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A REVIEW ON THE RESULTS OBTAINED FROM THE ANALYSIS OF ANIMAL FOOD PRODUCTS FROM MEAT IN SOME EUROPEAN COUNTRIES USING GFAAS AND FAAS TECHNIQUES

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Abstract

This review paper aimed to highlight the importance of heavy metals and their presence in animal bodies and in their food products. There are specific organizations that have the role of constantly monitoring the levels of heavy metals and their consequences for human health, if the maximum admissible limits imposed by European legislation are exceeded. Their surveillance has an important role to safeguard consumers in case of a food contamination incident. They address issues such as sustainability, biological diversity, climate change, nutritional economics, population growth, water supply, and access to food. Naturally, heavy metals are not found in the animal body or in the animal food products, but they can be discovered as a result of their conscious or accidental incorporation (contamination) in food and which, by exceeding the acceptable limits, can constitute a health risk factor. As methods of analysis, Graphite Furnace and Flame Atomic Absorbtion Spectrometry were used. Therefore, it is very important to continually assess the levels of these analytes (Lead, Cadmium), to ensure that the values fall within the maximum admissible limits.

Key words: *heavy metals, human food safety, GFAAS, maximum admissible limits, European legislation.*

INTRODUCTION

Food is any substance consumed to provide nutritional support for an organism. It is usually of plant or animal origin and contains essential nutrients such as carbohydrates, fats, proteins, vitamins or minerals (Ciobanu et al., 2012).

Human nutrition is very important, as it depends, to a great extent, on ensuring the optimal development of the organism during growth, as well as the gaining and maintaining of the body's resistance to external factors (climatic, toxic or infectious).

Meat is very important in our food diet because, for most of us, it represents the main element in our nutrition (Murphy, 2002).

Animals are used as food either directly or indirectly by the products they produce. Meat is an example of a direct product taken from an animal, which comes from muscle systems or from organs.

Many food products are regularly tested for a selection of trace elements to estimate possible nutritional or toxicological associations and to warrant agreement with government regulations or food safety (Ciobanu et al., 2012; Berg et al., 2002).

The concentration of the distinct element species in food is also required to estimate the food safety and nutritional quality (Murphy, 2002).

The consumption of polluted food is the main source of Lead (Pb) and Cadmium (Cd) intake. Pb is abundant in the environment from different sources include automotive gasoline piston engines, oil burners, lead pipes, incinerators, industrial effluents and smokestack fallout (Walker, 2014).

MATERIALS AND METHODS

In order to gather the most relevant articles for the target subject, we focused our attention on literature restricted in this domain, guiding us by following keywords: lead, cadmium, meat products, organs, graphite furnace atomic absorption spectrophotometry (GFAAS), dietary intakes.

Samples collection

We selected the samples that were analyzed by GFAAS and FAAS techniques in Europe in order to create a database at least for some European country regarding heavy metals concentrations (Pb, Cd) in meat food products.

For this purpose, muscle samples from pork, beef and chicken (hearts, livers, gizzards and muscle), were randomly gathered from different farms and retail markets all over.

Samples homogenization and preparation of the analytical solutions

After the complete calcination at a maximum temperature of 450 Celsius degree, the mineralizates were processed. 5 mL of hydrochloric acid 6 Mol/L and 10 mL of 0.1 HNO_3 were added. The brushes were carefully rotated, so all the ashes came into contact with the acid. It was covered with a watch bottle and allowed to sit for 1 hour to 2 hours.

In parallel, a blank sample was prepared, with the mineralization reagents, treating the reagent blank in the same way as the samples. After this, the samples were processed by GFAAS or FAAS (Seely et al., 2009).

Estimation of Pb and Cd by graphite furnace/flame atomic absorption spectrometer (FAAS)

Standard stock solutions of Pb and Cd (1000 ppm) were prepared and diluted to the corresponding expected mass fraction recovery of trace elements in the samples. Pb and Cd were analyzed by GFAAS and FAAS. The wavelength of k = 217 nm was used for detection of Pb while the wavelength of k = 228.8 nm for Cd. Two replicate determinations were done for each sample. Sample blanks were prepared by taking 10 mL of the reagents mixture through the same procedure (Seely et al., 2009).

RESULTS AND DISCUSSIONS

Humans can be exposed to heavy metals through a variety of means, including consumption of contaminated food. Although heavy metals are usually present in foods at very low levels, long term exposure can have negative health impacts. Two of the more important toxic elements that must be monitored are cadmium (Cd) and lead (Pb), which can enter food either through environmental processes or through contamination in processing and/or packaging. As a result, it is very important to accurately measure low levels of Cd and Pb in a variety of food matrices (Dong-Gyu et al., 2015).

Lead and Cadmium are toxic metals occurring in the environment naturally and from anthropogenic activities. These heavy metals can lead to chemical contamination of products entering in the human food chain (Walker, 2014).

Determinations of these heavy metals were made in food products of animal origin in order to assess the threat to people posed by their presence. We processed and interpreted all the relevant data regarding this subject, in order to highlight their serious potential consequences.

In the past few years, a number of instrumental developments have contributed to providing more reliable results and better detection limits for trace determination of lead and cadmium by GFAAS.

These include improved electrodeless discharge (EDL) and hollow cathode (HCL) lamps for increased light output, and improved wet ashing sample preparation techniques (e.g., microwave digestion). This work will focus on the use of GFAAS for the determination of lead and cadmium (Figures 1, 2, 3) in a variety of food samples (Seely et al., 2009).

Limits of detection and quantification

An important aspect of the method performance evaluation is the calculation of the limits of detection. The limits of detection, based on the repeated analysis of blank solutions, were calculated as instrument detection limit (IDL), while the average standard deviation of repeated analysis of sample blanks (or samples containing very low concentration of the analytes) were calculated as the method detection limit (MDL).

All detection limits were obtained by analyzing more blank/samples each (Murphy, 2002).

Regarding chicken giblets, AAS analysis was employed on livers, gizzards and hearts samples sold at retail markets.

The minimum and maximum estimated concentrations of Pb were widely variable in livers, gizzards and hearts samples.

The significant Pb concentrations were found in liver samples (0.8762 ± 0.2089 ppm), whereas gizzard samples contained 0.3186 ± 0.1462 ppm and the level of Pb was estimated 0.1733 ± 0.06777 ppm in heart samples.

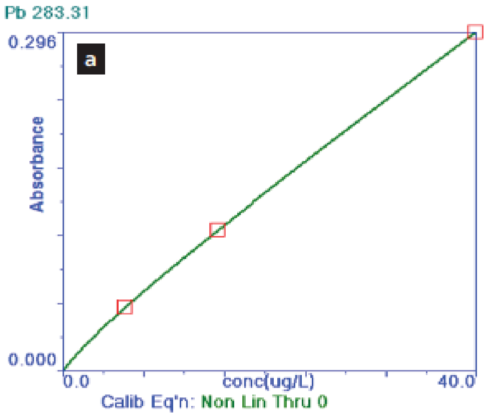

Figure 1. Three-points calibration curve for Pb (Seely et al., 2009)

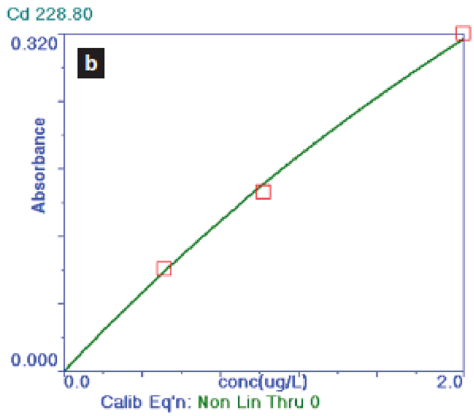

Figure 2. Three-points calibration curve for Cd (Seely et al., 2009)

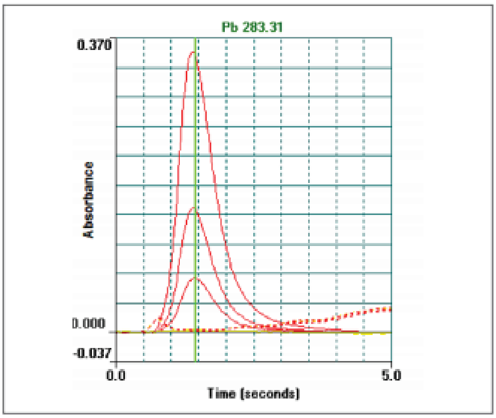

Figure 3. Overlay of spectral profiles of Pb standard solutions at 6 µg/L, 16 µg/L and 40 µg/L (Seely et al., 2009)

The results of one study indicated that broiler livers samples contain high Pb levels which exceed the maximum limit (0.5 ppm) in the Codex Alimentarius International Food Standards in some European areas.

This high level of Pb concentration could be attributed to the heavy environmental pollution with Pb which has high tendency for bioaccumulation in chicken tissue as it was deposited in kidneys (1.360 ppm), livers (0.500 ppm), ovarian tissue (0.320 ppm) and muscle (0.280 ppm) after experimental exposure of chicken-folk to chips of lead-based paint in their environment (Berg et al., 2002).

Finland

In a study made in Finland (1991), the average pb content of beef (tenderloin) was 10 µg/kg, ground beef 8 µg/kg, cow's liver 37 µg/kg, pork 9 µg/kg, pig's liver 11 µg/kg and chicken 6 µg/kg. The mean cd contents of beef, pork and chicken were lower than the limit of detection of the method employed. The mean cd content of cow's liver was 66 µg/kg (cow) and 36 µg/kg (heifer) and that of pig's liver 21 µg/kg. The contents of lead and cadmium were low in all samples studied in Finland (Tahvonen et al., 1994).

Sweden

In Sweden, the mean lead levels in pig meat, liver and kidney were < 0.005, 0.019 and 0.016 mg/kg, respectively: the mean levels in the corresponding bovine tissues were < 0.005, 0.047 and 0.097 mg/kg. The mean Cadmium levels in pig meat, liver and kidney were 0.001, 0.019 and 0.11 mg/kg, while those in the corresponding bovine tissues were 0.001, 0.070 and 0.39 mg/kg. Since toxic Pb residues were found to be in high levels in offals (the chicken livers), consistent surveillance and monitoring should be employed as its bioaccumulation could lead to serious human health problems among consumers (Jorhem et al., 1990).

Slovenia

Regarding Slovenian cattle and pigs, in a study made between 1989 and 1993, the mean concentrations of lead in bovine meat, liver and kidney were 0.05, 0.10 and 0.14 mg/kg wet weight and those in the corresponding pig tissues were < 0.05, 0.06 and 0.06 mg/kg wet weight. The mean Cadmium concentrations in bovine meat, liver and kidney were 0.004, 0.094 and 0.373 mg/kg wet weight, respect-tively, while those in the corresponding pig tissues were 0.010, 0.088 and 0.393 mg/kg wet weight. Quality assurance was carried out by analysis of certified reference materials and recovery tests.

Croatia

In rural areas from Croatia, trace element (As, Cd, Cu, Hg, Pb) concentrations were determined in the kidney of cattle, sheep, horses and pigs. The highest levels of Cd were found in horses and ranged 0.029–47.4 mg kg^{-1}, respectively. The European Union maximum levels for Cd in kidney were exceeded by 92.3% of horses, 14% of cattle and 16% of sheep. The highest levels of Pb were found in cattle (1.71 mg kg^{-1})

Toxic metals (lead, cadmium) were measured in muscle, liver and kidney samples of bovine and their relationships with heavy metal concentrations in consumed feed were studied. A total of 216 tissue samples from 72 cows and 216 feed samples from 18 farms were collected during four seasons and analyzed for heavy metals by inductively coupled plasma-optical emission spectrometry after wet digestion. The arithmetic mean concentrations (mg/kg wet weight) of lead (Pb), cadmium (Cd) were respectively, 0.221 and 0.028 in muscle, 0.273, and 0.047 in liver, 0.244, and 0.114 in kidney. All measured concentrations (with the exception of Pb in muscle) were below the European Union maximum residual limits (MRL). The Cd contents of the kidney were significantly higher than which observed in other tissues.

In addition, excessive consumption of offals originated from animals raised in Pb contaminated environment should be discouraged. Furthermore, garlic could be advised to antagonize Pb toxicity, as garlic contains chelating compounds capable of enhancing elimination of Pb. Garlic feeding can be exploited to safeguard human consumers by minimizing Pb concentrations in chicken meat which had been grown in a Pb polluted environment (Hanafy et al., 1994).

Certain meat tissues such as muscle, liver and kidney are widely consumed without any further processing, being considered a real delicacy (Doganoc, 1996).

Unfortunately, environmental pollution is increasing, creating many threats for animals and, consecutively, for humans (Murphy, 2002). The high industrialization rate can be considered responsible for the contamination with many toxic elements such as Lead and Cadmium. They can be moved away by the air and can be deposited in soil, water, and even in the plants that the ruminants feed with (Berg et al., 2002).

According to several studies, the high accumulation of such metals in the liver and kidney was found to be directly related to their function as storage and excretory organ, respectively (Suttie, 2017).

Such unidentified sources of toxic metals could very well be attributed to high accumulation of metals from the environment onto plants, municipal wastes, lead and nickel-cadmium batteries which are non-responsibly discarded, electronic wastes, all of which are dumped and burnt in each area. Considering the intra-level distribution of Pb and Cd in the various tissues studied, liver and kidney tissues of all studied organisms showed the highest amounts of bioaccumulation as opposed to all other tissues. This strongly suggests that consumption of contaminated liver and kidney tissues may present a health risk if included regularly in the diet.

The results show a large variability of lead and cadmium concentrations in some of the meat and meat products groups. However, this variability in biological samples is considered to be normal since the sources of this metal are numerous. Furthermore the lead and cadmium concentrations, also, depend on the environmental conditions and the food production methods. Even within a certain type of food, concentration variations can be large produced by heterogeneities in the distribution of the metal (Walker, 2014). All the samples were taken in different times and seasons. Thus the exposure to different metals was not constant contributing to a larger variability.

The concentrations of the considered metals can be slightly higher in meat product samples than in meat samples. This difference may be explained by the fact that offal (mainly liver and kidney) is often used as an ingredient in meat products and is, also, an important source of lead and cadmium.

Anatomo-pathological changes

High exposure to Pb may affect neurological, renal, reproductive and haematological systems with higher vulnerability in children. Meanwhile, Cd is known to primarily affect kidneys as well as demineralisation of bones.

Therefore, repeated determinations of the levels of lead and cadmium in meat and meat products from different animal species were performed.

The main toxic effect of **Lead** is dysfunction of the nerve system of the fetus and infants. In adults, it produces: blood-side effects; reproductive dysfunction; gastrointestinal damage; nephropathy; central damage as well as the peripheral nervous system and interference in the enzymatic systems that synthesize the group. Besides, it can occur arteriosclerosis, inhibition of growth, damage or inhibits the activity of the immune system depending on the dose.

Lead is known to induce reductions in cognitive development and intellectual performance in children and to increase the number of blood pressure and cardiovascular diseases in adults (Dong-Gyu et al., 2015).

Cadmium may accumulate in the human body and may induce renal dysfunction as well, bone diseases and reproductive system deficiencies. The toxic effect of cadmium occurs in the kidneys, although it has also been associated with pulmonary lesions (including lung tumor induction) and skeletal changes in professionally exposed populations. Cadmium is relatively poorly absorbed in the body, but once absorbed, it is slowly excreted, like other metals, and accumulates in the kidney causing renal lesions. The contaminated kidneys are a major source of cadmium in the diet, although lower levels are found in many other foods (Suttie, 2017).

In addition, we discovered some of the targeted studies that indicate the fact that there have been found higher levels of heavy metals such as lead and cadmium in canned meat products, regarding imports (Walker, 2014).

This can be a real danger to consumers, since canned meat products are easily accessible (very convenient price). There is a clear need to improve quality control in the processing of these canned meat products and also in imposing stricter guidelines by the competent authorities.

CONCLUSIONS

Regarding all of these anatomo-pathological changes, both animal breeders and final consumers of animal and non-animal products should constantly monitor and assess the levels of toxic metals in the environment and food in order to highlight the degree of contamination and its sources. By doing this, people will be able to take measures in controlling these levels in the future.

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