ASSESEMENT OF MINERAL NUTRIENTS, HEAVY METALS AND PESTICIDES IN POULTRY LIVER USING INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY AND GAS CHROMATOGRAPHY-MASS SPECTROMETRY

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Abstract

Poultry liver is considered to be one of the most important sources of mineral nutrients in humans' diet, but due to its specific structure tends to bind chemical contaminants such as heavy metals and pesticides. The aim of this study was to perform a short characterization of mineral nutrients concentration and heavy metals and pesticides contamination in commercial poultry liver samples and their possible effect on food safety.
Eleven commercial poultry liver samples coming from 3 different Romanian slaughterhouses were submitted to analysis. Heavy metals (Cd, Pb, Al) and mineral nutrients (Ni, Cr, Mn, Cu, Fe, Zn, Ca, Mg, K, Na) were determined by Inductively Coupled Plasma-Mass Spectrometry. For organochlorine and organophosphorus pesticides quantification Gas Chromatography/Mass Spectrometry was used.
The concentrations for heavy metals ranged from 0.008 to 0.03 mg/kg Cd, 0.02 to 0.06 mg/kg Pb, 0.001 to 0.002 mg/kg Hg and 0.09 to 0.6 mg/kg Al. For all samples, the values of organochlorine and organophosphorus pesticides were under the limit of detection. For mineral nutrients, concentrations ranged from 0.02 to 0.07 mg/kg Ni; 0.02 to 0.09 mg/kg Cr; 0.5 to 1.32 mg/kg Mn; 0.9 to 2.6 mg/kg Cu; 12.9 to 48.7 mg/kg Fe; 3.7 to 7.7 mg/kg Zn, 35.6 to 62.3 mg/kg Ca, 86.6 to 167.2 mg/kg Mg, 1555.9 to 1668 mg/kg K, 593.51 to 1127.8 mg/kg Na.
Although it is known that people ingest heavy metals and pesticides 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: *Gas Chromatography-Mass Spectrometry, heavy metals, Inductively Coupled Plasma-Mass Spectrometry, pesticides, poultry liver.*

INTRODUCTION

Poultry liver is considered to be one of the most important sources of mineral nutrients in humans' diet, but due to its specific structure tends to bind chemical contaminants such as heavy metals and pesticides.

Indeed, the liver, a major organ involved in metabolic processes, is considered to be one of the most eloquent witness of any disturbance in the body, as it is the subject to different types of etiologic attacks: infectious, toxic, metabolic, nutritional and traumatic (Doneley, 2004).

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 (European Food Safety Authority, 2011).

In particular, poultry liver consumption needs a special attention. Indeed, poultry liver is considered to be an important source of nutrients, such as vitamins, macro elements and microelements, in some countries, it is used in pregnant women diet and in nutritional disorders.

For food from animal origin, one of the possible causes of exclusion from consumption because of a risk for public health is the contamination with chemical substances, such as heavy metals and pesticide which are contaminants tending to accumulate in poultry liver.

According to the Commission Regulation 1881/2006, the maximum tolerance levels for heavy metals in liver, including poultry liver, are established only for cadmium (Cd) and lead (Pb), respectively 0.5 ppm (mg/kg) for both (European Union Regulation (EC) No 1881/2006).

Interactions between toxic and essential metals are central to mineral balance and the antioxidant defense system in mammals and birds (Lopez-Alonso et al., 2007; Pappas et al., 2010).

Most of the studies show that residues of aluminum, cadmium and lead are the most frequent heavy metals to be determinate in poultry liver (Goyer, 1997; Jihen et al., 2008).

The residues of pesticides have become a factor for the environmental pollution and their toxic effects have been observed in humans and animals.

Organochlorine and organophosphorus pesticides are fat-soluble components which bioaccumulate through food chain.

The acute health risks of pesticides, their long persistence and tendency to accumulate in body tissues have raised a great concern about possible human health impacts due to low but chronic exposure (Salem et al., 2009).

Using of Inductively Coupled Plasma-Mass Spectrometry for heavy metals and mineral nutrients monitoring and Gas Chromatography-Mass Spectrometry for pesticides quantification are one of the most commonly known techniques applied in animal production, including poultry industry.

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

MATERIALS AND METHODS

Eleven commercial poultry liver samples coming from 3 different Romanian slaughterhouses were submitted to analysis. The livers were 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 , 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 1).

Table 1. Parameters of sample digestion for heavy metals and mineral nutrients analyze

eating stages	Time (min)	Power (W)	Temperature (°C)
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 (Ni, 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.

For organochlorine and organophosphorus pesticides quantification GC/MS was used. The following sample preparation protocol was used: 5 to 10 grams of chopped livers were sonicatied in 20 mL methylene chloride. The extract was filtered through glass wool and sodium sulfate to remove water and any particulate. After solid-liquid extraction the extract was concentrated to 1 or 2 ml. An amount of 1 or 2 ml of clean-up extract was analyzed by PolarisQ – Quadrupole Ion Trap GC/MS.

An internal standard (Pestanal, Riedel de Haen – Fluka) for organochlorine pesticides (lindan, aldrin, dieldrin, DDT, ά-HCH) and organophosphorus pesticides (malation, paration, parathion-metil, fention, dimetoat, ethion, phorate) was added to each sample.

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 Inductively Coupled Plasma-Mass Spectrometer's limit of detection (LOD) for each heavy metal and mineral nutrient is presented in Table 2.

Table 2. LOD of ICP-MS for heavy metals and mineral nutrients

Chemical element	LOD (ppt)
Cd 114	0,08
Pb 208	0,07
Al 27	0,05
Ni 60	0,10
Cr 52	0,12
Mn 55	0,17
Cu 63	0,05
Fe 56	0,12
Zn 64	0,45
Ca 40	0,10
Mg 24	0,08
K 39	0,27
Na 23	0,14

The concentrations for heavy metals ranged from: 0.008 to 0.03 mg/kg for Cd, 0.02 to 0.06 mg/kg for Pb and 0.09 to 0.6 mg/kg for Al (Figure 1-3).

For mineral nutrients, concentrations ranged from: 0.02 to 0.07 mg/kg for Ni; 0.02 to 0.09 mg/kg for Cr; 0.5 to 1.32 mg/kg for Mn; 0.9 to 2.6 mg/kg for Cu; 12.9 to 48.7 mg/kg for Fe; 3.7 to 7.7 mg/kg for Zn, 35.6 to 62.3 mg/kg for Ca, 86.6 to 167.2 mg/kg for Mg, 1555.9 to 1668 mg/kg for K, 593.51 to 1127.8 mg/kg for Na (Figure 4-13).

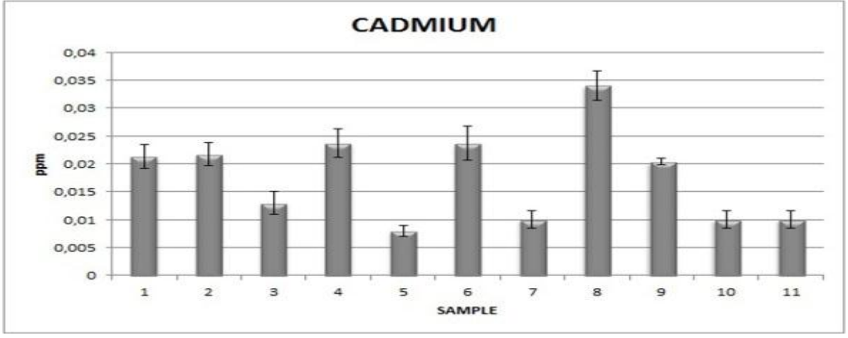

Figure 1. The content of cadmium (mean ± S.D. in mg/kg) in liver samples

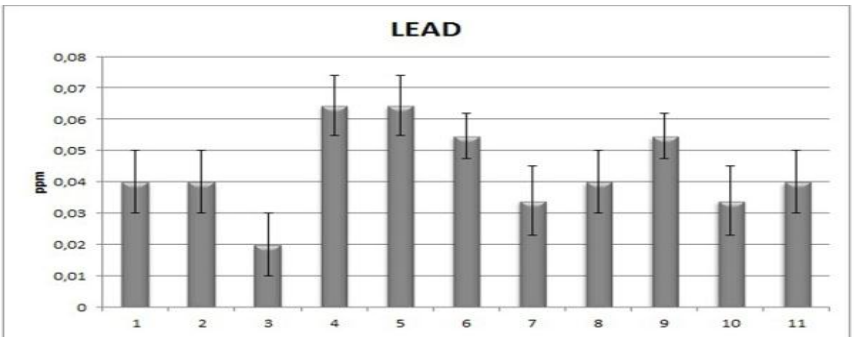

Figure 2. The content of lead (mean ± S.D. in mg/kg) in liver samples

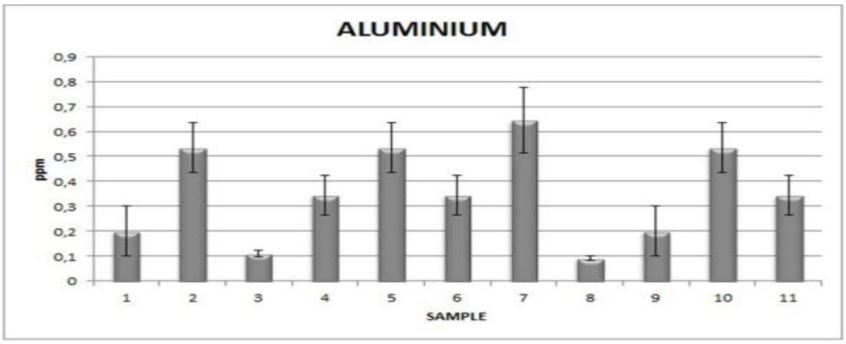

Figure 3. The content of aluminum (mean ± S.D. in mg/kg) in liver samples

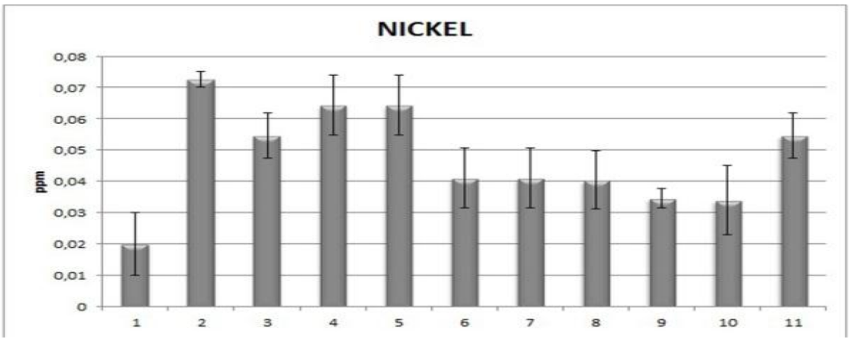

Figure 4. The content of nickel (mean ± S.D. in mg/kg) in liver samples

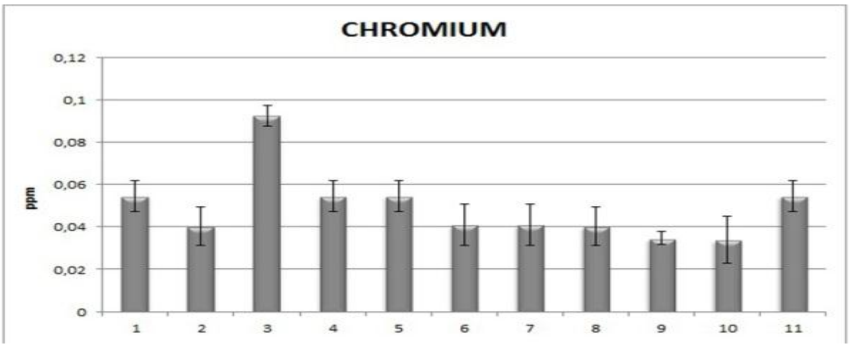

Figure 5. The content of chromium (mean ± S.D. in mg/kg) in liver samples

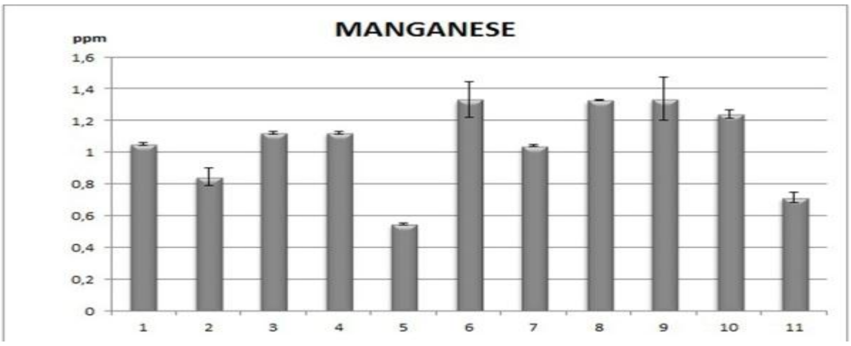

Figure 6. The content of manganese (mean ± S.D. in mg/kg) in liver samples

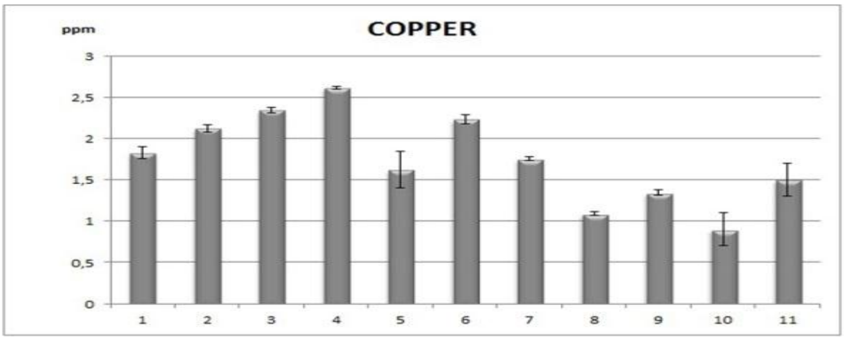

Figure 7. The content of copper (mean ± S.D. in mg/kg) in liver samples

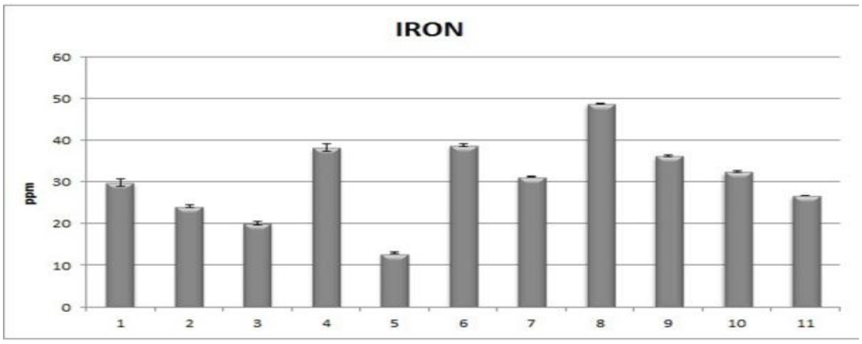

Figure 8. The content of iron (mean ± S.D. in mg/kg) in liver samples

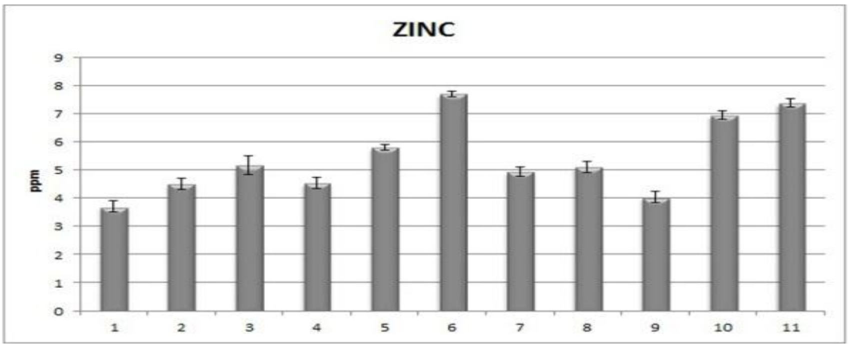

Figure 9. The content of zinc (mean ± S.D. in mg/kg) in liver samples

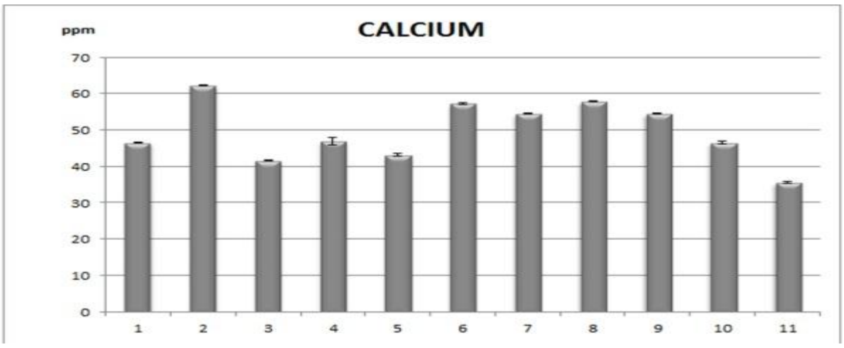

Figure 10. The content of calcium (mean ± S.D. in mg/kg) in liver samples

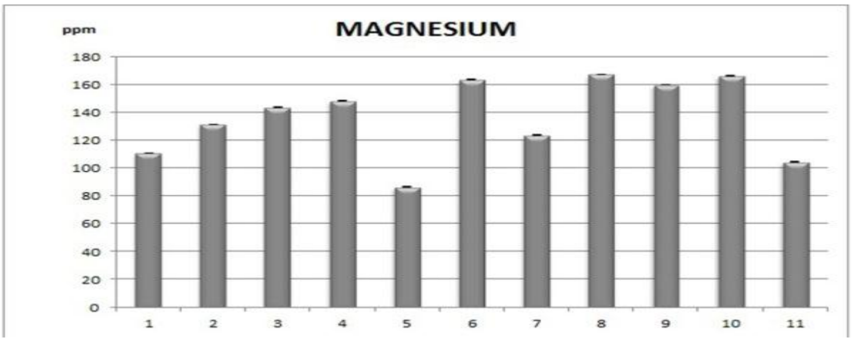

Figure 11. The content of magnesium (mean ± S.D. in mg/kg) in liver samples

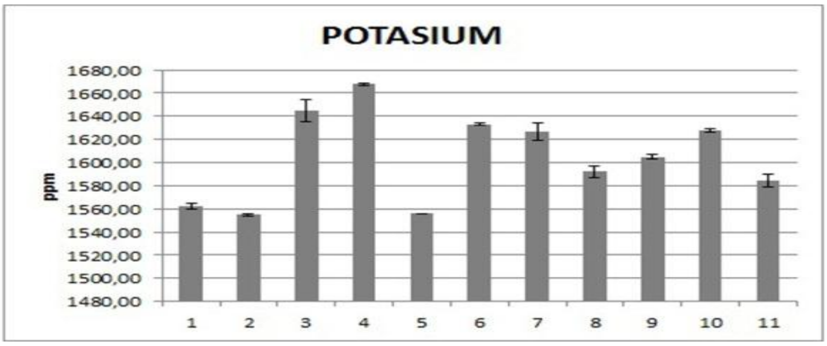

Figure 12. The content of potassium (mean ± S.D. in mg/kg) in liver samples

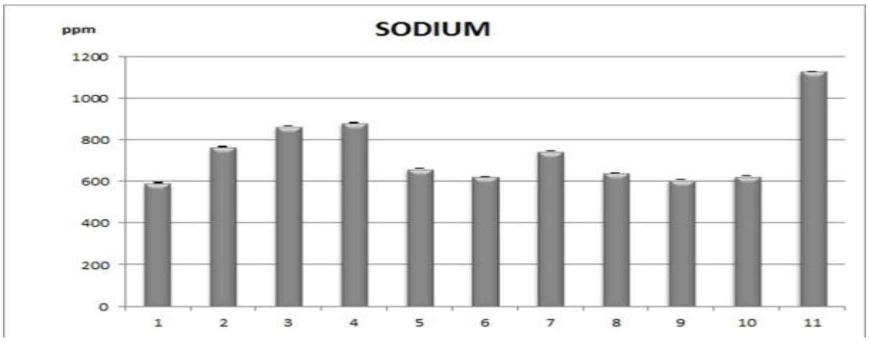

Figure 13. The content of sodium (mean ± S.D. in mg/kg) in liver samples

For all samples, the values of organochlorine and organophosphorus pesticides were under the limit of detection of the Gas Chromatography-Mass Spectrometer.

All poultry liver samples were under the maximum tolerance levels for heavy metals in liver, including poultry liver, which were established only for cadmium (Cd) and lead (Pb), respectively 0.5 ppm (mg/kg) for both (European Union Regulation (EC) No 1881/2006).

In this research, the concentrations of heavy metals and pesticides 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 (Baykov et al., 1996; Okoye et al., 2011).

Other sources of contamination can be dirty slaughter places and packaging.

CONCLUSIONS

Although it is known that people can ingest heavy metals and pesticides 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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