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HEAVY METAL CONCENTRATIONS AND THEIR RISK ASSESSMENT IN MARKETED SLAUGHTERED ANIMALS IN SHARKIA GOVERNORATE, EGYPT

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Abstract: Toxic metals (lead, cadmium and mercury) and essential trace elements (copper and zinc) were analyzed in a total number of 120 samples of muscle, kidney and liver collected from camel, cattle, buffalo and sheep using atomic absorption spectrophotometer after wet digestion. The concentrations of heavy metals ranged from 0.17 ± 0.6 to 0.49 ± 0.09, 0.03 ± 0.01 to 0.12 ± 0.03, 0.39 ± 0.1 to 1.19 ± 0.18, 0.10 ± 0.04 to 8.82±1.01 and 3.25 ± 0.16 to 8.35± 1.33 mg/kg for lead, cadmium, mercury, copper and zinc, respectively. In general, the liver samples had the highest level of lead and mercury, while kidney samples showed the highest content of cadmium as compared with muscle samples. Cadmium (Cd), copper (Cu) and zinc (Zn) levels in all of samples were less than the Egyptian standard limits. The estimation of human health risk for adults revealed an estimated daily intake (EDI) value of muscle and offal below threshold of oral reference dose (RFD) for all metals analyzed. Hazard index (HI) and Hazard quotient (THQ) for all the analyzed metals were below 1, demonstrating that human health risk through consumption of meat and offal is not possible.

Key words: heavy metals; hlaughter animals; EDI; THQ; HI

Introduction

Heavy metals toxicity is highly persistent and widespread environmental health problems owing to the stability and non-degradable properties of these elements (1). They can enter the food chain through natural environmental constituents or human anthropogenic activities for example, an extensive fertilizers and pesticides application in agriculture, fossil fuels burning, waste disposal, atmospheric deposition, and discharge from manufacturing industries (2). These metals can be bioaccu-mulated in the environment and biomagnified in the food and they might reach toxic levels when found even at low concentrations (3). The environment and food contamination are common and constitute the main pathways of heavy metals (4).

In Egypt, camel, cattle, buffalo, and sheep are domesticated animals and live under the same environment with human. These animals have the ability to accumulate various environmental pollutants in their muscle and edible tissues when exposed to such toxic substances (5). Moreover, the edible animal offal (liver and kidneys) have high economic importance and

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gastronomic value although they account for small portion of human diet and very little consumption rate as compared to meat (6). Accumulation of these heavy metals in meat constitute a potential health hazard because they are toxic at low concentrations (7). Lead, cadmium and mercury have no physiological functions in human body and are associated with organs dysfunctions, nervous system and bone diseases (8). Trace essential metals such as zinc and copper are necessary for living organisms at low concentration to maintain normal development and maintenance of human physiology, but the high-level exposure to these element causes human health risks (9).

Monitoring of heavy metal levels in the food by estimation of the heavy metals potential risks is needed. Risk assessment is a method required for human health hazard estimation, in general this method is depend on the target hazard quotients (THQ), a ratio between the contaminant estimated dose and the oral reference dose (RFD) as there is no significant risk below it (10) If the THQ is <1, the meat has no human health risk (11). Therefore, the current study investigated the heavy metals concentrations (Pb, Cd, Hg, Zn and Cu) in muscle and offal of camel, cattle, buffalo and sheep by using of the Atomic Absorption Spectrophotometer and assessed the human risk of these metals.

Material and methods

Sampling

A total number of 120 muscle, kidney and liver samples of camel, cattle, buffalo and sheep (10 of each) were randomly collected from Zagazig city, Sharkia, Egypt. The collected muscle and offal samples were packed in a cold polyethylene bags and then transferred to the Central Laboratory, Faculty of Veterinary Medicine, Zagazig University for the heavy metals analysis.

Heavy metals analysis:

From each sample, one gram was digested overnight in a digestion tube containing 3 ml of 65 % nitric acid (supra-pure, Merk Darmastadt, Germany) and 2 ml of 70 % perchloric acid (extra-pure-Merk, D-6100 Darmastadt, Germany) (12, 13). These tubes were incubated in water bath for 3 h at 70°C with vigorously shaken every 30 minute. Then the tubes were left to cool at room temperature and diluted with 20 ml of de-ionized water and then filtered with Whatman filter paper no. 42. The filtrates were collected in polyethylene films capped glass tubes and kept at room temperature until metals analysis is performed.

Blank solution was prepared from 2 ml of perchloric acid (70 %), 10 ml of nitric acid (65 %) and the standard solutions of Pb, Cd, Hg, Cu and Zn were prepared using pure specialized atomic absorption spectrophotometer standard of these metals. Both blank and standard solutions were treated by the wet digestion method and they diluted using 20 ml de-ionized water. The digested blank and standard solutions were analyzed for heavy metal content using Buck scientific 210VGPAtomic Absorption Spectrophotometer (AAS) (Per Kin Elmer model (spectra-AA10, USA) at the Central Laboratory in Faculty of Veterinary Medicine, Zagazig University, Egypt. The analysis procedure was performed by air/acetylene flow (5.5/1.11/m) flame in case of Pb, Cd, Cu and Zn, while cold vapor atomic absorption spectroscopy technique was used for Hg determination (14). The limits of detection (LOD) were 0.01, 0.005, 0.005, 0.02, 0.02 μg/g for Pb, Cd, Hg, Cu and Zn respectively. The concentrations of Pb, Cd, Hg, Cu and Zn were expressed as μg/g wet weight (ww) which equivalent to mg/kg. Residual metal concentrations in the examined samples were compared with the maximum permissible limits of metals set by Egyptian organization for Standardization (15) and other international standards.

Assessment of human health risk

Risk assessment was determined depend on the metals concentrations detected in the meat samples by means of United States Environment Protection Agency (16) for human health risk assessment. The ingested dose of the contaminant is the same to the adsorbed dose and the cooking not affect the heavy metals toxicity (17). Health risk assessment of heavy metals level in the examined samples of camel, cattle, buffalo and sheep meat were calculated using the following points: Estimated Daily Intake (EDI), Hazard Quotient (THQ) and Hazards index (HI).

Estimated daily intake (EDI)

The heavy metals estimated daily intake (EDI) was dependent on the heavy metals level in muscle and offal and the consumption rate. The metals EDI was calculated using the following equation: EDI=(Cm x FIR)/BW (11), as Cm = concentration of the heavy metal in the sample (mg/kg wet weight); FIR = bovine and camel meat ingestion rate (35.287 g/day), sheep meat ingestion rate (4.329 g/day) (18) and offal ingestion rate (0.1 g /day) (6,19) BW is the Egyptian adults body weight = 70 kg. Then compared to the metals tolerable daily intakes (TDIs) (20).

Target Hazard Quotient (THQ)

THQ was used to evaluate health risk accompanied with the non-carcinogenic and carcinogenic effect of any toxic metals. Muscle and offal consumption risks of camel, cattle, buffalo and sheep were evaluated according to the THQ. The THQ is a relation between the determined pollutant dose and the level of RFD. The reference dose is the daily exposure of a contaminant estimated which the population exposed along a lifetime continually with no significant hazard (21). If this relation is <1, the population has improbable no noticeable bad effects. The method of estimating THQ was provided. The risk assessment was determined by using the following equation (22): $THQ = \frac{EF \times ED \times FIR \times C}{RFD \times BW \times AT} \times 10^{-3}$, as EF is the frequency of exposure (365 days/year), ED is the duration of exposure (70 years, average duration), FIR is the ingestion rate of meat (g/day), C is the heavy metal concentration in meat (mg/kg); BW is the adult average body weight (70 kg), RFD is the oral reference dose (mg/kg/day) and AT is the exposure time average (365 days/ year × exposure years number, assume 70 years). The oral reference dose value for Pb, Cd, Hg, Zn and Cu is 0.004, 0.001, 0.0016, 0.3 and 0.04 (mg/kg bw/day), respectively (11).

Hazard index (HI)

To assess the potential human health risk among all heavy metal, the hazard index (HI) has been established by the summation of the THQ for all heavy metals in the subsequent equation. $HI = \Sigma HQ = HQ\ Pb + HQ\ Cd + HQ\ Hg + HQ\ Zn + HQ\ Cu$ Where Σ HQ is the summation of hazard quotients of all metals. When HI increases than 1, it poses an alarm for human health concerns (23).

Statistical analysis

The results were planned by using the SPSS computer program, Inc. version 22 (2012). The obtained results were expressed as the mean ± standard deviation (SD). All the statistical analyses were done at the significance level of 0.05 ($P<0.05$).

Results

Mean and standard deviation (Minimum-Maximum) of heavy metals concentrations in the various muscles and organs of camel, cattle, buffalo and sheep analyzed in this study are shown in Table 1. The muscle and organs of the same species have different metal concentration. In the main, muscle and organs were relatively rich in Zn followed by Cu, which are micronutrients followed by levels of Pb, Cd, and Hg which have no biochemical functions and are toxic at minute concentration. Of all detectable toxic metals, Pb in muscle samples and Hg in all muscle and offal were higher than the permissible limit of the Egyptian standards. The estimated daily intake of Pb, Cd, Hg, Zn and Cu in this study ranged from 0.0002 to 0.5646, 0.0001 to 0.2016, 0.0006 to 0.7057, 0.0002 to 0.2319 and 0.0054 to 4.2092 µg/kg BW/day, respectively (Table 2).

THQ for Pb, Cd, Hg, Zn and Cu ranged from 0.00006 to 0.14115, 0.00004 to 0.20164, 0.00035 to 0.44109, 0.00002 to 0.01403 and 0.000057 to 0.057972, respectively (Table 3). The probable health risk of the determined metals was also tested. The HI ranged from 0.0007 in camel kidney to 0.7065 in buffalo muscle and HI<1 means no hazard (Table 3).

Table 1: Statistical analytical results of f lead (Pb), cadmium (Cd), mercury (Hg), copper (Cu) and zinc (Zn) concentrations (mg/Kg wet weight) in the examined samples (No= 10 of each)

Organ	Animal	Lead	Cadmium	Mercury	Copper	Zinc
Muscle	**Camel**	0.322 ± 0.1^{ab} (0.29-0.65)	0.05 ± 0.02^{a} (0.04-0.09)	0.5± 0.09^{b} (0.63-0.74)	0.14 ± 0.04^{a} (0.02-0.28)	8.35± 1.33^{a} (6.1-12.9)
	Cattle	0.19± 0.02^{b} (0.12-0.23)	0.03 ± 0.02^{a} (0.01-0.09)	1.17 ± 0.28^{a} (0.55-1.88)	0.46 ± 0.17^{a} 0.02-0.28	5.91± 0.34^{ab} (4.87-6.48)
	Buffalo	0.17 ± 0.06^{b} (0.01-0. 3)	0.04± 0.016^{a} (0.01-0.09)	1.4± 0.2^{a} (0.65-1.84)	0.26 ± 0.07^{a} (0.11-0.49)	5.73 ± 0.32^{b} (4.54-6.41)
	Sheep	0.49± 0.11^{a} (0.2-0.66)	0.05± 0.02^{a} (0.001-0.08)	0.81 ± 0.21^{ab} (0.37-1.35)	0.10 ± 0.04^{a} (0.07-0.18)	7.02± 0.69^{ab} (5.26-8.37)
Kidney	**Camel**	0.31 ± 0.07^{a} (0.13-0.52)	0.12 ± 0.03^{a} (0.01-0.21)	0.39 ± 0.1^{b} (0.02-0.61)	0.16 ± 0.07^{b} (0.03-0.43)	3.8± 0.2^{b} (3.15-4.25)
	Cattle	0.32 ± 0.04^{a} (0.24-0.46)	0.06 ± 0.01^{a} (0.03-0.08)	1.18 ± 0.32^{ab} (0.35-1.98)	1.21 ± 1.10^{a} (0.04-5.62)	3.85 ± 0.08^{b} (3.69-4.16)
	Buffalo	0.17 ± 0.04^{a} (0.09-0. 3)	0.07± 0.01^{a} (0.05-0.1)	1.31 ± 0.25^{a} (0.47-1.83)	0.28 ± 0.06^{b} (0.12-0.40)	3.25 ± 0.16^{b} (2.77-3.6)
	Sheep	0.23 ± 0.08^{a} (0. 1-0.36)	0.07± 0.02^{a} (0.02-0.1)	1.01 ± 0.35^{ab} (0.32-1.42)	0.36 ±0.07^{b} (0.14-0.44)	4.54 ± 0.33^{a} (4.02-5.5)
Liver	**Camel**	0.40 ± 0.12^{a} (0.08-0.79)	0.11± 0.04^{a} (0.04-0.21)	0.62 ± 0.19^{b} (0.31-1.2)	2.10±0.91^{b} (0.64-5.59)	6.16± 0.67^{a} (4.57-8.51)
	Cattle	0.38 ± 0.08^{a} (0.18-0.55)	0.03 ± 0.01^{a} (0.01-0.07)	1.15 ± 0.27^{a} (0.15-1.76)	2.75 ± 1.42^{b} (0.15-7.91)	5.19 ± 0.38^{ab} (3.82-6.15)
	Buffalo	0.19 ± 0.05^{a} (0.09-0.36)	0.06± 0.02^{a} (0.02-0.11)	1.3 ± 0.18^{a} (0.76-1.77)	2.39 ± 0.67^{b} (1.00-4.64)	4.29 ± 0.24^{b} (3.64-4.92)
	Sheep	0.39 ± 0.09^{a} (0.15-0.6)	0.06± 0.03^{a} (0.02-0.11)	1.19 ± 0.18^{a} (0.84-1.61)	8.82±1.01^{a} (7.09-10.59)	5.36 ± 0.48^{ab} (4.81-6.31)

Mean of the same column for the same tissue carry different superscripted letter are significant different (P<0.05).

Table 2: Estimated daily intake (EDI) µg/ kg body weight of different metals in comparison to the Tolerable daily intake (TDIs) µg/ kg body weight

Animal	Samples	Pb	Cd	Hg	Cu	Zn
Camel	**EDI (Muscle)**	0.5646	0.0252	0.2521	0.0706	4.2092
	EDI (Kidney)	0.0004	0.0002	0.0006	0.0002	0.0054
	EDI (Liver)	0.0006	0.0002	0.0009	0.0030	0.0088
Cow	**EDI (Muscle)**	0.0958	0.0151	0.5898	0.2319	2.9792
	EDI (Kidney)	0.0005	0.0001	0.0017	0.0017	0.0055
	EDI (Liver)	0.0005	0.0004	0.0016	0.0039	0.0074
Buffalo	**EDI (Muscle)**	0.0857	0.2016	0.7057	0.1311	2.8885
	EDI (Kidney)	0.0002	0.0001	0.0019	0.0004	0.0046
	EDI (Liver)	0.0003	0.0001	0.0019	0.0034	0.0061
Sheep	**EDI (Muscle)**	0.0303	0.0031	0.0501	0.0062	0.4341
	EDI (Kidney)	0.0003	0.0001	0.0014	0.0034	0.0065
	EDI (Liver)	0.0006	0.0001	0.0017	0.0088	0.0077
TDIs		**3.57**	**1.0**	**0.71**	**500**	**300 –1000**

EDI=(Cm x FIR)/BW, as Cm = concentration of the heavy metal in the sample (mg/kg wet weight); FIR = bovine and camel meat ingestion rate (35.287 g/day), sheep meat ingestion rate (4.329 g/day) (18) and offal ingestion rate (0.1 g /day) (19, 6); BW is the Egyptian adults body weight = 70 kg. Then compared to the metals tolerable daily intakes (TDIs) (20).

Table 3: Target hazard quotient (THQ) and Hazard index (HI) of different metals from consumption of the examined samples

Animal	Samples	Pb	Cd	Hg	Zn	Cu	HI
Camel	Muscle	0.14115	0.02521	0.15753	0.01403	0.017644	0.3556
	Kidney	0.00011	0.00017	0.00035	0.00002	0.000057	0.0007
	Liver	0.00014	0.00016	0.00055	0.00003	0.000750	0.0016
Cow	Muscle	0.02394	0.01512	0.36862	0.00993	0.057972	0.4756
	Kidney	0.00011	0.00009	0.00105	0.00002	0.000432	0.0017
	Liver	0.00014	0.00004	0.00103	0.00002	0.000982	0.0022
Buffalo	Muscle	0.02142	0.20164	0.44109	0.00963	0.032767	0.7065
	Kidney	0.00006	0.00010	0.00117	0.00002	0.000100	0.0015
	Liver	0.00007	0.00009	0.00116	0.00002	0.000854	0.0022
Sheep	Muscle	0.00758	0.00309	0.03131	0.00145	0.001546	0.0450
	Kidney	0.00008	0.00009	0.00090	0.00002	0.000843	0.0019
	Liver	0.00014	0.00010	0.00106	0.00003	0.002196	0.0035

THQ values was determined using the following equation: $THQ = \frac{\text{EF x ED x FIR x C}}{\text{RFD x BW x AT}} x10^{-3}$(22). THQ is the target hazard quotient. EF is exposure frequency (365 days/year). ED is the exposure duration (70 years, average lifetime). FIR is the food ingestion rate (g/day). C is the heavy metal concentration in meat (µg/g). RFD is the oral reference dose (mg/kg/ day). BW is the average adult body weight (70 kg) and AT is the averaging exposure time (365 days/ year × number of exposure years, assuming 70 years). HI = Σ HQ = HQ Pb + HQ Cd + HQ Hg + HQ Zn + HQ Cu

Discussion

Concentration of metals in offal and muscles

In general, the liver samples had the highest level of Pb and Hg, while kidney samples showed the highest content of Cd as well as, muscle samples exhibited higher levels of Cu and Zn in all investigated animal. The metal concentration in the organs and muscle followed the order: liver > kidneys > muscle. Liver and kidneys are the target tissues for surveillance metal contamination in animals body since the main function of these organs is eliminating the toxic metals from body and so the metals accumulating in them (24).

Mean Pb concentrations as observed in the sheep muscle showed the highest mean concentration of 0.49 ± 0.09 mg/kg and the lowest concentration of 0.17 ± 0.6 mg/kg were recorded in buffalo kidney. In Egypt, the mean lead level in beef was lower than our study (0.008, 0.109 and 0.042 mg/kg) in muscle, kidney and liver samples, respectively (25). Lower Pb concentrations for bovine, buffalo and sheep muscle, of 0.061±0.03, 0.052±0.02 and 0.010±0.01 mg/kg from Egyptian rural area and 0.093±0.04, 0.081±0.03 and 0.081±0.03 mg/kg from Egyptian industrial areas were reported by Abou-Arab (24). In the same line, Alkmim Filho (26) reported Pb concentrations in Brazilian cattle kidney and liver were 0.226 mg/kg and 0.231 mg/kg, respectively. In addition, Pb concentration of 0.221±0.022, 0.244±0.029 and 0.273±0.034 mg/kg was detected respectively in bovine muscle, kidney and liver from Iran (27). Lead concentrations in the current study appear to be similar to that recorded in cattle liver (0.31±0.04) and in sheep liver from Pakistan (0.22±0.08 mg/kg) (28). However, higher Pb concentration of 2.62±0.08 and 5.48±0.01 mg/kg was recorded in sheep and camel muscle, respectively in Saudi Arabia (29), 0.534 mg/kg in cattle kidney from Iran (30), 21.1±3.30 and 17.05±5.17 mg/kg in cattle and sheep liver, respectively in Iran (31). Muscle, kidney and liver of sheep from control sites in China are obviously higher than those reported in the present study (0.86±0.41, 0.72±0.23 and 0.96±0.40 mg/kg, respectively) (32). The environmental contamination differences are the cause of this variation (27). Lead is one of the most toxic heavy metals. This study indicated that Pb concentrations were above the recommended limits of 0.1 mg/kg for muscle and below 0.5 mg/kg for offal set by Egyptian Organization for Standardization (EOS) (15), European Commission Regulation (ECR) (33) and United States Department of Agriculture (USDA) (34).

The highest Cd concentration (0.12 ± 0.03) was recorded in the kidney of camel while the lowest value (0.03 ± 0.01) was observed in muscle samples of the cattle. However, Cd concentration in bovine muscle was similar to (0.031±0.02 mg/kg) the concentrations in Egypt (24) and (0.03 mg/kg) South Africa (35). Higher Cd levels for muscle samples of 0.14 mg/kg in beef were reported in Nigeria (36), 1.25±0.02 in sheep and 1.07±0.02 mg/kg in camel from Saudi Arabia, respectively (29). Moreover, high Cd concentrations were reported in liver samples (0.14±0.02 and 0.21±0.4, respectively) and kidney samples (0.93±0.13 and 1.93±0.41 mg/kg, respectively) for cattle and sheep from Iran (31). Lower Cd levels of 0.005 mg/kg in beef muscle in Switzerland (37), 0.028±0.004, 0.114±0.025 and 0.047±0.010 mg/kg in bovine muscle, kidney and liver, respectively in Iran (27) and 0.006, 0.009 mg/kg in sheep kidney and liver, respectively in Kenya (38) were reported. In Egypt, the mean residual levels of cadmium in beef was lower than our study (0.0014, 0.014 and 0.062 mg/kg) in muscle, liver and kidney samples, respectively (25). Meanwhile, Abou-Arab (24) reported that Cd concentrations of animal organs (bovine and buffalo and sheep), respectively collected from Egyptian rural area were 0.010±0.01,0.006±0.004 and 0.011±0.01 for muscle, 0.220±0.11, 0.166±0.11 and 0.880±0.30 for kidney, 0.112±0.07, 0.080±0.04 and 0.082±0.06 mg/kg for liver samples. Generally, in the current study cadmium levels in kidney samples were relatively higher as compared to that found in muscle and liver samples. Camel kidneys had the highest Cd level than other animals as this animal had longer lifetime exposure. The high concentration of Cd in the kidney may be contributed to the excretory function of this organ, as toxic substances excreted from body through the kidney (27). In addition, animals insecure to Cd accumulation in their kidneys because of free protein-thiol groups' occurrence, which strongly join the heavy metals to their construction (39). Cadmium concentrations in the present study were within the permissible limit of 1.0 mg/kg for offal and 0.05 mg/kg for muscle samples (15) and was below the maximum permissible limit of 1.0 mg/kg (40).

Mercury was detected at concentrations ranging between 0.39±0.1 mg/kg in the camel kidney to 1.19±0.18 mg/kg in the liver of sheep. Lower concentrations of (0.00391, 0.0104 mg/kg and 0.00581) were recorded in muscle, kidney and liver of beef, respectively (25) in Egypt. Meanwhile, the concentrations of 0.023±0.006 and 0.039±0.002 mg/kg were observed in sheep and camel muscle from Saudi Arabia (29), and 0.07±0.03, and 0.03±0.03l in kidney and liver of sheep from Ghana (39). However, lower Hg concentrations (0.003, 0.002, 0.003 mg/kg) were reported for cattle muscle, liver and kidney, respectively in Iran (27). The accumulation of Hg was under 0.2 mg/kg in both liver and kidney of cattle (41) in Zambia and 0.00153 ± 0.00005 mg/ kg in liver of veal (42) in Spain. The mean concentration of Hg in bovine kidneys was 0.008 mg/kg in Ireland (43), which was lower than our study.

In the present study the Hg concentrations in muscles and offal were higher than the Egyptian permissible limit (0.2 and 0.5 mg/kg, respectively) (15) and higher than 0.05 mg/kg established by ECR (33) and USDA (34). The high levels of Hg especially in the offal of slaughtered animals could be problematic, as concentration levels exceeded the maximum values permitted in food. The high levels of Hg reflect the increased use of mercury in agricultural and industrial activities in the studied area. Animals' herds are usually seen grazing in and around these contaminated areas. They have the ability to accumulate some residues of these toxic metals. Therefore, the high levels of Hg in meat and offal of slaughtered animals could be due to contamination from soil, feed or water.

The highest Cu value was observed in sheep liver (8.82±1.01 mg/kg), and the lowest concentration (0.10±0.04 mg/kg) was recorded in the muscle of sheep since the liver serves as the main organ for Cu storage and homeostasis maintains in the body (4). In Egypt, Abou-Arab (24) reported higher Cu concentration in bovine, buffalo and sheep samples (muscle, kidney and liver). Higher Cu also found in muscle of sheep (4.60±0.21) and (1.33±0.07 mg/kg) in camel (29). Meanwhile, lower Cu concentration (0.498 mg/kg) in beef (37). The concentration of Cu in muscle is below their relevant concentrations in liver and kidney, which is coincided with Waegeneers et al. (44). The current study declared lower Cu concentrations than the Egyptian permissible limits of 15 mg/kg (15) and 20 mg/kg set by USDA (34) and ECR (33).

Mean Zn concentrations in all muscle and organs ranged between 3.25±0.16 and 8.35±1.33 mg/kg in buffalo kidney and camel muscle, respectively. Zinc concentrations in kidney and liver samples in the current study were lower than that found in muscle samples and this was in accordance with Abou-Arab (24). The concentration of Zn in this study was less than 17.55±1.097, 8.423±0.620 and 17.04±0.727 mg/kg for muscle, kidney and liver of bovine from Iran (27), 33.85±1.24 and 16.74±0.73 mg/kg for sheep and camel muscle from Saudi Arabia (29). Higher Zn also recorded in kidney (74.91±9.07) and in liver (77.34±13.09) of sheep form Ghana (39), as well as, higher Zn concentration was reported in liver (104.07 ± 5.34 and 105.19 ± 5.11) and kidney (87.94±6.44 and 102.05±5.05 mg/kg) of cattle and sheep, respectively from Iran (31). This difference may be attributed to the difference in the analytical method in other studies, the variations of environmental pollutants type and physiological conditions (27). Copper and zinc concentration in this study were below those reported in Egypt and Belgium (24, 44).

The current study proved that Cd is mostly accumulated in the kidney, Zn in muscle and Cu in the liver that was in agreement with Sedki et al., (45) in Morocco. Zinc levels in this study were below the FAO/WHO (40) permissible limit (50 mg/kg) for edible offal and muscle and below 50 mg/kg for muscle and 80 mg/kg for offal maximum permissible limit of Codex Alimentarium Commission (CAC) (46). The Cd concentrations was uniform in the all tissue of all animals groups in which they were detected and display no significant variation ($p>0.05$). Significant variation was observed for Pb and Zn in samples examined of the four animal groups analyzed ($p<0.05$). Liver of camel was significantly different from liver of cattle, buffalo and sheep in the mean Hg concentrations ($p\leq0.05$). Muscles of different animal species showed no significant ($p>0.05$) for Cu but other offal was significantly different on Cu level ($p<0.05$).

Human health risk assessment

Meat considered as the major sources of vitamins, animal protein, fatty acids and essential trace elements but meat and offal edible for consumption are necessary source for metals exposure (4). The toxicity of heavy metal depends on the daily intake of these metals. The EDI values for non-essential heavy metals Pb, Cd and Hg for adult of 70 kg BW prove that the EDI values obtained were less than the human oral reference dose. These results point to there was no possible human health hazard associated with meat consumed in our city.

The oral reference dose is the daily exposure estimation to the people, which is with no harmful risk through long-term exposure. If the intake is below the RFD (THQ<0.1), indicates no opportunity of any bad risk. The current study results are parallel to those found in other studies on sheep muscle and offal (47) as they found low daily intakes of Pb, Cd and Hg when compared with TDI. However, the EDI was lower than the RFD for Cd, Pb, Zn and Cu but not for Hg in animal tissues and offal examined (4). Chronic exposure to low doses of Pb, Cd and Hg over their safe limit may lead to many diseases as liver malfunctions, headache and neurologic involvement (4). The EDIs of Pb, Cd, Hg, Zn and Hg in muscle and offal of the examined slaughter animals were below FAO/WHO (20) tolerable daily intakes.

Health risk estimation due to muscle and offal consumption from all examined animals was assessed based on the THQ. The THQ value in the current study was below 1 that means improbable population exposure to cause any observable risk (11) from the individual metals intake during the muscle and offal consumption. In the main, the muscle consumption poses less human health risk than liver and kidney, as it accumulates less metal as it not an active place for detoxification. These findings were in agreement with Ogbomida et al. (4), Tyokumbur (48) and Ihedioha and

Okoye (49) who determined THQ value below 1 for cow meat. Additionally, HI of the combination of all metals was calculated by counting all the metals hazard quotients (THQ) together. The probable health hazard of all metals was existed when HI is ≥ 1 (50). The HI for all examined metals was less than 1 and this revealed no undesirable effects on human health from muscle and offal consumption in our city. Our results agreed with Ogbomida et al., (4) who found that all heavy metals analyzed had THQ<1.

Conclusion

It can be concluded that kidney and liver samples had higher metals concentrations than in muscles. The hazard index of these elements are less than 1 and appropriate steps are recommended to reduce the health hazard through consumption of meat as these metals have cumulative effect so as to protect the food chain. Finally, this research provides important data for other ongoing research on the slaughtered animals and their offal in our country.

Conflict of interest

The authors declare no conflict of interest.

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