Meat Science 94 (2013) 77–83

Contents lists available at SciVerse ScienceDirect

Meat Science

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

Influence of muscle type on physicochemical and sensory properties of foal meat

José M. Lorenzo *, Mirian Pateiro, Daniel Franco

Centro Tecnológico de la Carne de Galicia, Rúa Galicia Nº 4, Parque Tecnológico de Galicia, San Cibrán das Viñas, 32900 Ourense, Spain

ARTICLE INFO

Article history:
Received 17 April 2012
Received in revised form 13 December 2012
Accepted 2 January 2013

Keywords:
Foal meat
Muscle type
Meat quality
Sensory properties

ABSTRACT

The effect of muscle type on physico-chemical properties and sensory characteristics of foal meat was investigated. Six muscles: *longissimus dorsi* (LD), *semimembranosus* (SM), *semitendinosus* (ST), *biceps femoris* (BF), *triceps brachii* (TB) and *psoas major* & *minor* (PM) from twelve foals slaughtered at 15 months from an extensive production system in freedom regimen were extracted for this study. Regarding chemical composition, intramuscular fat content showed significant differences among muscle where PM presented higher values (0.7%) than the other ones. The heme-iron content also presented significant differences ranging between 1.5 and 2.4 mg/100 g fresh meat. ST was the lightest, while TB and PM presented a more intense redness. The muscles that had a greater capacity to hold water were ST and BF, which presented lower drip loss (2 and 2.2%) and cooking loss (17.3 and 17.2%), respectively. Textural traits established the following scale in response to the tenderness: LD > PM > ST > TB > BF > SM. Finally, sensory analyses revealed that color and texture traits (hardness, juiciness and fibrousness) were significantly influenced by muscle type.

1. Introduction

Foal meat consumption had a significant increase in recent years but it is not yet comparable to that of other meat (Franco et al., 2011). This growth requires a more detailed study on the quality of this product. Several physicochemical factors should be considered when assessing its acceptability, the most notable color and tenderness. These parameters are related to the sample sensory characteristics and therefore, they influence consumer acceptability (Belew, Brooks, McKenna, and Savell, 2003; Franco et al., 2011; Mennecke, Townsend, Hayes, and Lonergan, 2007; Sarriés and Beriain, 2006).

Color is a visual parameter associated with freshness (Carpenter, Cornforth, and Whittier, 2001; Rentfrow, Linville, Stahl, Olson, and Berg, 2004), while tenderness is linked to eating satisfaction and therefore to meat quality (Boleman et al., 1997). Previous works reflect that this parameter is influenced by the piece situation, so that muscles originated from various spots differ in fiber types and sensory properties (Kirchofer, Calkins, and Gwartney, 2002), giving different results depending on their location in forequarter or in hindquarter. Muscles are not the same within the same carcass (Anderson et al., 2012; Belew et al., 2003) which will affect cut quality traits (Anderson et al., 2012).

Unlike beef (Belew et al., 2003; Chávez et al., 2012; Jeremiah, Gibson, Aalhus, and Dugan, 2003) or mutton (Tschirhart-Hoelscher, Baird, King, Mckenna, and Savell, 2006), there is only one study (Tateo, De Palo, Ceci, and Centoducati, 2008) that evaluates the influence of muscle type on foal meat quality. On the other hand, horsemeat is considered nutritious and healthy, especially in regard to fat for its low content, higher digestibility and better unsaturated/saturated fatty acids proportion (Franco et al., 2011; Lorenzo, Fuciños, Purriños, and Franco, 2010). Thus, the aim of this study was to assess the influence of muscle type on physico-chemical properties (pH, chemical composition, color parameters and textural profile) and sensory characteristics in foal meat slaughtered at 15 months from an extensive system.

2. Materials and methods

2.1. Experimental design and animal management

Twelve foals of "Galician Mountain" breed were supplied for this research by "Monte Cabalar" (agricultural cooperative of "Galician Mountain" breed) (A Estrada, Pontevedra, Spain). Most of them were born in April and May 2010. Animals were reared with their mothers on pasture and they were kept suckling and grazing until the weaning age at 6–7 months. After weaning, foals were mainly fed ryegrass (*Lolium perenne*), *Ulex europaeus* L. and *Pteridium aquilinum* L., receiving complementary grass silage ad libitum when the grass available was limited, especially in the summer and winter time, but they never received concentrates. They were slaughtered at fifteen months.

Foals were transported to the abattoir the day before slaughter. The different groups were not mixed at any time, and stress was minimized as much as possible. Animals were stunned with a captive bolt, slaughtered and dressed according to current European Union regulations (Council Directive of the European Union 95/221EC), in an accredited abattoir.

* Corresponding author. Tel.: +34 988 548 277; fax: +34 988 548 276.
E-mail address: jmlorenzo@ceteca.net (J.M. Lorenzo).

0309-1740/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.meatsci.2013.01.001

2.2. Sample collection

Immediately after killing, carcasses were chilled at 4 °C in a cold chamber for 24 h. At this point, the following 6 muscles were excised from the left side of each carcass: *longissimus dorsi* (LD), *semimembranosus* (SM), *semitendinosus* (ST), *biceps femoris* (BF), *triceps brachii* (TB) and *psoas major* & *minor* (PM). Samples were cut into seven 2.5 cm thick steaks. The first three steaks were used to determine pH, color, and proximate composition. The fourth and fifth ones were packed under vacuum conditions (99%) (FRIMAQ, V-900, Lorca, Spain) during 4 days at 4 °C. Water holding capacity (WHC) and texture parameter were obtained after this period. The last steaks were used for sensory analysis.

2.3. Analytical methods

2.3.1. pH, color and heme-iron content

pH was measured using a digital pH-meter (Thermo Orion 710 A+, Cambridgeshire, UK) equipped with a penetration probe. A portable colorimeter (Konica Minolta CR-600d Osaka, Japan) with pulsed xenon arc lamp, 0° viewing angle geometry and 8 mm aperture size, was used to estimate meat color in the CIELAB space (lightness, L*; redness, a*; yellowness, b*) (CIE, 1976). Hue (Ho) and chroma (C*) were calculated from a* and b* values by means of this formula:

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

Heme-iron was measured in duplicate following Hornsey (1956) methodology according to this formula (Merck, 1989):

$$\text{Hematin (}\mu\text{g hematin/g muscle)} = \text{Absorbance} \times 342.44$$

$$\text{Heme iron(mg/100g meat)} = (\text{Hematin} \times 8.82)/100.$$

2.3.2. Chemical composition

Moisture, fat, protein (Kjeldahl N×6.25) and ash were quantified according to ISO recommended standards 1442:1997 (ISO, 1997), 1443:1973 (ISO, 1973), 937:1978 (ISO, 1978), and 936:1998 (ISO, 1998), respectively. Summarizing, moisture percentage was calculated by weight loss, keeping samples (5 g) in the oven (Memmert UFP 600, Schwabach, Germany) at 105 °C, until constant weight. Ash percentage was calculated by weight loss as well, maintaining the pieces (5 g) in a muffle furnace (Carbolite RWF 1200, Hope Valley, England) into a porcelain capsule at 600 °C until constant weight. In order to determine fat content, 3 g samples were subjected to a liquid–solid extraction using hexane in an extractor apparatus (FOSS Soxtec Avanti 2050, Höganäs, Sweden) during 3 h, previously hydrolyzing with HCl in a FOSS Soxtec System (2047 SoxCap, Höganäs, Sweden). Fat content was calculated by gravimetric difference. Protein content was determined according to Kjeldahl Total Nitrogen method, multiplying total nitrogen content by 6.25. One sample (1 g) was subjected to reaction with sulphuric acid (cuprum sulfate as a catalyst) in a digester (Gerhardt Kjeldatherm KB, Bonn, Germany). Organic nitrogen was transformed into ammonium sulfate, which was distilled in alkali conditions in a distillation apparatus (Gerhardt Vapodest 50 Carrousel, Bonn, Germany).

2.3.3. WHC and texture analysis

Steaks were cooked placing vacuum package bags in a water bath with automatic temperature control (JP Selecta, Precisdg, Barcelona, Spain) until they reached 70 °C *in quore*, controlling the heat by thermocouples type K (Comark, PK23M, UK) connected to a data logger (Comark Dilligence EVG, N3014, UK). After this stage, samples were cooled in a circulatory water bath set at 18 °C for 30 min and cooking loss percentage was recorded.

Seven meat pieces of 1×1×2.5 cm (height×width×length) were removed parallel to the muscle fiber direction and were completely cut using a Warner–Braztler (WB) shear blade with a triangular slot cutting edge (1 mm thick). Maximum shear force, shear firmness and total necessary cutting work were obtained. Texture profile analysis (TPA) was measured by compressing to 60% (19.85 cm^2 contact surface compression). Force-time curves were recorded at 3.33 mm/s crosshead speed. Hardness (kg), cohesiveness, springiness (mm) and chewiness (kg * mm) were obtained by means of a texture Analyzer (TA.XT.plus of Stable Micro Systems, Vienna Court, UK) and the available computer software (Texture Exponent 32 (version 1.0.0.68), Stable Micro Systems, Vienna Court, UK).

The water-holding capacity (WHC) was measured in two ways: cooking loss (CL) and drips loss (DL). CL was evaluated by cooking as described in texture analysis, measuring the difference in weight between cooked and raw samples.

To determine DL, an intact meat sample in a variable range of 80–100 g and 1.5 cm thick was weighed and put on top of a net, inside of a container which was closed after filling in order to avoid evaporation. This container was placed in a refrigerated chamber at 4 °C for 48 h and it was weighed again after this period.

2.4. Sensory analysis

The taste panel evaluation was conducted by eight panelists that were selected from the Meat Technology Centre of Galicia after one year training with the attributes and the scale to be used. Panel members were situated in a private red lighted cabinet during sessions. Water to clean the palates and remove residual flavors was given to them at the beginning of the performance and in between samples.

The sensory evaluation consisted of two sessions: first, to visually evaluate fresh foal meat, and second, to assess all sensory attributes after cooking. Samples were individually labeled with three-digit aleatory numbers and were randomly served one at a time. 9-point scales with word anchors at the edges were used to rate the appraisals. A randomized (complete) block design was followed. 12 sessions were completed, six samples each. The tasting order was designed to avoid first sample and carry over effects (MacFie, Bratchell, Greenhoff, and Vallis, 1989).

Fresh foal meat sensory traits were assessed at 24 h *post-mortem*. Samples (25 mm thick) were exposed to air for 30 min at 4 °C to allow complete bloom, prior to taste. Subjective measures for color (1 = pale pinkish-gray to white; 9 = dark purplish-red) were evaluated.

The samples for the cooked foal meat sensory evaluation were cut into 25 mm thick segments. Steaks were grilled in a frying pan at internal temperature of 68–70 °C, which was measured using a hand-held probe thermometer (HI-985011, Hanna Instruments, Spain). The cooked foal steaks were cut into 10×10×25 mm^3 pieces, that were placed on white plastic trays covered with aluminum foil, and immediately served. Pondered variables: intensity odor (1 = little intensity; 9 = very intensity), intensity rancid (1 = little rancid; 9 = very rancid), abnormal flavor (1 = very weak; 9 = very strong), taste (1 = very unacceptable; 9 = very acceptable), sweetness (1 = little sweet; 9 = very sweet), juiciness (1 = very dry; 9 = very juicy), hardness (1 = very tender; 9 = very tough), and fibrousness (1 = little fibrous; 9 = very fibrous).

2.5. Statistical analysis

One way analysis of variance (ANOVA) was performed for all variables considered in the study (SPSS package; SPSS 19.0, Chicago, IL, USA). The least square mean (LSM) was separated using Duncan's *t*-test. LSM tests were performed for $\alpha < 0.05$ significance level. Correlations between variables were determined by Pearson's linear