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Detection and Estimation of Heavy Metals in Broiler Meat Available in Lahore, Pakistan

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Abstract

Cadmium (Cd) and lead (Pb) are toxic environmental pollutants. These heavy metals create serious health issues in consumers. The current study aimed to identify the quantity of lead and cadmium in broiler chicken, including in its liver and kidneys, since the demand for chicken meat as a food source is increasing day by day. Forty (40) broiler chickens were purchased from the various markets of Lahore, Pakistan including the markets of Sadar Cantt area, Shahdra, Alkarim park, Anarkali, and Muslim town. These chickens were collected, processed, and analyzed to determine the levels of lead and cadmium in their internal organs (liver and kidneys) using atomic absorption spectrophotometer. This process was carried out in the laboratory of PCSIR after the digestion of all samples via nitric acid (HNO_3) and hydrogen peroxide using the wet digestion method. The range of the mean concentration of lead (4.50 - 8.50ug /g) and cadmium (25.00 - 27.75 ug/g) in the internal organs of broiler chicken exceeded the permissible level of 0.05% recommended by the World Health Organization (WHO). ANOVA analysis revealed that the presence of heavy metals was not significant in the internal organs of broiler meat collected from different areas of Lahore, since the p-value was greater than the significance level ($p > 0.05$). Hence, heavy metal concentrations were recorded as above the permissible level recommended by the WHO.

Introduction

Natural elements are constituents of all living organisms and they play different structural, functional, and organizational roles in their bodies. These elements are classified into essential, macro, micro, and trace elements according to their need in the body. Macro elements are required in huge amounts to facilitate its proper functioning, while micro elements are required in smaller amounts and only a minute amount of trace elements is required to be present in the body. Indeed, a higher percentage of micro and trace elements can disturb the proper functioning of the cell [1].

A balanced diet contains all essential and non-essential elements, as well as macro and micro molecules in a proper ratio to sustain all biological reactions and the cell functioning capacity of the body [2]. Proteins, carbohydrates, and fats are all macro molecules and building blocks of the

bodies of all living organisms. Protein, which is a macro molecule and a major component of cells, makes up about 16% of the body ratio and has a significant role in all metabolic reactions and proper functioning of the body [3].

Meat is an important component of a balanced and healthy diet due to its nutritional value. It consists of proteins, fats, and many other nutrients necessary for performing various biological functions in the body. Chicken meat is available at a relatively reasonable price and is full of nutrition due to the richness of proteins and other nutrients in it.

At present, the poultry industry is focused on raising the growth rate of broiler chickens. One of the most important features of broiler meat is that it can be digested by people of all ages as it contains high-quality protein and comes with a low percentage of saturated fats [4].

Heavy metals accumulate in the environment due to human activities, such as the disposal of industrial wastes, smelting, oil refining, ores, and incineration of disposed waste, vehicular emissions, sewage effluents, and domestic wastes. They are continuously added to water, air, soil, and fertilizers. Pollutants have high concentrations of heavy metals and due to their inhalation, ingestion, and contact with them, they become a part of an organism's body tissues and organs. Due to their bioaccumulation, biomagnification in the food chain, and toxicity, they pose serious threats to human health [5].

For the last few decades, environmental pollution has been increasing due to metallurgy. Heavy metals that cause poisoning and produce toxins are becoming a part of consumer's food and pose serious health threats [6].

Heavy metals are chemically heavy metallic elements that are highly toxic and poisonous, even in low concentrations, due to their high specific gravity as compared with water. Heavy metals cause toxicity in the gastrointestinal tract (GI). It results in loosening the bile contact and causes an inflamed and sore mouth, as in stomatitis. Moreover, heavy metals cause mental tension, abnormal uncoordinated movements, and tremors, writhing, and retching when they enter into the nervous system. Furthermore, pneumonia and hemoglobinuria (high percentage of hemoglobin in urine) are signs of toxicity caused by heavy metals including lead, mercury, cadmium, aluminum, arsenic, zinc, and copper [7].

Cadmium is a heavy metal mostly used in industries and it causes toxicity in both human beings and animals. Cadmium is carcinogenic and persistently poisons the body organs, such as the kidney, liver, brain, and also blood by accumulating in them [8]. Epidemiological studies and experiments have shown that exposure to cadmium is linked with prostate, renal, urinary bladder, pancreatic, liver, and lung cancer [8]. Furthermore, cadmium is also linked with reproductive disorders, neurological problems, osteomalacia, impairment, pancreatic abnormalities, and hepatic dysfunctions [9]. The risk of pollution reflects metal accumulation in the body [10].Cadmium exposure and toxicity have a chronic effect on the kidney as a primary organ.Cadmium is accumulated in the kidneys because in the renal proximal tubules, there is a highuptake of cadmium by metallothionein (MT) –bound cadmium (Cd – Mt) and receptor-mediated endocytosis. In lysosomes, there is a degradation of metallothionein- bound cadmium and endozymes discharge free cadmium Cd^{2+} in the cytosol of the cell. The

presence of free Cd^{2+} in the cytosol produces reactive oxygen species (ROS) and activates the cell death mechanism. The Accumulation of heavy metals such as cadmium decreases the reactivity of many enzymes. It also depletes the activity of glutathione endogenously and leads to increased oxidative renal stress. Renal damage can be a reason for oxidative stress and it also increases the serum creatinine level [11].

Lead is also a heavy environmental pollutant that has toxic effects on many body organs. Lead is absorbed by the skin, respiratory and digestive systems. Exposure to lead has deleterious effects on neurological, respiratory, urinary, and cardiovascular disorders. Various industrial wastes released in the environment cause the absorption of lead into the blood. Muscle weakness, loss of appetite, infertility, severe anemia, and weight loss have all been reported [12].

Considerable exposure to lead and its accumulation in the body damages the central nervous system by damaging the motor neurons in the spinal cord. It also causes axonal loss in the peripheral nervous system which results in muscle atrophy. Lead causes growth retardation even in trace amounts [13]. Lead poisoning results in soft tissue, bone weakness, or deposition with an increased blood volume [14].

The accumulation of lead in children has neurotoxic effects and chronic accumulation of lead causes abnormal development of the nervous system. The presence of lead in food or its excessive exposure reduces intellectual ability and cognitive development in children, while it increases blood volume and the risk of cardiovascular diseases in adults [15].

High exposure to lead decreases the level of antioxidant activities in the cells, as well as the amount of glutathione peroxidase, catalase, superoxide dismutase in the tissues of the liver and kidney.

Due to the increasing demand for broiler meat in the Lahore region of Pakistan, it is necessary to estimate the quality of meat, especially the accumulation of heavy metals in it due to the increasing pollution in the environment.

Materials and Methods

Sample Collection

To estimate the concentration of heavy metals in broiler meat, forty (40) samples were collected from different areas of Lahore, Pakistan including Sadar Cantt, Shahdra, Muslim town, Alkarim park, and Anarkali. Eight samples were collected from each area to analyze the heavy metal concentration in the available broiler meat. The research was held at PCSIR (Pakistan Council of Scientific and Industrial Research) lab. It is well equipped to store pure chemicals handled by the best research assistants. After slaughtering the rats, their organs were separated and packed in polyethylene bags, then taken to the above lab and frozen until analysis.

Sample Preparation

To determine the presence of heavy metals, the samples were prepared in the PCSIR lab using wet digestion method, since it is sufficient to solubilize all trace metals and to digest the organic content of meat. Hence, heavy metal concentrations can be determined more precisely and accurately using this method.

Sample Preparation Steps

Each sample weighted 2g and its weight was determined via the analytical balance available in the lab. After weighing, sample

digestion mixture was prepared by adding 10ml of HNO_3 (Nitric acid) and H_2O_2 (Hydrogen peroxide) in equal volumes 1:1 into the digestion flask. The samples were transferred into the digestion mixture and the solution was heated at the hot plate for one hour at 120°C. The solution was swirled after specific intervals of time to ensure the complete digestion of samples.

Samples were cooled after digestion and transferred into the standard flask of 20ml, then filtered using filter paper. After filtration, samples were introduced into a volumetric cylinder. The volume of 20ml samples was increased to 50ml by adding distilled water. All samples were transferred into polyethylene bottles. Samples were stored at room temperature until analysis using atomic absorption spectrophotometer (AAS).

Elemental Analysis

For elemental analysis, dilutions up to 50ml were prepared and metal concentrations were determined using the atomic absorption spectrophotometer under operating conditions at PCSIR, CEPS lab. Samples were run in replicates and integrated results were recorded for various metal concentrations in different organs. Each sample was run for 30 sec at 1000°C temperature set for this apparatus. The reliability of the apparatus was also checked by running a standard known and blank concentration of metals after every five samples.

Results

The methodology used for analysis is known as the valid triplicate methodology. The mean concentration of lead in all samples collected from Lahore Cantt was high in both organs of broiler meat. Among all the analyzed samples, the high mean value of lead was (8.5±0.533) ug/g for the kidneys, while the high mean value of cadmium was (26.04±0.108 ug/g) for the same organ (Table 4.1).

Table 4.1. Mean and Standard Deviation of Lead (Pb) and Cadmium (Cd) inKidney and Liver Samples Collected from Lahore Cantt

Sample No.	Concentration / Level of Heavy Metals in Kidneys (ug/g)		Concentration / Level of Heavy Metals in Liver (ug/g)	
	Pb	Cd	Pb	Cd
A	5.6±0.642	25.67±0.381	8.2±0.064	25.67±0.381
B	6.1±0.360	26.03±0.108	7.5±0.305	25.67±0.381
C	8.5±0.533	26.03±0.108	6.1±0.360	25.67±0.381
D	6.9±0.750	27.75±0.255	6.9±0.750	25.00±0.380
E	6.1±0.360	26.03±0.108	7.0±0.769	25.56±0.380
F	8.2±0.064	25.67±0.381	6.4±0.380	26.03±0.108
G	6.9±0.750	26.04±0.108	5.6±0.642	25.67±0.381
H	7.5±0.305	26.04±0.381	4.5±0.533	26.03±0.108

The mean value of lead was (8.5±0.533) ug/g for both organs, while the mean value of cadmium was (27.75±0.250) ug/g. It was high for the liver in the sample collected from Anarkali (Table 4.2).

Table 4.2. Mean and Standard Deviation of Lead (Pb) and Cadmium (Cd) in Kidney and Liver Samples Collected from Anarkali

Sample No.	Concentration/ Level of Heavy Metals in Kidneys (ug/g)	Concentration/ Level of Heavy Metals in Kidneys (ug/g)	Concentration/ Level of HeavyMetals in Liver (ug/g)	Concentration/ Level of Heavy Metals in Liver (ug/g)
	Pb	**Cd**	**Pb**	**Cd**
A	8.1±0.360	26.03±0.108	5.6±0.642	25.67±0.381
B	7.0±0.769	26.03±0.108	4.5±0.533	26.03±0.108
C	7.9±0.750	25.67±0.381	5.6±0.642	26.03±0.108
D	8.2±0.642	26.03±0.108	6.1±0.360	27.75±0.250
E	8.5±0.533	26.03±0.108	8.5±0.533	26.03±0.108
F	6.5±0.533	26.03±0.108	6.9±0.750	25.67±0.381
G	6.5±0.533	26.03±0.108	6.1±0.360	26.03±0.108
H	6.6±0.642	26.03±0.108	8.2±0.064	26.03±0.108

Samples collected from the Shahdra region had the highest mean concentration with mean values (8.5±0.533) ug/g for lead in the liver and (27.75±0.108) ug/g for cadmium in the kidney (Table 4.3).

Table 4.3. Mean and Standard Deviation of Lead (Pb) and Cadmium (Cd) in Kidney and Liver Samples Collected from Shahdra

Sample No.	Concentration / Level of Heavy Metals in Kidneys (ug/g)	Concentration / Level of Heavy Metals in Kidneys (ug/g)	Concentration/ Level of Heavy Metals in Liver (ug/g)	Concentration/ Levelof Heavy Metals in Liver (ug/g)
	Pb	**Cd**	**Pb**	**Cd**
A	6.9±0.750	26.03±0.108	5.6±0.642	26.00±0.108
B	7.5±0.305	26.03±0.108	6.1±0.360	26.00±0.108

Sample No.	Concentration / Level of Heavy Metals in Kidneys (ug/g)	Concentration / Level of Heavy Metals in Kidneys (ug/g)	Concentration/ Level of Heavy Metals in Liver (ug/g)	Concentration/ Levelof Heavy Metals in Liver (ug/g)
C	6.1±0.360	26.03±0.108	8.5±0.533	25.75±1.038
D	8.2±0.064	26.22±0.064	6.9±0.750	26.00±0.108
E	5.6±0.642	25.67±0.381	8.2±0.064	25.67±0.381
F	6.1±0.360	26.03±0.108	7.5±0.305	25.67±0.381
G	8.2±0.533	26.03±0.381	6.1±0.360	25.67±0.381
H	6.9±0.750	27.75±0.108	6.9±0.750	25.67±0.381

Samples collected from Alkarim park had the highest concentration of lead with mean value (8.2±0.064) ug/g for the kidney and the concentration of cadmium with mean value (26.03±0.108) ug/g for both organs (Table 4.4).

Table 4.4. Mean and Standard Deviation of Lead (Pb) and Cadmium (Cd) in Kidney and Liver Samples Collected from Alkarim Park

Sample No.	Concentration / Level of Heavy Metals in Kidneys (ug/g)		Concentration / Level of Heavy Metals in Liver (ug/g)	
	Pb	**Cd**	**Pb**	**Cd**
A	6.1±0.360	26.03±0.108	7.0±0.769	25.67±0.381
B	8.2±0.642	25.67±0.381	6.4±0.380	26.03±0.108
C	6.9±0.750	26.03±0.108	5.6±0.642	25.67±0.381
D	7.5±0.305	26.03±0.108	4.5±0.533	26.03±0.08
E	8.1±0.360	26.03±0.108	5.6±0.642	25.67±0.381
F	7.5±0.769	26.03±0.108	4.5±0.533	26.03±0.108
G	7.9±0.750	25.67±0.381	5.6±0.642	26.03±0.108
H	8.2±0.064	26.03±0.108	6.1±0.360	27.75±0.251

Sample collected from Muslim town showed the highest concentration of lead with mean value (8.5±0.533) ug/g for liver and mean value (26.03±0.108) ug/g for both organs. All samples showed equally the concentration of cadmium at 25% (Table 4.5).

Table 4.5. Mean and Standard Deviation of Lead (Pb) and Cadmium (Cd) in Kidney and Liver Samples Collected from Muslim Town

Sample No.	Concentration / Level of Heavy Metals in Kidneys (ug/g)		Concentration / Level of Heavy Metals in Liver (ug/g)	
	Pb	Cd	Pb	Cd
A	8.5±0.065	26.03±0.108	8.5±0.533	26.03±0.108
B	6.5±0.533	26.03±0.108	6.9±0.750	25.67±0.381
C	6.5±0.533	26.03±0.108	6.1±0.360	26.03±0.108
D	6.6±0.533	26.03±0.108	8.2±0.064	26.03±0.108
E	6.9±0.750	26.03±0.108	5.6±0.642	26.00±0.106
F	7.5±0.305	26.03±0.108	6.1±0.360	26.00±0.106
G	6.1±0.360	26.03±0.108	8.5±0.533	25.75±0.381
H	8.2±0.064	26.22±0.064	6.9±0.750	26.00±0.106

A high percentage of cadmium (26%) was determined in the kidneys (Fig. 4.5). All of the collected samples were found to have an equal concentration of cadmium in the kidneys. Lead was also found in the kidneys in all the samples collected from the Cantt area of Lahore (Fig. 4.1).

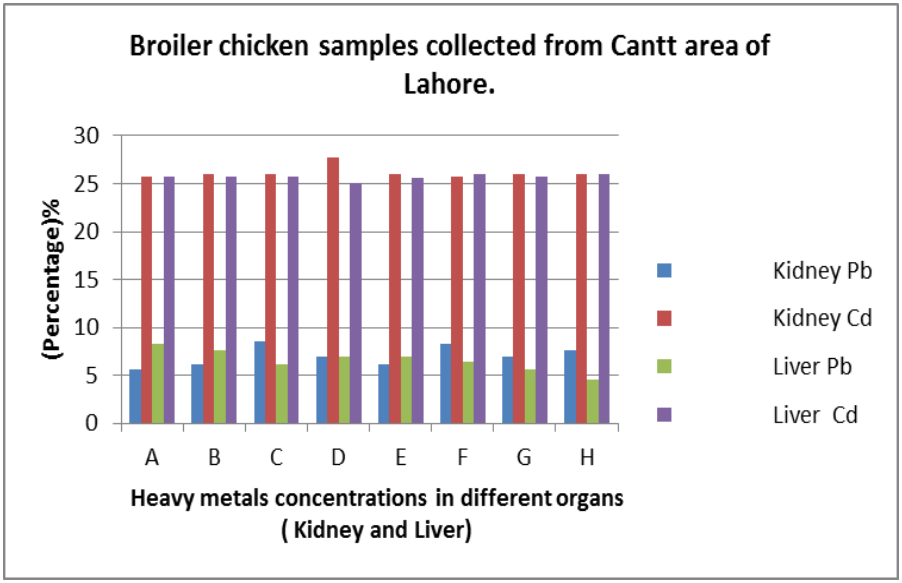

Figure 4.1. Showing Boiler Chicken Samples Collected from Cantt Area Lahore.

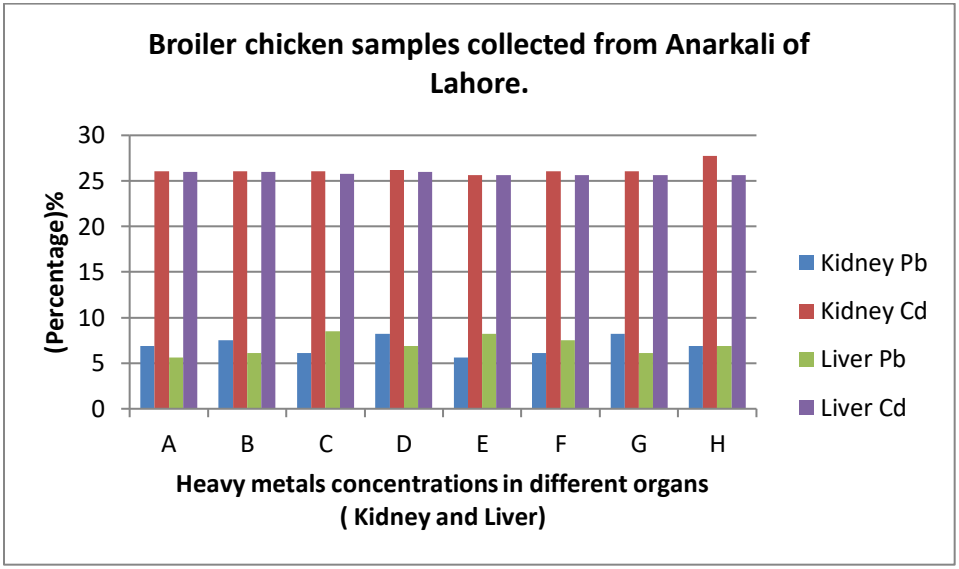

Figure 4.2. Showing Boiler Chicken Samples Collected from Anarkali Lahore.

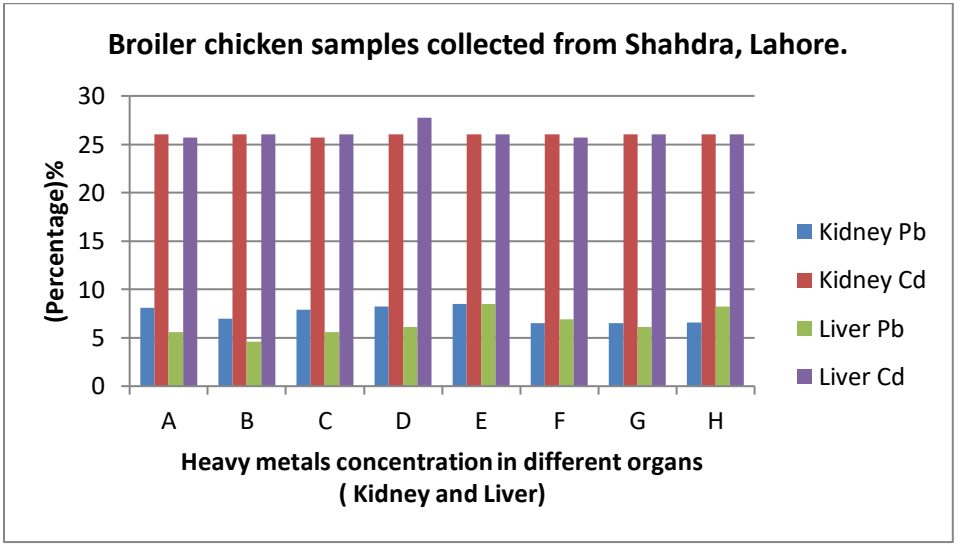

Figure 4.3. Showing Boiler Chicken Samples Collected from Shahdra Lahore.

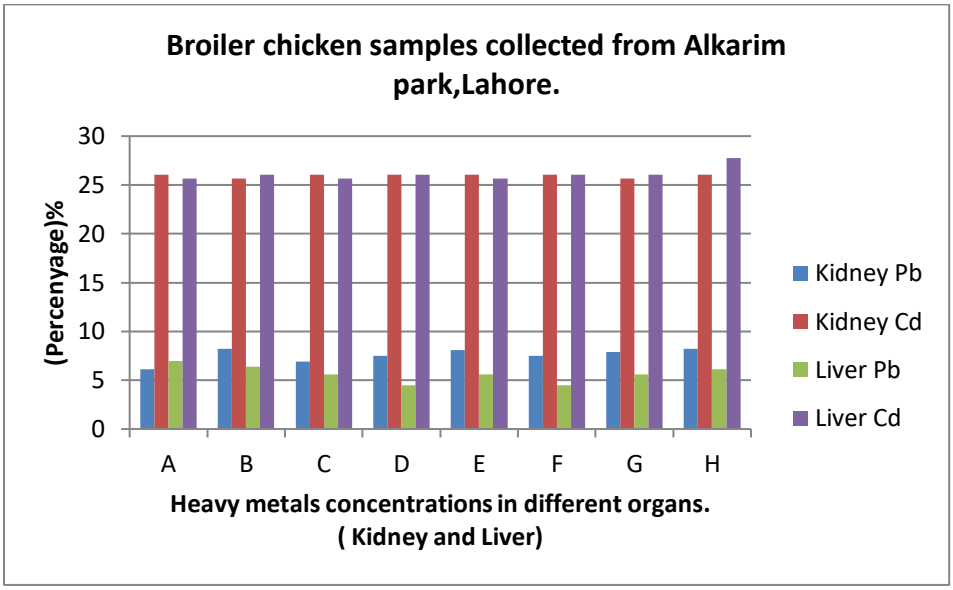

Figure 4.4. Showing Boiler Chicken Samples Collected from Alkarim Park Lahore.

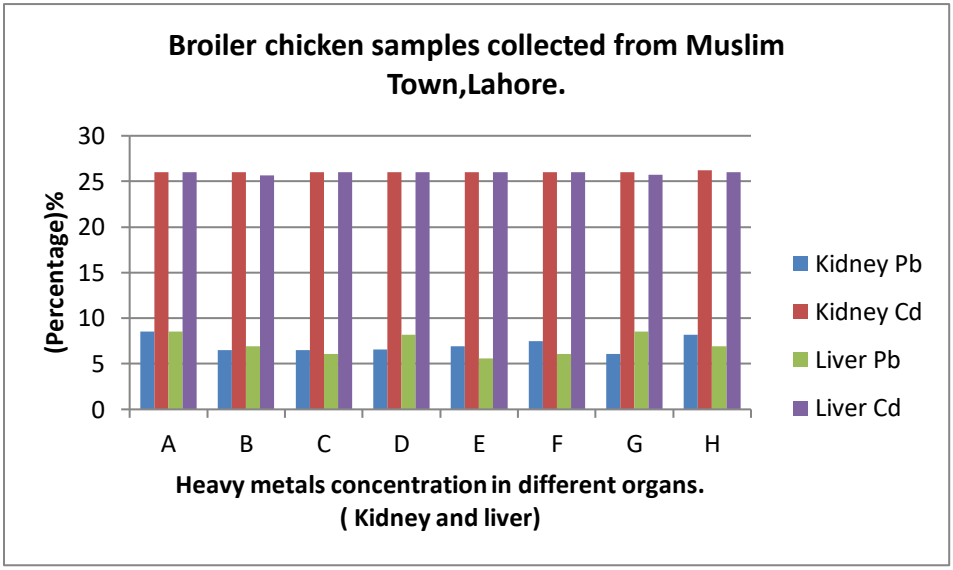

Figure 4.5. Showing Boiler Chicken Samples Collected from Muslim Town Lahore

Statistical Analysis

In all the five selected areas of Lahore, heavy metals were found in maximum or at

highest concentrations in collected samples as compared with another study. ANOVA was applied to estimate or determine significant differences among the selected areas of Lahore regarding the concentration and accumulation of heavy metals in internal organs within the collected samples of broiler meat. The analysis revealed that there was no significant difference among the selected areas of Lahore regarding the concentration of heavy metals in the internal organs of broiler chicken.

The results also showed that there was no significant association among the selected areas of Lahore. Descriptive statistics revealed the different concentrations of heavy metals in the internal organs of broiler meat in the samples collected from different areas of Lahore. However, ANOVA analysis showed that there was no significant difference between heavy metal concentrations in the internal organs of broiler meat among the collected samples.

A high level of lead concentration in the kidneys in samples collected from different areas of Lahore was noted. The concentration level varied in the following sequence: Alkarim park > Anarkali > Muslim town > Shahdra and Lahore Cantt. Samples from Shahdra and Cantt area were found to have more significant concentrations than that of Alkarim park and Anarkali, whereas the samples from Cantt and Shahdra were found to have no differences in heavy metal concentrations (Table 4.6).

Table 4.6: Comparison of Lead Concentrations in Kidneys within Different Areas of Lahore

Descriptive Statistics

Kidney-Pb

Region	Mean	Std. Dev	Min	Max
Lahore Cant	6.9750	1.03751	5.60	8.50
Anarkali	7.4125	0.84589	6.50	8.50
Shahdra	6.9375	0.97825	5.60	8.20
Alkarim Park	7.5500	0.73679	6.10	8.20
Muslim Town	7.1000	0.87342	6.10	8.50

The p-value suggests no actual differences among all areas with lead concentration in the kidneys. Moreover, p-value is greater than the significance level, so the mean values are all equal. It was concluded that the difference among the groups in terms of mean values is not statistically significant.

ANOVA

Kidney-Pb

	Sum of Sqs	Df	Mean Sq	F-value	p-value
Between Groups	2.377	4	0.594	0.733	0.576
Within Groups	28.383	35	0.811		
Total	30.759	39			

High levels of cadmium concentration were found in the kidneys in broiler meat samples collected from different areas of Lahore in the following order: Lahore Cantt > Shahdra > Anarkali > Alkarim park > Muslim town. The concentration levels in Cantt and Shahdra were not significant. Similarly, they were insignificant in Anarkali and Alkarim park. Muslim town was found to have a significant concentration level as compared with Lahore Cantt and Shahdra (Table 4.7).

Table 4.7. Comparison of Cadmium Concentrations in Kidneys within Different Areas of Lahore

Descriptive Statistics				
Kidney-Cd				
Region	**Mean**	**Std. Dev**	**Min**	**Max**
Lahore Cant	26.1575	0.66416	25.67	27.75
Anarkali	25.9850	0.12728	25.67	26.03
Shahdrah	26.2238	0.63514	25.67	27.75
Alkarim Park	25.9400	0.16665	25.67	26.03
Muslim Town	26.0538	0.06718	26.03	26.22

The p-value suggests no actual differences among all areas with cadmium concentration in the kidneys. The p-value (p>0.05) is greater than the significance level, so the mean values are all equal. ANOVA test revealed a p-value of 0.649, which is far greater than 0.05 (the significant value). Hence, it was concluded that the difference among groups in terms of mean values is not statistically significant.

ANOVA					
Kidney-Cd					
	Sum of Sqs	**Df**	**Mean Sq**	**F-value**	**P-value**
Between Groups	0.445	4	0.111	0.623	0.649
Within Groups	6.251	35	0.179		
Total	6.696	39			

A high level of lead concentration was determined in the kidneys in broiler meat samples collected from different areas of Lahore including Anarkali, Shahdra, and Muslim town with no significant difference in the concentration of heavy metals (Table 4.8.)

Table 4.8. Comparison of Lead Concentrations in Liver Samples Collected from Different Areas of Lahore

Descriptive Statistics				
Liver-Pb				
Region	**Mean**	**Std. Dev**	**Min**	**Max**
Lahore Cantt	6.5250	1.15109	4.50	8.20
Anarkali	6.4375	1.36061	4.50	8.50
Shahdra	6.9750	1.03751	5.60	8.50
Alkarim Park	5.6625	0.86510	4.50	7.00
Muslim Town	7.1000	1.16251	5.60	8.50

The p-value suggests no actual differences among all areas. The p-value (p>0.05) is greater than the significance level, so the mean values are all equal. ANOVA revealed a p-value of 0.113, which is greater than the significance value (.05). Hence, it was concluded that the difference among the groups in terms of mean values is not statistically significant.

ANOVA					
Liver-Pb					
	Sum of Sqs	**Df**	**Mean Sq**	**F-value**	**P-value**
Between Groups	10.269	4	2.567	2.021	0.113
Within Groups	44.468	35	1.271		
Total	54.736	39			

A high level of cadmium concentration was determined in the liver in broiler meat samples collected from different areas of Lahore including Anarkali, Alkarim park, Lahore cantt, Muslim town, and Shahdra. Moreover, Shahdrah was found to have a significant difference in mean concentrations as compared to Anarkali and Alkarim Park (Table 4.9).

Table 4.9: Comparison of Cadmium Concentrations in Liver Samples Collected from Different Areas of Lahore

Descriptive Statistics Liver-Cd				
Region	**Mean**	**Std. Dev**	**Min**	**Max**
Lahore Cantt	25.6625	0.32066	25.00	26.03
Anarkali	26.1550	0.66468	25.67	27.75
Shahdrah	25.8038	0.16475	25.67	26.00
Alkarim Park	26.1100	0.68619	25.67	27.75
Muslim Town	25.9388	0.14347	25.67	26.03

The p-value suggests no actual difference among all areas. The p-value ($p>0.05$) is greater than the significance level, so the mean values are all equal. ANOVA revealed a p-value of 0.195, which is greater than the significance value. Hence, it was concluded that the difference among the groups in terms of mean values is not statistically significant.

ANOVA Liver-Cd					
	Sum of Sqs	**df**	**Mean Sq**	**F-value**	**p-value**
Between Groups	1.364	4	0.341	1.604	0.195
Within Groups	7.442	35	0.213		
Total	8.807	39			

The highest concentration of lead was estimated in Alkarim park and the lowest in the Shahdra area of Lahore, while cadmium concentration was highest in the Lahore Cantt area and lowest in Alkarim park. Fig. 4.6 reveals that there is no statistical difference between the values of cadmium in these areas.

The highest concentration of lead was recorded in Muslim town and the lowest in Alkarim park in the liver samples, whereas the highest concentration of cadmium was determined in Anarkali and the lowest in Cantt area. There were no statistically significant difference among these areas regarding heavy metal concentrations in broiler meat.

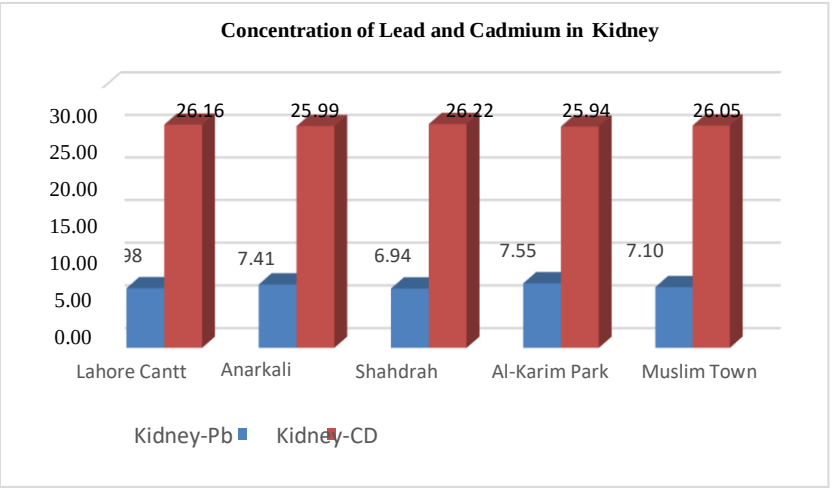

Figure 4.6. Concentration of Lead and Cadmium in Kidneys in All Areas of Lahore

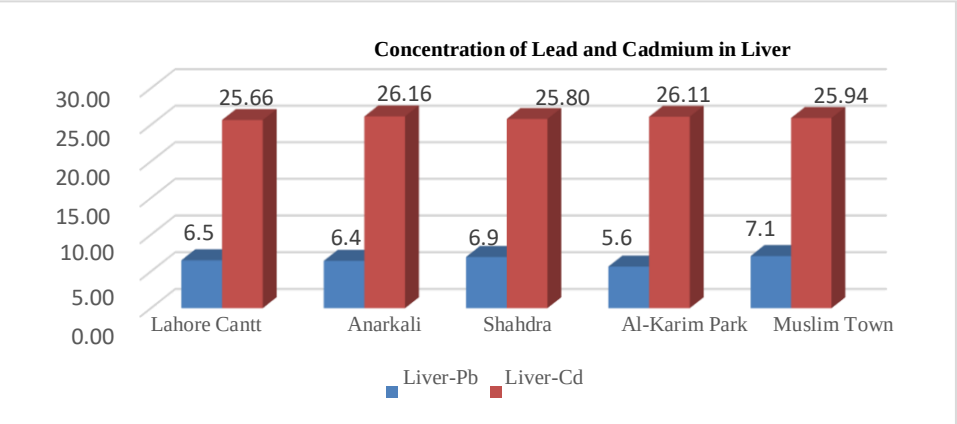

Figure 4.7. Concentration of Lead and Cadmium in the Liver in All Areas of Lahore

Discussion

The presence of heavy metals in broiler meat is due to the presence of these metals in the feed of broilers needed to fulfill the metal requirements within an optimum range and to improve poultry production. Heavy metals enhance the growth rate of broilers if they are added to the poultry feed. Both lead and cadmium have no biochemical benefits for the human body or for animals [16].

The predominant sources of lead include widespread industrial production of fats, oils, perfumes, cement, limestone, bricks, agricultural discharges, sewage materials or effluents, and smelting procedures. All of the waste material from manufacturing discarded into the air, water, soil, and food becomes toxic to human beings and animals [11]. The predominant sources of cadmium include industrial oil manufacturing, tires, diesel, rubber, disposal of fertilizers, and sludge containing cadmium [17].

In the current study, the level of cadmium was determined to be above the permissible level suggested by WHO recommendations in different organs of broiler meat (liver and kidneys). The presence of cadmium and lead, however, was estimated to be above the safe limit recommended by WHO. Both cadmium and lead are toxic metals and cause serious health issues. The toxic effects of both metals depend on their accumulationin the animal body. Calcium and phosphates also increase the absorption of lead in the blood [18].

Research indicated a greater absorption of lead during fasting than when ingested with food. The samples were collected from different cities and the results did not show maximum difference in the concentrations of both heavy metals, that is, lead and cadmium, in the collected samples.

The mean values of heavy metals (lead and cadmium) in different organs (liver and kidneys) did not vary in broiler chicken samples collected from different areas of Lahore. Random samples were collected from different regions of Lahore to determine the concentration of heavy metals in them. For both metals, the concentration was high in broiler meat organs (liver and kidneys) as compared

with the permissible value or the limit recommended by WHO [18].

The presence of metals in the internal organs (liver and kidneys) of broiler meat also showed that these metals are not easily metabolized. Hence, they are accumulated in chicken meat as revealed by the results of ANOVA. ANOVA determined the p-value as greater than the significance value $p > 0.05$. ANOVA also showed that since each organ is tailored for its function, therefore, heavy metals are accumulated in them differently. Consequently, kidneys accumulate higher concentrations of heavy metals than the liver of broiler meat (kidney > liver) [14]. Liver performs the metabolic function of the body, while the kidneys are associated with the excretory process [18].

ANOVA determined the same high concentration of lead and cadmium in all the samples collected from across the Lahore city. It could be due to the same polluted climate caused by urbanization and industrialization. The results reported a high concentration of lead with mean value (6.4375± 1.36061ug/g) and cadmium with mean value (26.2238±0.63514ug/g) [19].

Among different samples of broiler chicken, the maximum cadmium concentration in the kidneys was recorded as (26.019+- 0.421) ug/g, while in the liver it was (26.019+-0.0178) ug/g. The cadmium mean concentration in both organs of broiler chicken was found to be above the permissible limit of 0.5 ppm set by the WHO/FAO in 2000. As compared to the previously reported studies, the cadmium concentration was found lower in both organs [14], which reported its high concentration in meat, while lower concentrations of cadmium in broiler meat in some previous studies were reported [15], their reported concentration of cadmium was higher than others [19]. Skeletal dysfunctions or damage caused by low levels of cadmium exposure resulting in osteoporosis or osteomalacia and fractures of bone were also reported [19].

Lead is also a toxic metal and has no biochemical benefits in the animal body. The minimum and maximum lead concentrations in broiler kidneys were estimated to be much higher than the permissible limit recommended by WHO. The absorption of lead into the blood is caused by various industrial waste exposures in air and soil. Lead poisoning results in soft tissue, bone weakness, and deposition with increased blood volume. Lead, when accumulated in children, has neurotoxic effects and its chronic accumulation causes abnormal development of the nervous system. The presence of lead in food or its excessive exposure reduces intellectual ability and cognitive development in children, while it increases blood volume and the risk of cardiovascular disease in adults [20].

Based on the results of this study, it was determined that the concentration of heavy metals (lead and cadmium) in internal organs (liver and kidneys) of broiler meat was statistically not significant ($p > 0.05$). The accumulation of heavy metals in the body and the environment due to primary and secondary pollutants is uniform across different areas of Lahore because of their persistence for longer duration.

The current study evaluated the presence of heavy metals in the internal organs of broiler meat (kidneys and liver). Further studies are necessary to control the accumulation of these heavy metals in meat products by antioxidants.

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