RESEARCH ARTICLE

Human health risk assessment of some important trace elements in boneless whole chicken meat [version 1; peer review: 2 approved with reservations]

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Abstract

Background: Excessive trace element exposure has been linked to a variety of harmful health impacts. The goal of this study was to track the amounts of several trace elements in boneless whole chicken samples collected from various shops in Amman, Jordan.

Methods: Using inductively coupled plasma-optical emission spectroscopy (ICP-OES), 30 samples were collected and examined for aluminum (Al), arsenic (As), cadmium (Cd), chrome (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), iron (Fe), lead (Pb), and zinc (Zn). The calculated health risk in Jordanians was based on the measured concentrations of these elements.

Results: The element concentrations were such that $Fe > Zn > Al > Mn > Cu > Cr > As > Pb > Cd > Hg$, with As, Cu, Mn, and Zn exceeding the maximum allowable levels. The combined THQs for these trace elements, on the other hand, were 25.22, a value > 1 , indicating a non-carcinogenic effects in adult population. As, Cd, and Cr had cancer risk factors that were 46.80, 8.81, and 41.42 times higher than the acceptable lifetime carcinogenic risk (10^{-5}), respectively.

Conclusions: Current research shows that Jordanian consumers are at risk of eating boneless whole chicken.

Keywords

Trace elements, Fish, Estimated daily intake, Health risk assessment, Carcinogenic risk, Non-carcinogenic risk, ICP-OES.

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Introduction

Poultry chicken meat is a major source of animal protein and is distinguished by the presence of numerous essential amino acids that are necessary for human health and growth. Despite its high biological value, the quality of poultry meat may be compromised by trace element contamination caused by emissions from various anthropogenic activities (Mottalib *et al.*, 2018). Bioaccumulation of trace elements in meat poses a risk to human health and can result in a variety of adverse health effects due to its persistent and non-biodegradable nature (Al-Subeihi, 2021). Without pollution prevention measures, industrial activities cause increased concentrations of trace elements to enter the environment (Akan *et al.*, 2010). Consumption of contaminated food may establish a significant source of non-occupational exposure for the general population (Filippini *et al.*, 2019). Trace elements in poultry meat may pose potential health risks to humans (Mottalib *et al.*, 2018). Few studies have been conducted to investigate the accumulation and contamination of trace elements in chicken diets in order to assess the potential risk of human consumption (Mottalib *et al.*, 2016).

As a result, it is very important to determine the trace elements content of chicken meat so that it does not harm health and keeps its levels within acceptable ranges (Uysal *et al.*, 2008; Palaniappan and Karthikeyan, 2009). Regulatory bodies in several countries, including the World Health Organization (WHO), Food and Agriculture Organization (FAO) and the European Union (EU), have established maximum permissible concentrations of trace elements in foods (Xue *et al.*, 2012; Sridhara Chary *et al.*, 2008). The maximum acceptable limits for Lead (Pb), Cadmium (Cd), Copper (Cu), and Zinc (Zn) in poultry meat, for example, are 0.1, 0.05, 1, and 20 mg/kg (EU, 2006; FAO/WHO, 2002). Chronic ingestion of large amounts of toxic trace elements from food has been associated with nervous system disorders, increased mortality, cardiovascular disease, morphological abnormalities, kidney disease, growth retardation, various forms of cancer, and genetic effects in humans (Shariatifar *et al.*, 2020). Aluminum (Al), for example, has been shown to cause neurotoxicity in humans. It has been linked to the cause of sporadic Alzheimer's disease (AD) and other neurodegenerative diseases (Yokel, 2012). Mercury can also harm the central nervous system and kidneys (Kimáková *et al.*, 2018). Additionally, the International Agency for Research on Cancer (IARC) has identified several trace elements, including Cd, Nickel (Ni), and Arsenic (As), as carcinogens to humans. (Mulware, 2013). Exposure to inorganic As, for example, has been related to lung and skin cancer (Perschagen, 1981). Cd is a lung carcinogen that also causes prostatic and renal cancers (Rahimzadeh *et al.*, 2017). Long-term exposure to chemical contaminants is most likely associated with potential health risks, which can be estimated using both the cancer risk measure (CR) and the target hazard quotient (THQ) (USEPA, 2011). CR assesses the risk of cancer after exposure to trace elements during one's lifetime (Bello *et al.*, 2017). THQ, on the other hand, is defined as the proportion of exposure to the measured concentration to the oral reference dose, which is the highest concentration at which no adverse health effects are expected (Kortei *et al.*, 2020). Despite Jordan's food and drug administration (JFDA) inspects food for some unwanted chemicals, it is unfortunate that trace elements are not inspected in boneless chicken (Shawarma) in Jordan. The main goal of this study is to use an appropriate spectroscopic method to quantify trace element concentrations in chicken samples (Shawarma) collected from various shops in Amman, Jordan. Another goal is to compare the findings of this study to previous studies published in the literature, as well as the international maximum acceptable levels. Finally, the potential health risk associated with trace element consumption will be estimated, and recommendations for both Jordan's official administrators and consumers will be established.

Methods

Sample collection

The sampling period was completed in June 2021. A total of 30 random samples of boneless whole chicken were purchased from various shops in Amman, Jordan, and immediately dried in an oven at the selected temperature. The trace element content of each chicken sample was expressed in milligrams per kilogram of dry weight.

Materials

A purification water system from Millipore was used to deionize water. Nitric acid 70% was bought from Biosolve chemical company (Valkenswaard, Netherlands), and multielement standard calibration solution 1000 mg/L was obtained from Accustandard supplies (New Haven, USA). All glassware used in this study was decontaminated overnight with 10% HNO₃ and rinsed with purified water.

Sample preparation

Whole boneless chicken samples were dried in oven at 105 °C until a consistent weight was achieved. Following that, one gram of each dry sample was placed in a pressure-resistant Teflon (PTFE-TFM) flask and digested with Milestone ETHOS 1 microwave oven (Soriso, Italy) in accordance with the food safety and standards authority of India (FSSAI) (FSSAI, 2016) with modifications on the digestion protocol which includes the temperature, the time, and the microwave power. For each chicken sample, 7 ml of HNO₃ and 1 ml of H₂O₂ were introduced into separate flask. The flask was capped tightly then heated following the microwave digestion protocol: 1800 W at 180°C (ramp time 15 minutes, holding time 15 minutes, and cooling time 15 minutes). After cooling, all digested combinations were filtered and diluted to 100 mL with distilled water.

Analysis of digested chicken samples

A Thermo Fisher Scientific iCAP 7400 ICPOES Due was used in combination with a Burgener mira mist atomizer and a glass cyclone chamber to detect trace elements in digested chicken samples. For optimal operating conditions, the ICPOES was tuned to a radio frequency (RF) power of 1150 W, nebulizer gas flow at 0.5 L/min, cooling gas flow at 14.5 L/min, and auxiliary gas flow at 0.5 L/min. Each digested sample was tested three times.

Validation of analytical method

Percent recovery, linearity, limit of quantitation (LOQ), limit of detection (LOD), and precision are validation parameters for the analytical method, as shown in Table 1. The validation of the method was carried out in accordance with the International Conference on Harmonization (ICH) guidelines (ICH, 1996). Furthermore, a certified reference material (CRM) was used to validate the current study's analytical approach (Animal Origin Reference Material). After being treated to a microwave acid digestion, the CRM was tested with ICP-OES in the same way as actual chicken samples.

Risk assessment

Risk scores for the current study were calculated by examining chicken samples to determine daily intake (EDI), risk ratio (THQ), and carcinogenic risk (CR).

Estimated daily intake (EDI)

Ingestion is a common way humans are exposed to trace elements. The daily intake (EDI) of trace elements for adults eating boneless chicken was calculated using the following equation (Alipour and Banagar, 2018):

$$EDI = \frac{C_m \times FIR \times EF \times ED}{(BW \times TA)}$$

where C_m is the metal concentration in mg/kg dry weight in boneless chickens. EF - frequency of exposure (365 days/year). FIR - Chicken consumption rate (for adults, 0.085 kg/(person × day); ED is the duration of exposure (60 years). Assume an average adult body weight (BW) of 79 kg and TA is the mean time to non-carcinogenic substances (365 days/year × ED) (Saha *et al.*, 2016). When calculating health risks, it was assumed that the swallowed pollutant quantity is equivalent to the absorbed contaminant amount (USEPA, 1989) and that cooking had no influence on contaminant concentrations (Cooper *et al.*, 1991). The exposure parameters considered in risk estimations are listed in Table 2 (USEAP, 2012).

Target hazard quotient (THQ)

The non-carcinogenic risk to the population from consuming contaminated chicken was calculated using the target hazard quotient (THQ). THQ was calculated by dividing the estimated daily intake (EDI) of trace elements in polluted boneless chicken by the reference oral dose (RfD) for each element (Mortazavi and Fard, 2017). When THQ is less than 1, trace elements is less likely to have serious health effects. A THQ greater than 1 increases the likelihood that this trace element is hazardous to health (USEAP, 2012). THQ was calculated using the following formula:

Table 1. Validation of the ICP-OES analytical method for determining the selected boneless whole chicken samples.

Trace element	Certified value (mg/kg)	Measured value (mg/kg)	LOD (mg/kg)	LOQ (mg/kg)	Recovery (%)	Intraday precision (mg/kg)	Inter-day precision (mg/kg)	Linear range (mg/kg)
Al	3.00	3.33	0.00352	0.0045	107%	1.5550%	0.29000%	0.0045-5.0
As	3.00	3.015	0.0015	0.0025	98.40%	0.1900%	0.17000%	0.0025-5.0
Cd	3.00	2.881	0.001	0.005	96.98%	0.0010%	0.22000%	0.0005-5.0
Cr	3.00	2.86	0.005	0.001	109.95%	0.0052%	0.33000%	0.001-5.0
Cu	3.00	2.752	0.005	0.0025	91.75%	0.0039%	0.33000%	0.0025-5.0
Fe	3.00	2.753	0.0015	0.0025	91.77%	0.0157%	0.55000%	0.0025-5.0
Hg	3.00	3.89	0.001	0.005	117%	1.6570%	0.89000%	0.0005-5.0
Mn	3.00	2.688	0.001	0.001	89.60%	0.0015%	0.55000%	0.0005-5.0
Pb	3.00	2.729	0.005	0.001	90.99%	0.0017%	0.23000%	0.0001-5.0
Zn	3.00	3.07	0.005	0.005	102.34%	0.0120%	0.17000%	0.001-12.0

Table 2. Exposure parameters used for the assessment of health risk from food consumption (USEPA, 2012).

Parameter	Unit	Adult
Body weight	kg	79
Exposure Frequency (EF)	Days/years	365
Exposure Duration (ED)	Years	30
Average Time (AT)	Days/years	
For carcinogenic		365×70
For non-carcinogenic		$365 \times ED$

$$THQ = \frac{EDI}{RfD}$$

Carcinogenic risk (CR)

The CR is a measure of the likelihood of developing any type of cancer as a result of lifetime exposure to carcinogenic elements. Using the cancer slope factor, the CR over a lifetime of exposure was predicted using the following equation (Peng *et al.*, 2016; Shaheen *et al.*, 2016):

$$CR = \frac{EF \times ED \times FIR \times Cm \times CSF}{(BW \times TA)}$$

where CSF denotes the cancer slope factor (mg/kg/day), and the rest of parameters have already been described. An acceptable lifetime carcinogenic risk of 10^{-5} has been established by USEPA (Saha *et al.*, 2016).

Statistical analysis

Microsoft Excel software was used in performing all statistical analysis. Descriptive statistics include the arithmetic mean (AM), percentile (P), standard deviation (SD), and range (min-max). Pearson's correlation coefficient analysis (PCA) can be applied to the measurement data to determine the source of trace elements quantified by ICP-OES. PCA calculates the strength of association between two variables on a scale of -1 (perfect inverse relation) to +1 (perfect sympathetic relation) (Adebiyi *et al.*, 2020). If two variables have a strong relationship, they may be derived from the same parent.

Results and discussion

Concentrations of trace elements in boneless chicken meat

The central limit theorem (CLT) was used to determine the sample size ($n = 30$) (Mascha and Vetter, 2018; Brussolo, 2018; Kwak and Kim, 2017). ICP-OES was used to test boneless chicken samples for Al, As, Cd, Cr, Cu, Fe, Hg, Mn, Pb, and Zn. Table 3 displays some basic statistics for trace element concentrations in boneless chicken samples. The mean

Table 3. Concentrations of trace elements with various confidence intervals^a.

Trace element	Mean (mg/kg)	SD (mg/kg)	Min	P25	P50	P75	Max
Al	8.77	5.79	2.25	5.18	8.23	12.92	25.52
As	0.29	0.06	0.142	0.25	0.29	0.32	0.419
Cd	0.013	0.0045	0.006	0.01	0.012	0.016	0.024
Cr	0.77	0.16	0.524	0.67	0.73	0.89	1.089
Cu	1.37	0.26	0.943	1.22	1.35	1.46	2.316
Fe	23.44	6.89	15.629	20.78	23.25	27.30	44.48
Hg	<0.0005	-	-	-	-	-	-
Mn	3.74	1.43	1.532	2.60	3.88	4.54	6.473
Pb	0.063	0.035	0.003	0.043	0.062	0.079	0.169
Zn	28.22	5.01	19.51	26.21	27.83	30.67	43.33

^aThe statistical parameters of Min, Max, Mean, SD, and P were used to show the variations in data.

Table 4. International guidelines levels.

Trace element	Variation of data (mg/kg)	Mean concentration (mg/kg)	MHPRC permissible limit (mg/kg)	FAO/WHO permissible limit (mg/kg)	EC permissible limit (mg/kg)	USEPA permissible limit (mg/kg)	WHO permissible limit (mg/kg)
Al	2.25 – 25.52	8.77	-	-	-		
As	0.142 – 0.419	0.29	-	0.1 ^d			0.1
Cd	0.013 – 0.24	0.013	0.1 ^e	0.05 ^e	0.05 ^e		
Cr	0.16 – 1.089	0.77				1 ^d	
Cu	0.943 – 2.316	1.37	10 ^e	1 ^e	1 ^e		0.4 ^d
Fe	15.629 – 44.48	23.44		-	-		
Hg	N.D.	<0.0005			1 ^g		
Mn	1.532 – 6.473	3.74		0.5 ^f			
Pb	0.003 – 0.169	0.063	0.2 ^e	0.1 ^e	0.1 ^e		
Zn	19.51 – 43.33	28.22	100 ^e	20 ^e	20 ^e		

^aMHPRC (2013).^bEl-moselhy *et al.* (2014).^cHosseini *et al.* (2015).^dMottalib *et al.* (2018).^eZhuang *et al.* (2014).^fJayanthi (2019).^gMathaiyan *et al.* (2021).

concentrations of Al, As, Cd, Cr, Cu, Fe, Hg, Mn, Pb, and Zn were 8.77, 0.29, 0.013, 0.77, 1.37, 23.44, 0.0005, 3.74, 0.063, and 28.22 mg/kg, as shown in [Table 3](#). Concentrations of trace elements in boneless chicken samples decreased in the following order: Zn > Fe > Al > Mn > Cu > Cr > As > Pb > Cd > Hg. The concentrations of Al, As, Cd, Cr, Cu, Fe, Mn, Pb, and Zn in boneless chicken samples ranged from 2.25 to 25.52 mg/kg, from 0.142 to 0.419 mg/kg, from 0.006 to 0.024 mg/kg, from 0.524 to 1.089 mg/kg, from 0.943 to 2.316 mg/kg, from 15.629 to 44.48 mg/kg, from 1.532 to 6.473 mg/kg, from 0.003 to 1.69 mg/kg, from 19.51 to 43.33 mg/kg, respectively. On the other hand, the concentration of Hg in all investigated chicken samples was below the limit of detection (<0.0005 mg/kg).

According to [Table 4](#), the mean As concentration in this study (0.29 mg/kg) was approximately three times higher than the maximum allowable As limits in chicken reported by FAO/WHO and WHO guidelines. This concentration was lower than that reported by [Dionísio *et al.* \(2010\)](#), who found that the concentration range of As determined in chicken production-related samples ranged from 1.30 to 29.8 mg/kg.

Cd is a non-essential element that is not present at birth ([Thabetelsharawy *et al.*, 2019](#)). The mean Cd content in the current study was lower than that reported by [Thabetelsharawy *et al.* \(2019\)](#), which was 0.056 mg/kg ([Table 5](#)). The mean Cd content in this study was below the MHPRC, EC, and FAO/WHO standards of 0.1, 0.05, and 0.05 mg/kg, respectively, as shown in [Table 4](#).

Cu is involved in blood formation as well as glucose and lipid metabolism ([Kwon and Lee, 2001](#)). The mean Cu content in this study was seven times higher than the values published by [Thabetelsharawy *et al.* \(2019\)](#), but equivalent to the concentration reported by [Zhuang *et al.* \(2014\)](#) ([Table 5](#)). The mean Cu content in this study surpassed the WHO, EC, and FAO/WHO standards of 0.4, 1, and 1 mg/kg, respectively, as shown in [Table 4](#).

Hg is a harmful trace element that enters the body through the intake of fish ([Jaishankar *et al.*, 2014](#)). The type, amount, and frequency of exposure to Hg all contribute to human toxicity. Hg salts mostly harm the renal and intestinal walls, whereas elemental mercury vapour causes severe pneumonitis ([Kalay, 1999](#)). Hg is toxic to the human nervous system, and there is evidence of a link between fetal Hg exposure and neurodevelopment in children ([Kimáková *et al.*, 2018](#)). In this study, the Hg content (0.0005 mg/kg) did not exceed the maximum EC limit for chickens of approximately 1.0 mg/kg ([Mathaiyan *et al.* 2021](#)). According to [Mathaiyan *et al.* \(2021\)](#), Hg concentrations ranged from 0.0477 to 0.5457 mg/kg ([Table 5](#)).

Zn promotes wound healing, lipid and glucose metabolism, hormonal function and hair growth ([Topcuoglu *et al.*, 2002](#)). As shown in [Table 4](#), the average Zn concentration (28.22 mg/kg) in this study exceeded the maximum permissible limit for Zn in chicken meat stipulated by FAO/WHO and EU, but did not exceed the maximum limit stipulated by the People's Republic of China's Ministry of Health of China (MHPRC). According to [Table 5](#), the average Zn concentration in this study (28.22 mg/kg) is lower than the corresponding average concentration reported by [Zhuang *et al.* \(2014\)](#).

Table 5. Comparison of the total elemental concentration in this study with similar studies.

Element (mg/kg)	Current study	Amália <i>et al.</i> (2010)	Thabetelsharawy <i>et al.</i> (2019)	Zhuang <i>et al.</i> (2014)	Mottalib <i>et al.</i> (2018)	Korish and Attia (2020)	Mathaiyan <i>et al.</i> (2021)
Al	8.77						-
As	0.29	1.30 to 29.8	-	-	-	-	-
Cd	0.013	-	0.04	0.059	-	-	-
Cr	0.77	-	-	-	3.98	-	-
Cu	1.37	-	0.19	1.43	-	-	-
Fe	23.44	-	7.13	-	-	-	-
Hg	<0.0005	-	-	-	-	-	0.0477 to 0.5457
Mn	3.74	-	-	-	-	241.9 to 297.7	-
Pb	0.063	-	0.30	0.52	-	-	-
Zn	28.22	-	-	42.0	-	-	-

Pb has been linked to delayed development, lower IQ, decreased attention span, hyperactivity, and mental deterioration in children. Memory loss, nausea, insomnia, anorexia, joint weakness, brain, nervous system, red blood cells, and kidney damage in adults (Wuana and Okieimen, 2011). As shown in Table 4, the mean Pb concentration in this study (0.063 mg/kg) was lower than the maximum allowable Pb limits in chicken reported by FAO/WHO, the European Commission, and the People's Republic of China's Ministry of Health (MHPRC). Mean Pb concentrations were found to be lower in the current study than the data of 0.30 mg/kg and 0.52 mg/kg reported by Thabetelsharawy *et al.* (2019) and Zhuang *et al.* (2014), respectively.

Cr has shown to produce skin irritation and ulceration in humans after acute exposure, as well as kidney and liver malfunctions, circulatory and nervous system damage (Wuana and Okieimen, 2011). According to Table 4, the mean Cr concentration was less than the USEPA's concentration threshold (1.0 mg/kg) (Mottalib *et al.* 2018). The mean Cr concentration in this study was 0.77 mg/kg, which was lower than the value found by Mottalib *et al.* (2018) in broiler chicken (3.98 mg/kg).

The mean Mn concentration in this study was 3.74 mg/kg, which was lower than the value reported by Korish and Attia (2020).

Pearson's correlation coefficient analysis (PCA)

Table 6 shows the results of PCA analysis of trace elements tested in boneless chicken samples. A positive correlation was found between As/Pb, Pb/Fe, Cd/Cr and Cu/Cr in PCA analysis. A positive relationship indicates that the elements in the sample have a similar genetic origin, chemical affinity, and/or a common background level, while a negative relationship indicates that the elements are not chemically similar or originate from different sources.

Health risk assessment

Estimated daily intake (EDI) and target hazard quotient (THQ)

Table 7 summarizes the oral reference doses (RfD) of the trace elements studied in this study. The estimated daily intake (EDI) of Al, As, Cd, Cr, Cu, Fe, Mn, Hg, Pb, and Zn in adults is 9.4×10^{-3} , 3.12×10^{-4} , 1.40×10^{-5} , 8.3×10^{-4} , 1.5×10^{-3} , 4.59×10^{-2} , 4.0×10^{-3} , 5.38×10^{-7} , 6.78×10^{-5} , and 3.0×10^{-2} , respectively. Except for Al and As, the EDI values of the investigated elements were lower than their corresponding RfD values. Table 7 shows that the calculated THQ of the trace elements (Al and As) was greater than 1, indicating that Jordanians have a potential health risk if they eat boneless chicken containing these elements.

Cancer risk (CR)

The current study found that the CR factors for As, Cd, Cr, and Pb during a lifetime consumption of contaminated fish were 4.68×10^{-4} , 8.81×10^{-5} , 4.14×10^{-4} , and 5.76×10^{-7} , respectively (Table 7). The United States Environmental Protection Agency has set an acceptable limit for a lifetime cancer risk of 10^{-5} (Saha *et al.*, 2016). The CR of As, Cd, and Cr in this study were higher than the USEPA acceptable value, indicating that people who eat boneless chicken are at a higher risk of developing cancer.

Table 6. Correlation coefficient values between investigated trace elements.

Pearson's <i>r</i>	Al	As	Cu	Cd	Pb	Zn	Fe	Hg	Mn	Cr
Al	1									
As	-0.3	1								
Cu	0.15	-0.37	1							
Cd	-0.03	-0.36	0.33	1						
Pb	0.034	0.53	-0.1	-0.36	1					
Zn	-0.26	0.29	0.25	-0.08	0.12	1				
Fe	0.6	0.12	0.21	-0.24	0.66	-0.045	1			
Hg	0	0	0	0	0	0	0	1		
Mn	0.22	-0.08	0.22	0.4	0.28	0.03	0.26	0	1	
Cr	0.37	0.37	0.49	0.58	-0.26	-0.04	0.12	0	0.3	1

Table 7. Calculated Cancer Risks (CA) and Target Hazard Quotients (THQ) of trace elements in chicken samples.

Trace element	Mean (mg/kg)	RfD (mg/kg bw per day)	EDI (mg/kg bw per day)	THQ	CR
Cu	1.37	0.0371 ^a	1.5×10^{-3}	0.040	-
Zn	28.22	0.3 ^b	3.0×10^{-2}	0.10	-
Pb	0.063	0.0035 ^b	6.78×10^{-5}	0.019	5.76×10^{-7}
Cd	0.013	0.001 ^b	1.40×10^{-5}	0.014	8.81×10^{-5}
Hg	<0.0005	0.0003 ^b	5.38×10^{-7}	0.002	-
Al	8.77	0.0004 ^a	9.4×10^{-3}	23.59	-
As	0.29	0.0003 ^{a,b}	3.12×10^{-4}	1.04	4.68×10^{-4}
Fe	23.44	0.7 ^b	4.59×10^{-2}	0.036	-
Mn	3.74	0.14 ^b	4.0×10^{-3}	0.029	-
Cr	0.77	0.003 ^b	8.3×10^{-4}	0.28	4.14×10^{-4}

^aSource: Kusin *et al.* (2018).^bSource: USEPA (2012).^cSource: Kowalska *et al.* (2020).

Conclusion and recommendation

Concentrations of ten trace elements (Zn > Fe > Al > Mn > Cu > Cr > As > Pb > Cd > Hg) in boneless whole chicken samples collected from various Jordanian markets were determined using ICP-OES in the present study. Zn has the highest average concentration of trace elements in chicken samples, while Hg has the lowest. Health risk assessment of ten trace elements was investigated for a Jordanian population. As a result, toxic elements were ranked in the order of Al > As > Cr > Zn > Cu > Fe > Mn > Pb > Cd > Hg based on the THQ index, highlighting that the total THQ of all trace elements was greater than one. Furthermore, the CRs of As, Cd, Cr, and Pb were 4.68×10^{-4} , 8.81×10^{-5} , 4.14×10^{-4} , and 5.76×10^{-7} , respectively. It can be concluded that exposure to As, Cd and Cr may pose a threat to human health. These metals can accumulate to harmful levels, so JFDA is required to monitor trace elements levels in chicken products commonly consumed in Jordan. In addition, the results of this research shed the light that ICP-OES is a suitable and rapid technique for the determination of trace element concentrations when applied in food industry. Nevertheless, the exposure of these trace elements from many other food sources has not been taken into account in this assessment, which could contribute to the exposure from chicken consumption.

Data availability

Underlying data

Open Science Framework: Human health risk assessment of some important trace elements in boneless whole chicken meat, <https://doi.org/10.17605/OSF.IO/C6VAB> (Al-Subeihi, 2022).

This project contains the following underlying data:

- Table 1. xlsx
- Table 2. xlsx
- Table 3. xlsx
- Table 4. xlsx
- Table 5. xlsx
- Table 6. xlsx
- Table 6_Additional.xlsx

- Table 7. xlsx
- Table 7_Additional.xlsx

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

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Open Peer Review

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Version 1

Reviewer Report 07 April 2022

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Md. Abdul Mottalib

Institute of Leather Engineering and Technology, University of Dhaka, Dhaka, Bangladesh

The author has addressed their findings well in the manuscript. However, please add significance of your findings in a single line in conclusion. Please try to add more recent references especially from 2021-2022 and the author should follow a standard style for all the provided references. There are many mistakes found in the reference part (those are mentioned below) and the author is advised to refined them.

In some cases, Title of the study, incomplete volume and page numbers found in the following references:

1. Alipour H, Banagar GhR: **Title missing** *Iranian Journal of Fisheries Sciences*. 2018; **17**: 21 - **no ending page number**.
2. Bello S, Muhammad BG, Bature B: **Title missing** *J. Sci. Eng.* 2017; **6**. - **Page number missing?**
3. Cooper CB, Doyle ME, Kipp K: **Title missing** *Environmental Health Perspectives*. 1991; **90**: 133. - **Ending page number missing?**
4. El-moselhy KM, Othman AI, El-azem HA, *et al.*: **Title missing** *Egypt. Journal of Basic and Applied Sciences*. 2014; **1**: 97. - **Ending page number missing?**
5. Kowalska G, Pankiewicz U, Kowalski R: **Title missing** *Journal of Analytical Methods in Chemistry*. 2020; **2020**: 1. **Publisher Full Text** - **Volume is 2020, is it correct?**
6. Kusin FM, Azani NNM, Hasan SNMS, *et al.*: **Title missing** *Catena*. 2018; **165**: 454. - **Ending page number missing?** **Publisher Full Text**
7. Mortazavi S, Fard PN: **Title missing** *Iran. J. Heal. Sci.* 2017; **5**: 10.
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10. Wuana RA, Okieimen FE: Heavy metals in contaminated soils: a review of sources, chemistry, risks and best available strategies for remediation. *ISRN Ecology*. 2011; **2011**: 1–20. [Publisher Full Text](#) - **Volume no. 2011?**

The article may be Approved after the above mentioned corrections.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Environmental chemistry, Translocation of heavy metals from industrial waste into human body.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 30 March 2022

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Rasha M. El Bayomi

Department of Food Control, Faculty of Veterinary Medicine, Zagazig University, Zagazig, Egypt

Reviewing Report

The manuscript entitled "Human health risk assessment of some important trace elements in boneless whole chicken meat. The authors quantify trace element concentrations in chicken samples and estimate the potential health risk associated with these trace element consumption. The language of the manuscript needs some modification.

I would suggest Major Revision by addressing the outlined comments:

Major comments

1. Title

- The title is explained but the study area should be included. Please add the study area in the title. I suggest "Human health risk assessment of some important trace elements in chicken meat retailed in Amman, Jordan"

2. The Abstract:

- **Page 1 Line 26:** Repeated iron and lead. Please delete the repetition.
- **Page 1 L33:** a value of > 1 , indicating a carcinogenic effect in adult population. Please check this sentence. If the value >1 is non carcinogenic so why were the Jordanian consumers are at risk?

3. Keywords

- You say fish - did you examine chicken meat or fish? It is not matching with the title of your manuscript? Please revise very well.

4. Introduction

- What is the meaning of the word **bodies** in the second paragraph?
- In the second paragraph, (The maximum acceptable limits for) please include the max. acceptable limits for the other trace elements (Fe, Al, Mn, Cu, Cr, As and Hg).
- "Chronic ingestion of...can be estimated" - Here you mentioned the risk for some heavy metals and you missed some the others such as lead (Pb). please complete this important point.
- Why do the author calls the samples "boneless whole chicken meat (shawarma)"? Shawarma contains other additives rather than meat. Please delete the word shawarma.

4. Materials and Methods

- The sampling period should be mentioned as from...to...
- **Page 5:** All abbreviations used in this equation (Carcinogenic risk (CR)) should be mentioned below under it. Please add them. The author described the equation parameters in the text before in EDI equation but in my opinion all parameters in the equation should be described under each equation.

5. Results & Discussion:

- **Page 5, table 3:** Which form of Hg you have measured? Please indicate organic or inorganic mercury.

- **Page 7, the first paragraph:** You mentioned in table 1 that LOD of Hg is 0.001. and here you mention that it is 0.0005 (limit of detection (<0.0005 mg/kg).), please revise it.
- **Page 7, the fifth paragraph:** Please transfer such information to the introduction section.
- **Page 8, the third paragraph:** What about the other trace elements such as AL, Fe, and others? You have to mention them too. Please discuss all results for all trace elements. The reasons behind these variations in your results compared to the other studies.
- **Page 9, table 7:** Please check this ^c source under the table I cannot find the superscript letter (c) in this table. Please revise.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Food hygiene

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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