Meat Science 93 (2013) 630–638

Contents lists available at SciVerse ScienceDirect

Meat Science

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

Influence of type of muscles on nutritional value of foal meat

José M. Lorenzo *, Mirian Pateiro

Centro Tecnológico de la Carne de Galicia, Rúa Galicia N° 4, Parque Tecnológico de Galicia, San Cibrán das Viñas, 32900 Ourense, Spain

ARTICLE INFO

Article history:
Received 12 June 2012
Received in revised form 17 October 2012
Accepted 10 November 2012

Keywords:
Foal meat
Type of muscle
Fatty acid
Cholesterol
Amino acid
Mineral compounds

ABSTRACT

The effect of type of muscle on nutritional characteristic (fatty acid profile, amino acid content, cholesterol and major and minor mineral) 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. Horse meat is characterized by low fat, low cholesterol content, rich in iron and in vitamin B. Statistical analysis showed that the cholesterol content did not show significant differences ($P>0.05$) among muscle with mean value range between 0.62 and 0.57 mg/100 g. Most fatty acid presented significant differences ($P<0.05$) with respect to the type of muscle. The obtained results showed that except for the polyunsaturated linoleic acid, the highest contents of fatty acids were found in the hindquarter muscles. Regarding amino acid profile, significant differences ($P<0.05$) were observed among muscles and our results indicated that, 100 g of foal meat covered from 80.6 to 86.7% for the daily requirement for an adult man weighing 70 kg for essential amino acids for ST and LD muscles, respectively. Statistical analysis showed significant differences ($P=0.050$) for the EAA (essential amino acids) index, which was highest for TB muscle, followed by BF and SM muscles, while the lowest values were reported by ST muscle. Finally, foal meat seems to be a very good nutritional source of major and minor minerals. The higher nutritional value of foal meat will be of great importance in the promotion of this meat.

1. Introduction

The nutritional characteristics of foal meat reveal that this type of meat may be considered as a new alternative in meat consumption, being regarded as a "dietary" meat (Badiani, Nanni, Gatta, Tolomelli, & Manfredini, 1997). This had led to their consumption that has increased in recent years but still not comparable to the consumption that occurs with other types of meat (Franco et al., 2011). Horse meat is characterized by low fat, more digestibility than that from sheep and cattle (Levine, 1998), a lack of marbling or intramuscular fat (Franco et al., 2011), low cholesterol content (Sarriés, Murray, Troy, & Beriain, 2006) and rich in iron (Badiani et al., 1997). This meat has a favorable dietetic fatty acid profile, with a high content of unsaturated fatty acids relative to saturated acids (Badiani et al., 1997; Lorenzo, Fuciños, Purriños, & Franco, 2010; Sarriés et al., 2006; Tateo, De Palo, Ceci, & Centoducati, 2008) and contains a greater proportion of components from the α-linolenic fatty acid family (Levine, 1998). In addition, foals carcasses are characterized by high meat contents (68.41%; Franco, García Fontán, Temperan, García Clavo, & Lorenzo, 2010), confirming the suitability of foal meat for meat production.

Recent studies revealed that the breed and production system, including slaughter weight and feeding have influence on the fatty acid composition of foals (Juárez et al., 2009; Lorenzo et al., 2010; Sarriés et al., 2006), however, there are hardly information about amino acids and mineral composition (Badiani et al., 1997). On the other hand, there are few studies that evaluate the influence of type of muscle has on nutritional quality of foal meat (Tateo et al., 2008). The limited information that exists is related to the *longissimus dorsi* muscle (Juárez et al., 2009; Lanza, Landi, Scerra, Galofaro, & Pennisi, 2009; Lorenzo et al., 2010; Sarriés et al., 2006). Therefore, it would be interesting to study other muscles, especially the hindquarter muscles [*longissimus dorsi* (LD), *semimembranosus* (SM), *semitendinosus* (ST), *biceps femoris* (BF) and *psoas major & minor* (PM)], since these have a considerable importance, both because they are highly valued and because they represented a high percentage of the carcass (Badiani et al., 1997). Thus, the aim of the present work was to study the influence of the type of muscle on nutritional meat quality, with regard to intramuscular fatty acid, amino acid profile and mineral composition of foal meat.

2. Materials and methods

2.1. Experimental design and animal management

For this study, twelve foals of the "Galician Mountain" breed were obtained from "Monte Cabalar" (agricultural cooperative of "Galician Mountain" breed) (A Estrada, Pontevedra, Spain). The majority of the foals were born in the months of April and May 2010. The animals were reared with their mothers on pasture and they were kept

* 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 © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.meatsci.2012.11.007

suckling and grazing until the weaning age at 6–7 months. After weaning, foals were fed mainly with 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. Animals were slaughtered at fifteen months years old.

They were transported to the abattoir the day before slaughter. Foals from 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.

2.2. Sample collection

Immediately after slaughter, 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). Muscle samples were minced and stored at −80 °C for no longer than four weeks until analysis.

2.3. Analytical methods

2.3.1. Analysis of fatty acid methyl esters and total cholesterol

Fatty acid profile of intramuscular fat expressed as a percentage of total fatty acids identified and total cholesterol was determined following Franco, Rois, Vázquez, and Lorenzo (2012).

2.3.2. Protein amino acid profile

The hydrolysis of the protein, derivatization, and identification of the hydrolyzed were carried out following the procedure described by Lorenzo et al. (2011).

2.3.3. Protein quality: chemical score of amino acids

Once the amount of amino acids in the different muscles was determined, the chemical score of the essential amino acids (CS) was calculated in relation to the reference on pattern protein proposed by FAO/WHO/UNU (2007) applying the following equation:

$$CS = \frac{\text{g EAA in tested protein}}{\text{g EAA in pattern protein}} \times 100.$$

The essential amino acids index (EAA) value was also calculated applying the following equation described by Shahidi and Synowiecki (1993):

$$EAA = 100 \times \sqrt[n]{\frac{a}{a_p} \times \frac{b}{b_p} \times \frac{c}{c_p} \times \ldots\ldots \frac{j}{j_p}}$$

where:

a, b, c,….j content of histidine, isoleucine, leucine, lysine, methionine, phenylalanine, tyrosine, threonine and valine in each sample

a_p, b_p, c_p, ….j_p content of histidine, isoleucine, leucine, lysine, methionine, phenylalanine, tyrosine, threonine and valine in protein Standard (FAO/WHO/UNU, 2007).

n number of amino acids used.

2.3.4. Mineral composition

Macro and mineral profile of foal meat was measured according to a description by Lorenzo et al. (2011).

2.3.5. Analysis of haem iron

Total haem pigments in meat samples were determined as hemin after extraction with acidified acetone solution described by Hornsey (1956).

2.3.6. Analysis of non-haem iron

The non-haem iron was determined by the ferrozine method (Purchas, Simcock, Knight, & Wilkinson, 2003).

2.4. Statistical analysis

For the statistical analysis of the results, an analysis of variance (ANOVA) of one way using SPSS package (SPSS 19.0, Chicago, IL, USA) was performed for all variables considered in the study. The least squares mean (LSM) was separated using Duncan's t-test. All statistical tests of LSM were performed for a significance level $\alpha < 0.05$. Correlations between variables were determined by correlation analyses using the Pearson's linear correlation coefficient with the above statistical software package mentioned.

To evaluate the relation between variables a factorial analysis of the nutritional profile with significant differences ($P < 0.05$) among the six muscles was carried out. Principal component analysis (PCA) was used as extraction method and was performed on the correlation matrix.

In order to verify the capacity of the nutritional profile as a tool for the six different types of muscles a stepwise discriminate analysis was done. An “a priori” equal probability for a sample to be in one group independently of the group size was considered. The criterion for the selection of variables was Wilks' lambda (F to enter and out values of 3.84 and 2.71, respectively).

3. Results and discussion

3.1. Effect of type of muscle on cholesterol content

The results of cholesterol content of the six different studied muscles are shown in Fig. 1. Statistical analysis showed that the cholesterol content did not find significant differences ($P > 0.05$) among muscles. The cholesterol content was found in the following order: LD = TB > PM > ST > SM > BF and their mean values were from 0.62 to 0.57 mg/100 g. Our values were similar to those reported by Badiani et al. (1997) who found values of 0.61 mg/100 g in horse meat. The mean cholesterol content recorded in this study exceeded the only data that can be found in the literature for horse meat: 40 mg/100 g fresh in the *longissimus dorsi* of milk-fed foals (Catalano & Quarantelli, 1979), and 55 mg/100 g in the hind leg muscles of nature horses (Sinclair, Slattery, & O'Dea, 1982). On the basis of a daily consumption of a 150 g steak, trimmed of all visible fats, except for

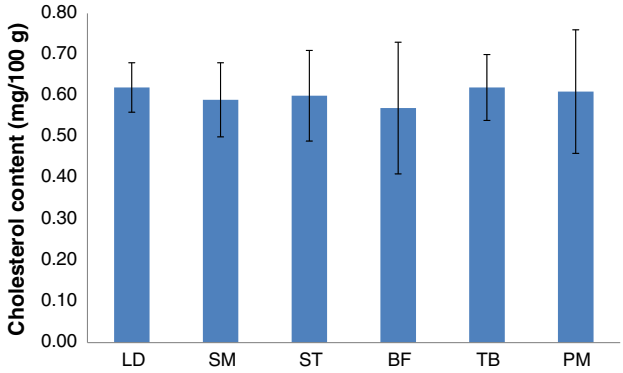

Fig. 1. Cholesterol content (mg/100 g) of the six muscles of foal studied (mean ± standard deviation values) (n = 12). LD: *longissimus dorsi*; SM: *semimembranosus*; ST: *semitendinosus*; BF: *biceps femoris*; TB: *triceps brachii*; PM: *psoas major & minor*.