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Study on Some Heavy Metals of Poultry Meat and Its Products in New Valley Governorate, Egypt

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Abstract

The food chain creates potential health hazards with regards to the transmission of toxic elements to animal tissues, and subsequently to humans. Poultry meat and egg products contain a wide range of trace elements; some of these are of important nutritional value, such as iron (Fe), copper (Cu), zinc (Zn), and manganese (Mn), while others have toxic effects, such as lead (Pb), cadmium (Cd), arsenic (As) and mercury (Hg) of poultry meat and its products. Therefore, this study was conducted in the laboratories of the Food Sci. and Techno. Depart. Fac. Agric. of New Valley University Egypt. The objective of this study is to study the trace element types in poultry meat (breast & thigh) and egg, to ensure the safety of this products offered in the market from any Pollutants. The results indicated that there were significant differences in heavy elements of poultry meat and egg such as Fe, Cu, Zn, Mn, Pb, Cd, As and Hg. The studied heavy elements of poultry meat and egg were under detectable levels in poultry meat and egg, suggesting that there is no threat from toxic heavy metals set by Egyptian Organization for Standardization and Quality Control. More governmental efforts are needed to control the environmental pollution and improve the environment quality of New Valley Governorate Egypt.

Keywords: Chicken meat, breast, thigh, liver, hen egg, and heavy metal.

Introduction

The poultry industry is representing the largest sector of animal food production and is rapidly increasing as an industry in Egypt. Contamination of heavy metals in food and water is a major concern due to food safety issues. Heavy metals can easily enter the food chain. Heavy metals (Pb, Cd, As, and Hg) are potentially toxic sources. Other mineral elements which are nutritionally important and this category include iron, copper, manganese, and zinc (**Islam, et al.2007**). Accumulations of heavy metals such as arsenic, cadmium, lead, and mercury that occur through poultry products such as hen meat and egg eventually make their course into the body tissue (Islam **et al., 2016; Rahman, et al.2020 and Alam, et al. 2021**).

Recently, there had been an increase in heavy metals of animal food, especially poultry meats (due to geochemical structures and agricultural activities is a serious problem for environmental and human health (**Iwegbue, et al.2008; Hussaian, et al.2012 and Faten, et al. 2014**). Animal Foods contain a wide range of trace elements; some of these are of important nutritional value, such as iron (Fe), copper (Cu), zinc (Zn), and manganese (Mn), while others have toxic effects, such as iron (Fe), copper (Cu), zinc (Zn), and manganese (Mn), while others have toxic effects, such as lead (Pb), cadmium (Cd), arsenic and mercury. The toxicity of heavy metals negatively affects human health and depends on the type of metals, metal intake, age, and health status of humans (**Anklam & Battaglia, 2001; Dauwe et al., 2004 and Li et al., 2005**).

Therefore, estimation of the heavy metals content in the poultry products is necessary because these may have negative effects at several health levels (**Iwegbue, et al.2008; Hussaian, et al.2012**) **(Korish & Attia 2020).** Because of pollution related to environmental problems of soil, food, and water in New Valley Governorate, Egypt. This work aims to quantify the essential trace metals, i.e. Fe, Cu, Zn, and Mn and heavy metal concentrations (Pb, Cd, As, and Hg) of poultry meat samples (breast and thigh) and its products (liver and hens eggs) which directly affect human health.

Materials and Methods

Sampling

Ten broilers (from each farm) were collected from four broiler farms in each of El.Gharga and El.Daghla Oases, New Valley Governorate, Egypt, to represent the broiler farms. Broilers having similar age and weight (45 days age and about 2.0 ± 0.1 kg weights). The carcasses were divided to breast, thigh and liver. Then, breast and thigh deboned and skinned. Breast, thigh and liver were cut into small pieces and minced using a meat mincer (Moulinex-HV8, Paris, France). Additionally, 20 fresh hen eggs from four layer farms (20 eggs from each farm) were collected. The eggs were cracked open, and the edible parts (albumen and yolk) were mixed and homogenized using a Moulinex-HV8 (France). All the samples were transported in an icebox to the laboratory and stored in -20 ^{o} C freezer before analysis.

Sample preparation and analysis:

2 gram of the studied samples was digested by nitric acid (HNO3)and add sulphuric acid (H_2SO_4). The digestion process was continued until the solution become clear. The essential trace elements (Fe, Cu, Zn, and Mn) and heavy metals (Pb, Cd, As, and Hg) were determined by an atomic absorption spectrometer (Rayleigh WFX 210) using standard method as in **Horwitz(1975)** and **Gilliland (2016).**

Statistical Analysis

Measurements were performed in triplicate for each sample and mean values and standard errors were reported. Statistical analyses were carried out using Costat software (version 6.400). One-way analysis of variance (ANOVA) was used to establish the significance of differences among the samples. Calculations were performed considering statistical significance at 5 % according to **Montgomery, (2017).**

Results and Discussion

Essential trace metals in poultry meat and its products

It could be noticed from data in Figs. 1-4, clarified that there were significant differences in essential trace elements, i.e., Fe, Cu, Zn, and Mn among the studied poultry products (poultry meat, i.e., breast and thigh, as well as its products such as liver and table hen eggs). The present study revealed that the liver significantly contains the highest concentrations of Fe, Cu, Zn, and Mn (56.86, 19.40, 68.44, and 0.43 ppm), respectively. However, breast meat contained the lowest concentrations of Fe and Cu (41.36 and 0.05 ppm). On the other hand, the lowest concentrations (33.12 and 0.31 ppm) of Zn and Mn were found in thigh meat and hen eggs, respectively. This observation could be attributed to that the liver is the main metabolic organ (Mariam et al., 2004). In this respect, they found a high level of Zn in the liver of poultry (54.53 ppm) than in muscle (28.52 ppm). The concentrations of Mn in chicken breast, thigh, liver, and table hen egg are below the WHO reference standard of 0.5 ppm. Hen eggs are one of economical foods and nutritious in the daily diet. The obtained findings are in the same trend as those reported by Mohammed et. al., (2013); Elsharawy & Elsharawy, (2015), Khan, et al. (2016) and Rahman et al. (2020) who demonstrated liver chicken contains the highest concentration of Fe (54.0 ±7.02,) followed by thigh (43.3 ± 4.72,) while breast contains the lowest (41.39±5.10 ppm). Also, they indicated that the concentration of Mn in the liver was the highest compared with the thigh and breast. Zinc (Zn) being an essential element is involved in protein synthesis and is also a part of many metallic-enzymes and the requirement of Zn is generally 35 to 45 ppm. However, Zn becomes toxic when given in excess quantity. Such data conflicted with those of Akan et al. (2010) who found a concentration of Zn to be (3.11 ppm) in the liver and (1.1 ppm) in the muscle of chicken. This difference might be due to the differences in the studied type, age, and weight of chickens and the environment and interaction among them.

The Egyptian Organization for Standardization and Quality Control (ES, 2010) and FAO/WHO 2011) set a permissible limit for iron, copper, zinc, and manganese residues in poultry products which must not exceed 1mg/kg for meat & liver and 10 mg/kg for table eggs for copper metal, 20mg/kg for meat & liver, and not available for table eggs for zinc, 0.50 mg/kg for meat & liver, and not available for table eggs for manganese and not available levels for iron. According to these limits, all examined samples (100%) were within the permissible limits and considered safe for human consumption, except zinc metal. The obtained results were higher than the permissible limit.

Heavy metals in poultry meat and its products

The results listed in Figs. 5-8, revealed that there were significant differences in heavy metals, i.e., lead (Pb), cadmium (Cd), and mercury (Hg) among the studied poultry meat (breast and thigh) and its products (liver and table hen eggs), except arsenic (As) was un-significant. The results revealed that the concentrations of as metal in the liver, thigh, breast, and table hen eggs did not differ significantly. The results indicated that chicken liver significantly contains the highest concentrations of Pb, Cd, and Hg (0.28, 0.08, and 0.03 ppm), respectively. However, the table hen egg had the lowest concentrations of Pb, Cd, As, and Hg (0.09, 0.03, 0.02, and 0.07 ppm), respectively. This result could be attributed to that the use of contaminated water by heavy metals for drinking purposes (**Mariam et al., 2004**). This subsequently led to the rapid intake of heavy metals from the underground water by poultry. This contaminated water has been used for drinking as well as for irrigation resulting in the entry of heavy metals to the food chain. These results are in agreement with those reported by **Mohammed et. al., (2013);Elsharawy & Elsharawy, (2015); Khan, et al.(2016), and Korish & Attia (2020)** who scored that liver contains the significantly highest concentration of lead (Pb) compared with thigh and breast meat. They showed that the liver accumulates lead more than other tissues. Excess Pb can lead to reduced cognitive development and intellectual performance in children and high blood pressure and cardiovascular disease incidence in adults (Commission of the European Communities, 2001). There was no significant difference was recorded in thigh and breast meat with regard to Cd metal and is within the range of 0.5 ppm permissible limit set by (**FAO/WHO, 2011)**. Mercury is a widespread and persistent pollutant in the environment and is among the most highly concentrated trace metals in the human food chain. Mercury is a constant component of municipal sewage, which may be used as a soil conditioner and agricultural fertilizer, which creates a serious danger of introducing this heavy metal into food products and feeds for farm animals. The main source of heavy metals in chicken meat arises from the contamination of poultry feed and drinking water. Other sources of contamination can be vehicle emissions and dirty slaughter places (**Clarkson, 2002; Zarski et. al., 2003; Tuzen et. al., 2009 and Ghimpeteanu et. al., 2012**). They indicated that contamination with heavy metals of poultry meat and its products is a serious threat because of their toxicity, bioaccumulation and bio-magnification in the food chain

The Egyptian Organization for Standardization and Quality Control (**ES, 2010** and **FAO/WHO, 2011)** is set a permissible limit for iron, copper, zinc, and manganese residues in poultry products which must not exceed 0.1mg/kg for meat & liver and 0.50 mg/kg for table eggs for lead metal, 0.05 mg/kg for meat & liver, and table hen eggs for cadmium, 0.10 mg/kg for meat & table eggs, and not available for liver for arsenic metal and 0.02 mg/kg for meat & table eggs, and liver for mercury metal. According to these limits, all examined samples (100%) were within the permissible limits and considered safe for human consumption, except lead metal. The obtained results were higher than the permissible limit. Moreover, the liver contained a higher amount of Hg. There is limited information on the Hg content in chicken meat and hen egg.

Conclusion

The consumption of the liver can meet the recommended daily allowance (RDA) for all trace elements while contributing a higher intake of Pb and Cd. From a safety point of view, eggs and chicken meat meet the RDA for trace elements and do not present a threat of toxicity from any heavy metals. Legislation is required for control of poultry products' meat quality. Both the public and private sectors must cooperate in tackling the problem.

Conflicts of Interest/ Competing Interest

All authors declare that they have no conflicts of interest.

Data Availability Statement:

All data sets collected and analyzed during the current study are available from the corresponding author on reasonable request.

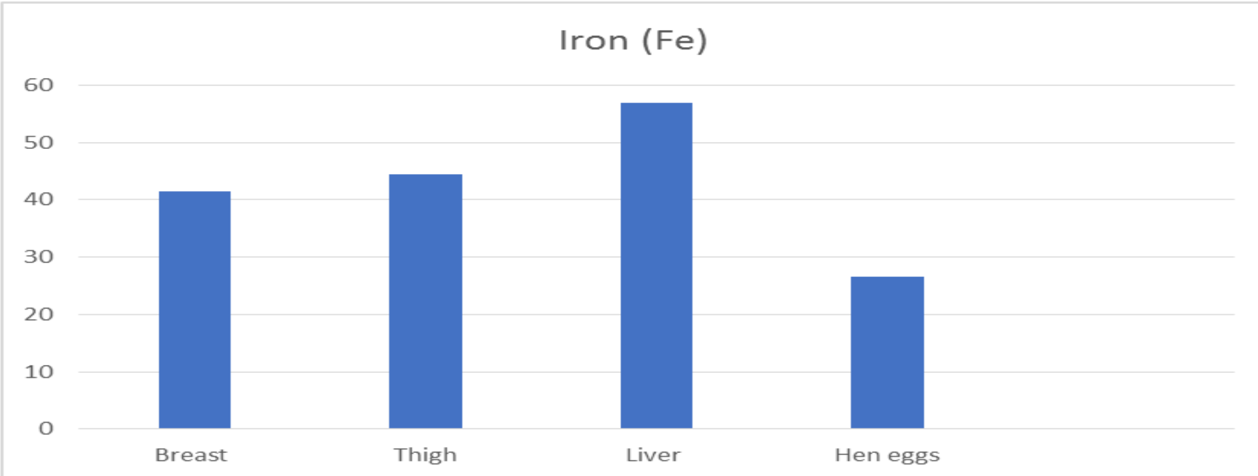

Fig. 1: Iron content (ppm) of poultry meat (breast and thigh), liver and hen eggs.

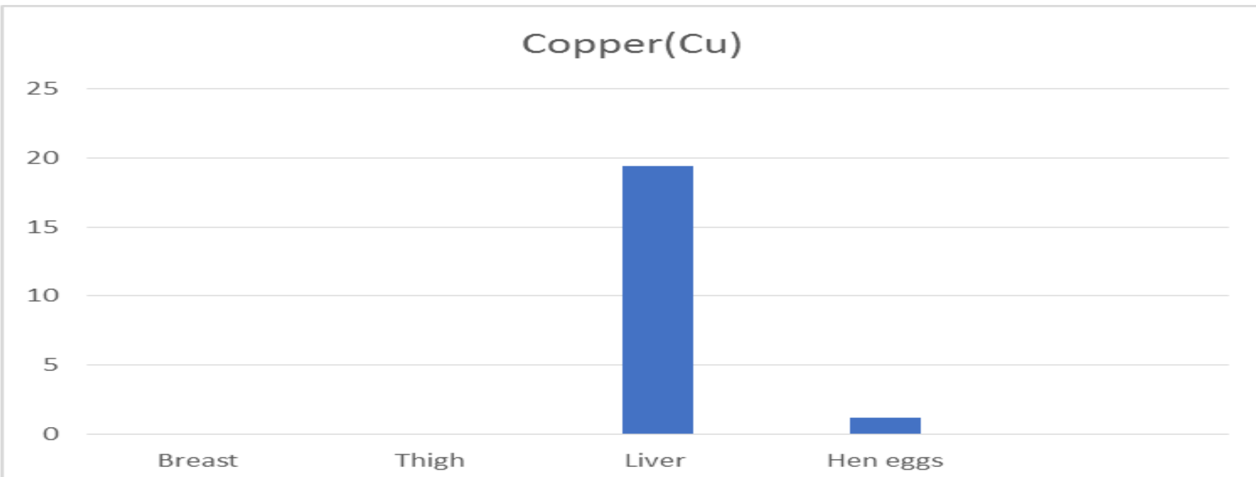

Fig. 2: Copper content (ppm) of poultry meat (breast and thigh), liver and hen eggs.

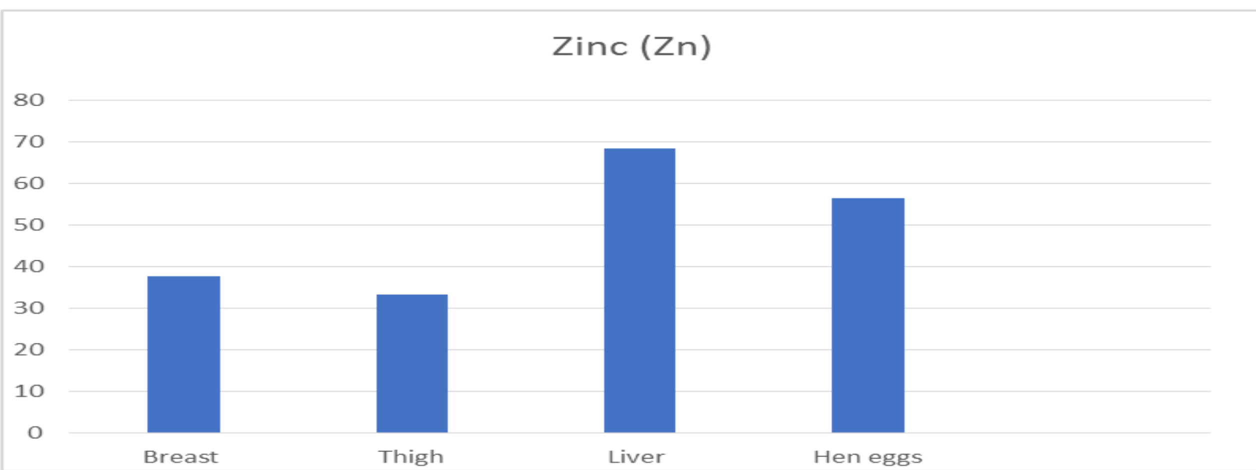

Fig. 3: Zinc content (ppm) of poultry meat (breast and thigh), liver and hen eggs.

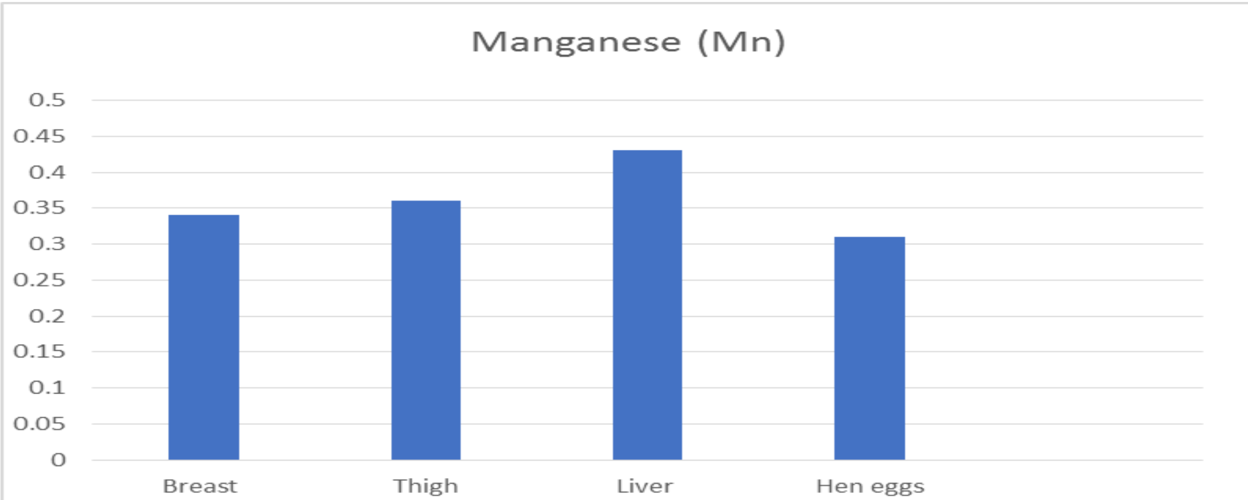

Fig. 4: Manganese content (ppm) of poultry meat (breast and thigh), liver and hen eggs.

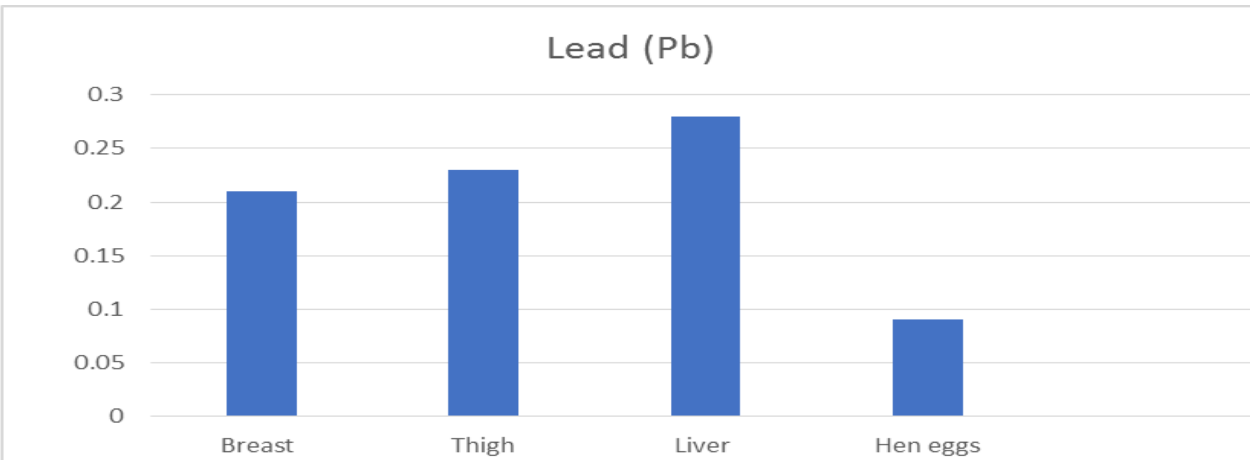

Fig. 5: Lead content (ppm) of poultry meat (breast and thigh), liver and hen eggs.

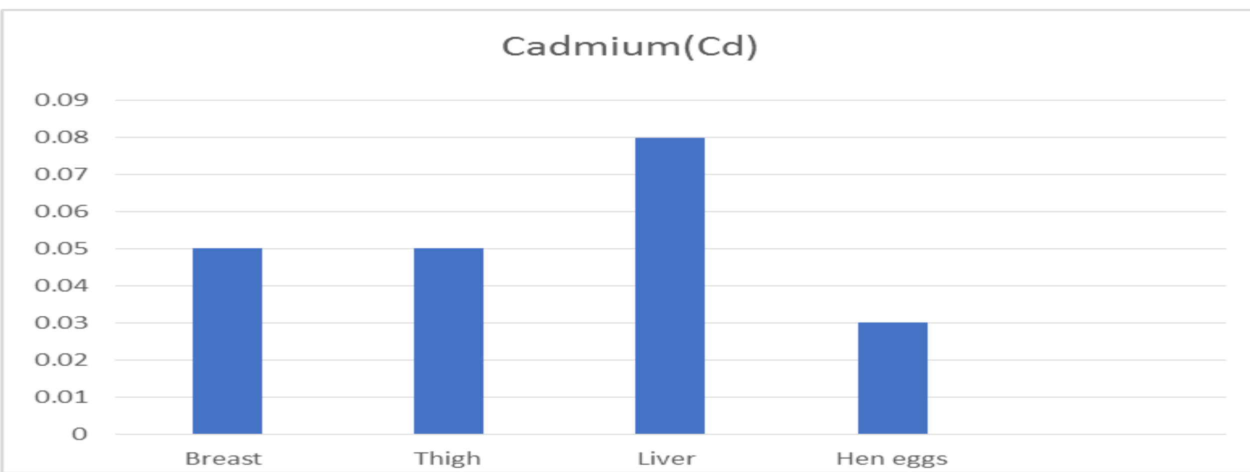

Fig. 6: Cadmium content (ppm) of poultry meat (breast and thigh), liver and hen eggs.

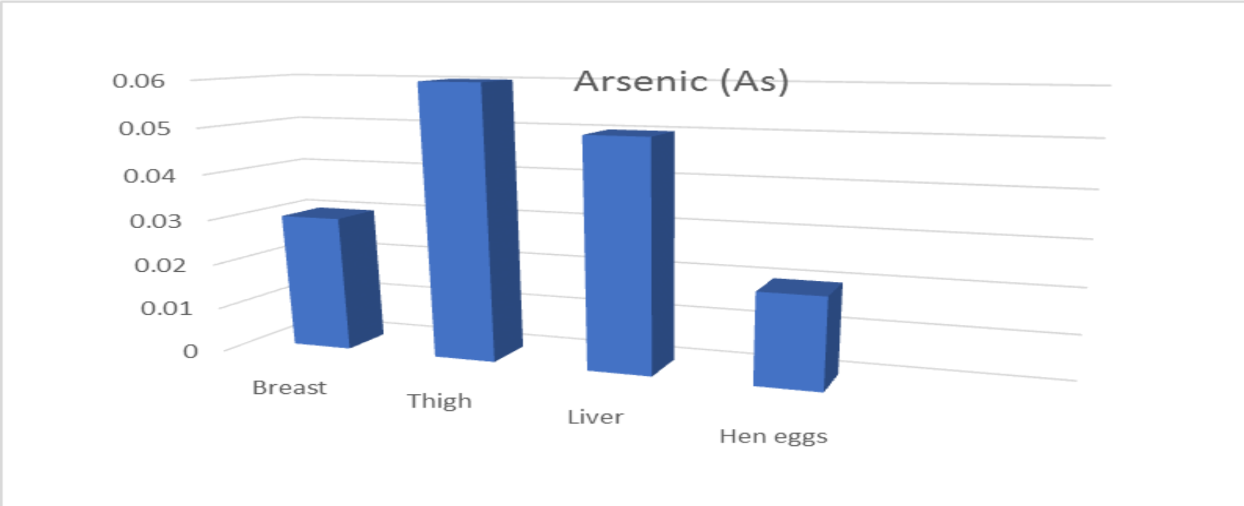

Fig. 7: Arsenic content (ppm) of poultry meat (breast and thigh), liver and hen eggs.

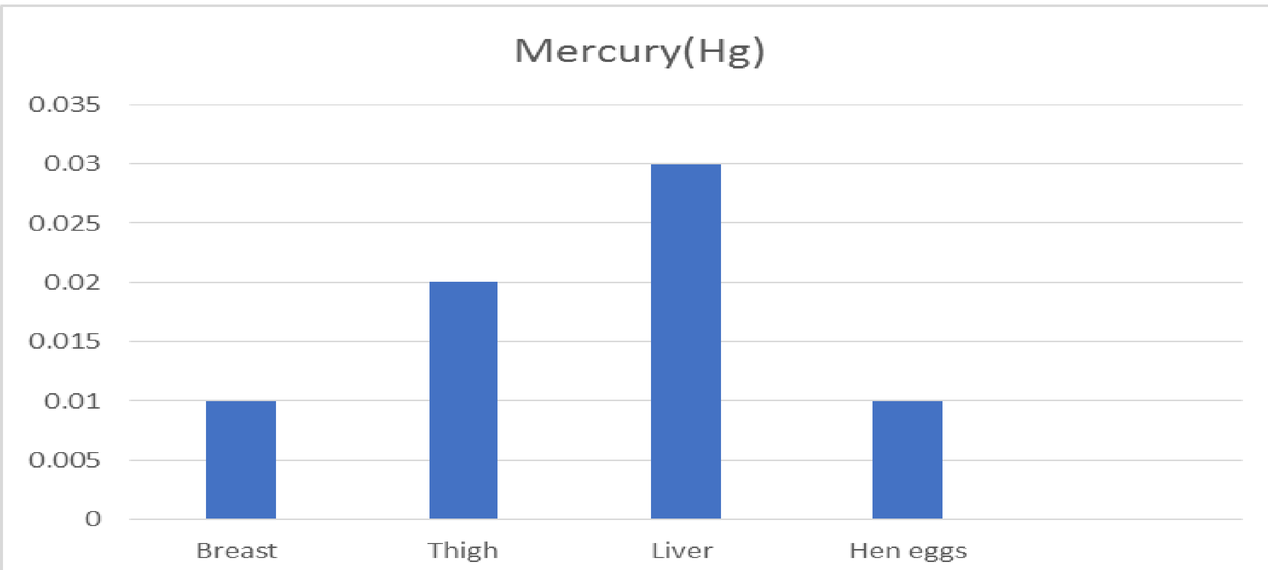

Fig. 8: Mercury content (ppm) of poultry meat (breast and thigh), liver and hen eggs

List of Abbreviations

AOAC	Association of Official Analytical Chemists
FAO	Food and Agriculture Organization
WHO	World Health Organization
ES	Egyptian Standards

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