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Journal of Agroalimentary Processes and Technologies 2016, 22(2), 102-107

Journal of Agroalimentary Processes and Technologies

Trace elements contribution of meat to the recommended dietary allowances

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Received: 13 May 2016; Accepted: 10 June 2016

Abstract

The paper presents the results of the determination of essential (Fe, Zn, Cu and Se) and toxic (Pb and Cd) microelements in veal leg and in gammon, as determined through the Inductively Coupled Plasma - Mass Spectrometer (ICP-MS) method. Experimental results point to important contents of Zn (23.15 mg/kg and 16.30 mg/kg, respectively) and Fe (12.84 mg/kg and 5.97 mg/kg, respectively), appreciable contents of Cu (0.470 mg/kg and 0.335 mg/kg, respectively) and Se (0.074 mg/kg and 0.106 mg/kg, respectively) and very small amounts of Pb (0.031 mg/kg and 0.013 mg/kg, respectively) and Cd (0.016 mg/kg and 0.012 mg/kg, respectively), i.e. below maximum admitted toxicity limits. Mineral supply of veal and pork leg to the daily recommended diet estimated under experimental conditions show different values between 13.06% (in men and women) – for Cu in the pork leg and 72.34% (in women) – for Zn, in the veal leg. There are higher values of mineral supply in veal leg – 72.34% Zn (in women) – and 52.61% Zn (in men) and pork leg – 50.94% Zn (in women) and 48.18% Se (in men and women). There were appreciable values of the mineral supply in the veal leg – 40.13% Fe (in men) and 33.64% Se (in women and men) – and in the pork leg – 37.05% (in women). The supply in copper had the lowest values ranging between 9.31% (pork leg) and 13.06% (veal leg).

Keywords: meat, veal leg, pork leg, essential microelements, toxic elements, mineral supply, daily diet

1. Introduction

Meat, defined as the edible part of the skeletal muscles of an animal (healthy upon slaughtering) [1], is an important nutrient in man's diet, made up mainly if proteins, fats and some important essential elements [2]. Animal proteins have a high biological value supplying all essential amino acids such as lysine, treonine, methionine, phenylalanine, tryptophan, leucine, isoleucine, valine, etc. [3]. In addition, meat is an appreciated source of niacin, vitamins B_6 and B_{12}, and easily bio accessible essential minerals such as phosphorus, zinc, iron, selenium, etc. [3, 4]. The shares of these major (water, proteins, lipids, sugars) and minor (vitamins, enzymes, minerals, pigments, aromas) constituents in meat make meat have a particular structure, texture, taste, colour and nutritive value [5]. The nutritive value of meat and, implicitly, the concentration of minerals depend on several factors,

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including species, breed, gender, age upon slaughtering, cuts (fillet, neck, and leg), raising system, feeding type, geographical area, etc. [6].

Lean red meat, implicitly beef and pork, is considered a mineralising food since it supplies increased amounts of essential minerals with high bioavailability, particularly Fe and Zn [7, 8].

Besides these essential elements, meat also contains heavy metals (Pb, Cd, Hg etc.), toxic minerals that can easily accumulate in living bodies and that, even in small concentrations, can cause important dysfunctions of the body [9,10, 11, 12].

Taking into account that meat is a main component of human diet and, implicitly, an important source of minerals, it is essential not only to know and constantly update the content in bio-elements (essential elements), but also to measure the content of non-essential elements that are toxic to humans.

The interest in the distribution of mineral elements in different assortments of meat is illustrated by a number of research papers such as those of Ramos, A. et al., 2012 [4]; Gerber, N. et al., 2008 [6]; Litwińczuk, Z. et al., 2015 [7]; Valaitiene, V. et al., 2015 [8]; Pilarczyk, R., 2014 [9], Nkansah, M.A. et al., 2014 [10], Al-Zuhairi, W. Sh. et al., 2015 [11], Lei, B. et al. (2013) [12], Hosseini, S.V. et al., 2015 [13], that present numerous data regarding the concentration in mineral elements of beef, pork, mutton, poultry, fish, etc., as well as measurement techniques.

The goal of this study was to determine the concentration of some essential, potentially toxic elements in meat in order to evaluate meat mineral supply to the recommended daily diet. We measured concentrations of Fe, Mn, Cu, Zn, Se, Pb and Cd in veal and pork legs from native production available on the local market. Analytical data allowed us to evaluate the mineral supply of these two meat assortments and the degree of availability of the necessary minerals recommended for the daily diet from this food.

2. Materials and Method

2.1. Material

In order to reach the goal of this research, we sampled fresh meat – veal leg and gammon – from native livestock, from which we prepared three working samples necessary to analyse mineral elements.

The meat samples were purchased from the local market in Timisoara, Romania; all the samples analyzed were at the beginning of their shelf life.

2.2. Reagents

- Super-pure nitric acid 65% - Merck, with which we prepared, by dilution with distilled water, the solution of HNO_3 0.5 n;

- Merck purity concentrated standard calibration solution with which we prepared, by dilution with distilled water, standard working solutions to cover the concentration intervals in the samples analysed;

- Distilled water.

2.3. Apparatus

- A Bruker - Aurora M90 - Quadrupole ICP-MS spectrophotometer, to determine the concentration of Fe, Zn, Cu, Se, Pb and Cd through the ICP-MS method;

- A Nabertherm calcination oven made in Germany, Model LE 6/11/B150, 2006;

2.3. Procedure

The total concentration of Fe, Zn, Cu, Se, Pb and Cd of the meat samples was measured by the Inductively Coupled Plasma - Mass Spectrometer (ICP-MS) method after sample calcination at 550^0C and ash extraction with a solution of HNO_3 with 0.5 N adapted to the working conditions in our laboratory [6, 8, 14].

We used a Bruker - Aurora M90 - Quadrupole ICP-MS spectrophotometer, observing the working parameters recommended by the producer.

3. Results and Discussion

Results regarding the measurement of the content of Fe, Zn, Cu, Se, Pb and Cd in the meat samples are presented in Table 1 below.

As we can see in Table 1, the shares of minerals in the meat samples we analysed are not even. The best represented of the elements analysed are bio-elements, among which zinc and iron. Copper and selenium were identified in much smaller amounts than zinc and iron. Lead and cadmium, elements that are highly toxic, were identified in very low concentrations, much below the limit of toxicity admitted by current legislation: 0.5 mg/kg in Pb and 0.1 mg/kg in Cd [15].

Zinc, an essential microelement that acts as a co-factor since is makes up many enzymes involved in the metabolism of macronutrients and in cell replication [16], was determined in the highest concentration: its mean concentrations were 23.15 mg/kg in veal leg and 16.30 mg/kg in pork leg.

Iron, an essential microelement important particularly in the transport of oxygen since it is indispensable in the production of haemoglobin [17], was determined in low concentrations than zinc, its mean values ranging between 5.97 mg/kg in pork leg and 12.84 mg/kg in veal leg.

Copper, a particularly important bio-element, a functional component of numerous enzymes that are essential for physiological functions, also known as copper-enzymes [18], was identified in concentrations much lower than zinc and iron, its mean concentrations reaching values relatively close in the two meat assortments we analysed: 0.355 mg/kg in pork leg and 0.470 mg/kg in veal leg.

Selenium, a micro-element of particular interest due to its role in anti-oxidant selenium-proteins as protectors against oxidative stress (initiated by excess reactive oxygen species and reactive nitrogen species) [19], was determined in very low concentrations compared to zinc and iron and low concentrations compared to copper. However, the mean values of selenium content in the two meat assortments we analysed – 0.074 mg/kg in veal leg and 0.106 mg/kg in pork leg – are considered important when taking into account health issues.

Lead and *cadmium* are heavy metals that are very toxic to humans: they are tolerated only in extremely low concentrations and higher concentrations are associated with adverse effects on human health such as kidney lesions, chronic toxicity symptoms, including affecting the functioning of other organs, low reproductive capacity, hypertension, tumours and dysfunctions of the liver and brains, etc. [13]. In veal and pork leg, lead and cadmium were determined in very low concentrations – 0.031 and 0.013 mg/kg in Pb, respectively, and 0.016 and 0.012 mg/kg in Cd, respectively – i.e. below the maximum admitted toxicity limit [15].

As for the share of essential elements in the two meat assortments we analysed, there were higher concentrations of zinc and iron in veal leg than in pork leg; the concentrations of copper and selenium had almost the same values.

By comparing the values of the concentrations in Fe, Zn, Cu, and Se measured in veal leg and in gammon with results obtained by other researchers who analysed similar meat products (sirloin, chop, and cut meat), there are no notable differences. This is confirmed by Pilarczyk, R., 2014 [9]; Valaitiene, V. et al., 2015 [8]; Nkansah, M.A. et al., 2014 [10]; Litwińczuk, Z. et al., 2015 [7]; Domaradzki, P. et al., 2016 [20]; Gerber, N. et al., 2008 [6]; Lei, B. et al., 2013 [12] who, analysing the content in Fe, Zn, Cu, Se, Pb and Cd of fresh beef and pork meat samples showed that they contain 13.7-17.0 mg/kg Fe, 33.9-39.7 mg/kg Zn, 0.521-0.618 mg/kg Cu, 0.045-0.049 mg/kg Se, 0.201-0.208 mg/kg Pb, and 0.020-0.021 mg/kg Cd – in veal fillet; 9.2163-10.6834 mg/kg Zn, 0.1351-0.1406 mg/kg Se, 0.4022-0.4536 mg/kg Cu, and 5.7445-7.4080 mg/kg Fe – in sirloin; 0.079 µg/g Cd – in beef, 0.01 mg/kg Cd – in pork and 1.154 µg/g Pb – in beef, 0.237 µg/g – in pork; 20.6-38.5, 30.0-37.3 and 25.2-44.7 mg/kg Cu, 12.2-23.5, 14.1-18.8 and 11.6-26.9 mg/kg Fe, 0.3-0.7, 0.6-0.8 and 0.0-0.6 mg/kg Cu – in veal fillet; 20.72-56.16 and 13.45-47.61 mg/kg Zn, 12.00-32.19 and 6.58-27.93 mg/kg Fe, 0.41-0.96 and 0.30-0.78 mg/kg Cu – in veal fillet; 0.2-0.6 mg/100 g Fe, 3.7-3.8 mg/100 g Zn, 0.5-0.6 µg/100 g Cd, 2-1.9 mµ/100 g Pb, 19 -30 µg/100 g Se, and 49.8-77.5 µg/100 g Cu – in beef fillet and 0.7 mg/100 g Fe, 1.5 mg/100 g Zn, 0.6 µg/100 g Cd, 1.8 mµ/100 g Pb, and 18µg/100 g Se – in pork chop, 15.8-132 µg/g Fe, 28.0-87.7 µg/g Zn, 0.000136-

0.00331μg/g Cd, and ND-0.0814 μg/g Pb – in beef and 5.90-62.4 μg/g Fe, 16.2-38.0 μg/g Zn, 0.000242-0.00616 μg/g Cd, ND-0.153 μg/g Pb – in pork.

The levels of concentration of essential elements determined in the two meat assortments we analyse – veal and pork leg – point out the fact that these foods contain important amounts of iron and zinc, appreciable amounts of copper and selenium, and very small amounts (below the maximum admitted limit of toxicity) of lead and cadmium – therefore, they can be considered mineralising foods. A food can be considered mineralising if it covers the necessary essential elements of a recommended daily diet.

In the current experiment, based on the concentrations of Fe, Zn, Cu and Se determined experimentally (Tables 1 and 2) and on the recommendations regarding the necessary minerals in the recommended daily diet (Table 3), we determined the supply of essential elements in the daily diet corresponding to 250 g of fresh veal or pork leg (Table 4).

Table 1. Concentration of Fe, Zn, Cu and Se in the fresh veal and pork leg meat

Specification	Values	Element analysed (mg/kg of fresh produce)					
		Fe	Zn	Cu	Se	Pb	Cd
Veal leg	**Minimum**	11.17	21.81	0.468	0.077	0.028	0.011
	Maximum	14.57	24.48	0.473	0.071	0.034	0.020
	Mean	12.84 ± 1.700	23.15 ± 1.888	0.470 ± 0.004	0.074 ± 0.004	0.031 ± 0.004	0.016 ± 0.006
Pork leg	**Minimum**	5.73	15.93	0.350	0.101	0.013	0.010
	Maximum	6.21	16.66	0.320	0.111	0.014	0.014
	Mean	5.97 ± 0.024	16.30 ± 0.365	0.335 ± 0.015	0.106 ± 0.005	0.013 ± 0.001	0.012 ± 0.002

Table 2. Content of Fe, Zn, Cu and Se (mean values) (per 250 g of fresh meat)

Specification	Bio-element (mg)			
	Fe	**Zn**	**Cu**	**Se**
Veal leg	3.21	5.788	0.118	0.019
Pork leg	1.493	4.075	0.0838	0.027

Table 3. Reference values of the necessary Fe, Zn, Cu and Se in the daily-recommended diet [21]

People range	Recommended necessary intake (mg/day)			
	Fe	**Zn**	**Cu**	**Se**
Men aged 19-50	8	11	0.9	0.055
Women aged 19-50	18	8	0.9	0.055

Table 4. Recommended mineral supply in the daily diet (per 250 g of fresh meat)

Specification	People range	Mineral supply (%)			
		Fe	**Zn**	**Cu**	**Se**
Veal leg	*Men aged 19-50*	40.13	52.61	13.06	33.64
	Women aged 19-50	17.83	72.34	13.06	33.64
Pork leg	*Men aged 19-50*	18.66	37.05	9.31	48.18
	Women aged 19-50	8.29	50.94	9.31	48.18

Experimental data presented in Table 4 show that, in the current experiment, veal and pork leg supply different amounts of minerals as determined by the concentration of the bio-element in the meat assortment analysed and the recommended daily intake (in men and in women). The degree of coverage of the necessary mineral in the daily diet, i.e. the recommended mineral supply of the veal and pork leg in the daily diet under experimental conditions show different values ranging between 13.06% (in men and women) in Cu, in pork leg, and 72.34% (in women) in Zn, in veal leg.

There were higher values of the mineral supply in veal leg – 72.34% Zn (in women) and 52.61% Zn (in men) and in pork leg – 50.94% Zn (in women) and 48.18% Se (in men and women), respectively.

There were appreciable values of the mineral supply in veal leg – 40.13% Fe (in men) and 33.64% Se (in women and in men) and in pork leg – 37.05% (in women).

The supply of copper had the lowest values ranging between 9.31% (pork leg) and 13.06% (veal leg).

4. Conclusions

Results obtained in the analysis of veal and pork leg show that they contain important amounts of iron and zinc, appreciable amounts of copper and selenium, and very small amounts of lead and cadmium (below the maximum limit of admitted toxicity).

The mineral supply of veal and pork leg in the recommended daily diet under experimental conditions shows different values ranging between 13.06% (in men and women) in Cu, in pork leg, and 72.34% (in women) in Zn, in veal leg.

There are higher values of the mineral supply in veal leg – 72.34% Zn (in women) and 52.61% Zn (in men) and in pork leg – 50.94% Zn (in women) and 48.18% Se, respectively (in men and women).

There were appreciable mineral supplies in veal leg – 40.13% Fe (in men) and 33.64% Se (in women and in men) and in pork leg – 37.05% (in women).

The values of the concentrations of Fe, Zn, Cu and Se of the mineral supplies evaluated point out that the meat assortments we analysed might be grouped in the category of mineralising foods particularly due to their supply of Zn, Se and Fe

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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