ANALYSIS OF HEAVY METAL ACCUMULATION FOOD WITH X-RAY FLUORESCENCE SPECTROMETRY

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ABSTRACT

The theme of the study is the examination of heavy metal accumulating ability of commercially available chicken, pork and beef liver samples and comparison with the limits specified by the laws. The measurements were carried out with the Delta XRF device manufactured by Innov-X, which operates on the principle of X-ray radiation. The lead content of all samples of the first and second sampling were beyond the maximum level (0.5 mg/kg) which is required by the Commission Regulation 1881/2006. The measured values were between 2 and 3 mg/kg for both samplings. In case the samples of the third sampling the lead content could not be detected by the applied device. The cadmium contents of the all samples of three samplings exceeded the required cadmium limit in the regulation (0.5 mg/kg). The measured values were between 10 and 20 mg/kg in case of all samples. Tin and mercury contents were not detected in the investigated samples by the applied measurement method. Among the non-toxic heavy metals the samples contained high amounts of iron and manganese, in additional each samples contained small amount of zinc, rubidium and antimony but these does not constitute a health risk due to the minimal amounts.

Keyword: heavy metals, chicken liver, pork liver, beef liver, X-ray fluorescence spectrometry

1. INTRODUCTION

In rapidly developing world, next to the intensive agriculture the increasing industrial activity means more and more problems and causes serious environmental pollution by the increasing metal emission.

The internal organs include in the group of heavy metal accumulating food, but their characteristic is rapidly deterioration. However the traditional test methods are time-consuming in most of cases and it possible to examine just small amount sample from each items. In light of the knowing a development and application of rapid method will be promising solution for determination of heavy metal content of these samples.

The offal such as the liver is one of the most important iron sources for people, because the iron which originates from degradation of haemoglobin, stores in this organs. Many vitamins (C, B, A, D) can be found in the liver and in additional many minerals and trace elements also. Because the liver performs detoxification function the heavy metals are able to accumulate in the liver.

Ayhan (1999) investigated metal contents (Cd, Ca, Cu, Fe, Pb, Mg, Mn, Hg, K, Na and Zn) of three different ages chicken groups (4 weeks, 8 weeks, 18 weeks) in different tissue parts (heart, gizzard, kidney, spleen. liver) with atomic absorption spectroscopy. The results showed varied distributions for analysed elements in different tissue parts. In case of the liver the highest cadmium content was in the four weeks chicken (0.05 mg/kg), the highest lead content was in the eight weeks chicken (0.092 mg/kg) and the highest mercury content was in the 18 weeks chicken (0.084 mg/kg).

A Nigeria research focused the metal contents such as lead, cadmium, copper and zinc in different body parts of chicken. The chicken meat is the major protein source for the people

who live this area, but the metal concentration may increase in the food on the effect of the air pollution and chemicals. The samples originated from the local market of Nsukka and Enugu. As the first step the liver, gizzard and muscles were removed from the body, and after the samples were prepared for the wet ashing. Followed by this the heavy metal content was measured by atomic spectroscopy. The results showed the cadmium content was 1.78-15.32 μg/g, the lead content was 9.7-147.07 μg/g, the copper content was 15.82 -47.79 μg/g and a the zinc content was 0.03 -2.29 μg/g in the samples (Okoye et al.,2011).
A South Korean research had the aim to determine the heavy metal content in some meat products. During the research beef, pork, chicken ham and sausages were investigated. During the investigation wet ashing and microwave technique were combined, but the reproducibility of the microwave measurement was much better than the reproducibility of the wet ashing. The mercury level was determined by mercury analyzer. The lead contents of the metals were 9 μg/kg in beef meat, 10 μg/kg in pork meat, 6 μg/kg in chicken meat, 7 μg/kg in duck, 5 μg/kg in ham and 9 μg/kg in sausage. The cadmium contents were 0.4 μg/kg in beef meat, 4 μg/kg in pork meat, 0.5 μg/kg in chicken meat, 12 μg/kg in duck, 1.5 μg/kg in ham and 1.9 μg/kg in sausage. The arsenic contents were 16 μg/kg in beef meat, 4 μg/kg in pork meat, 21 μg/kg in chicken meat, 10 μg/kg in duck, 14 μg/kg in ham and 18 μg/kg in sausage. The mercury contents were 0.713 mg/kg in beef meat, 0.902 mg/kg in pork meat, 0.710 mg/kg in chicken meat, 0.796 mg/kg in duck, 1.141 mg/kg in ham, 1.052 mg/kg in sausage. The results were compared with the values published by FAO/WHO, which shown the heavy metal concentrations in food were below the harmful level so healthy damage can not occurre during the consumption of these products (Hwang et al., 2011).

2. MATERIAL and METHOD

Materials

During the investigation the heavy metal contents of the chicken, pork and beef liver were determined. The sampling was implemented three times over three consecutive weeks from the same butcher shops (Chicken liver: ChM: Maxim Sándor, ChW: Wippi és Társa Kft.; Pork liver: PM: Maxim Sándor, PSz: Szabóhús Mix Kft.; Beef liver: BL: Lázár és Társa Kft, BSz: Szabóhús Mix Kft.).
The pulping of the samples was carried out with blender so the samples become into proper for filling of the sample holder. The samples were compacted into the sampler holder to the bubble-free state. The filled with samples jars were covered with a special (mylar) film what was stretched out by a clamping ring on the samples surface.

Method

The determination of the accumulated in liver samples heavy metal contents were used X-ray fluorescence spectrometer (XRF). The used equipment is a brand InnovX, portable Delta XRF device, whose measurement period was 105 sec in case of the investigated samples. The X-ray fluorescence spectrometry as an instrumental analytical method is able to determine elemental composition of solid and fluid samples from minimal prepared sample size, additionally this method can be used for direct analysis of solid and liquid materials as well. In the course of the process the sample is shot by the X-ray thus the atoms within the sample got into excited position so typical characteristic radiation for particular elements is emitted. Energy (wavelength) of these characteristic radiations changes element by element and this fact is considered as the bottom line of the qualitative element analysis. The intensity of characteristic radiation of the element is commeasurable to its concentration which permits of the qualitative analysis.

3. RESULTS and CONCLUSION

The measurement results of the samples of first sampling showed the lead contents were greater amounts by the permitted by the legislation value (0.5 mg/kg). The same could be observed by the cadmium content, by which the approved level is 0.5 mg/kg too (1881/2006 EC Regulation).
Another group of heavy metal includes those metals which are essential for the human body such as the iron, which could be found in all samples. But it can be observed the pork and beef liver included higher amount the chicken liver. The manganese and zinc have important role in functioning of the human body because the absence of manganese and zinc can cause bone development problems. These elements were significant amount in all samples (Fig.1).

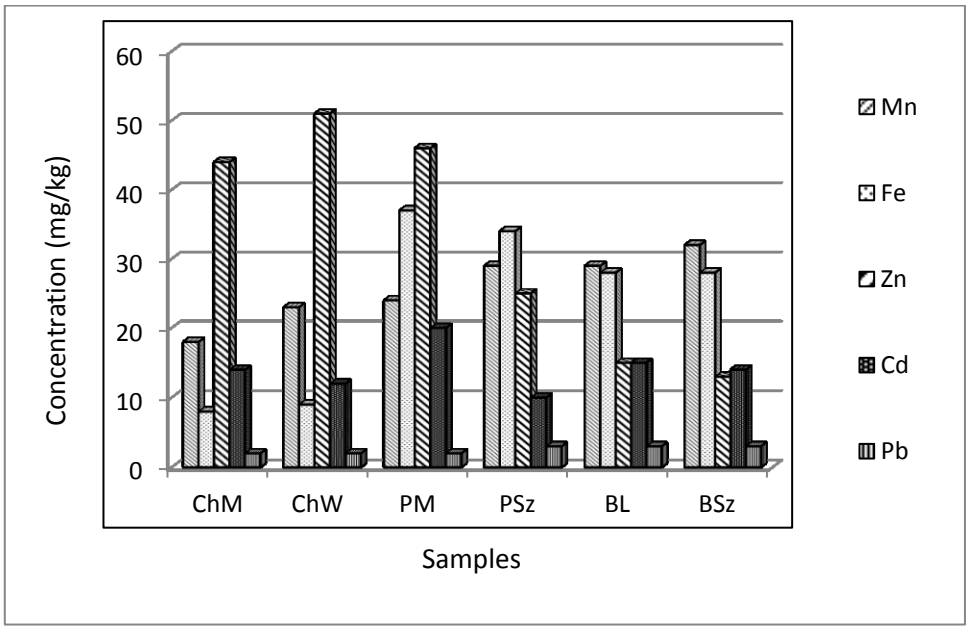

Figure 1 Measurements result of the first sampling

The results of the second sampling showed the lead and cadmium values were higher than the required by the legislation levels (0.5 mg/kg). The iron content of the pork liver was extremely high compared with the iron content of the chicken and pork liver and relative to the results of first sampling too. The distribution of the manganese was relatively uniform as samples, but the manganese contents of the samples of the second sampling were five times more than the manganese contents of the samples of the first sampling (Fig.2).

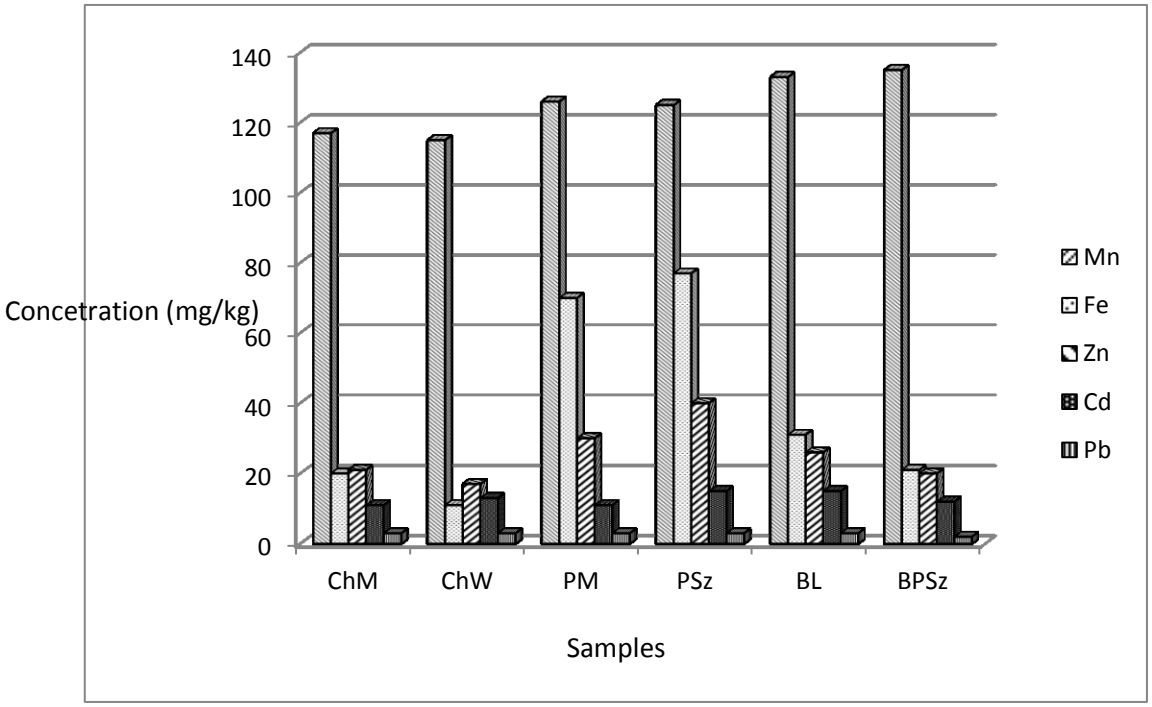

Figure 2 The measurements result of the second sampling

In case of the third sampling the same can be concluded, so the cadmium contents were above the limit. In these samples lead contents were not detected by the device. The iron was found large quantities in the samples, especially by one of beef lives the iron content was 303 mg/kg. Based on the data the manganese was the smallest amount in the samples of the third sampling (Fig.3).

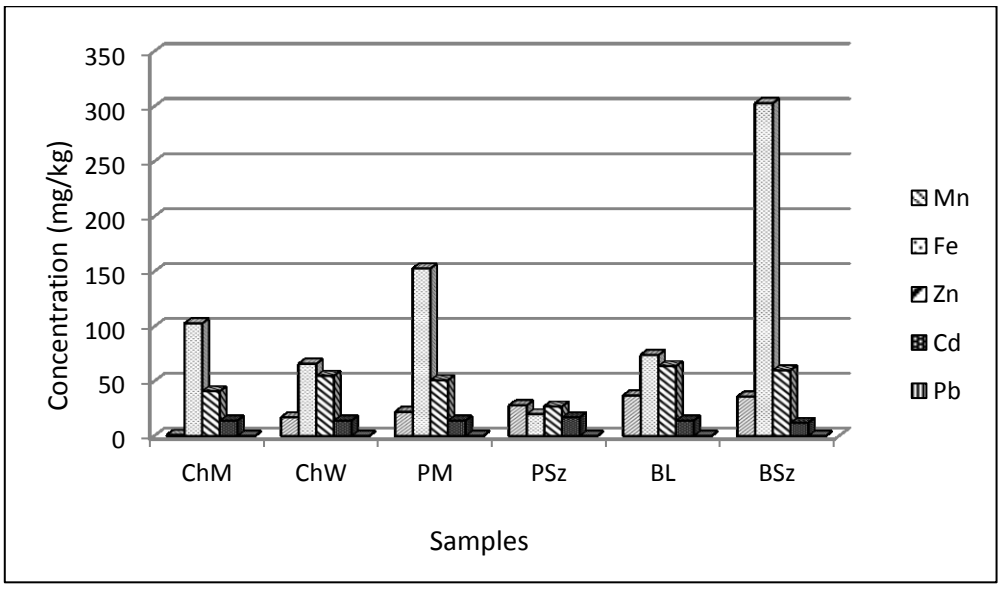

Figure 3 The measurements results of the third sampling

Based on the experimental results it can be said that among the highly poisonous, toxic heavy metals the lead and the cadmium could be detected above the limits all of samples which can cause metal toxicity in long term consumption.

Among the non-toxic heavy metals the samples included iron and manganese, further all samples included zinc, rubidium and antimony, however their minimal amounts does not constitute health risk.
The advantage of the XRF measurement technique is that the analytical test can be completed quickly, which is great advantage in case of the perishable samples. The measurement does not destroy the structure of the samples and the technique is able to analyse large amount samples.
The possible disadvantages of this method are that the instrument calibration per elements may be necessary, and the device is sensitivity for the matrix effects and the surface inhomogeneity during the measurements.
It would be worth to compare the results with other analytical methods, but the realization raises serious problems because the device does not distinguish between the compounds so in case of the tripping based analytical methods some portion of the differences may result from the sample preparation.
Significant difference was observed between the concentrations of some elements in case of some samples, so it would be worth to continue the investigation with more detailed exploration of the origin of the liver samples such as the examinations of the feeding and housing conditions effect.

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