EAS Journal of Nutrition and Food Sciences
Abbreviated Key Title:EAS J Nutr Food Sci
ISSN: 2663-1873 (Print) & ISSN: 2663-7308 (Online)
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-2 | Issue-3 | May-June; 2020 | DOI:10.36349/easjnfs.2020.v02i03.019

Research Article

Detection of Lead and Cadmium Residues in Various Tissues of Broiler in Omdurman Locality- Khartoum State- Sudan

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Article History
Received: 06.06.2020
Accepted: 11.06.2020
Published: 25.06.2020

Journal homepage:
https://www.easpublisher.com/easjnfs

Quick Response Code

Abstract: The objective of this study was to evaluate the possible bioaccumulation of certain heavy metals – namely Lead (Pb) and Cadmium (Cd) -in the internal parts of chickens. A total of 80 chicken muscles, kidney, liver and gizzard samples (20 of each) were randomly collected from different chicken farms, in Omdurman locality- Sudan. Water samples were also obtained from the water reservoir in each farm. Then wet digestion of samples was done followed by the use of Atomic Absorption Spectrometer (AAS) to measure the level of Pb and Cd. The two heavy metals were found to be present in all studied parts of the chickens. The concentration of Cd varies significantly within the poultry tissue but fall within the permissible limits for meat consumption set by the FAO and Sudanese Standards and Metrology Organization (SSMO). The mean values of Cd were 0.013 ±0.001µg/g, 0.033±0.002µg/g, 0.028 ± 00.005µg/g and 0.037±0.003µg/g, in muscles, kidneys liver and gizzard respectively. The concentration of Cd in water was 0.0031±0.003µg/l which was within the permissible limits. The level of Pb varied significantly within the poultry tissue but was above the permissible limits. The mean values of Pb in gizzard was the highest followed by kidney then liver and the least concentration was detected in muscles 0.224±0.013µg/g, 0.295±0.007µg/g,0.266±0.014µg/g and 0.350±0.026µg/g respectively, while the concentration in water was 0.150±0.006µg/ and was also higher than the permissible limits. Precocious steps must be taken to monitor and reduce the concentrations of lead in water and feed used by poultry farmers. Also governmental efforts are needed to control the environmental pollution which may be an additional source for contamination.

Keywords: Chickens, tissues , water, Cadmium , Lead , Sudan

INTRODUCTION

The world-wide commercial poultry industry is well-developed and is the largest supplier of animal protein and good source of essential amino acids, vitamins and minerals for human consumption in the form of meat and eggs (Järup, 2003). Its significance is even greater in developing countries where chicken are relatively cheap and can be kept in a small area, usually providing an excellent source of high quality and most palatable animal protein due to its high meat yield, low shrinkage during cooking and low cost (Islam *et al.*, 2007).

The chicken meat has a good advantage in comparison with beef meat, but sometime poultry may carry heavy metals and other elements which may be naturally present in air, water, soil and poultry feed or can reach it as a result of human activities such as industrial and agricultural processes (Faten *et al.*, 2014). Some of the metals of particular concern in relation to harmful effects on health are mercury, lead, cadmium, tin and arsenic, which are often referred to as "heavy metals". The toxicity of these metals is in part due to the fact that they accumulate in biological tissues, a process known as bioaccumulation (Pikkemaat, 2009). This process of bioaccumulation of metals occurs in all living organisms as a result of exposure to metals in food and the environment, including feed animals such as poultry, fish as well as humans (Johnson, 2004).These metal may have a toxic effect on the central and peripheral nervous systems, gastrointestinal and genital systems, damage of tubular cells in gizzards, hepatic toxicity, immune system and carcinogenesis (Baykov *et al.*1996). Demirezen and Uruc 2006 indicated that contamination with heavy metals is a severe health hazard since they are toxic, bio-accumulates and biomagnify in the food chain. Contamination of food with heavy metals is a serious problem which is recognized in most countries of the world.

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This study was conducted to assess the accumulation of heavy metals in broiler in order to draw the attention of people fort the safety of food products from all these hazardous agents.

MATERIAL AND METHODS

Study Area:

A cross-sectional study was conducted in poultry farms at Omdurman locality -Khartoum state. The chemical analyses were carried out in the Center Researches Laboratory Institute – Soba, Sudan.

Questionnaire

A questionnaire was designed to obtain data regarding sources of water , type of containers for storing water, location of the farm ,type of equipments used in processing and frequency of analysis of water.

Sampling:

A total of 80 random samples of chicken organs: kidney, muscles, liver and gizzard (20 of each) were collected from the slaughterhouse. Each samples was rapped in plastic bag then identified and transferred in an ice-box to the laboratory for evaluation of Pb and Cd. Also water samples were obtained from the reservoir in each farm, stored in sterile containers and transferred to the laboratory.

Sample preparation:

The procedure for sample preparation in this study was adopted from Belton (2006). The collected tissue and organs were cleaned and washed with demineralized water. The wet digestion procedure was used in which 5.0 g of each sample was introduced into the digestion flask, 10 ml of concentrated sulphuric acid was added to the sample and the content of digestion flask was heated to 70°C for 3 hrs with occasional swirling at 3 minutes interval. After complete digestion, the digest was allowed to cool and then transferred into a 20 ml standard flask with de-ionized water. The solution were transferred into acid-leached polyethylene bottles and kept at room temperature until analysis with atomic absorption spectroscopy (AAS) using Varian atomic absorption spectrophometer model1275 AA equipped with lamps for different elements. Standard working solutions and standard curves were prepared. The standard curve for each metal was plotted and the amounts of metal present in the study samples were calculated from the standard curve.

Statistical Analysis

All data collected from chemical analysis were subjected to analysis of variance using General Linear Model (GLM) with factorial arrangement done by Statistical Package for Social Science (SPSS) software program version 21 IBM. The results were shown as mean with their standard deviation, for mean comparison Duncan Multiple Range Test was used and considered significant at ($P<0.05$).For the questionnaire frequency of distribution was used.

RESULTS AND DISCUSSION

The study was conducted in four poultry farms in Omdurman area. All the farm were applying the close system rearing, 25% of the farms were near the industrial area of Omdurman locality. All the farms visited receive water supply from wells within the farm. The water reservoir in 50% of the farms was plastic container, and 75% of farmers don't filter the water during processing. (Table 1).

Table 1: Results of the questionnaire

Items	Percentage (%)
A) Type of farm design	
Closed	100
B)Location of the farm near industrial facilitates	
1-Yes	25
2- No	75
C) Source of water in the farm	
Well	100%
D) Type of water reservoir	
1-Aluminum	25
2-Plastic	50
3- Steel	25
E) How frequently is chemical analysis of farm water done	
1- Every six month	50
2- Per year	50
G) Are there documentation system for the water analysis	
1- Yes	50
2- No	50
H) Nature slaughter tools (machine, knife and scarfskin etc)	
Steel	100
J) Is the water source for washing operation filtered	
1-Yes	25
2-No	75

Pb and Cd are toxic metals occurring in the environment naturally and from anthropogenic activities and can lead to chemical contamination of products entering in the human food chain (Ciobanu *et al.*, 2012).

Considering the four farms there was a significant differences in the concentration of the Pb and Cd between farm one and farm two, between farm one and farm four but the differences were not significant between farm one and farm three. This may be due to the location of farm one and three which are more closer to the industrial areas compared to farm two and farm four (Table 2, Appendix 1)

Table (2) Mean concentration of Pb and Cd in different farms

Farms	**Metals**	
	Pb(µg/g)	Cd(µg/g)
Farm(1)	0.272 ± 0.045^{b}	0.025 ± 0.009^{c}
Farm(2)	0.293 ± 0.051^{a}	0.031 ± 0.010^{a}
Farm(3)	0.273 ± 0.043^{b}	0.026 ± 0.009^{c}
Farm(4)	0.297 ± 0.054^{a}	0.029 ± 0.009^{b}

* Concentrations are expressed as Mean±SD

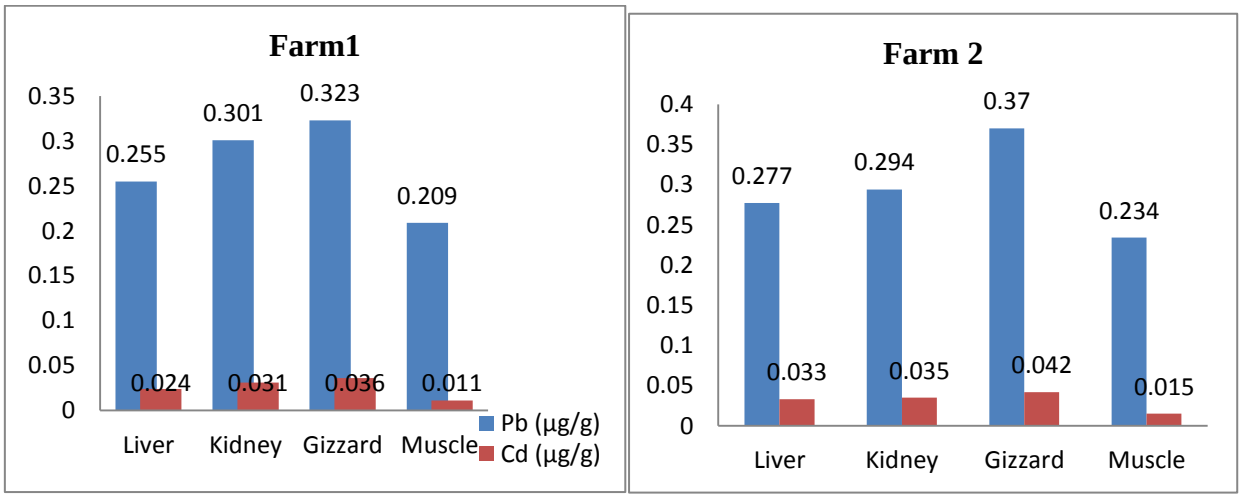
** An alphabet on mean in column refers to significantly different at (P<0.05).

The mean level for Lead and Cadmium residues in muscles, kidneys, livers and gizzards samples are presented in table (3) and Fig.1 for the different farms. For Cd there was no variation between the concentration of the metal in the sample and the standard level as set by FAO which is 0.05 µg/g. Pb sample analysis revealed variation from the standard level in all organs with considerable increase in the gizzard samples .This may be due to contamination of poultry feed ,as a result of human activities such as industrial and agricultural processes (Järup, 2003; Islam *et al*., 2007 and Faten *et al.*, 2014). More over there is no water pollution regarding Cd (Table 4) that can affect the level of the heavy metals under study.

Table (3): Concentration of metals in different organs

Organs	**Metals**	
	Cd (µg/g)	**Pb (µg/g)**
Livers	0.028 ± 0.005^{c}	0.266 ± 0.014^{c}
Kidney	0.033 ± 0.002^{b}	$0.295\pm a0.007^{b}$
Gizzard	0.037 ± 0.003^{a}	0.350 ± 0.026^{a}
Muscles	0.013 ± 0.001^{d}	0.224 ± 0.013^{d}

An alphabet on mean in column refers to significantly different at (P<0.05).



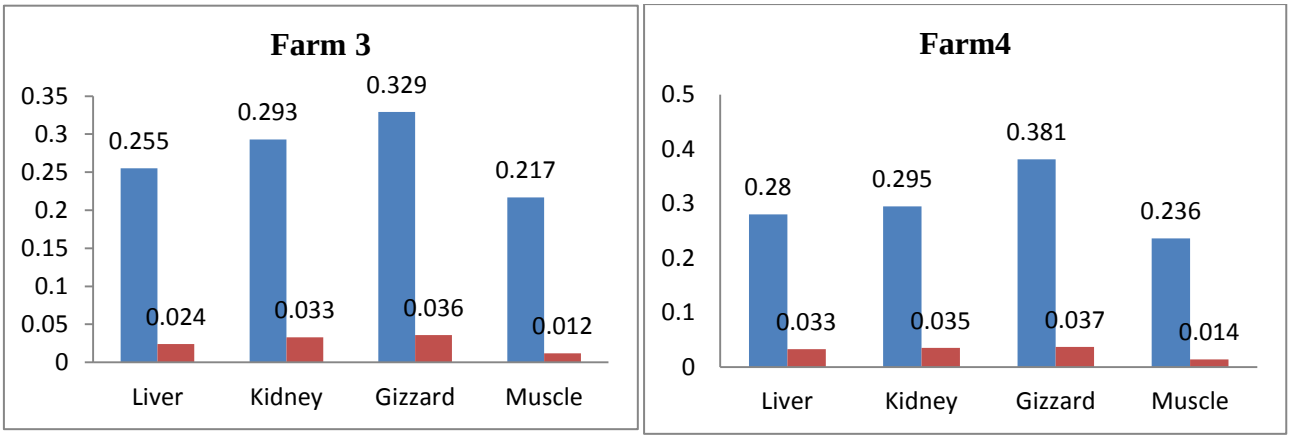


Fig 1: Mean level of Pb, Cd in all organs in different Farms

Cadmium

The mean concentrations level for cadmium residues in poultry muscles, kidneys, livers and gizzards samples, were 0.013±0.001µg/g, 0.033±0.002µg/g, 0.028±0.005µg/g and 0.037±0.003µg/g, respectively (Table 3). The cadmium concentration levels were higher in Gizzard followed by Kidney then Liver and the least concentration was detected in Muscles. It was clear that the concentration of Cadmium in different poultry organs varies significantly with *(P≤0.05)* table (3).The higher level of Cd in gizzard may be due to the fact that the Cd accumulates in the gizzard and that increases with increasing of age *(*Nasef and Hamouda, 2008*;*Atiah, 2011 and Khalafalla *et. al.,* 2011).Other investigators were in line with results of this study (Iwegbue*et. al.,* 2008; Reem *et. al.,* 2012; Hamasalim and Mohammed, 2013 , Faten *et al.,* 2014*)*.

Furthermore, all the examined samples (100%) for Cd in poultry meat and offal were within the permissible limits determined by EOS (2010) , which reported that the permissible limit for cadmium residues must not exceed 0.05 µg/g for meat and 1.0 µg/g for poultry offal. Cadmium causes severe respiratory symptoms, gizzard dysfunction such as; nephrotoxicity, glucosuria, aminoaciduria and decrease the glomerular filtration rate, cadmium may lead to hypertension, hepatic injury and lung damage(Akesson *et. al.,* 2009). Cadmium chloride at teratogenic dose induces significant alterations in the detoxification enzymes in the liver and the gizzard and may cause osteoporosis and osteomalacia and Itai-Itai disease (Akesson*et. al.,* 2009; Akan *et. al.,* 2010 and Faten *et. al.,* 2014).

Lead

The mean concentrations level for Lead residues in poultry muscles, kidneys, livers and gizzards samples were 0.224±0.013µg/g, 0.295±0.007µg/g, 0.266±0.014µg/g and 0.350±0.026µg/g, respectively (Table 3). The Lead concentration was found higher in gizzard followed by kidney, livers and muscles, respectively. It was clear that the poultry organ show a significant variation *(P<0.05)* between the Lead levels in the examined samples. Similar results were reported by (Mariam *et al*., 2004; Iwegbue *et. al.,* 2008; Oforka *et. al.,* 2012 and Okeke *et al.,* 2015) who found the concentration of Pb in the same tissues to be 0.226±0.014µg/g, 0.296±0.006µg/g, 0.267±0.013µg/g and 0.351±0.028µg/g, respectively. Furthermore, all examined muscle samples for Lead were above the permissible limits set by (FAO,2012)which reported that the permissible limit for Lead residues must not exceed 0.05 µg/g .

Water analysis:

Poultry can be very sensitive to the chemistry of water with some chemical elements causing diuretic or laxative effect and others upsetting the digestive tract or be unpalatable to the birds causing bitter and unpleasant taste which can slow crop growth.

Table (4) shows the concentration of Pb and Cd in water from the different farms. According to FAO (2012)the standard permissible limit in water is 0.1ppm . There were no significant differences between the standard permissible limit of Cd and the concentration in water in the respondent farms.

Table 4: Water analysis in the study area

Metals	**Farms**				**Mean± SD**
	Farm(1)	Farm(2)	Farm(3)	Farm(4)	
Pb	0.144	0.150	0.149	0.160	**0.150±0.006**
Cd	0.009	0.0010	0.0012	0.0013	**0.0031±0.003**

CONCLUSION AND RECOMMENDATIONS

This study concluded that the concentration of Pb and Cd was found to be high in gizzard and kidney but low in muscles and liver. The levels of Cd in tissues and offal were found to be within the permissible levels but for Pb it was higher

Efforts should be made in minimizing environmental pollution from fossil fuels combustion and the use of alternative renewable energy such as biodiesel and bioethanol production and utilization should be promoted. Application of hazard analysis and critical control point (HACCP) system may be the appropriate solution to ensure quality and safety of such products.

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Appendix 1: Statistical differences between the four farms regarding level of Pb and Cd

(I) Farm	(J) farm	Mean Difference (I-J)	Cd	Pb
farm1	farm2	-.0058-*	.000	.000
	farm3	-.0008-	.234	.589
	farm4	-.0044-*	.000	.000
farm2	farm 1	.0058*	.000	.000
	farm 3	.0050*	.000	.000
	farm 4	.0014*	.039	.116
farm3	farm1	-.0050-*	.000	.589
	farm2	-.0036-*	.000	.000
	farm4	.0044*	.000	.000