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Assessment of heavy metal concentration in poultry meat collected from chromate mining area of Balochistan, Pakistan

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Abstract

Chicken meat and its products are the excellent and cheaper source of protein and nutrition in the third world population but contamination of the foodstuffs by toxic metals is a clear warning and their long-term exposure has negative effects on the human health. Therefore, to assess the contamination of heavy metals a comparative study has designed to monitor the heavy metals i.e Cd, Cr, Cu, Fe, and Zn in broiler and domestic reared chicken samples (liver, kidney, and heart). The present study is focused on determination of trace metals concentration in domestic reared and broiler chicken collected from chromate mining area of Balochistan, Pakistan. The heavy metals in chicken samples were analyzed using atomic absorption spectroscopy. The result of the study shows elevated level for heavy metals in broiler chicken as compared to domestic reared chicken specially in liver, which was Pb,1.09±0.78mg/L, Cd,1.47±0.82mg/L, Cr,1.55±0.81mg/L, Fe,3.31±2.0478mg/L, Zn,0.81±0.67mg/L and Cu,0.51±0.02mg/L followed by broiler kidney which was Pb,2.85±2.76mg/L, Cd,1.25±1.51mg/L, Cr,1.81±0.50mg/L, Fe,3.17±1.65mg/L, Zn,1.17±1.38mg/LandCu,0.19±0.15mg/L and then in heart which was Pb,0.06±0.07mg/L,Cd,0.57±0.49mg/L,Cr,0.32±0.24mg/L,Fe,0.69±1.00mg/L,Zn,0.87±0.85mg/L, Cu,0.27±0.35mg.The highest value of Fe, Cr, Cd, and Pb was observed in broiler chicken samples while Cu and Zn were at low level as compared to domestic reared chicken samples.

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Introduction

Contamination with heavy metals is a major environmental concern due to food safety and human health issue through the food chain. Human introduction to heavy metals has raised drastically because of an exponential increment of their utilization in advance modern, horticultural, local, and mechanical applications. A number of anthropogenic activities i.e mining, fossil fuel, metallurgy, transportation activities, rapid industrialization and urbanization, poor planning in waste management, domestic effluents, irrigated farmland, pharmaceutical and atmospheric sources are among the foremost factors.

Chicken meat and meat product are widely consumed throughout the world because of ease of availability and cheaper price. It is one of the major sources of essential nutrients like vitamins, protein, fats and minerals but, often contaminated with heavy metals. Poultry could take up heavy metal and compounds from different sources and residues may concentrate in their meat. The requirement for these mineral depends on the age, physiological state and feed intake as well as on breeding condition in the farms. The poultry meats and meat products are often contaminated with heavy metals. Although the toxic content is generally low, offal products like liver often accumulates high level of metals than other foods. The physical appearance, chemical composition, and quality of meat depend upon on both the type and feeding pattern (Schonfeldt and Gibson, 2008; Nisianakis *et al*., 2009).

Both environment and human heath has positive and negative effects of trace elements. Environmental pollution with heavy metals is the most serious health issue confronting human and animal life. Heavy metals are probably part of all living organisms, plays important and vital role in structural, of control mechanisms, enzyme activator and in redox systems. They make their way into living organisms, accumulate into tissue, and persist for long time as a result from dietary and non-dietary exposure (Jaishankar *et al*., 2014**).**

Arsenic, cadmium, chromium, lead, and mercury are among the main toxic metals that enter into human system through food chain and have antagonistic consequences on human health. Some metals are very essential required for good humans health but all metals are toxic if present at higher concentrations. Metals like arsenic, cadmium, lead, and chromium are persistence, toxic, accumulate for long period inside bird, untimely transfer to human, and can cause acute or chronic toxicity. World Health Organization reports that the heavy metal contamination and their toxicity even at low level can give rise to serious health effect and diseases in human and animals (Lane and Morel, 2000).

A number of studies reported that the human and natural activities are also responsible in altering the natural geological distribution of heavy metals and their redistribution into the environment (Rajaganapathy *et al*., 2011; Ismail and Abolghait, 2013).

Thus, the purpose of the current study was to estimate the level of Cd, Cr, Cu, Pb, Fe and Zn in kidney, liver and heart of broiler and domestic reared chickens which is cheaper source of protein and popular among the low income population and their possible side effects on human health.

Materials and methods

Study area

The study area is located in the northwestern (31.0140° N, 68.3339° E) region of Balochistan, Pakistan having huge deposit of chromates.

Sample collection

Heart, liver, and kidney samples of domestic reared and boiler chicken were collected from different locations throughout the mining district. The polyethylene bags duly tagged and the samples were stored in cool basket and transported to Environmental laboratory, Institute of Biochemistry, University of Balochistan, and Quetta for analysis. The samples were stored at -4°C and were analyzed as soon as possible.

Sample preparation

Atomic Absorption Spectrophotometer (Solaar S4 Thermo, USA) measured the amounts of heavy metal. All laboratory works were performed at environmental laboratory, Institute of Biochemistry, University of Balochistan, Quetta. The samples were cut into small pieces, kept them in Petri dishes to dry at 120 ^{O}C for 3 hours to remove the moisture content. The samples were grinded with the help of mortar and pestle, labeled, and stored at -4^{o}C. The sample were digested with 5ml HNO_3 added in each sample and gently heated on a hot plate in fume hood till a clear solution was observed. Finally, the samples were kept for cooling and makeup to the mark with deionized water in 25mL volumetric flask. The digested samples were filtered through Whatman No.1 filter paper, stored in falcon tube and analyzed through Atomic Absorption spectrophotometer (Elsharawy, 2015).

Calibration standards

Various dilutions from stock standard solutions (1000 ppm, Merck, Pakistan) of each element were prepared freshly every day. Three calibration standards were prepared as recommended in the cookbook of the Atomic Absorption Spectrometer (Solaar S4 Thermo Corporation).

Determination of heavy metals

The sample solutions were analyzed for cadmium, copper, nickel zinc, iron, lead and cobalt at required wavelength using (Solaar S4 Thermo Corporation, USA) Atomic absorption spectrophotometer.

Statistical analyses

For statistical data analysis, Graph Pad Prism software was used. Heavy metal levels were expressed by minimum, maximum, mean, standard deviation, and p-value. P-value considered significant when it less than 0.05. The Microsoft Excel 2007 was used to create the graphs.

Result and discussion

Concentration of Lead (Pb) in poultry meat

The concentration of lead in boiler and domestic reared chicken are present in Table (3). In the present study, the lead concentration in liver ranges form 0.155-2.43mg/L, having a mean value of 1.09±0.79mg/L while in domestic chicken liver, the lead ranges from 0.00-0.21mg/L, with a mean value of 0.21±0.312mg/L.

Table 1. Age and weight of different type of Chicken.

S.No	Types of Chicken	Weight	Age
1.	Broiler chicken	1.5-2.5kg	34-40 days
2.	Domestic reared chicken	1.5-2 kg	8-10 months

The result of the kidney samples of broiler chicken revealed that the lead ranges from 0.00-8.23mg/L having mean value of 2.85±2.76mg/L. In the kidney samples of domestic grown chicken, the lead ranges 0.00-0.77mg/L having a mean value of 0.10±0.21mg/L. In case of the heart sample of broiler chicken, the lead concentration ranges from 0.01-0.00mg/L, mean range was 0.06±0.07mg/L.

The analysis results showed 0.00-0.09mg/L of lead concentration in the heart of domestic chicken with the mean range of 0.01±0.03mg/L. Similar results are reported by Skalicka *et al.,* 2002 who also reported higher concentration in liver as compared to breast and thigh muscles while dealing with poultry birds. The results of our finding are also in agreement with Khan *et al.*, 2016 who reported higher concentration of lead in chicken meat samples.

Lead concentration of 0.2 ppm are considered as safe for human consumption, above 0.8 ppm in mature human and 0.6 ppm in young ones having have detrimental effects on human health and may cause kidney disease, convulsions and anemia. Excess lead can lead to intellectual performance and also reduce cognitive development in children.

Table 2. Instrumentation Conditions of Investigated Elements.

S.No	Element	Air/Acetylene (L/Min)	Stock solution prepared	Wavelength (nm)	Signal
1	Pb	0.9-1.2 L/Min	03	247.6nm	9.4mg/L gives about 0.4 Abs.
2	Zn	0.9-1.2L/Min	03	213.9nm	1.2mg/L gives about 0.4 Abs
3	Cu	0.8-1.1L/Min	03	324.8nm	3.7mg/L gives about 0.4 Abs
4	Fe	0.8-1.0L/Min	03	248.3nm	5.5mg/L gives about 0.4 Abs
5	Cr	4.0-4.4L/Min	03	357.9nm	4.5mg/L gives about 0.4 Abs
6	Cd	1.0-1.3L/Min	03	228.8nm	3mg/L gives about 0.4 Abs

The high blood pressure and cardiovascular disease may also link with elevated level of lead. The results of the study shows that lead concentrations in the kidney, liver and heart of boiler chicken were higher than the Permissible Limit of 0.2 ppm as directed by FAO/WHO (Official J. European Communities, 2001).

Concentration of Chromium (Cr) in poultry meat

The concentration of chromium in boiler and domestic reared chicken is summarized in Table (2).

The result of the present study shows that the chromium content in boiler chicken varies from 0.32-3.32mg/L having a mean value of 1.54±0.80, in liver sample of domestic chicken the chromium level was in between 0.00-0.53mg/L having mean value 0.09±6.1.

Table 3. Concentration of Lead in Chicken Samples.

Lead Value	Broiler Liver	Domestic Liver	Broiler Kidney	Domestic Kidney	Broiler Heart	Domestic Heart
Min	0.15	0.00	0.00	0.00	0.01	0.00
Max	2.42	0.90	8.21	0.77	0.29	0.09
Mean	1.09	0.21	2.85	0.10	0.06	0.09
Std. Dev	±0.78	±0.31	±2.76	±0.10	±0.07	±0.03

The concentration of chromium ranged from 0.04-0.79mg/L and 0.00-0.10 in the kidneys of broiler and domestic chicken respectively having a mean value of 0.32±0.24mg/L and 0.02±0.03 respectively.

The heart sample of broiler chicken, the chromium concentration was 0.00-0.09mg/L with the mean value of 1.81±0.50. The result of the study revealed that chromium concentration ranges from 0.00-0.09mg/L had mean value of 0.01±0.27. The result of the study shows that some of the liver samples (broiler) have above the 0.5 ppm permissible as directed by WHO/FAO (FAO/WHO, 2000).

Our results of the study are comparable with Akan *et al.*, 2010 who reported higher concentration in liver (0.65 ppm) than muscle (0.29 ppm). Similar results are also obtained Mahmoud and Abdel-Mohsein, 2015, who obtained highest concentration of Cr in thigh 1.26 ppm followed by breast 0.734 ppm and liver 0.415 ppm.

Concentration of Cadmium (Cd) in poultry meat

The concentration of cadmium in boiler and domestic reared chicken are present in Table (4). In the present study, the cadmium concentration in the broiler chicken liver was 0.15-2.42mg/L, having a mean value 1.09±0.78. On the other hand, domestic raised chicken showed the concentration between 0.00-0.90mg/L with the mean of 0.21±0.312.

In case of broiler chicken kidney samples, the cadmium was in range 0.00-8.21mg/L, having a mean value of 2.85±2.76. As well as the domestic

chicken was showed the concentration level between 0.00-0.77 with the mean of 0.10±0.10.

The heart chicken sample contains 0.00-0.09mg/L of cadmium having a mean value of 0.06±0.07. While in the heart of domestic raised chicken, the cadmium concentration was 0.00-0.09mg/L with the mean of 0.09±0.03.Mariam *et al.*, 2004 reported higher cadmium content in liver and muscles of local produced chicken, which are in support our finding. Our results are also in accordance with the reported value Iwegbue *et al.*, 2008, who reported a higher cadmium concentration level in the liver.

Doganoc, 1996 reported a higher level of zinc and cadmium in the liver and kidney of cock and ducks, which exceeded the permissible limit of 0.5 ppm set by WHO/FAO, are not in agreement with our finding.

Table 4. Concentrations of Chromium in Chicken Samples.

Chromium Value	Broiler Liver	Domestic Liver	Broiler Kidney	Domestic Kidney	Broiler Heart	Domestic Heart
Min	0.32	0.00	0.04	0.00	1.02	0.00
Max	3.32	0.53	0.79	0.10	2.29	0.09
Mean	1.54	0.09	0.32	0.02	1.81	0.01
Std. Dev	±0.80	±6.15	±0.24	±0.03	±0.50	±0.27

Table 5. Concentration of Cadmium in Chicken Samples.

Cadmium value	Broiler Liver	Domestic Liver	Broiler Kidney	Domestic Kidney	Broiler Heart	Domestic Heart
Min	0.15	0.00	0.00	0.00	0.01	0.00
Max	2.42	0.90	8.21	0.77	0.29	0.09
Mean	1.09	0.21	2.85	0.10	0.06	0.09
Std. Dev	±0.78	±0.31	±2.76	±0.10	±0.07	±0.03

Concentration of Iron (Fe) in poultry meat

The concentration of iron in boiler and domestic reared chicken are present in Table (6).

In broiler chicken liver, the iron ranges from 0.23-6.06mg/L, having a mean value of 3.13±2.04 and as compared to domestic chicken liver the iron 0.00-0.090mg/L, mean value 0.49±0.28. In broiler chicken kidney the Iron value ranges from 0.07-2.09mg/L, mean value 0.69±1.00 while in case of kidney of domestic chicken, the iron ranges from 0.07-0.13mg/L, mean value of 0.05±0.05.

Table 6. Concentration of Iron in Chicken Samples.

Iron Value	Broiler Liver	Domestic Liver	Broiler Kidney	Domestic Kidney	Broiler Heart	Domestic Heart
Min	0.23	0.02	0.07	0.07	1.37	0.01
Max	6.06	0.90	2.09	0.13	7.64	0.92
Mean	3.13	0.49	0.69	0.05	3.17	0.30
Std. Dev	±2.04	±0.28	±1.00	±0.05	±1.65	±0.27

In Broiler chicken heart the Iron range was 1.37-7.64mg/L, mean range was 3.17±1.65 and as compared to domestic chicken heart the Iron ranges from 0.01-0.9mg/L, having a mean value of 0.30±0.03. Our findings are in accordance with the findings of Iwegbue *et al.*, 2008, who obtained high levels of Fe (4.65±0.30 ppm) in liver than chicken meat (1.92 ppm).

Concentration of Zinc (Zn) in poultry meat

The concentration of zinc in boiler and domestic reared chicken are present in Table (7). In the present study, the zinc concentration in broiler chicken liver was between 0.01-0.05mg/L, with the mean value of 0.01±0.02. On the other hand, the liver of domestic chicken liver the zinc concentration ranges from 0.00-0.15mg/L, mean having a mean value of 0.04±0.06. In case of broiler chicken kidney samples, the zinc level varies from 0.00-2.77mg/L, having a mean value of 0.87±0.85 and as compared to 0.00-0.63mg/L of domestic kidney sample, having a mean value 0.19±0.27. Broiler heart sample the zinc content varies from 0.01-0.00mg/L with the mean of 0.06±0.07 as compared to domestic chicken sample, which have a value of 0.00-0.09mg/L having mean value of 0.01±0.03. The reason of low level of zinc may be due to Zn deficient soils or as a result, the water available to poultry is deficient of Zn. This might be one of the reasons for low tissue content of Zn. In the present study the zinc concentration in liver, kidney and heart samples were lower than permissible limit of 150 ppm as reported by FAO/WHO.

Table 7. Concentration of Zinc in Chicken Samples.

Zinc Value	Broiler Liver	Domestic Liver	Broiler Kidney	Domestic Kidney	Broiler Heart	Domestic Heart
Min	0.01	0.00	0.00	0.00	0.00	0.00
Max	0.05	0.15	2.77	0.63	4.49	0.50
Mean	0.01	0.04	0.87	0.19	1.16	0.11
Std. Dev	±0.02	±0.06	±0.85	±0.27	±1.38	±0.15

The relationship between the concentration of zinc in Broiler and domestic chicken was significantly strong. The concentration of zinc in the kidneys of Broiler and domestic chicken showed significance in relationship. As well as the relation of heart of Broiler and domestic chicken was significantly strong. Our reported values are not in accordance withMariam *et al.*, 2004 who obtained high level of Zn in the liver (54.53 ppm) and muscle (28.52 ppm). Our finding are also not in accordance with the work conducted Akan *et al.*, 2010, who reported Zn level of (3.11 ppm) in the liver and (1.1 ppm) in the muscle of chicken.

Table 8. Concentration of Copper in Chicken Samples.

Copper Value	Broiler Liver	Domestic Liver	Broiler Kidney	Domestic Kidney	Broiler Heart	Domestic Heart
Min	0.02	0.00	0.00	0.00	0.00	0.00
Max	0.01	0.23	0.97	0.11	0.66	0.56
Mean	0.05	0.04	0.26	0.01	0.19	0.12
Std. Dev	±0.02	±0.06	±0.35	±0.03	±0.15	±0.18

Concentration of Copper (Cu) in poultry meat

The concentration of copper in boiler and domestic reared chicken are present in Table (8). In the liver of broiler chicken, the copper concentration ranges from 0.02-0.01mg/L having a mean value of 0.05±0.02. In case of domestic chicken the copper value ranges from 0.00-0.23mg/L in liver, mean value was 0.04±0.06. In broiler chicken, the copper range was 0.00-0.97mg/L in kidney, mean was 0.26±0.35, while in the domestic chicken the copper was 0.00-0.77mg/L in kidney, mean having a mean value of 0.10±0.21.

In the heart of broiler chicken the copper ranges from 0.00-0.56 with a mean range of 0.12±0.18. In domestic chicken, the concentration varies from 0.00-0.09mg/L of copper in heart and means range was 0.12±0.18.

Principal Component Analysis

The variability in the obtained data was explained by the first principal component, which includes the maximum amount of variance in the data followed by first and second principal components. PCA was conducted to obtain concentration of heavy metals in broiler and domestic chicken liver, kidney and heart. The Euclidean biplot acquired from the PCA is shown in Fig.1 explained the concentration of heavy metals broiler and domestic chicken samples. Two principal components with significant eigen values were identified, the first component PC1 showed the highest eigen value (3.41) explained maximum difference in data set, followed by the eigen value for PC2 (1.85). These two principal components showed a contribution of 87.68% to its total variance.

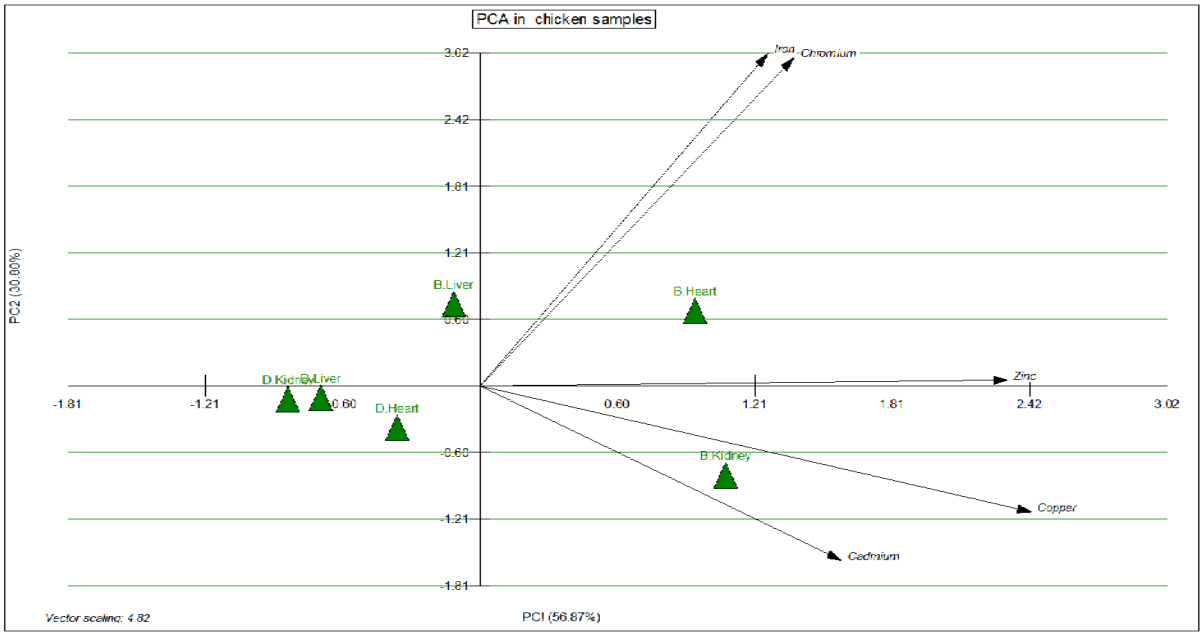

Fig. 1. Principal Component Analysis representation.

The PC1 showed a maximum variance with 56.87% while PC2 showed 30.80%. According to Figure-1 the dependent variables were chicken samples while independent variables were heavy metals. Arrows were drawn from joint centered ordination axis to the point we presenting each variable.

The PC1 was positively associated with axis-1 Lead (0.504), copper (0.504) and Zinc (0.482). While negatively associated with axis-2 Lead (-0.238), Cadmium (-0.032) and Copper (-0.238). The PC2 was positively correlated with broiler kidney (1.08) and broiler heart (0.95) while negatively correlated with domestic liver (-0.109), broiler kidney (-0.813), domestic kidney (-0.122) and domestic heart (-0.381). Broiler heart is correlated with Iron and Chromium and broiler kidney is correlated with copper and cadmium. There is no any variance in broiler liver and domestic chicken kidney, heart and liver.

Conclusion

The result of the study shows elevated level for heavy metals in liver as compared to kidney and heart samples. The highest value of Pb, Cd, Cr, Fe, Zn and Cu were present in nearly all parts of body parts in broiler chicken is of great concern and may cause serious health problems.

The sample checked for the concentration of heavy metals clearly showed that the concentration of Pb, Cd, Cr, Fe, Zn and Cu were found to be present more in boiler chicken than domestic reared chicken. This indicates that the food of boiler chicken feed contains more heavy metals than domestic chicken. Therefore author recommend a continuous need to monitor and identify sources of heavy metals and step must be taken to control it as well as awareness programme for the community about the ill effect of these heavy metals.

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