DOI : 10.5958/2277-8934.2022.00013.3 *Vol 29 No 1, p 89-99*

SELECTED HEAVY METALS AND THEIR RISK ASSESSMENT IN CAMELS (*Camelus dromedarius*)

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ABSTRACT

The study was carried out to determine the residual levels of heavy metals (zinc, iron, copper, lead, and cadmium) in tissues (meat, liver and kidney), serum and hair of 3 camel breeds (Magaheem, Maghateer and Wadha) collected from Al-Omran slaughterhouse, eastern province, Saudi Arabia by using Atomic Absorption Spectrometer. Camel breed influenced Zinc (Zn) accumulation and distribution in organs, muscle, and arranged in descending manner as follows: hair> liver> muscle > kidney> serum. The iron content in all male camel samples was considerably greater than in female camel. Furthermore, significant strong positive correlation between muscle and serum iron was established. All examined samples contained copper (Cu), the highest value was 17.78 ± 0.85 mg kg^{-1} detected in liver samples of Maghateer breed. The descending manner of Cu as follows: liver > muscle > hair > kidney > serum. In addition, the female liver contained significantly higher Cu than the male liver. Lead (Pb) residue was detected in all examined samples among different breeds except muscle samples of Maghateer and Magaheem breeds. The cadmium (Cd) values ranged from 0.0001 mg kg^{-1} in the muscle of the Maghateer breed to 4.5113 mg kg^{-1} in the hair of the Wadham breed. The meat and offal of all examined breeds contained lower Pb and Cd levels than the maximum permissible limit. The estimated daily intake (EDI) due to consumption of camel meat below the tolerable daily intake (TDI). In addition, the hazard ratio (HR) and hazard indices (HIs) values were far below one for adults.

Key words: Camel, heavy metals, metal toxicity, risk assessment, tissues

Metals like zinc (Zn), copper (Cu), and iron (Fe) are essential elements for maintaining proper bodily processes and blood synthesis. Metals like lead (Pb), cadmium (Cd), and arsenic (As) detected in contaminated food from both animal and plant sources are considered as toxic. Consequently, for both food safety and human health, monitoring the concentrations of these elements in human food is critical (Bortey-Sam *et al,* 2015; Hassan *et al,* 2020).

Heavy metal contamination in the environment has primarily been caused by natural geology or anthropogenic industrial sources, such as cadmium (Cd) and lead (Pb) (Van der Voet *et al,* 2011). Heavy metal pollution is regarded as one of the most serious issues since these metals cannot be degraded and so remain in the environment indefinitely (Baykov *et al,* 1996). Heavy metals are considered a dangerous environmental pollutant due to their ability to enter the food chain as well as their cumulative effect as residues (Asli *et al,* 2020). Although human exposure to these elements during meat consumption rarely leads to severe poisoning, their accumulation in the body may have negative effects on health (Chen *et al,* 2013).

Many investigators found the heavy metals in muscle, edible offal (liver and kidney) and serum of camel carcasses (Eltahir *et al,* 2010; Badis *et al,* 2014; Khalafalla *et al,* 2015; Meligy *et al,* 2019; and El-Ghareeb *et al,* 2019). Determining heavy metal residues in meat and edible offal is a very important issue to protect consumers in Saudi Arabia, as well as measuring these residues in camel hair to investigate the extent of environmental pollution.

The current research was aimad to determine the levels of toxic metals (Pb and Cd) as well as the necessary elements (Zn, Cu, and Fe) in camel meat, serum, hairs and offals. The metals-dietary intake and health risk assessment were also determined from public health point of view.

Materials and Methods

Collection of Samples

A total of 225 tissue samples (muscles, liver, and kidney), serum, and hair samples (n = 75) were

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taken from three local camel breeds at random from the Al-Omran central slaughter house in Saudi Arabia from November 2020 to February 2021. Age of the animals was < 5 to > 10 years. The sampled animals were apparently healthy. Samples were collected in plastic falcon tubes and kept at -20°C until these were extracted and measured.

Sample preparation and extraction

The Shimadzu AA-7000 Atomic Absorption Spectrophotometer (Japan) was used in conjunction with Flame Atomic Absorption Spectrometry (FAAS) and a graphite furnace atomic absorption spectrometry system (GFAAS) to assess the amounts of the trace elements Fe, Zn, Cu, Cd, and Pb. In addition, air/acetylene gas (10:1.5) was employed in FAAS.

For the analysis of Cu, Fe, and Zn, flame atomic absorption was applied whereas, Cd and Pb were measured using GFAAS system (argon being an inert gas). The Shimadzu ASO6100 Automatic Sampler was used to inject the samples into the GFAAS and FAAS. The Mars Xpress Microwave Digestion System (CEM Cooperation, Mathews, North Carolina, USA) was used to digest the samples. Polytetrafluoroethylene vessels were used for all digesting procedure. Before each digestion step, the containers were washed with 5 ml concentrated nitric acid. External calibration was used to conduct a quantitative examination of the samples. In polytetrafluoroethylene digesting tubes, 1 ml of serum, 1 gm of meat, and 0.25 gm of hair were combined with 5 ml of 65% nitric acid and 3 ml of 30% hydrogen peroxide (Meligy, 2018; Waheed *et al* 2018). In 50 ml tubes, the samples were diluted to 50 mlwith MilliQ water (Millipore, Bedford, MA). After dilution and filtration with Whatman filter paper 1, the digested samples were analysed using atomic absorption spectrophotometry according to Meligy (2018) method.

Stock solutions and standard solution (1000 mg/L) of Cu, Cd, Fe, Zn, and Pb (Merck; Darmstadt, Germany) were used to create calibration curves. The average recovery rate ranged from 95 to 106%. Metal concentrations were calculated using standard curves for all metals studied. Wet weight (ww) basis was used to calculate all of the results.

Quality assurance and control

Measurement of IAEA142/TM from IAEA certified reference materials (muscle homogenate) was used to ensure the accuracy of the assay (Vienna, Austria). The certified samples' recovered concentrations were within 5% of the certified values. Triplicates of each sample were evaluated.

Estimated daily intake (EDI)

The following equation from the Human Health Evaluation Manual (US Environmental Protection Agency, 2010) was used to calculate the estimated daily intake (EDI) of the metals studied: EDI = Cm FIR / BW. Where, EDI is expressed in μg/kg/day; Cm is the metal concentration in the sample (measured in mg/kg wet weight); FIR is for Saudi Arabia's meat intake rate, which was assessed to be 146 grams per day; BW stands for Saudi adults and children body weight, which was assessed to be 70 kilograms for adults and 30 kilograms for children (Adam *et al,* 2014).

Health risk assessment

The non-cancer risk caused by the consumption of metal-contaminated edible tissues to the Saudi population (adults and children) was assessed using the guidelines set by the US Environmental Protection Agency (2010). The following equation was used to determine the hazard ratio (HR):

Hazard Ratio (HR) = EDI/RfD × 10×3.

Where EDI stands for estimated daily intake and RfD stands for recommended reference doses in mg/kg/ day (0.001 for Cd, 0.004 for Pb, 0.3 for Zn, 0.04 for Cu and 0.7 for Fe). To evaluate the risk of mixed metals, the hazard ratios (HRs) can be summed together to provide a hazard index (HI). The following equation was used to generate HI = $\sum$ HRi where i represent each metal. A HR and/or HI of ≥ 1 implies that there is a potential risk to human health, whereas a result of ≤ 1 shows that there is no risk of adverse health impacts.

Statistical analysis

SPSS (version 19) was utilised to conduct statistical analyses. To see if variables were normally distributed, the Kolmogorov-Smirnov normality test was used. One-way analysis of variance was applied to compare the means of the groups (ANOVA) when breed used as a factor. To examine the impact of breed on the analysed parameters, the Duncan multiple range test (Steel and Torrie, 1980) was used. The differences between genders were tested by independent t-test. The Pearson correlation coefficient was used to establish a link between variables and to confirm their significance. Statistical significance was determined at $p < 0.05$.

Results and Discussion

Zinc

Zinc is important for the activity of over three hundred enzymes that are responsible for digestion,

metabolism, nerve function, and other processes in man and animals (Zastrow and Pecoraro, 2014). The recorded data in table 1 declared that mean values of Zn ranged from 29.77 to 40.11, 11.58 to 13.36, 17.57 - 25.83, 14.84 - 17.93, 54.81- 90.45 mg kg^{-1} in liver, kidney, muscle, serum, and hair, respectively. The Zn values significantly varied between breeds ($P<0.05$). Furthermore values were arranged in descending manner, i.e. Hair> liver> muscle > kidney> serum. The maximum Zn concentration found in hair samples from different camel breeds was in accordance to the finding of Petukhov *et al* (2016) who examined muscle, tissues, and hair of cattle in western Siberia and found high level of Zn in hair. Relatively higher levels of Zn were reported in the liver compared with the muscle in previous studies as 34.4 mg kg^{-1} (Bakhiet *et al,* 2007), 43.67 mg kg^{-1} (Abdelrahman *et al,* 2013) and 70.625- 155.351 mg kg^{-1} (Asli *et al,* 2020) in livers. Comparable Zn values were obtained in camel meat 16.74 ± 0.73 - 40.17 ± 2.62 mg kg^{-1} (Alturiqi *et al,* 2012), mg kg^{-1} 10.88 ± 1.73 mg kg^{-1} (Chafik *et al,* 2014) and 23.254 to 49.991 mg kg^{-1} (Asli *et al,* 2020). Camel breed influences Zn accumulation and distribution in camel organs and muscle. Significant variations ($p < 0.05$) were found across breeds, which can be explained by each breed's environment being in a distinct geographical location with varying concentrations of metals in soil, forages, and water. Camel feeding, watering and even breathing resulted in Zn deposition in tissues and organs, which reflected the amount of environmental pollution. There was a strong relationship between soil and grasses, and the Zn content in forages was more than half that of soil (Yan *et al,* 2012). Regarding the effect of gender as shown in Table 2 all male collected samples had substantially greater ($P <0.05$) Zn levels than female samples, with no significance in hair. Nearly similar results were obtained in Iran where sex was a significant parameter affecting Zn level, i.e. male and female camels contained 39.128 and 34.616 mg kg^{-1} in meat, 120.743 and 102.947 mg kg^{-1} in liver, respectively (Asli *et al,* 2020). In addition, Faye *et al* (2008) detected significantly higher zinc level in male than female camels collected from Emirates. The correlation coefficient between Zn concentrations in organs and serum with breed and gender in table 3 revealed a strong positive correlation between muscle, liver, kidney, and serum. Moreover, a positive correlation was detected between serum and hair. The positive correlation attributed to Zn which can enter the body through the digestive tract from food or drink water or lungs after inhalation of Zn dust. Zn increases in blood rapidly after exposure. The negative correlation obtained for both of breed and gender may be attributed to accumulation of heavy metals in the animal body related to environmental factors such as air pollution, feeding, and available water sources.

Iron

Iron is a critical component for nearly all living creatures' development and survival (Valko *et al,* 2005). It is found in organisms like algae, enzymes like cytochromes and catalase, as well as oxygen-transporting proteins like myoglobin and hemoglobin (Vuori, 1995). Significant differences ($P<0.05$) were found between breeds according to their contents of iron between kidney and serum (Table 4). The iron variations in our findings are attributable to variances in the availability of iron in forages that are grown in the grazing areas. Comparable iron values were obtained 38.088- 77.364 mg kg^{-1} of muscle and 55.110- 101.927 mg kg^{-1} of liver samples in Iran (Asli *et al,* 2020). Meanwhile, higher iron values were found in liver 558.1 ± 266.4 mg kg^{-1} in Sudan (Tartour, 1969), 295.2 ± 21.6 mg kg^{-1} in Saudi Arabia (Al-Busadah, 2003) and 560.0 ± 38 mg kg^{-1} at eastern Sudan (Bakhiet *et al,* 2007). The variation in iron concentration in different studies may be due to the method of sample preparation and calculation according to wet weight or dry weight. In our study camels from all examined breeds showed a higher concentration of iron in the hair> liver > kidney> muscle> serum. But camel samples from Iran showed a higher concentration of iron in the liver > kidney > muscle > serum > hair (Badiei *et al,* 2006). The

Table 1. Effect of breed on zinc concentrations (PPM) in organs, muscle and camel serum.

	Wadha	Maghateer	Magaheem	SE	Minimum	Maximum	P value
Liver	40.111^{a}	29.771^{b}	30.461^{b}	1.1441	22.3	48.6	<0.001
Kidney	13.369^{a}	11.579^{b}	11.705^{b}	0.3414	7.4	16.1	0.054
Muscle	25.73^{b}	17.5727^{a}	25.8307^{b}	0.93315	10.08	31.78	<0.001
Serum	17.936	14.842	17.0427	0.68995	4.52	24.55	0.171
Hair	90.4513^{a}	54.8107^{b}	60.4587^{b}	2.7512	39.98	102.45	<0.001

Values with different superscript in a row different significantly ($P<0.05$).

iron content in all male camel samples studied was considerably greater ($P < 0.05$) than in female camel samples (Table 5). Iranian male and female camels had iron in muscle at levels of 60.10 and 59.31 mg kg^{-1}, respectively which was similar to our findings. In addition, adult male and female camel from Al-Najaf city, Iraq contained total serum iron as 84.043±1.74 and 79.985±2.83 µg/dl, respectively (Ghali and Al-Qayim, 2020). Of contrast, the serum iron of adult female camels in the Najdi breed in Central Saudi Arabia was greater than that of adult male camels (Hussein *et al,* 1997). The data in table 6 revealed a significant positive correlation between liver and kidney. Furthermore, significant strong positive correlation between muscle and serum was found. Torrance *et al* (1968) reported that muscle storage of iron can increase with increase iron in serum; breed and hair also showed significant strong positive correlation.

Copper

Although, copper accumulation in the inner organs is not the norm, adding copper to farm animal feed has been shown to result in increased copper levels in the liver (Franson *et al,* 2012). The results in table 6 declared that the lowest value for Cu was detected in serum sample of Magaheem breed 1.039± 0.05146 mg kg^{-1} meanwhile, highest value was 17.7873± 0.85 mg kg^{-1} detected in liver samples of Maghateer breed. The significant differences among breeds ($P< 0.05$) detected in kidney and hair that may attributed to the level of Cu in forages and rate of excretion and accumulation of Cu in kidney or hair of different breed. The Cu concentration

Table 2. Effect of gender on zinc concentration levels in organs, muscle and camel serum.

	gender	Mean	Std. Error	Minimum	Maximum	P
Liver	Male	39.133[a]	1.2809	29.2	48.6	<0.001
	Female	28.473[b]	1.0681	22.3	39.7	
Kidney	Male	13.942[a]	0.3206	10.5	16.1	<0.001
	Female	10.709[b]	0.3575	7.4	14.5	
Muscle	Male	27.29[a]	0.70011	21.67	31.78	<0.001
	Female	19.3296[b]	1.21027	10.08	29.65	
Serum	Male	20.5052[a]	0.50287	15.34	24.55	<0.001
	Female	13.1958[b]	0.65654	4.52	19.46	
Hair	Male	70.6305	4.54384	51.64	102.45	0.49
	Female	66.7738	3.33752	39.98	97.18	

Table 3. Correlations between zinc concentrations in organs and serum with breed and gender.

Zinc	Breed	Gender	Liver	Kidney	Muscle	Serum	Hair
Breed		.000	-.519**	-.300*	.007	-.080-	-.671**
Gender	.000		-.701**	-.712**	-.642**	-.797**	-.105-
Liver	-.519**	-.701**		.793**	.615**	.695**	.557**
Kidney	-.300*	-.712**	.793**		.580**	.691**	.358*
Muscle	.007	-.642**	.615**	.580**		.689**	.417**
Serum	-.080-	-.797**	.695**	.691**	.689**		.361*
Hair	-.671**	-.105-	.557**	.358*	.417**	.361*	

Values presented in the table are correlation coefficient

**. Correlation is significant at the 0.01 level *. Correlation is significant at the 0.05 level

Table 4. Effect of breed on Iron concentration (PPM) levels in organs, muscle and camel serum.

	Wadha	Maghateer	Magaheem	SE	Minimum	Maximum	P value
Liver	56.71	55.5	52.67	0.76	44.37	68.4	0.08
Kidney	50.73[b]	55.58[a]	55.7[a]	0.78	38.78	62.73	<0.01
Muscle	26.82	24.97	25.07	0.42	19.64	32.78	0.13
Serum	4.47[a]	3.23[b]	3.59[b]	0.16	1.65	6.23	<0.01
Hair	181.99	144.1	146.28	6.87	80.35	250.88	<0.05

in examined samples was arranged in descending manner as follows liver > muscle > hair > kidney > serum. Regarding Cu concentration, several values have been reported for camel livers in Sudan 6.5–125 mg kg^{-1} (Abu Damir *et al,* 1983), in Egypt 30–286 mg kg^{-1} (Khalifa *et al,* 1973), at Djibouti 19–88 mg kg^{-1} (Faye *et al,* 1992), in Saudi Arabia 265 ± 30 mg kg^{-1} (Al-Busadah, 2003), at the eastern region of Sudan 103 ± 12.3 mg kg^{-1} (Bakhiet *et al,* 2007), in Morocco 14 ± 6.12 mg kg^{-1} (Chafik *et al,* 2014) and in Iran 1.555–4.381mg kg^{-1} (Asli *et al,* 2020). The level of Cu reported as 1.10±0.24 and 1.43±0.14 mg kg^{-1} for muscle and kidney, respectively in Morocco (Chafik *et al,* 2014), 1.29±0.141 and 1.77±0.9 mg kg^{-1} for muscle and kidney, respectively in Egypt (Khalafalla *et al,* 2015), and 220- 2.940 mg kg^{-1} for meat in Iran (Asli *et al,* 2020). The effect of gender on the distribution of Cu showed no significant difference (P > 0.05) in between kidneys meanwhile, female livers contained significantly higher concentrations than the male liver. Male muscle, serum, and hair samples contained significantly higher Cu (P0.05) than female muscle, serum, and hair samples (Table 8). In previous reports sex had a significant effect on Cu concentration in camel samples (Rashed, 2002; Badiei *et al,* 2006). In other studies, sex had no significant effect on Cu in the tissues and serum of the camels (Chafik *et al,* 2014; Asli *et al,* 2020). The data in Table 9 revealed a positive significant correlation between liver and kidney. Furthermore, strong positive correlation was seen between muscle and serum; breed, and hair.

Lead

Lead and its compounds have accumulated in the environment, including air, water, and soil, because of human activities such as mining, manufacturing, and fossil fuel burning. Batteries, cosmetics, metal items such as bullets, solder and pipes are all made using lead (Jaishankar *et al,* 2014). Lead can negatively affect kidney function and haemopoiesis, as well as the gastrointestinal and nervous systems (Daniel *et al,* 1995). The lead residue was detected in all examined samples among different breeds except muscle samples of Maghateer and Magaheem breeds. The lowest detectable value obtained in muscle of Wadha breed 0.001 mg kg^{-1} and the highest value belongs to hair of Magaheem breed 1.979 ± 0.085 mg kg^{-1} and generally descending distribution of lead residue was hair > liver > kidney > serum > muscle (Table 10). The highest level of Pb in edible tissue obtained in liver come in parallel with Morshdy *et al* (2018) in Egypt and Bala *et al* (2018) in

Table 5. Effect of gender on iron concentrations in organs, muscle and camel serum.

	Gender	Mean	Std. Error Mean	Minimum	Maximum	P
Liver	Male	58.622[a]	0.795	52.360	68.400	<0.001
	Female	51.761[b]	0.815	44.370	60.340	
Kidney	Male	57.105[a]	0.762	49.670	62.730	<0.001
	Female	51.285[b]	1.025	38.780	58.990	
Muscle	Male	26.906[a]	0.551	22.770	32.780	<0.01
	Female	24.493[b]	0.539	19.640	29.770	
Serum	Male	4.473[a]	0.186	3.220	6.230	<0.001
	Female	3.149[b]	0.185	1.650	4.670	
Hair	Male	185.941[a]	8.833	110.360	250.880	<0.001
	Female	132.538[b]	7.232	80.350	210.340	

Table 6. Correlations between iron concentrations in organs and serum with breed and gender.

Iron	Breed	Gender	Liver	Kidney	Muscle	Serum	Hair
Breed		.000	.082	0.161	-.021-	-.021-	0.428**
Gender	.000		.284	-.207-	-.399**	-.399**	-.453**
Liver	.082	.284		.375*	-.375*	-.375*	-.080-
Kidney	.161	-.207-	.375*		-.112-	-.112-	.217
Muscle	-.021-	-.399**	-.375*	-.112-		1.000**	.291
Serum	-.021-	-.399**	-.375*	-.112-	1.000**		.291
Hair	.428**	-.453**	-.080-	.217	.291	.291	

Values presented in the table are correlation coefficient based on Pearson Correlation coefficients.
**. Correlation is significant at the 0.01 level *. Correlation is significant at the 0.05 level.

Nigeria. Comparable to our finding the lead was not detected in camel meat from Iran (Asli *et al,* 2020) meanwhile, lead residues were detected in camel muscle from Egypt as 1.402±0.52 mg kg^{-1} (Khalafalla *et al,* 2015) and in camel meat from Al-Ahsa Abattoir, Saudi Arabia as 0.00730 ± 0.0012 mg kg^{-1} (Meligy *et al,* 2019). The examined camel liver samples in our study contained (0.142- 0.204 mg kg^{-1}) which were relatively lower than 3.4 ± 0.31 mg kg^{-1} in camel livers from Egypt (Khalafalla *et al,* 2015), (0.093–1.563 mg kg^{-1}) in Iranian camel livers (Asli *et al,* 2020). The residual level of lead in the kidney ranged from 0.123 to 0.323 mg kg^{-1} meanwhile, higher lead values in kidney tissues was obtained 1.41±0.23 mg kg^{-1} in Egypt (Khalafalla *et al,* 2015), 5.05-11.88 mg kg^{-1} in Saudi Arabia (El-Ghareeb *et al,* 2019). The hair samples contained lead residues from 0.612 to 2.615 mg kg^{-1} in our study meanwhile, higher values were obtained in camel hair samples 4± 0.51 to 13±4.32 mg kg^{-1} from different locations in Egypt (Rashed and Soltan, 2005). The variation in the level of lead contamination may be attributed to differences in accumulation rate in the environment, such as air, water, and soil due to human activities like manufacturing, mining, and fossil fuel burning. All the examined camel muscle and offal in our study below the maximum permissible limit of Pb (0.1 and 0.5 mg/kg ww for muscle and offal, respectively) established by the European Commission (2006). There is no significant difference in lead residue (P> 0.05) related to gender among examined samples (Table 11) indicating that equal exposure to lead sources between males and females. The correlation between lead concentration in Table 12 revealed a positive correlation between liver and breed while the strong positive correlation between breed, serum, and hair.

Table 7. Effect of breed on copper concentrations in organs, muscle and camel serum.

	Wadha	Maghateer	Magaheem	SE	Minimum	Maximum	P value
Liver	13.6053	17.7873	14.7349	0.85	7.59	30.44	0.114
Kidney	1.26227^{b}	2.03527^{a}	1.46527^{b}	0.077759	0.735	2.746	0.000
Muscle	2.1133	2.2213	2.078	0.10291	1.04	3.57	0.845
Serum	1.0567	1.1107	1.039	0.05146	0.52	1.78	0.845
Hair	2.2427^{b}	3.4974^{ab}	3.8559^{a}	0.23199	1.02	6.78	0.009

Table 8. Effect of gender on copper concentrations in organs, muscle and camel serum.

	Gender	Mean	Std. Error Mean	Minimum	Maximum	P
Liver	Male	13.662^{b}	1.397	52.36	68.4	0.05
	Female	16.875^{a}	0.946	44.37	60.34	
Kidney	Male	1.701	0.137	49.67	62.73	0.19
	Female	1.487	0.079	38.78	58.99	
Muscle	Male	2.428^{a}	0.11	22.77	32.78	0.007
	Female	1.882^{b}	0.15	19.64	29.77	
Serum	Male	1.214^{a}	0.055	3.22	6.23	0.006
	Female	0.941^{b}	0.075	1.65	4.67	
Hair	Male	3.944^{a}	0.328	110.36	250.88	0.002
	Female	2.546^{b}	0.267	80.35	210.34	

Table 9. Correlations between copper concentrations in organs and serum with breed and gender.

Copper	Breed	Gender	Liver	Kidney	Muscle	Serum	Hair
Breed		.000	.082	.161	-.021-	-.021-	.428**
Gender	.000		.284	-.207-	-.399**	-.399**	-.453**
Liver	.082	.284		.375*	-.375*	-.375*	-.080-
Kidney	.161	-.207-	.375*		-.112-	-.112-	.217
Muscle	-.021-	-.399**	-.375*	-.112-		1.000**	.291
Serum	-.021-	-.399**	-.375*	-.112-	1.000**		.291
Hair	.428**	-.453**	-.080-	.217	.291	.291	

*. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Cadmium

Humans are most exposed to Cd by inhalation and ingestion and can develop acute and chronic intoxications (Jaishankar *et al,* 2014). It can also cause kidney dysfunction, increases in blood pressure, hepatocellular and pulmonary damage (Daniel *et al,* 1995). The results in table 13 showed that Cd values ranged from 0.0001 mg kg^{-1} in muscle of Maghateer breed to 4.5113 mg kg^{-1} in hair of Wadha breed. There were no significant differences between breeds in all examined samples except significant lower value in hair samples of Maghateer breed than other breeds. Comparable Cd values were obtained in Iranian camel muscle 0.006-0.012 mg kg^{-1} (Asli *et al,* 2020). On the other hand, the residual level of Cd in liver, kidney and muscle in this study was greatly lower than 0.46 ± 0.09, 0.85 ± 0.26 and 0.2 ± 0.03 mg kg^{-1}, respectively observed in Egypt (Khalafalla *et al,* 2015), 1.95, 1.82 and 0.15 mg kg^{-1}, respectively in Saudi Arabia (El-Ghareeb *et al,* 2019). The Cd residues in examined meat and offal in this study were within the maximum permissible limits (MPLs) of Cd in the meat and organ (0.5 to 1.0 mg/kg ww, respectively) established by the European Commission (2006). The hair samples in this study contained the highest Cd residue level ranged from 2.0937 to 4.5113 mg kg^{-1}. Nearly similar Cd residues in camel hair obtained 0.25 ± 0.09 to 5.75 ± 0.87 mg kg^{-1} in Egypt (Rashed and Soltan, 2005). In addition, Medvedev (1999) reported lower Cd residue in camel hair 0.25 mg kg^{-1}. Animal hair, with its unique capacity to preserve the picture of environment imprinted over time, is becoming more important than other tissues in assessing heavy metal concentrations in the environment in which animals were reared. According to the researchers, animals eliminate pollutants by sequestering them in their hair, and molting is the primary method of heavy metal excretion (Rose and Parker, 1982; Braune and Gaskin, 1987; Honda *et al,* 1987). According to data in table 14 males had significantly

Table 10. Effect of breed on lead concentration levels in organs, muscle and camel serum.

	Wadha	Maghateer	Magaheem	SE	Minimum	Maximum	P value
Liver	0.142^{b}	0.204^{a}	0.179^{ab}	0.008	0.088	0.287	0.002
Kidney	0.240^{a}	0.190^{b}	0.171^{b}	0.007	0.123	0.323	0.000
Muscle	0.001	0.000	0.000	0.000	0.000	0.005	0.102
Serum	0.004^{b}	0.003^{b}	0.040^{a}	0.003	0.000	0.081	0.000
Hair	1.052^{b}	0.892^{b}	1.979^{a}	0.085	0.612	2.615	0.000

Table 11. Effect of Gender on lead concentration levels in organs, muscle and camel serum.

	Gender	Mean	Std. Error Mean	Minimum	Maximum	P
Liver	Male	0.177	0.009	0.111	0.268	0.82
	Female	0.173	0.012	0.088	0.287	
Kidney	Male	0.208	0.011	0.124	0.323	0.32
	Female	0.194	0.009	0.123	0.290	
Muscle	Male	0.001	0.000	0.000	0.005	0.21
	Female	0.000	0.000	0.000	0.002	
Serum	Male	0.020	0.005	0.000	0.076	0.22
	Female	0.012	0.004	0.000	0.081	
Hair	Male	1.486^{b}	0.136	0.790	2.615	0.04
	Female	1.152^{a}	0.099	0.612	1.955	

Table 12. Correlations between Lead concentrations in organs and serum with breed and gender.

Lead	Breed	Gender	Liver	Kidney	Muscle	Serum	Hair
Breed		0.000	.302*	-.607**	-0.289-	0.657**	0.669**
Gender	0.000		-0.035-	-.151-	-0.207-	-.189-	-0.295*
Liver	0.302*	-.035-		-.125-	-.006-	-.166-	-0.092-
Kidney	-.607**	-.151-	-.125-		0.198	-.355*	-0.189-
Muscle	-0.289-	-0.207-	-0.006-	0.198		-0.115-	-0.034-
Serum	.657**	-.189-	-.166-	-.355*	-.115-		0.744**
Hair	0.669**	-0.295*	-.092-	-0.189-	-.034-	0.744**	

higher Cd values (P< 0.05) in liver and serum than females, which may attributed to higher feed intake than females. On the contrary, females contained higher Cd in hair samples may be due to long life in breeding and reproduction then introduced to slaughter. Liang *et al* (2017) reported that heavy metal concentrations varied according to age groups, and higher concentrations for Cd appeared in female hair. The data in table 15 revealed a significant positive correlation between muscle and liver in addition to a strong significant positive correlation muscle, serum and hair, which attributed to the action of hair as a biological matrix is it contains information about metabolic pools of toxic elements in animals (Miroshnikov *et al,* 2019).

Health risk assessment

The health risk assessment due to consumption of camel meat from different breeds in Saudi Arabia *via* estimated daily intake (EDI) in comparison with tolerable daily intake (TDI). The calculated data in Table 16 revealed that EDI of all examined metals from all breeds below the TDI established by FAO/WHO (2010). The EDI of toxic metal as Pb and Cd was lower than previous report in Nigeria from cattle meat (Ihedioha and Okoye, 2013), in Saudi Arabia from camel meat (El-Ghareeb *et al,* 2019) and in Iran from cattle meat (Zeinali *et al,* 2019). The non-carcinogenic hazard ratios (HRs) and hazard indices (HIs) were assessed in this study in Table 16. HIs due to consumption of Wadha breed slightly higher than Maghateer or Magaheem but all HR and HIs values were far below 1, which proved no potential exposure to risk due to consumption of camel meat from different breeds. Our results in the same line with Orellana *et al* (2021) who find that no undesirable health risk for adults and children combined with the consumption of Alpaca meat in Huancavelica, Peru.

Table 13. Effect of breed on cadmium concentration levels in organs, muscle and camel serum.

	Wadha	Maghateer	Magaheem	SE	Minimum	Maximum	P value
Liver	0.0039	0.0127	0.0091	0.0012	Not detected	0.0345	0.009
Kidney	0.0101	0.0072	0.0049	0.0014	0.0005	0.0657	0.308
Muscle	0.0009	0.0001	0.0002	0.0002	0.0000	0.0050	0.066
Serum	0.0153	0.0195	0.0175	0.0010	0.0004	0.0357	0.231
Hair	4.5113[a]	2.0937[b]	4.1480[a]	0.2749	0.8700	8.2400	<0.0001

Table 14. Effect of Gender on cadmium concentration levels in organs, muscle and camel serum.

	Gender	Mean	Std. Error	Minimum	Maximum	P
Liver	Male	0.011419[a]	0.002024	Not detected	0.0345	0.03
	Female	0.006074[b]	0.001292	0.00065	0.02031	
Kidney	Male	0.00985	0.002813	0.00347	0.0657	0.09
	Female	0.005234	0.000453	0.00046	0.00954	
Muscle	Male	0.00017	0.000042	0.0001	0.0008	0.14
	Female	0.00059	0.000276	0.0001	0.005	
Serum	Male	0.021172[a]	0.001278	0.01467	0.0357	<0.001
	Female	0.014155[b]	0.001184	0.00039	0.02111	
Hair	Male	2.5419[b]	0.24543	0.87	4.56	<0.001
	Female	4.4965[a]	0.38433	2.01	8.24	

Table 15. Correlations between cadmium concentrations in organs and serum with breed and gender.

Cadmium	Breed	Gender	Liver	Kidney	Muscle	Serum	Hair
Breed		**.000**	**-.325***	**.391****	**-.256-**	**-.334***	**-.320***
Gender	.000		**-.674****	**-.561****	**-.430****	**-.609****	**-.584****
Liver	-.325*	-.674**		**.257**	**.330***	**.627****	**.543****
Kidney	.391**	-.561**	.257		**.247**	**.149**	**.165**
Muscle	-.256-	-.430**	.330*	.247		**.578****	**.463****
Serum	-.334*	-.609**	.627**	.149	.578**		**.765****
Hair	-.320*	-.584**	.543**	.165	.463**	.765**	

Table 16. Estimated daily intake (µg/kg/day) and risk assessment (HR and HI) due to ingestion of camel meat from different breeds.

		Zn	Iron	Cu	Pb	Cd	HIs
Wadha	EDI (Adult)	53.67	55.94	4.41	0.00208	0.00188	
	EDI (child)	125.22	130.52	10.28	0.00486	0.00438	
Maghateer	EDI (Adult)	36.65	52.08	4.63	0	0.00021	
	EDI (child)	85.52	121.52	10.81	0	0.00048	
Magaheem	EDI (Adult)	53.88	52.29	4.33	0	0.00042	
	EDI (child)	125.71	122.01	10.11	0	0.00097	
	TDI	1000	800	500	3.57	1	
Wadha	HR (Adult)	0.18	0.08	0.11	0.00052	0.00188	0.371
	HR (child)	0.42	0.19	0.26	0.00121	0.00438	0.867
Maghateer	HR (Adult)	0.12	0.07	0.12	0	0.00021	0.313
	HR (child)	0.29	0.17	0.27	0	0.00048	0.729
Magaheem	HR (Adult)	0.18	0.07	0.11	0	0.00042	0.363
	HR (child)	0.42	0.17	0.25	0	0.00097	0.847

TDI: Tolerable daily intake according to FAO/WHO (2010)

However, much care should be taken as exposure to heavy metals also from vegetables, water and air which may increase the HIs especially in children. The obtained values for HR and HIs were found lower than those seen in Ghana (Bortey-Sam *et al,* 2015), Egypt (Darwish *et al,* 2015), Iran (Zeinali *et al,* 2019), and in Saudi Arabia (El-Ghareeb *et al,* 2019).

It was concluded that heavy metals distributed among camel samples of different breeds and toxic metal Pb and Cd in meat and offal were below the international maximum permissible limit. The correlation between samples reflected the role of hair as a good tool for identification of heavy metal pollution. In addition, no potential health hazards among camel meat consumers in Saudi Arabia especially, adults were seen.

Acknowledgements

The authors would like to acknowledge the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia for the financial support of this project under annual funding track [Project No. GRANT132].

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