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Evaluation of Heavy Metals Contamination and Assessment of Mineral Nutrients in Poultry Liver Using Inductively Coupled Plasma-Mass Spectrometry

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Abstract. The aim of this study was to perform a short characterization of heavy metals and mineral nutrients concentration in poultry liver samples with macroscopic lesions and their possible effect on food safety.

Thirty-eight poultry liver samples with macroscopic lesions were submitted to analysis. Heavy metals (Cd, Pb, Al) and mineral nutrients (Cr, Mn, Cu, Fe, Zn, Ca, Mg, K, Na) were determined by ICP-MS. The concentrations for heavy metals ranged from 0,1 to 1,29 mg/kg for Cd, 0,02 to 0,08 mg/kg for Pb and 0,13 to 8,85 mg/kg Al. For mineral nutrients, concentrations ranged from 0,13 to 2,66 mg/kg for Cr; 0.24 to 1,08 mg/kg for Mn; 0.74 to 2,92mg/kg for Cu; 14,11 to 54,65 mg/kg for Fe; 4,37 to 17,86 mg/kg for Zn, 43,2 to 199,51 mg/kg for Ca, 78,35 to 275,81 mg/kg for Mg, 989,54 to 3108,65 mg/kg for K, 276,28 to 1059,16 mg/kg for Na. Although it is known that people ingest heavy metals from animal products, the concentrations obtained in this study showed that there is no risk for human health linked to the consumption of poultry liver.

Keywords: poultry liver, heavy metals, mineral nutrients, inductively coupled plasma-mass spectrometry

1. Introduction

The liver is the most important organ involved in metabolic processes and is considered to be one of the most eloquent witnesses of any disturbance in the body, as it is the subject of different types of etiologic attacks: infectious, toxic, metabolic, nutritional, traumatic [1].

Offal consumption is not negligible in European Union. Analyzing the data extracted from the «Comprehensive European Food Consumption Database; Concise Data Base summary statistics - Total Population », it can be seen that the consumption of edible offal, including poultry liver, is between 1 g/day in Ireland and 26.1 g/day in Poland, with an average of 7.12 g/day for the European Union, considering the countries that participated to the survey [2].

Interactions between toxic and essential metals are central to mineral balance and the antioxidant defense system in mammals and birds [3], [4]. Most of the studies show that residues of aluminum, cadmium and lead are the most frequent heavy metals to be determinate in poultry liver [5], [6].

The risk associated with the exposure to heavy metals present in foodstuffs represents a concern in human health. Improvements in the food production and processing technology increased the chances of contamination of food with various environmental pollutants, especially heavy metals [7].

Essential trace metals may modify health risks from exposure to nonessential toxic metals. A well-known example of this is the reduction of cadmium (Cd) toxicity after pretreatment with zinc (Zn) or the simultaneous administration of Zn with Cd [8]. On the other hand, the ingestion of a diet that is deficient in a

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particular essential element can enhance the accumulation and toxicity of some toxic metals. Calcium (Ca), iron (Fe) and Zn deficiency, for instance, enhance susceptibility to Cd and Pb toxicity [5], [6].

Lead is one of the most toxic elements, because it binds and inactivates essential enzymes. Renal, gastrointestinal, nervous and haemapoietic systems are affected by the lead intoxication [9].

The principal source of cadmium contamination in humans is represented by food [9]. Cadmium bioaccumulates through the food chain and reaches the maximum concentration in carnivores, where it increases by a factor of 50-60 times [10]. Toxic effects of cadmium are kidney dysfunction, hypertension, lung damage and hepatic injury. Cadmium disrupts the antioxidant enzyme system, resulting in increased oxygen radical production, which causes damage to membranous structures such as mitochondria and endoplasmic reticulum [11].

2. Materials and Methods

Thirty-eight poultry liver samples with macroscopic lesions from a Romanian slaughterhouse were submitted to analysis. The samples presented the following macroscopic lesions: 16/38 hepatosis (42,10%), 10/38 miliary necrotic hepatitis (26,31%), 3/38 perihepatitis (7,89%), circulatory disturbances 14/38 (36,84%) (Figure 1).

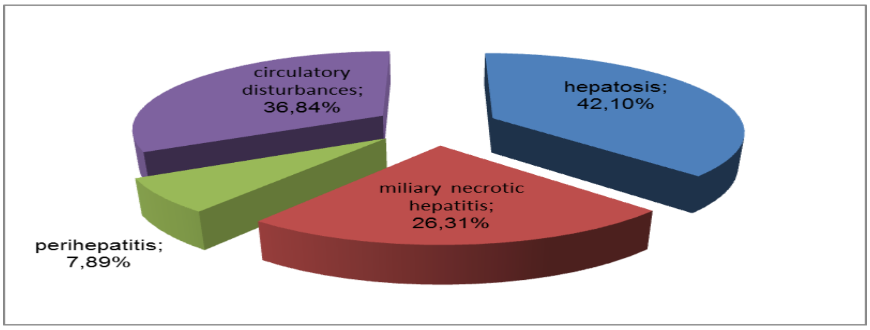

Fig. 1: Distribution of lesions type for poultry liver samples

The 38 livers came from industrial intensive indoor rearing birds that were slaughtered at 40 days of age.

For heavy metals and mineral nutrients analyze, using Guirlet and Das (2012) protocol [12], approximately 500 mg of each poultry liver sample were digested with 2 ml concentrated nitric acid, 5 ml deionized water and 1 ml H_2O_2, in microwave pressure digestion system, type Berghof speed wave MVS-3 (Table I).

Table I: Parameters of sample digestion for heavy metals and mineral nutrients analyze

Heating stages	Time (min)	Power (W)	Temperature (℃)
1	5	300	120
2	5	500	160
3	5	600	190
4	10	400	190
5	5	Pause	Pause

Samples were diluted to 25 ml with ultrapure water and analyzed by an Inductively Coupled Plasma-Mass Spectrometer (ICPMS, Perkin Elmer, Sciex, DCR 2) to determine heavy metals (Cd, Pb, Al) and mineral nutrients (Cr, Mn, Cu, Fe, Zn, Ca, Mg, K, Na). An internal standard (^{103}Rh, CertiPUR®, Merck) was added to each sample and calibration standard solutions.

3. Results and Discussions

The results are presented (ppm or mg/kg) as mean values of a triplicate analysis of the sample extract and statistical analyses were performed with SPSS software version 19 for Windows.

The concentrations for heavy metals ranged from 0,1±0,01 to 1,29±0,06 mg/kg for Cd, 0,02±0,01 to 0,08±0,03 mg/kg for Pb and 0,13±0,02 to 8,85±0,4 mg/kg Al. (Figur 2- Figure 4).

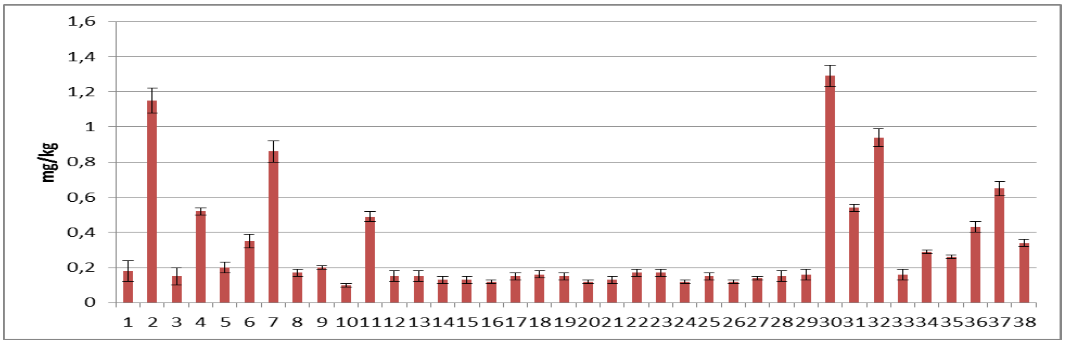

Fig. 2: The content of cadmium (mean ±S.D.)

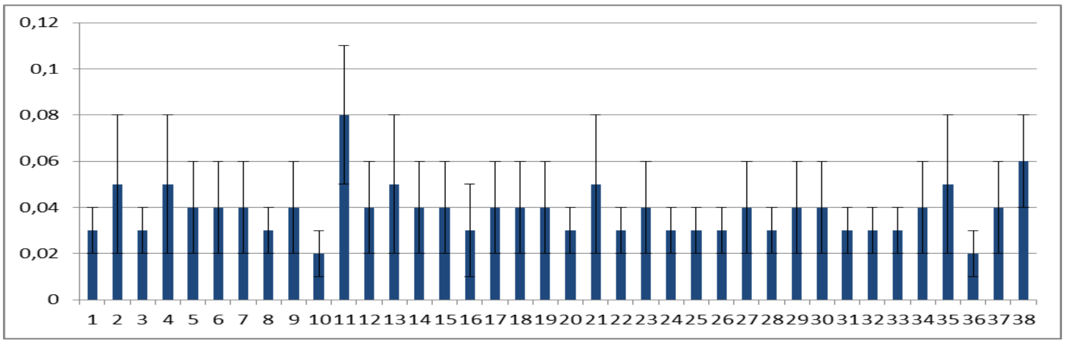

Fig. 3: The content of lead (mean ±S.D. mg/kg)

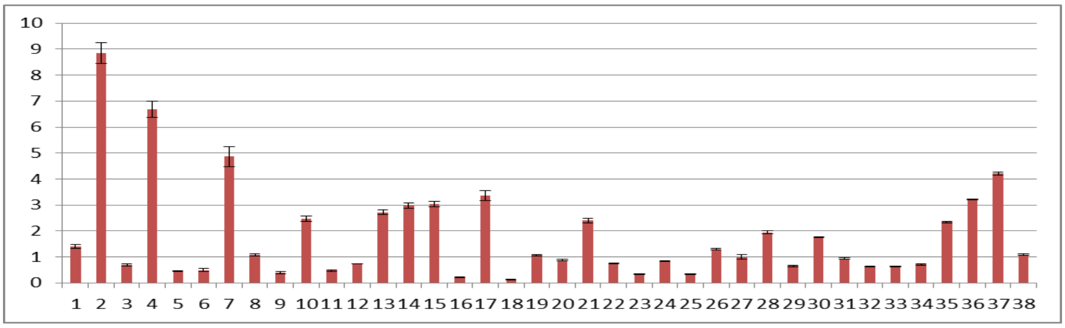

Fig. 4: The content of aluminium (mean ±S.D. mg/kg)

For mineral nutrients, concentrations ranged from 0,13±0,02 to 2,66 ±0,02 mg/kg for Cr; 0.24±0,02 to 1,08 ±0,03 mg/kg for Mn; 0.74±0,02 to 2,92 ±0,02 mg/kg for Cu; 14,11±0,55 to 54,65 ±0,25 mg/kg for Fe; 4,37±0,21 to 17,86 ±0,51 mg/kg for Zn, 43,2±0,23 to 199,51 ±1,36 mg/kg for Ca, 78,35±0,85 to 275,81 ±1,92 mg/kg for Mg, 989,54±2,99 to 3108,65±5,02 mg/kg for K, 276,28±1,87 to 1059,16 ±6,54 mg/kg for Na (Figure 5-Figure 13).

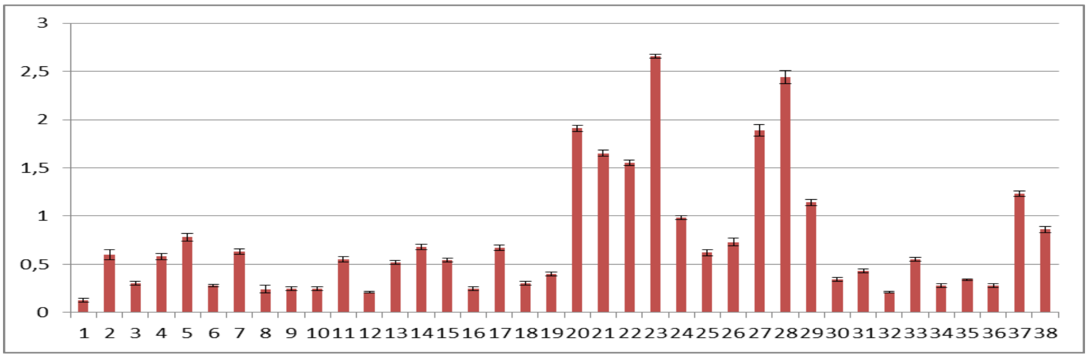

Fig. 5: The content of chromium (mean ±S.D. mg/kg)

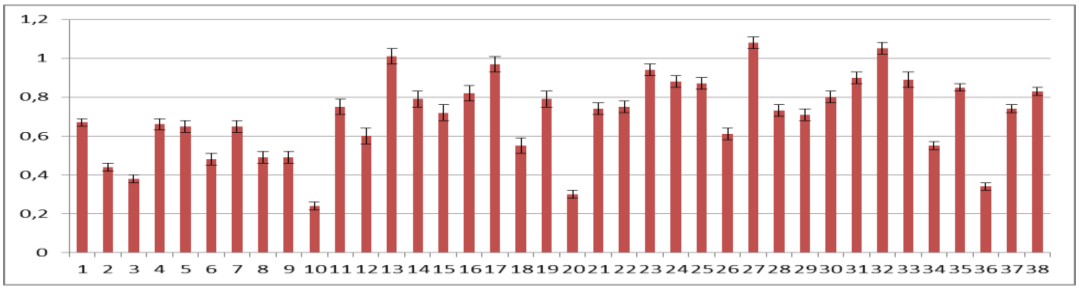

Fig. 6: The content of manganese (mean ± S.D. mg/kg)

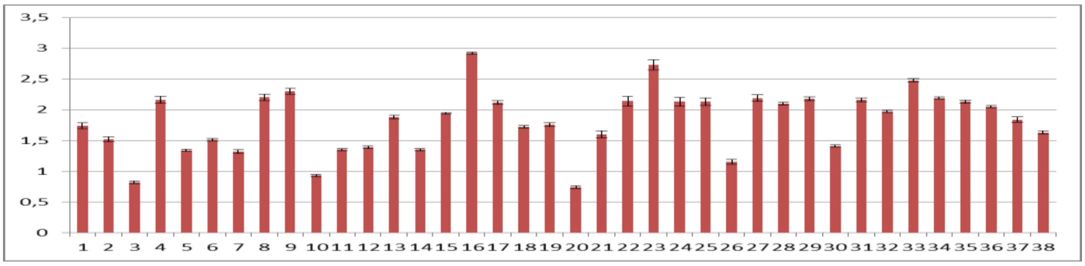

Fig. 7: The content of copper (mean ± S.D. mg/kg)

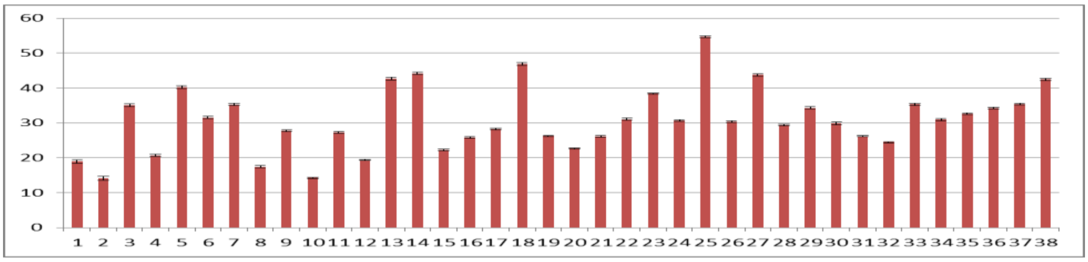

Fig. 8: The content of iron (mean ± S.D. mg/kg)

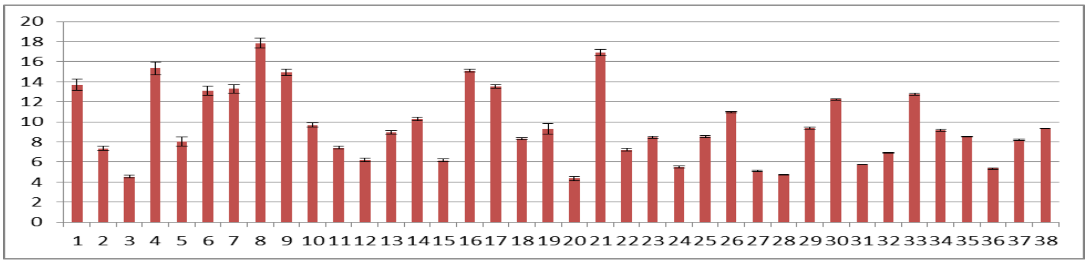

Fig. 9: The content of zinc (mean ± S.D. mg/kg)

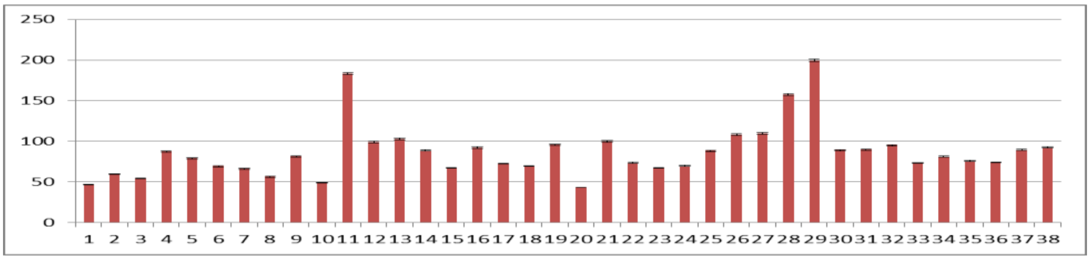

Fig. 10: The content of calcium (mean ± S.D. mg/kg)

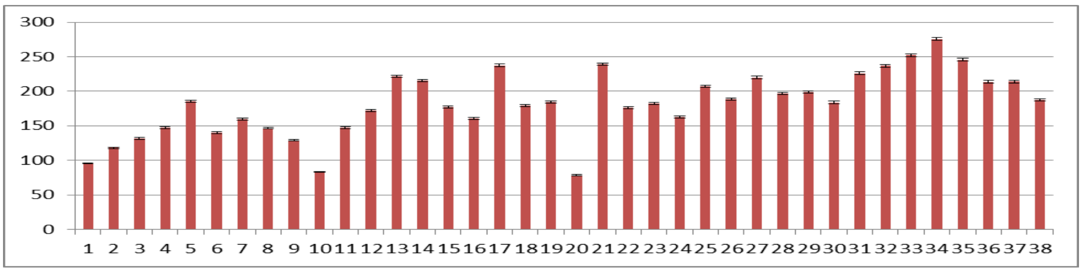

Fig. 11: The content of magnesium (mean ± S.D. mg/kg)

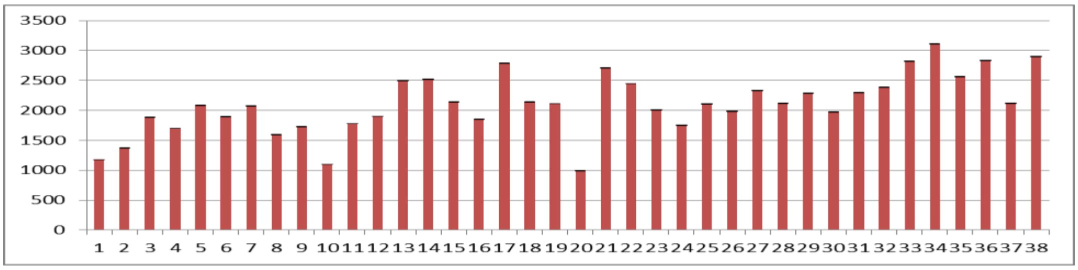

Fig. 12: The content of potasium (mean ± S.D. mg/kg)

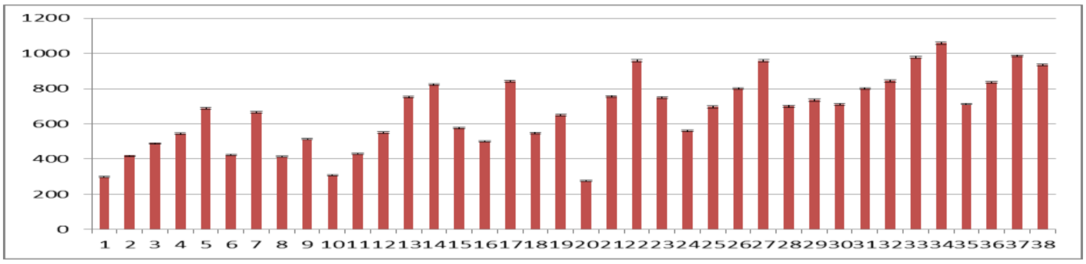

Fig. 13: The content of sodium (mean ± S.D. mg/kg)

All poultry liver samples were under the maximum tolerance levels for lead (Pb), respectively 0.5 ppm (mg/kg) [13]. For cadmium were observed some values that exceeded the maximum tolerance level, but these represented only 10,52% of the number of samples.

In this research, the concentrations of heavy metals and were not measured for water and feed of these poultry, but from literature it is known that the main source of heavy metals in chicken and turkey meat arises from contamination of poultry feed and drinking water [9], [14].

Also, Pearson coefficient (r^2) was used to calculate the correlation between heavy metals and mineral nutrients concentration in order to establish the mutual influence in the bioaccumulation process, respectively Cd- Zn (r^2= 0 ,01), Cd- Fe (r^2= - 0 ,19), Cd- Cu (r^2= -0 ,13), Cd-Ca (r^2= - 0 ,01), Pb-Ca (r^2= 0 ,42). For data analyze, it can be seen that the most important correlation was between lead contamination and the presence of calcium in liver samples.

4. Conclusions

Although it is known that people can ingest heavy metals because of background levels especially in animal products, we show here, from a very limited study, that this intake from liver is most probably not exceeding the current total daily intake and thus it can be considered that there is no risk for human health linked to the consumption of poultry liver. However, in case of accidents, when large amounts of these chemical substances are spread in the environment, heavy metals and pesticides contamination represent a real risk for the consumer health, because of their bioaccumulation thought the food chain and a risk assessment should be performed, in order to quantify the exposure of humans to that precise contamination.

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