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Original Research Article

# The effect of cooking methods on nutritional value of foal meat

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ABSTRACT

The present study deals with the effect of four different cooking techniques (roasting, grilling, microwave baking and frying with olive oil) on nutritional value (fatty acid, amino acid profile and chemical scores of the essential amino acids) of foal meat from "Galician Mountain" breed (slaughtered at 15 months and with 102.6 kg of carcass weight). Cooking treatment decreased ($P < 0.05$) the amount of saturated fatty acids. Fried meat had lower saturated fatty acid content due to the incorporation of mono-unsaturated ($C_{18:1n-9}$) fatty acids from oil. Statistical analysis displayed that total essential amino acids and non-essential amino acids were no affected by cooking treatment. However, the content of methionine, phenylalanine, hydroxyproline, tyrosine and cysteine increased ($P < 0.001$) and the content of histidine and lysine decreased ($P < 0.001$) with cooking treatments. Finally, chemical scores of the essential amino acids presented differences between raw and cooked samples. Cooking treatment decreased the chemical scores of histidine and lysine, and increased methionine and phenylalanine + tyrosine scores. Heat treatments also increased the essential amino acid index, although the grilled and fried samples showed no significant differences from raw meat. In conclusion, the grilled and roasted would be the best cooking techniques from the nutritional standpoint.



## 1. Introduction

Cooking of meat is essential to achieve a palatable and safe product. Moreover, it may affect basic traits related to consumer preferences, such as flavor, tenderness, color and appearance (García-Segovia et al., 2007; Meinert et al., 2007; Modzelewska-Kapituła et al., 2012). Previous studies found that there is a direct relationship between cooking method and the formation of volatile compounds (Domínguez et al., 2014a,b; Lorenzo and Domínguez, 2014) which could influence consumer acceptance. Although cooked meat flavor is influenced by water-soluble components that contribute to taste, it is the volatile compounds formed during cooking that produce the aroma attributes that contribute the characteristic flavors of meat. Based on sensory evaluation, eight general odor qualities (buttery, caramel, burnt, green, fragrant, oily/fatty, nutty and meaty) have been used to describe cooked meat odor (Mottram, 1998). Therefore, meat composition combined with a specific cooking methodology (time and temperature) is one of the factors that mostly affect the final quality of meat products (Chiavaro et al., 2009).

Fat and fatty acid composition of meat are important for consumer health. It is well known that low polyunsaturated fatty acids (PUFA)/saturated fatty acids (SFA) and a high *n*-6/*n*-3 ratio contribute to an imbalance in the fatty acid intake (Wood et al., 2004) and promote several kinds of pathogenesis, including cardiovascular disease, cancer and inflammatory and autoimmune diseases, whereas increased levels of *n*3 PUFA (and low *n*6/*n*3 PUFA ratios) exert suppressive effects (Simopoulos, 2004).

Foal meat has high amounts of *n*-3 PUFA, mainly α-linolenic acid, and has high amounts or eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Lorenzo, 2013; Lorenzo et al., 2014a). The proteins from animal sources are most desirable since they meet the human nutritional requirements. Amino acid composition greatly determines the nutritive value of meat. Foal meat is known to be a source of protein rich in essential amino acids (histidine, threonine, valine, methionine, lysine, isoleucine, leucine and phenylalanine) (Lorenzo et al., 2014a). Moreover foal meat is also low in fat and cholesterol and rich in iron (Franco and Lorenzo, 2014; Lorenzo and Pateiro, 2013), and therefore it is excellent meat for a healthy diet.

However, heat treatment can lead to undesirable modifications, such a decrease of thermolabile compounds, vitamins, fatty acids (mainly PUFA) and minerals (Gerber et al., 2009). The PUFA, such EPA and DHA, are considered to be especially susceptible to oxidation during heating (Bou et al., 2001). In addition, as a result

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of the reduction of soluble proteins due to cooking treatments (Murphy et al., 2001) can also cause changes in the amino acid composition. Therefore, changes produced by heat treatments should be known in order to limit the loss of valuable compounds, improve the process itself and achieve foods with the best nutritional value (Jannat-Alipour et al., 2010).

This study was therefore conducted to assess the influence of four common cooking methods (roasting, grilling, microwave baking and frying with olive oil) on the nutritional value of foal meat.

## 2. Material and methods

### 2.1. Animal management

The foals used in this study (10 foals of 'Galician Mountain' breed) were obtained from 'Monte Cabalar' (agricultural cooperative of 'Galician Mountain' breed) located in a mountain (A Estrada, Pontevedra, Spain). The majority of the foals were born in the months of April and June 2012. Animals were reared with their mothers on pasture and they kept suckling and grazing until the weaning age of 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 wintertime, but they were never given concentrates. Animals were reared with their mothers on pasture and were allowed to suck freely. These animals were slaughtered when they were 15 months old (102.5 ± 7.7 kg of carcass weight). They were transported to the abattoir (20 km) the day before slaughter. The animal stress was minimized as much as possible. Animals were stunned with a captive bolt and slaughtered and dressed according to current European Union regulations (Council Directive of the European Union 95/221EC) in an accredited abattoir.

### 2.2. Sample preparation

Ten *longissimus thoracis* (LT) muscles were obtained of foal carcasses at 24 h after slaughter (one muscle for each carcass). The LT muscles were sliced into 20 mm thick steaks (85.25 ± 15.16 g). Five steaks of each muscle were used in the study. These steaks were divided into five groups. One group was used as control (raw meat) (one steak of each LT muscle), and the other groups were cooked using the following methods: grilled at 130–150 °C for 5 min on each surface, using an electrical griddle (Delonghi, Mod. CG660, Treviso, Italy); microwave cooking at 1000 W for 1.5 min on each surface, using a microwave oven (Panasonic, Mod. NE-1037, Osaka, Japan); fried using 15 mL refine olive oil, at 170–180 °C during 4 min on each surface; roasted at 200 °C for 12 min using an electrical oven (Rational, Mod. SCC101, Barcelona, Spain). A heating treatment was considered to be complete when all the samples had reached a temperature of 70 ± 4.7 °C internal temperature controlling the heat by thermocouples type K (Comark, PK23M, Vienna Court, UK) connected to a data logger (Comark Dilligence, EVG N3014, Vienna Court, UK). After cooking and cooling samples were minced, vacuum-packed and stored at −30 °C for no longer than 4 weeks until fatty acid and amino acid analysis was carried out.

### 2.3. Fatty acid profile

Total lipids were extracted from 100 g of ground meat sample, according to Folch et al. (1957) procedure. Fifty milligrams of fat was used to determine fatty acid profile. Fatty acids were transesterified as follow: 4 mL of a sodium methoxide (2%) solution were added to the fat, vortexed every 5 min during 15 min at room temperature, then 4 mL of a $H_2SO_4$:methanol solution (1:2), vortexed a few seconds and vortexed again before adding 2 mL of distilled water. Organic phase (containing fatty acids methyl esters) was extracted with 2.5 mL of hexane. Separation and quantification of the FAMEs was carried out using a gas chromatograph (GC-Agilent 6890N; Agilent Technologies Spain, S.L., Madrid, Spain) equipped with a flame ionization detector and an automatic sample injector HP 7683, and using a Supelco SPTM-2560 fused silica capillary column (100 m, 0.25 mm i.d., 0.2 μm film thickness). The chromatographic conditions were as follows: initial column temperature 120 °C, maintaining this temperature for 5 min, programmed to increase at a rate of 5 °C $min^{-1}$ up to 200 °C, maintaining this temperature for 2 min, then at 1 °C $min^{-1}$ up to 230 °C, maintaining this temperature for 3 min. The injector and detector were maintained at 260 and 280 °C, respectively. Helium was used as the carrier gas at a constant flow-rate of 1.1 mL $min^{-1}$, with the column head pressure set at 35.56 psi. The split ratio was 1:50 and 1 μL of solution was injected. Nonadecanoic acid (C19:0) at 0.3 mg $mL^{-1}$ was used as internal standard and added to the samples prior methylation. Individual FAMEs were identified by comparing their retention times with those of authenticated standards (Supelco 37 component FAME Mix). Data regarding FAME composition were expressed in g/100 g of fat.

### 2.4. Amino acid profile

The hydrolysis of the protein, derivatization and identification of hydrolyzed was carried out following the procedure described by Lorenzo et al. (2011). The hydrolysis of the protein was carried out on 100 mg of minced foal meat with 5 mL of hydrochloric acid (6 N) in an ampoule glass sealed for 24 h at 110 °C. After hydrolysis, the solution was diluted with 200 mL of distilled water and filtered through a 0.45-μm filter (Filter Lab, Barcelona, Spain). Tryptophan determination was not possible because acidic hydrolysis transforms it into ammonium (Lorenzo et al., 2011).

The derivatization of standards and samples and chromatographic analysis conditions were as follows: 10 μL of sample was buffered to pH 8.8 (AccQ-Fluor borate buffer) to yield a total volume of 100 μL. Derivatization was initiated by the addition of 20 μL of AccQ-Fluor reagent (3 mg $mL^{-1}$ in acetonitrile). Reaction of the AccQ-Fluor reagent kit with all primary and secondary amines was rapid, and excess reagent was hydrolyzed within 1 min. Completion of hydrolysis of any tyrosine phenol modification was accelerated by heating for 10 min at 55 °C. The HPLC systems used were a high-performance liquid chromatograph (Alliance 2695 model, Waters, Milford, MA) and a scanning fluorescence detector (model 2475, Waters). Empower 2 advanced software (Waters) was used to control the system operation and management of results. Separations were carried out using a Waters AccQ-Tag column (3.9 × 150 mm, with a particle size of 4 μm) with a flow rate of 1.0 mL $min^{-1}$ and were performed at 37 °C. The gradient profile and composition of the mobile phase were adapted from methodology developed by Van Wandelen and Cohen (1997). Detection was accomplished by fluorescence with excitation at 250 nm and emission at 395 nm. Amino acids were identified by retention times and quantified by external standard technique using an amino acid standard (Amino Acid Standard H, Thermo, Rockford, USA). Data regarding amino acid composition were expressed in g/100 g of protein.

### 2.5. 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 (CSEAA) or CS was calculated in relation to the reference on pattern