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Essential and toxic trace element concentrations in different commercial veal cuts in Spain

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ABSTRACT

The aim of this study was to evaluate essential and toxic element concentration of ten commercially available veal cuts, together with diaphragm, cardiac muscle and liver tissue from 10 animals of "Galician Supreme Veal". Essential trace elements (Co, Cr, Cu, Fe, Mn, Mo, Ni, Se and Zn) and toxic elements (As, Cd, Hg and Pb) were determined by ICP-MS. Essential trace element concentrations ranged from 0.002–55.64 mg/kg between muscles. Toxic element concentrations were very low, and high numbers of samples showed unquantifiable residues of Cd and Pb. Veal cuts including muscles with a high proportion of oxidative slow-twitch fibers (diaphragm and cardiac muscle) showed significantly higher essential trace element concentrations, the lower concentrations being found in veal cuts including glycolytic fast-twitch fibers (eye round). Our results suggest that essential and toxic trace element concentration could be used as a new meat quality parameter, or to add further value to certain products (i.e. livestock reared on extensive systems with high physical activity).

1. Introduction

Meat is an important component of dietary consumption patterns in today's society, with beef and cattle products accounting for a significant portion of the global food market. Consumption rates in Europe were estimated to be over 10.5 kg of beef and cattle meat per capita in 2014 (https://data.oecd.org/agroutput/meat-consumption.htm). Meat and meat products for human consumption have been traditionally evaluated in terms of their proximate macronutrient composition (i.e. moisture, protein and fat contents). Recently, other characteristics such as the fatty acid profiling of meat from different animal species (Enser et al., 1998; Morán et al., 2013; Waszkiewicz-Robak et al., 2015), vitamin composition (i.e. B12) (Szterk, Roszko, Małek, Czerwonka, & Waszkiewicz-Robak, 2012) as well as essential and toxic trace element concentration have gained increased attention due to variation related to factors such as breed, the age of the animal, feeding practices and geographical conditions amongst others (Czerwonka & Szterk, 2015). The accumulation of trace elements is important from a toxicological point of view and lead the European Union to set up maximum limits for certain toxic elements in foodstuff for human consumption (Commission Regulation (EC), No 1881/2006).

To date, studies investigating essential and toxic element concentrations in different animal species have primarily analyzed samples from the liver and kidney, focusing on the relationship between concentrations found in these organs and the health and mineral status of the animals under different production systems (Tomović et al., 2011) or experimental conditions (García-Vaquero, Miranda, Benedito, Blanco-Penedo, & López-Alonso, 2011). The accumulation patterns of trace elements were also described within these organs, analyzing differences in metal accumulation between the medulla and cortex in the kidney (Olsson & Oskarsson, 2001), different accumulation in the lobules in the liver (Miranda et al., 2010) and histological differences due to variation at hepatic cellular and sub-cellular levels (Garcia-Vaquero, Benedito, Lopez-Alonso, & Miranda, 2012).

There is a notable absence of research investigating essential and toxic trace element accumulation in muscle tissue, the current research is limited to a range of commercial cuts (Czerwonka & Szterk, 2015; Dermauw et al., 2014; García-Vaquero, Miranda, Benedito, et al., 2011; McGilchrist, Greenwood, Pethick, & Gardner, 2016) and non-specified muscular tissue in other instances (Abou-Arab, 2001; Sedki, Lekouch, Gamon, & Pineau, 2003). Recent studies report metal accumulation in treated meat, such as smoked meat (Mitić, Stojković, Pavlović, Tošić, & Mitić, 2012) and other meat products such as sausages and hamburgers (Abedi, Ferdousi, Eskandari, Seyyedahmadian, & Khaksar, 2011; González-Weller et al., 2006).

This study seeks to investigate essential and toxic trace element concentrations in order to develop a complete trace element distribution

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profile of different commercial cuts of veal, representative of the beef carcass and patterns of human consumption in Spain and many other countries.

2. Material and methods

2.1. Experimental design and sample collection

For this study veal samples from ten male Galician blond calves from Lugo (Galicia, Spain) were selected. Animals were raised under the regulations of the protected geographical indication (PGI) of "Galician Veal" and its meat was certified and labelled as "Supreme Galician Veal" category. "Galician veal" was selected for being one of the main meat production systems in our region and due to its high presence in the national market, with >50% of the PGI meat commercialized in Spain certified as "Galician Veal" in the year 2014 (http://www.terneragallega.com/pdf/informe_castellano.pdf). Basically, in this production system calves are suckled on their mothers until slaughter and the diet of the mother is based on local pasture that could be supplemented with fresh forage and grain-based authorized concentrate (Council Regulation (EC), No 510/2006 ; Commission Regulation (EC), No. 2400/1996; Regulation, (EU) 2015/1393).

Samples were collected at slaughter when calves were approximately 9 months old and 242 ± 7 kg carcass weight. Ten muscle cuts were taken from each animal, being representative of the different commercial categories (extra, first A, first B, second and third categories) in Spain (Sañudo & Campo, 1998) (see Fig. 1). The commercial veal cuts selected for this study (rib boneless entrecote (RBE), tenderloin (TEN), eye round (EYE), thick flank (THF), tail of rump (TAR), chuck tender (CHT), shin (SHI), upper chunk (UPC), flank (FLA) and brisket (BRI) are represented in Fig. 1. The muscular fibres constituting the different commercial veal cuts selected are summarized in Table 1. In addition, based on previous trace element accumulation studies in calves (Gutiérrez, 2009), samples of diaphragm (DIA) and cardiac muscles (CAR), as well as liver - one of the main target organs of trace element accumulation and mineral status of the animals (Nwude, Okoye, & Babayemi, 2011) - were collected.

All samples of approximately 100 g were collected immediately after slaughter, packed individually and refrigerated at 4–6 °C for 2 h until further processing in the laboratory and then stored at −18 °C for further analysis.

Table 1
Commercial veal cuts and muscles integrating each selected cut.

Commercial veal cuts	Muscles involved
Rib boneless entrecote (RBE)	*Longissimus thoracis* and L. *costarum*, *Spinalis dorsi*, *Multifidi dorsi*, *Complexus* and *internal/external intercostal*
Tenderloin (TEN)	*Psoas major*, *P. minor* and *Iliacus*
Eye round (EYE)	*Semitendinous* muscle
Thick flank (THF)	*Quadriceps femoralis*
Tail of rump (TAR)	*Tensior fasciae latae*
Chuck tender (CHT)	*Supraspinatus* muscle
Shin (SHI)	*Brachialis*, *Biceps*, *Coracobrachialis* and *Extensor carpi radialis*
Upper chunk (UPC)	*Rhomboideus*
Flank (FLA)	*Rectus abdominalis*
Brisket (BRI)	*Pectoralis profundus*

2.2. Chemicals

The following chemicals were purchased for trace element determination of the muscular samples: concentrated nitric acid (65%, Suprapur grade, Merck), hydrogen peroxide (30% p/v, Sigma-Aldrich) and certified reference material (Standard Reference Material® 1577c Bovine Liver, National Institute of Standards & Technology, USA). Ultra-pure water of resistivity 18 MΩ cm was obtained from a Milli-Q® Plus model (Millipore Co.).

2.3. Sample analysis

Tissue samples of approximately 1 g were digested with nitric acid and hydrogen peroxide in a microwave digestion system (Millestone Ethos Plus) and diluted to 15 mL with ultrapure water following the protocol previously described by García-Vaquero, Miranda, López-Alonso, Castillo, and Benedito (2011). The concentrations of essential (cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn)) and toxic (arsenic (As), cadmium (Cd), lead (Pb) and mercury (Hg)) trace elements were determined by inductively coupled plasma mass spectrometry (ICP-MS; VGElemental PlasmaQuad SOption) under the following previously established operational conditions (Gutiérrez, 2009). Briefly, the main analytical parameters consisted on RF power 1.35 kW, plasma flow rate of 14 mL/min, auxiliary gas flow rate 1 mL/min, nebulizer gas flow 0.8 mL/min and 3 readings/replicates.

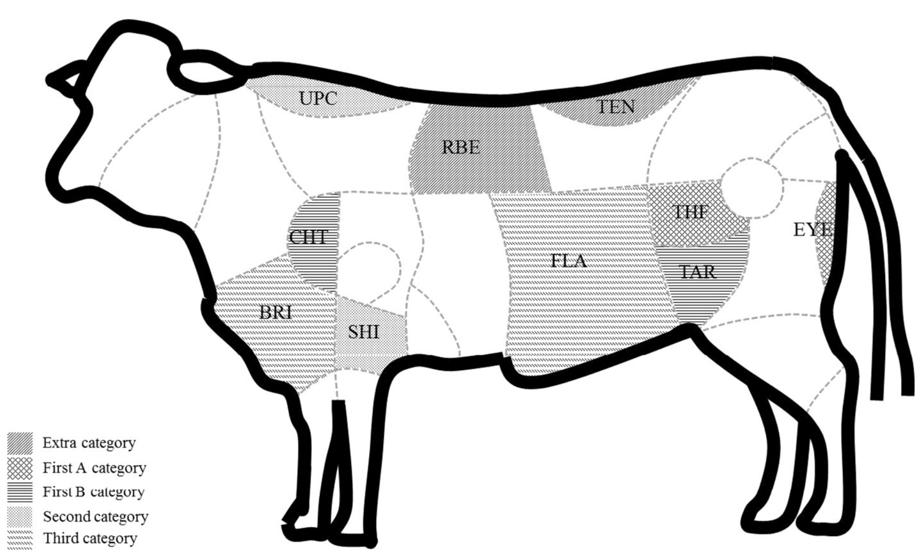

Fig. 1. Carcass showing the commercial muscle cuts selected. Muscle abbreviations are as follows RBE (rib boneless entrecote), TEN (tenderloin), EYE (eye round), THF (thick flank), TAR (tail of rump), CHT (chuck tender), SHI (shin), UPC (upper chuck), FLA (flank) and BRI (brisket). Commercial categories of veal cuts according to the Spanish regulations are represented in the figure by different filling patterns.