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Determination of Heavy Metal Residue in Backyard Chicken at Various Regions in Sulaymaniyah Province

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ABSTRACT

In Kurdistan Region-Iraq, poultry meat and their products (local or backyard chicken) are widely consumed from population. the present study was conducted to access the concentration levels of Cadmium (Cd), Copper (Cu) and Lead (Pb) heavy metals from some selected regions of Sulaymaniyah province (Bazyan, Dukan, Mergapan and Tanjaro) were measured in different body parts (breast and liver) or one part and one organ of backyard chicken. The results revealed that the residues of cadmium (Cd) in both samples (breast and liver) from all regions were within the permissible limit (0.3 mg/kg) by FAO/WHO, except Dukan region for liver sample. The concentration of Copper (Cu) in breast and liver samples of all regions was exceeding than the permissible limit (0.3 mg/kg), levels proposed by FAO/WHO and the highest concentration was detected in liver from Dukan region. Lead (Pb) was found exceeding the permissible limit levels of 0.1 mg/kg in the liver samples of all regions, except for Mergapan which recorded low value. Concerning Pb concentration in breast samples the value from Dukan and Tanjaro was exceeding the permissible limit while, the value of lead for samples obtained from Bazyan and Mergapan was within permissible limit. As the most consumed section of the chicken has been determined to be among the tissues with the least contamination, liver, which is often less consumed by the local populace as compared to meat, was discovered to have relatively higher metal concentrations.

تقدير بقايا المعادن الثقيلة في الدجاج محليا في مناطق مختلفة من محافظة السليمانية

شه وين برهان محمد فرج [1]، زيد خلف خضر[2] و هيمن غازي ظاهر[2]
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الخلاصة

في إقليم كردستان العراق ، تستهلك لحوم الدواجن ومنتجاتها (خاصة الدجاج المحلي) على نطاق واسع من قبل المستهلكين. وعلى هذا الاساس تم تصميم هذه التجربة لتقدير تركيز المعادن الثقيلة للكادميوم (Cd) والنحاس (Cu) والرصاص (Pb) في بعض المناطق من محافظة السليمانية (بازيان ودوكان وميركه بان وتانجرو) وفي أجزاء مختلفة (الصدر والكبد) من جسم الدجاج المحلي. اوضحت النتائج أن بقايا الكادميوم (Cd) في كلتا العينتين (اللحوم والكبد) في جميع المناطق كانت ضمن الحد المسموح به (0.3 مجم / كجم) من قبل منظمة الأغذية والزراعة / منظمة الصحة العالمية ، باستثناء منطقة دوكان لعينة الكبد. كان تركيز النحاس (Cu) في عينات اللحوم والكبد في جميع المناطق قد تجاوزت الحد المسموح به (0.3 مجم / كجم)، والمقترحة من قبل منظمة الأغذية والزراعة / منظمة الصحة العالمية. وقد سجلت منطقة دوكان تليها منطقة ميركه بان اعلى مسوى لعنصر النحاس على التوالي لعينة الكبد. تبين من نتائج الدراسة بان تركيز الرصاص (Pb) تجاوزت الحد المسموح به وهو 0.1 مجم / كجم في عينات الكبد لجميع المناطق، باستثناء منطقة ميركه بان والتي سجلت قيمة منخفضة. اما بالنسبة لتركيز الرصاص في عينات الصدر فقد تجاوزت ايظا الحد المسموح به في منطقة دوكان وتانجرو، بينما كانت القيم في بازيان وميركه بان في حدود الحد المسموح به. وقد لوحظت بان تراكيز المعادن الثقيلة كانت أعلى نسبيًا في عينات الكبد والتي يقل استهلاكها بشكل عام من قبل المستهلكين المحليين عند مقارنتها بلحوم الدجاج ، حيث وجد أن الجزء الأكثر استهلاكًا من الدجاج هو من بين الأنسجة الأقل تلوثًا..

الكلمات المفتاحية: المعادن الثقيلة، الدجاج المحلي، الكبد، الصدر

INTRODUCTION

The animal protein found in poultry meat is crucial to human development and growth, leading to its widespread consumption, poultry meat offers several benefits, including a sufficient degree of nutritional value, a delectable flavor, a relatively inexpensive price, its accessibility, and its acceptance by all social strata and cultures. Products, like chicken meat, that can compete in a worldwide market are essential during this time of globalization. It's not just that the current chicken meat industry has a large production capacity and low production costs; chicken products are also safe to eat (Wahyono & Utami, 2018). In the Kurdistan Region, chicken meat consumption is extremely high, in fact the highest of all accessible meats. In the Kurdistan area, two types of chicken are consumed: broiler chicken in big amounts and backyard chicken in second place.

Chicken meat and edible offal, especially livers, are widely consumed in the Kurdistan Region of Iraq because they can be utilized in a wide range of cuisines, including fast food. The essential organ of the liver is in charge of the metabolism and detoxification of a wide range of substances, including medicinal medications, chemically harmful substances, microbial toxins, and heavy metals (Almazroo, Miah, & Venkataramanan, 2017; Gupta, 2012). Contamination of meat and meat products is a significant concern for public health, meanwhile it can lead to illness of human due to inattention in the handling, treatment and storage of meat. Meat and meat products may be contaminated by variety of contaminates in which the principal contaminants include heavy metals, antibiotics, microorganisms, metabolites, mycotoxins, hormones, nitrates, nitrites, pesticide residues, dioxins, toxic pigments, and melamine etc (Hu *et al.*, 2017). Because of carelessness in the handling, treatment, and storage of meat, contamination of meat and meat products poses a serious risk to human health and can result in disease. Heavy metals are among the main contaminants that can contaminate meat and meat products. A major worry is the presence of heavy metals in meat, which are discharged as a result of home sewage and industrial waste discharge and may have a negative effect on human health. Heavy metals are metallic elements with a high density (more than 5 g.cm-3) in comparison to water. They are mostly found in the earth's crust.

Living things are critically dependent on a group of heavy metals known as micronutrients, which include Cu, Mn, Ni, Se, Cr, and Zn. Enzyme reactions, gene expression regulation (in RNA folding, ribozyme catalysis, and ribosome activities), and energy metabolism all rely on heavy metals to function properly (Ali, Almashhadany, & Khalid, 2020). Other heavy metals, like Pb, Cd, and As, are extremely dangerous when consumed. High levels of heavy metal pollution are mostly due to the industrial Revolution and ongoing agricultural fertilizer development. Food chains do not absorb and get their due share of the heavy metal pollution that builds up in the soil, crops, and water that make up the food chain. Through the intake of contaminated food, inhalation of contaminated air, and dermal deposition from a variety of sources, humans are exposed to heavy metals. Numerous studies on the origins, bioaccumulation, and potential health hazards of heavy metals have been conducted as a result of the steadily rising amounts of heavy metals in food (Rai, Lee, Zhang, Tsang, & Kim, 2019). Because it compromises the ecosystem's structural and functional integrity, heavy metal intake at the local, regional, and international levels is a serious problem. The contamination of meat by heavy metal pollution is a serious threat to human health and food safety because the majority of these metals are toxic even at extremely low concentration levels (Abduljaleel, Shuhaimi-Othman, & Babji, 2012).

Cd and Pb are examples of toxic non-essential metals that tend to be accumulated in animal products. For instance, Pb in meat is ingested by people through their digestive systems, interfering with the body's ability to make hemoglobin and perhaps inhibiting many enzymes. Furthermore, heavy metals can cause a variety of harms to biochemical systems, including problems with the heart, bones, kidneys, brain, liver, and nervous system (Ekhator *et al*., 2017). Some studies on the presence of heavy metals in meat samples revealed a clear association with animal feeds and concluded that the primary intake source for these metals is the bioaccumulation of these metals in animal feeds (Kim & Koo, 2007). Between different animal species and between different types of tissues within the same animal, there are considerable differences in the distribution and bioaccumulation of trace elements (John and Jeanne, 1994). Pb and Cd are some examples of heavy metals that may be hazardous, whereas Cu is example of heavy metals that are necessary. When exposed to the body over an extended length of time, toxic metals are exceedingly detrimental even at minimal amounts. Excessive ingestion of necessary metals can also have toxic effects (Abduljaleel *et al*., 2012; Nighat *et al*., 2016; Uluozlu, Tuzen, Mendil, & Soylak, 2009).

The Sulaymaniyah region's massive agricultural and industrial operations are the primary cause of environmental contamination. Additionally, Sulaymaniyah is an economically active city with several industries, including the cement, iron, and steel sectors, in addition to a sizable power plant and a sizable vehicle factory.

There is a dearth of information on the concentrations of heavy metals and their potential negative effects on the consumer population, making native chicken species grown in the Kurdistan region one of the underappreciated foods. To the best of our knowledge, no research has been done to date to estimate the presence of trace elements in the tissues of local chicken in the province of Sulaymaniyah. This study's objective is to ascertain the residual concentration levels of a few heavy metals in various backyard chicken parts (liver and breast).

MATERIALS AND METHODS

Study area and sample collection

Sulaymaniyah province, also known as Slemani. It is bounded to the northeast by the Azmar, Goyzha, and Qaywan Mountains, to the south by Baranan Mountain, and to the west by the Tasluja Hills. It has a semi-arid climate, therefore the city has very hot and dry summers and cool and wet winters.

The sample collection, the tested region is divided into four sub-regions (Bazyan, Dukan, Mergapan and Tanjaro) as shown in Figure 1. Sixty (60) backyard chickens were collected from these regions

(15 chickens from each region). All chickens almost had the same age and weight, (6-9) month of age and (1.5-2) kg of weight. However, all chickens ingest the same diet which include same cereals and home food waste in village. The collected chickens were then directly transported to a higher education research laboratory, College of Agricultural Engineering Sciences, where different tissue parts including breast and liver were isolated after dissection. A total of 60 liver tissues in adult backyard chickens were collected by means 15 samples for each region similarly a total of 60 breast muscle tissues in adult backyard chickens will be collected by means 15 samples for each region. The samples were stored in clean polythene bags at -20 °C until further processing.

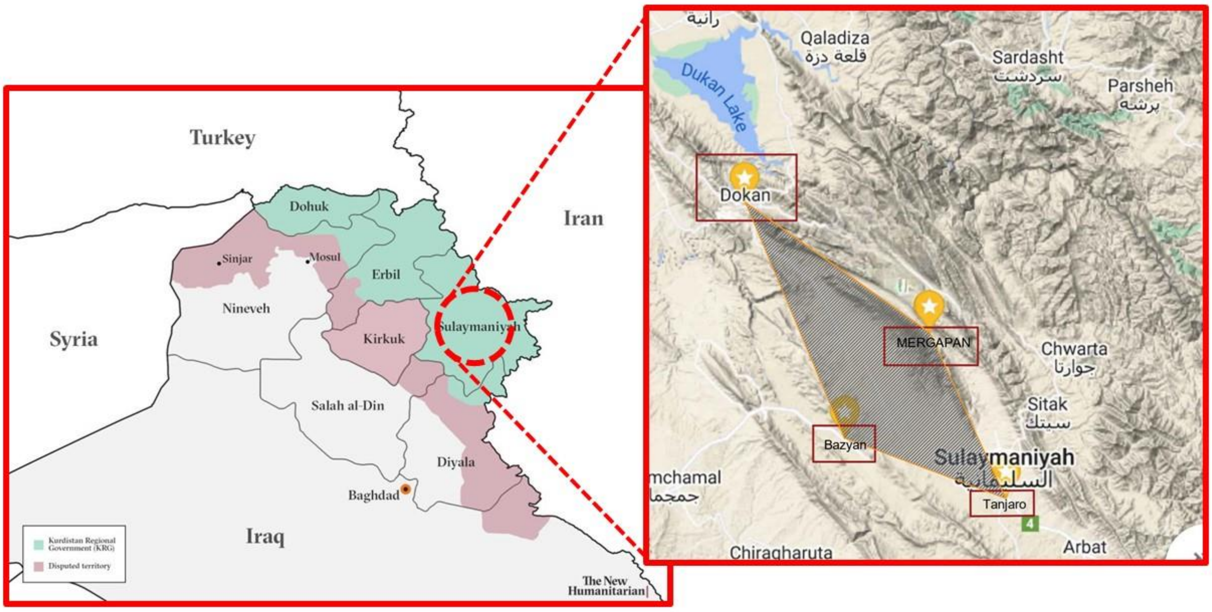

Fig1. Study area in Sulaymaniyah province

Sample preparation and microwave digestion procedure

Metal analysis was carried out using the previously described procedure (Sadeghi *et al*., 2015). Briefly, liver and breast samples were cut into individual pieces, fully homogenized using a stainless-steel knife, and dried in an oven at 105°C for 12 hours or to get constant weights.
Samples were ground to a fine powder in a kitchen mixer grinder to accelerate the digesting process. From each sample, three subsamples were selected for analysis.
In this study, a microwave oven with 16 Teflon digesting vessels was employed. The polytetrafluoroethylene (PTFE) digestion vessels were properly cleaned with doubly distilled water and rinsed with 5 ml of concentrated nitric acid before each digestion. One (1) g of the dried and homogenized sample was precisely weighed and added to the designated vessel.
Eight (8) mL of 69% nitric acid (HNO_3) and 1 mL of 30% hydrogen peroxide (H_2O_2) were poured into each vessel. The procedure's details were modified somewhat from (Gebretsadik, Berhanu, & Kefarge, 2015). Under a fume hood, each sample was given at least 5 minutes to stand before being firmly sealed. Immediately following digestion, the vessels were allowed to cool to room temperature. After any necessary filtering water (with a Whatman No. 40 filter), the mixture was placed into a 50 mL volumetric flask and diluted to volume with distilled deionized. Prior to analysis, all samples were kept in plastic bottles and storage at incubator at 25ºC for 24 hr. until analysis.

Metal analysis

For the elemental analysis of digestion solutions, iCAP 7600 Dual/ ICP-OES (Thermofisher-Germany) was used. All of the digested samples' heavy metal concentrations for Cd, Cu , and Pb

were assessed using standardized techniques (Deng, Zhang, Chang, & Wang, 2007; Sadeghi *et al*., 2015). The estimated concentrations were then measured in µg·mL-1 (parts per million), and after using the dilution factor, converted to mg·g-1 (Deng *et al*., 2007; Sadeghi *et al*., 2015).
Average concentrations were compared to the Codex Alimentarius Commission's acceptable limits (FAO/WHO, 2014).

Statistical analysis
The (XL Stat) application was used to do statistical analysis. The computed results of the heavy metal determination were displayed as mean ± SD, and a one-way analysis of variance (ANOVA) was performed to assess if there was a statistically significant difference in the total quantity of metal present in the various tissue parts and geographical locations. To determine if there were statistically significant variations between means, we utilized Duncan's multiple range tests, with a P-value of.0.05.

RESULT AND DISCUSSION
Cadmium
The concentration of Cd detected in the liver samples collected from Bazyan, Dukan, Mergapan and Tanjaro in Sulaymaniyah province (Table 1) were 0.266, 0.355, 0.227 and 0.132 mg/kg, respectively. Cd concentration in the liver sample from Dukan area was significantly higher ($P<0.05$) than other area and ascending order was Tanjaro < Mergapan < Bazyan < Dukan.
The FAO/WHO Codex Alimentarius and the European Union set a permissible limit of 0.5 mg/kg in liver for Cd in chicken samples (Zhuang, Zou, Lu, & Li, 2014). However, the obtained results for Cu was greater than it, while the results for Cd and Pb were least than it.

Table 1. Mean concentrations of heavy metals in backyard chicken liver samples in four locations at Sulaymaniyah province expressed as mg/kg (mean ±SD).

Regions	Cd	Cu	Pb
Bazyan	ab 0.266 ±0.071	b 6.701 ±0.326	a 0.729 ±0.269
Dukan	a 0.355 ±0.06	a 11.541 ±0.476	b 0.158 ±0.014
Mergapan	ab 0.227 ±0.02	a 11.372 ±1.208	b 0.091 ±0.023
Tanjaro	b 0.132 ±0.019	b 5.755 ±0.453	b 0.147 ±0.021

Means with different superscript in the same column are significantly different at ($p\leq0.05$)

Concerning Cd level in the breast sample, the data pertaining to the observed mean concentration of Cd in the analyzed samples of four locations mentioned above in backyard chickens at Sulaymaniyah province are presented in Table 2. The average Cd concentration in the studied breast tissue decreased as follows: Mergapan > Dukan > Tanjaro > Bazyan. Mergapan had the highest mean Cd concentration (0.022 mg/gm), whereas Bazyan had the lowest (0.011 mg/kg). Breast meat samples had Cd levels below the FAO/WHO Codex Alimentarius and European Union maximum allowed level of 0.3 mg/kg for poultry (Zhuang *et al*., 2014).
On the other hand, concerning the mean concentrations of detected Cd in backyard chickens (breast and liver) together are depicted graphically in Figure 2. There is a significant ($P<0.05$) difference

between regions in terms of Cd heavy metal. According to the Figure all of the regions except Dukan region have acceptable limit that is below (0.3 mg/ kg) for the Cd content according to the limit fixed by FAO/WHO Codex Alimentarius and European Union (Zhuang *et al*., 2014). The data obtained from Figure 2 observed that Dukan region had a higher Cd content (0.375 mg/kg) and Tanjaro region had a lower content (0.147 mg/kg).

From the results it could be observed that the Cd contamination was high in the liver samples collected from backyard chicken in Dukan region but was within permissible quantity in liver and breast samples in backyard chicken collected from the rest of region, indicating that all potential sources of Cd contamination, including feeds and the atmosphere, are relatively low (Jose, Srimuruganandam, & Nagendra, 2019). There for it could be said that it is safe for consumption.

The current study indicated that the concentration of Cd in all samples (liver and breast) was greater than study conducted by (Aljaff, Rasheed, & Salh, 2014) in Kurdistan when assessment the concentration of heavy metals in liver of cow, chicken and sheep. However, are in agreement with that obtained by (Jawad, Abedali, & Khalef, 2021) in Iraq (0.025-0622 mg/kg), (Ersoy, Uzatıcı, & Bilgücü, 2020) in Turkey (0.0135-0.0518 mg/kg), (Hussain, Ebraheem, & Moker, 2012) in Iraq (0.124 mg/kg), (Abduljaleel *et al*., 2012) in Malaysia (0.159 mg/kg) and (Sadeghi *et al*., 2015) in Iran (0.37 mg/kg).

In contrast to this study, researchers in Turkey found that the Cd concentrations in chicken samples to be between 0.25 and 6.09 µg/kg (Vickers, 2017) while, in Canada it was between 1 and 2 µg/kg (Dabeka & Mckenzie, 1995), and in Nigeria it was between 0.05 and 0.9 mg/kg (Onianwa, Lawal, Ogunkeye, & Orejimi, 2000).

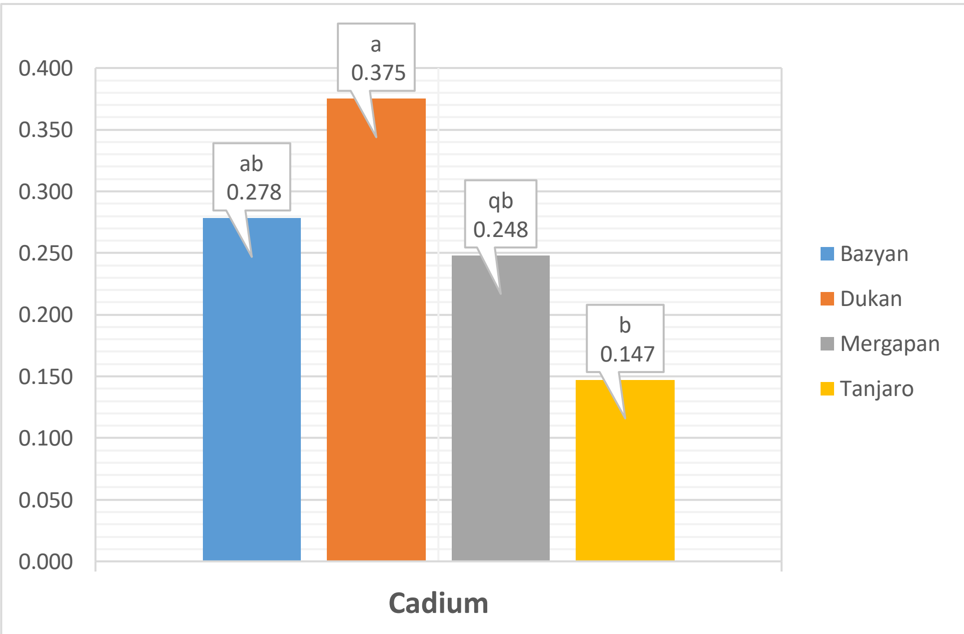

Fig 2: Mean concentration of Cadmium level expressed as (mg/kg) in backyard chickens (breast and liver) together at various regions of Sulaymaniyah province

Cd exposure may have occurred when animals encountered Cd-plated objects, garbage, paint, plastic, or electroplating wastes. The amount of Cd in meat was dependent on the levels of Cd in the diet and increased as the animal aged. (Elsharawy & Elsharawy, 2015) stated that Cd can build up in human body and cause kidney disease, hypertension, hepatic damage, and lung damage.

Lubricating oils, diesel oil, fertilizers, rubber car tires, and the usage of Cd-containing fertilizers and sludge are the main sources of exposure to Cd (Skalicka, Korenekova, & Naď, 2008). Due to their ability to sense Pb and Cd poisoning in water, air, and soil, animals in the wild may act as sentinels for these metals (Bischoff, Priest, & Mount-Long, 2010; Ceruti *et al*., 2002). Cd buildup in humans can result in skeletal deterioration, kidney failure, and reproductive issues (Fallah, Saei-Dehkordi, Nematollahi, & Jafari, 2011; Uluozlu *et al*., 2009).

Copper

Table 1 displays the findings of Cu concentration (mg/kg) measurements made in liver backyard chickens in various Sulaymaniyah province locations. Cu concentrations in liver samples taken from Bazyan, Dukan, Mergapan, and Tanjaro were 5.755, 6.701, 11.372, and 11.541 mg/kg, respectively. Tanjaro had the lowest concentration of Cu (5.755 mg/kg), and Dukan had the highest concentration (11.541 mg/kg). Samples taken from the remaining regions showed values ranging from 5.755 to 11.372 mg/kg.

Because the measured Cu contents in the liver samples were higher than the FAO/WHO Codex Alimentarius and European Commission's maximum permitted level (1.0 mg/kg) for poultry (Zhuang *et al*., 2014),it is suggested that the consumers in the studied regions of Sulaymaniyah province may be at risk and that the liver is contaminated with Cu. While Cu accumulates mostly in muscle and liver, where it serves as a necessary element, it can also have long-term harmful effects on both animals and humans when concentrations exceed safe levels.

Table 2. Mean concentrations of heavy metals in backyard chicken breast samples in four locations at Sulaymaniyah province expressed as in mg/kg (mean ±SD).

Location	Cd	Cu	Pb
Bazyan	b 0.011±0.003	a 3.832±0.748	ab 0.082±0.056
Dukan	a 0.020±0.001	ab 2.397±0.325	ab 0.118±0.034
Mergapan	a 0.022±0.002	ab 2.928±0.987	b 0.022±0.009
Tanjaro	b 0.015±0.002	b 1.683±0.286	a 0.149±0.029

Means with different superscript in the same column are significantly different at ($p \leq 0.05$)

Regarding the Cu level in breast sample, Table 2 indicated the mean concentration of Cu in the examined breast samples of backyard chicken at Bazyan, Dukan, Mergapan and Tanjaro area of Sulaymaniyah province. Among the analyzed locations, the mean concentrations of Cu followed the descending order of: Bazyan > Mergapan > Dukan > Tanjaro. Data about the levels of Cu residue in backyard chickens' samples (Breast and liver) together collected from Sulaymaniyah province are presented in Figure 3. According to the available data, all the analyzed regions had high average Cu element concentrations with a significant difference between them. These means were interestingly greater than the standard permitted values of Cu, which were 0.4 mg/kg according FAO/WHO Codex Alimentarius and European Commission (Zhuang *et al*., 2014). Mergapan region recorded the highest concentration (14.301 mg/kg) of Cu, while the Tanjaro region recorded the lowest concentration (7.438 mg/kg).

Tanjaro had the lowest mean concentration of Cu (1.68 mg/kg), while Bazyan had the highest (3.83 mg/kg). Statistically significant differences ($P<0.05$) were observed for Cu concentrations among locations of breast chicken meat samples. The breast studied samples had Cu levels higher than the FAO/WHO Codex Alimentarius and European Union's maximum allowed Cu content (0.4 mg/kg) in poultry (Hussain *et al*., 2012; Zhuang *et al*., 2014), indicating these meats are contaminated with Cu and may be dangerous for consumers. Cu element concentrations were found in the current study to vary significantly between locations and were found to be relatively high in both the liver and breast samples of backyard chickens. Cu's FAO/WHO-recommended maximum allowable level is 0.4 mg/kg, therefore these averages are far higher than that.

The obtained results was higher than previous results conducted by many researcher (Jawad *et al*., 2021) who reported that the concentration of Cu in liver and meat chickens at Thi-Qar province in Iraq were in the range (0.338-3.370 mg/kg). (Ersoy *et al*., 2020) who found that copper residues in chicken and their products reared near the cement industry were (0.332-2.489 ppm). Also with result obtained by (Aljaff *et al*., 2014) when assessing heavy metals in the livers of chickens in Kurdistan and stated that the concentration of copper was (0.1583 mg/kg).

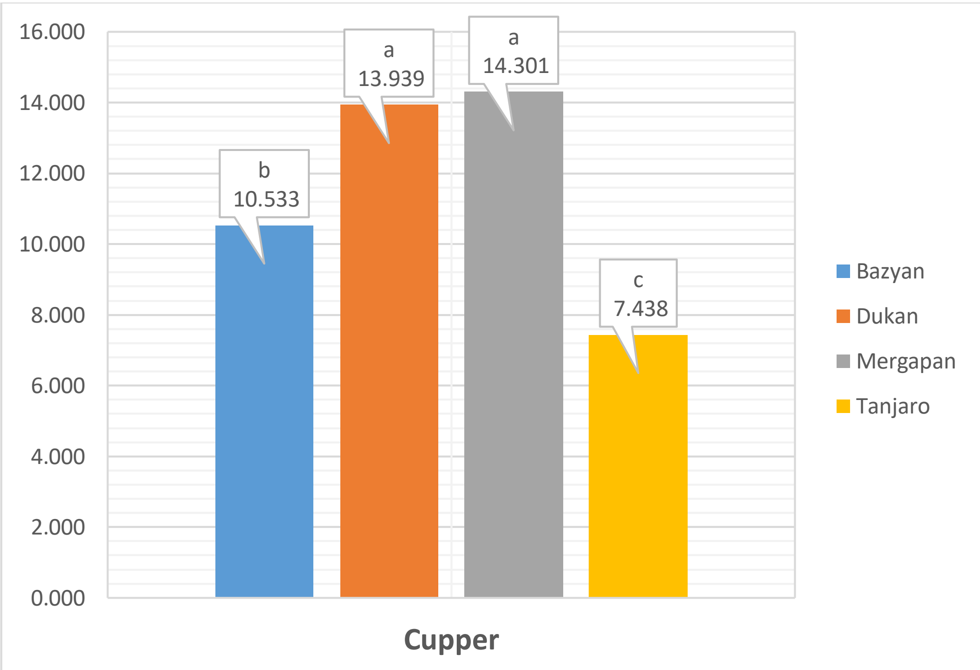

Fig 3: Mean concentration of copper level expressed as (mg/kg) in backyard chickens (breast and liver) together at various regions of Sulaymaniyah province

Cu concentrations in chicken samples have been reported in other research to range from 1.00-1.13 µg/g in Nigeria (Onianwa, Adeyemo, Idowu, & Ogabiela, 2001), 0.3-3.5 µg/g in Brazil (Ferreira *et al*., 2005), 0.10-114 µg/g in Turkey (Uluozlu *et al*., 2009), and 0.34-3.67 µg/g in Ghana (Bortey-Sam *et al*., 2015). For biological systems, Cu is both necessary and harmful (at higher levels). Cu enters the food chain through various routes, including industrial food processing, environmental contamination from agricultural inputs, metal-based industries, and the transfer of Cu from contaminated soils to the crops themselves (Onianwa *et al*., 2001).

The liver is known to have the highest concentration of heavy metals since it processes all the material that enters the digestive tract and is thus exposed to toxic elements (Jawad *et al*., 2021). Throughout the present research, we discovered that heavy metal levels differed significantly from one place to the next. It's possible that regional variations in poultry farming and diet explain these results. Pollution of feed and water for poultry, were found to be major contributors to the increased concentration of heavy metals, notably Cu, in backyard chickens across all regions studied (Ghimpeţeanu, Das, Militaru, & Scippo, 2012). However, the main reason for the rise in the concentration of Cu heavy metal in backyard chickens is the widespread use of chemical fertilizers in agriculture and industry in the Bazian region.

Lead

Table 1 displays information regarding the average Pb levels found in liver samples collected from backyard chickens across Sulaymaniyah province. Liver samples in Bazyan, Dukan, Mergapan and Tanjaro showed Pb concentrations (mg/kg) of 0.729, 0.158, 0.091, and 0.147, respectively. Pb concentration in backyard chicken liver from Bazyan location was significantly higher ($P<0.05$) than other locations and reported to be contaminated with Pb at relatively higher level (0.729 mg/kg). The concentration for liver samples was in the order of Bazyan > Dukan > Mergapan > Tanjaro. It is worth noting that, with the exception of the Mergapan location, all of the analyzed liver samples of backyard chicken contained Pb levels that were greater than the maximum allowable Pb concentration (0.1 mg/ kg) in poultry specified by the FAO/WHO Codex Alimentarius and the European Union (Zhuang *et al*., 2014). About Pb levels in breast backyard chicken samples, the mean concentration of Pb (mg/kg) found of four locations at Sulaymaniyah province are presented in Table 2. Among the analyzed breast samples, the mean Pb concentrations followed the descending order of: Tanjaro > Dukan > Bazyan > Mergapan. The highest mean concentration of Pb in chicken breast sample (0.149 mg/kg) was observed in Tanjaro region and the lowest (0.022 mg/kg) was found in Mergapan region. Higher levels of Pb have been found in the Tanjaro and Dukan area than the FAO/WHO Codex Alimentarius and European Union limit permitted lead concentration (0.1 mg/ kg) in chicken (Zhuang *et al*., 2014).

Results achieved in Figure 4 revealed that the concentrations of Pb in the examined samples of backyard chicken (breast and liver) together at four regions in Sulaymaniyah province. The Pb levels in the analyzed regions were found to be significantly ($P<0.05$) affected by the poultry samples. FAO/WHO Codex Alimentarius and the European Union have established a threshold of 0.1 mg/kg for the allowable level of Pb in chicken (Zhuang *et al*., 2014). According to these limits, all tested samples from all regions were higher than allowable levels. The Bazyan region had the highest lead concentration (0.811 mg/kg), followed by Tanjaro (0.296 mg/kg), Dukan (0.276 mg/kg), and finally by (Mergapan), which had the lowest lead content (0.113 mg/kg).

The present study was exposed that the mean concentration of Pb elements in liver and breast samples of backyard chickens were high in all studied region except liver and breast samples collected from Mergapan region and breast sample collected from Bazyan region with significant difference between them. Curiously, these averages were greater than the FAO/WHO Codex Alimentarius and European Union-mandated maximum allowable limits of Pb, which are 0.1 mg/kg (Zhuang *et al*., 2014).

This study is consistent with the findings of a number of other studies that have reached similar conclusions. (Jawad *et al*., 2021) observed that the Pb concentration in liver and meat samples of chickens in Thi-Qar province in Iraq in the range of 0.120-1.1.177 mg/kg. However, Ersoy *et al*.

(2020) stated that the lead residues in poultry and their products that are bred around cement industry in Turkey were in the range (0.0138-0.0650 ppm).

However, (Hussain *et al.*, 2012) found that the Pb level of chicken sold at local markets in Basrah City, Iraq, varied between 0.171 to 3.269 mg/kg. After analyzing the Pb residual levels in chicken giblets sold in Ismailia, Egypt, (Ismail & Abolghait, 2013) found that the highest concentrations were observed in liver samples (0.8762 ppm), followed by gizzard samples (0.3186 ppm), and finally heart samples (0.1733 ppm). One possible source of Pb contamination is the high levels of the element in the air over polluted areas. Any contaminated location in Sulaymaniyah province could have such a high percentage of Pb. Higher levels of Pb were found in the liver samples of backyard chickens from the Bazyan region of Sulaymaniyah province, which may be attributable to the greater concentration of vehicles and refining companies in that area. In addition, the prevalence of contaminated industrial areas has led to an increase in the careless disposal of trash.

The high bio accumulative qualities of Pb in muscle tissues of animals may explain the increased levels of Pb seen in meat samples. Pb contamination in agricultural soils due to air deposition shows a potential increase in Pb residue deposition (Islam & Desk, 2018).

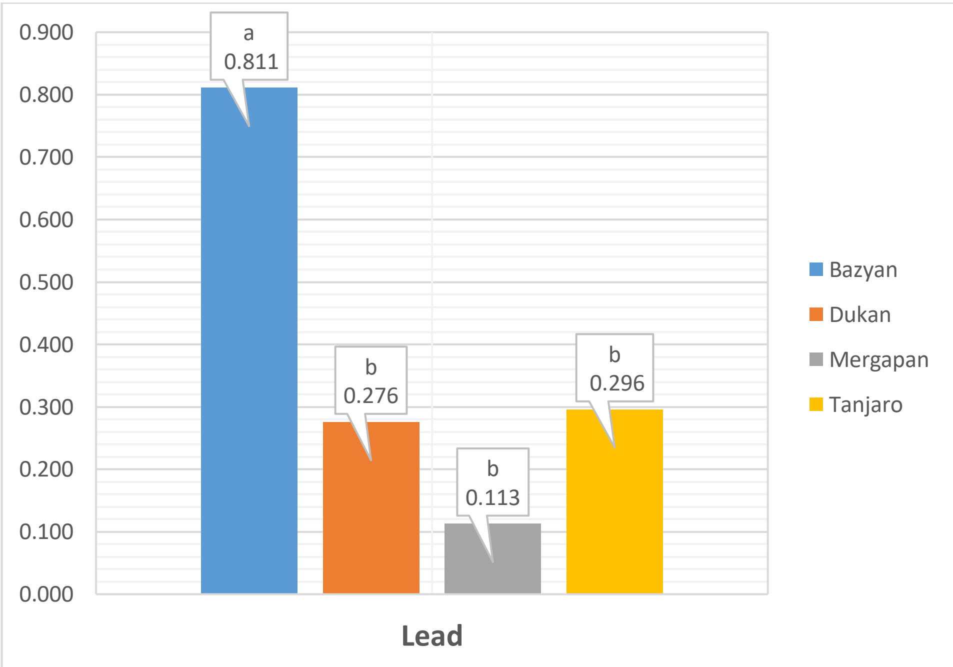

Fig 4: Mean concentration of Lead level expressed as (mg/kg) in backyard chickens together at various regions of Sulaymaniyah province

The main sources of Pb in the environment are the widely used industrial processes for producing perfumes, batteries, oils and fats, cement, and bricks, as well as agricultural discharges, sewage effluents, highways, or motorboat traffic, mine and smelting operations. Manufactured waste products dumped into the environment (including but not limited to air, land, water, and food) have poisoned countless people and animals (Humphreys, 1991; Mahaffey, 1977). According to (Jawad *et al.*, 2021), the exposure of the chicken to diverse sources of contamination at each of the study locations led to differences in the results.

Because no amount of Pb exposure is considered acceptable by the World Health Organization, Pb is one of the potentially harmful elements found in environmental samples, and its increased level in foodstuffs is of particular concern. Adults can safely consume no more than 3 mg of Pb per week.

(Organization, 1978). One of the main reasons why Pb poisoning occurs is due to Pb's affinity for attaching to the sulfhydryl group found in many enzymes. Pb exposure has been linked to intellectual disability in children and increased risk of cardiovascular disease in adults (Uluozlu *et al*., 2009). Chickens in Turkey were found to have Pb concentrations of 0.01 to 0.40 μg/g (Uluozlu *et al*., 2009), whereas those in Ghana had Pb contents of 0.13 to 0.38 mg/kg (Bortey-Sam *et al*., 2015). Bangladeshi and Iranian studies have found previously documented elevated Pb levels in chicken meat and offal, respectively (Islam *et al*., 2015; Sadeghi *et al*., 2015). A detailed trend analysis of monitoring results conducted in the Netherlands (Adamse *et al*., 2017) revealed, however, that the use of feed components of mineral origin and toxic binders of clay origin could be the source of any potential Pb contamination of feeds. Contaminated water, fuel, and paint can all be sources of Pb exposure. Pb toxicity was particularly dangerous for humans, both young and old, and might result in a wide range of adverse health effects, including neuropathy, liver apoptosis, renal toxicity, and hemolytic anemia (Khalafalla, Ali, Schwagele, & Abd-El-Wahab, 2011).

CONCLUSIONS

Conclusions drawn from this study indicate that all samples of backyard chickens tested positive for heavy metals (Cd, Cu, and Pb). The results demonstrated that, in most cases, the concentration of (Cu and Pb) was more than what is considered safe by the FAO/WHO. The levels of metals in breast samples are generally the lowest, whereas liver samples have the highest levels overall. Therefore, regulation is needed to oversee the quality of poultry and poultry products, as well as the feeding and litter of chickens, in order to improve the quality of poultry and poultry products for human consumption

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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