are especially important in meats that with a have a high fat content. On the other hand, there is also a need for prolonged ageing owing to the cow's age and to the convenience of being able to access points of sale at long distances from the production site. It was, therefore, considered best to study the process of ageing under vacuum conditions because vacuum packaging of fresh meat provides sufficient shelf life for primal cuts for long-term storage and intercontinental transport (Hotchkiss, 1994; Lee & Yoon, 2001).

Therefore, the aim of this study is to investigate the effect of length of finishing on the daily gain and on the commercial parameters of the meat from the carcass of Holstein–Friesian culls cows and the effect of ageing time on the main attributes of quality, such as textural properties, colour and fatty acid oxidation status.

2. Materials and methods

2.1. Animals: experimental design and live and post-slaughtered controls

Eighteen cows of the Holstein–Friesian breed, culled from the experimental herd of Agricultural Research Centre of Mabegondo, were used for this study. Thirteen cows were culled due to age, four due to problems related to the udder health and one due to reproductive. Cows were not pregnant when the study started, most of them had had their last calving between 10 and 13 months ago, two had had an abortion six and four months before being finished. The dry-off proceeding was as described: cows were separated from the herd and fed with hay and water only for a week. During this week, milk production decreased to 3–5 l. At this time 12 g of antibiotic (Cepravin®) were administered. After veterinary treatment, cows were fed with hay for two or three days until they returned to the pasture. Animals were together in a single group, in spring pasture for at least three months before they were separated into three groups of six animals, blocked by live weight. Six of this animals, were immediately slaughtered, (control group or T0). This group was not used for ageing treatment and was not possible to include in *postmorten* study. Animals from the others groups were not finished indoors; they were finished in an area without pasture. One group spent two months (T2), while the second group spent only one month before being slaughtered (T1). Animals from T0, T1 and T2 were 8.8 ± 2.3, 7.7 ± 2.7 and 8.7 ± 4.6 years-old, respectively. Live weight at start of pasture was 679 ± 55, 653 ± 77 and 633 ± 58 for T0, T1 and T2, respectively. The concentrate ration consisted of corn silage "*ad libitum*" and three kilograms of concentrate per head per day. The chemical composition of grass and corn silage was respectively, in percentage (49.01 and 36.05 of dry matter (DM); 9.6 and 7.32 of crude protein (CP); 26.6 and 23.4 of acid detergent fiber (ADF); 49.7 and 44.94 of neutral detergent fiber (NDF)). The chemical composition of concentrate was 88.16 of DM, 16.22 of CP and 5.06 of FC. The net energy value of corn silage and concentrate, expressed as Unité Fourragere Viande (UFV) (Vermorel, 1978) was 0.64 and 1.14 respectively. The live weight of each animal was simple-weighing and measured during pasture (at start and end) and in the end of the finishing period. There were not any diseases or veterinary treatments during the experiment. Animals were conventionally slaughtered at a commercial abattoir four kilometres from the field where they had been grazing. Carcasses were classified using a conformation score, according to the EUROP scale (Conformation: $P = 1$, $O = 2$, $R = 3$, $U = 4$, $E = 5$) (C.E.E. n° 2273/91), and a fatness score average, according to the European classification fatness score scale, which ranges from 1 (low fat) to 5 (high fat) (C.E.E. n° 2273/91). Immediately after slaughter, carcasses were weighed and chilled at 4 °C in a cold chamber for 24 h. At this point, the *Longisimus thoracis* (LT) muscle was extracted from the left half of each carcass, between the fifth and the tenth rib. Samples were taken immediately to the laboratory under refrigerated conditions.

2.2. Analytical methods

2.2.1. pH, colour, myoglobin content and chemical composition

LT muscle was cut into seven steaks and all steaks were systematically assigned, the first steak was aged for one day, the second steak for seven days and so on and so forth for the other steaks". Steaks were cut using a cutting machine (Leader, Milano, Italy) into six steaks of 2.5 cm of thickness. On the first steak, pH, colour and proximate composition were determined. The other six steaks were individually packed under vacuum conditions (98%) (Tecnotrip EV-15-1CD, Terrasa, Spain) and were stored at 4 °C until analysis at 7, 14, 21, 28, 35 and 42 days. The pH was measured using a pH-meter (Hanna Instrument HI-9024, Portugal) equipped with a glass probe for penetration. A portable colorimeter (Minolta CR-300 Osaka, Japan settings machine from CR-300 measuring head are: pulsed xenon arc lamp, angle of 0° viewing angle geometry and aperture size of 8 mm) was used to measure meat colour in the CIELAB space (Lightness, L^*; redness, a^*; yellowness, b^* (CIE, 1978). Hue (h_{ab}) and chroma (C^*) were calculated from the a^* and b^* values according to expressions:

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \quad \text{and} \quad h_{ab} = \arctan\left(\frac{b^*}{a^*}\right)$$

Samples were allowed to bloom for 1 h before measuring directly in contact with air (Insausti et al., 1999). All measurements were made in triplicate. Heminic pigments (expressed as myoglobin) were measured in duplicate, according to the methodology of Hornsey (1956). A near infrared spectrophotometer (Foss Tecator NIRS 6500, Denmark) was used to determine chemical composition, in duplicate, according to the methodology proposed by Moreno et al. (2007).

2.2.2. Texture analysis

To measure properties of texture, the meat was cooked in a water bath at 75 °C for 1 h by immersion in water with automatic temperature control (Selecta Tectron Bio, Barcelona, Spain). Then samples were cooled to room temperature by placing the vacuum package bags in a circulatory water bath set at 18 °C for a period of 30 min. The samples for WB shear test were obtained by cutting pieces of approximately 1 × 1 × 2.5 cm (height × width × length) of cross section, parallel to the muscle fibre direction. They were completely cut through using a WB shear blade with a triangular slot cutting edge and three parameters were measured. The first was the maximum shear force (Møller, 1980), represented by the highest peak of the force-time curve thus representing the maximum resistance of the sample to the cut. The second parameter measured was the firmness to the cut; the shear firmness (Brady & Hunecke, 1985), represented by the slope from the beginning of the cut up to the highest point of the force-time curve, and finally the total work required to cut the sample, represented by the area under the curve obtained. Textural parameters, measured using the WB probe (of 3 mm of thickness) were obtained with the sample at room temperature. Samples for TPA (Bourne, 1978) were obtained by cutting cubes of 1 × 1 × 1 cm approximately perpendicular to the muscle fibre direction and then compressing to 80% with a compression probe of 19.85 cm^2 of surface contact. Between the first and second compression, there was an interval of 2 s. In this test the following variables were obtained: hardness,