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Assessment of Lead, Cadmium, Nickel, and Chromium Residues in Camel Meat and Offal

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Abstract

In several nations of the Middle East, camel meat is a significant source of animal-derived protein, vitamins, and minerals. In the Arab and African continents, camels are extremely significant. The study was conducted to determine the residual levels of heavy metals (lead, cadmium, nickel, and chromium). Camel meat plays a significant role in these regions as a source of protein, but it may also contain many toxic substances as residues contamination with heavy metals, which are considered serious threats not only due to their toxicity but also because of bioaccumulation in the food chain. The average lead levels in the analyzed samples of muscles, kidneys, and livers were 0.11±0.03, 0.47±1.18, and 0.7±0.13 mg/kg, respectively. The mean concentrations of cadmium in muscles, livers, and kidneys, however, were 0.13±0.04, 0.43±0.12, and 0.85±0.34 mg/kg, respectively. While the residual chromium levels in the muscles, livers, and kidneys were, respectively, 0.1±0.45, 0.21±0.11, and 0.25±0.07 mg/kg. The residual level of all the metals in different tissues were found to be substantially different, with a p-value <0.05, whereas nickel was 0.13, 0.16, and 0.23 mg/kg. In conclusion, liver and kidneys has higher concentrations of the tested metals compared with muscles. However, the recorded concentrations of the tested metals lies within the acceptable limits set by the regulatory authorities.

KEYWORDS
Camel, Heavy metals, Lead, Cadmium, Nickel.

INTRODUCTION

Camel is a significant animal in many countries, particularly in the Middle East. Heat stress has a negative impact on the health of animals in hot areas, although camels can provide nutritious meat even under the worst environmental conditions (Bouhaddaoui *et al.*, 2019). According to Kadim *et al.* (2008), camel meat has a good nutritional value and contains vitamins and omega -3 polyunsaturated fats. According to FAO (2001), camel meat production accounts for 0.7% of global meat production. In terms of less fat, less cholesterol, and high protein content, it is also healthier than other meats like beef and mutton (Kadim *et al.*, 2008). However, they may also contain some toxic substances like heavy metals, which are less prevalent in muscles than organs like the liver and kidney (Khalafalla *et al.*, 2011).

When present in trace amounts, heavy metals are classified as either essential or hazardous components. They enter food before moving on to tissues (Thompson and Darwish, 2019). Also today it spreads through medications to animals. Additionally, as food production and processing technology advances, the likelihood of heavy metals and other environmental pollutants contaminating food increases. Animals ingesting these pollutants cause residues to accumulate in meat and offal (Darwish *et al.*, 2015). Because remnants cannot be tasted, smelled, or seen, they are present in tissue but are hidden and pose a serious threat to public health. These metals are poisonous by nature, and even little amounts of their presence can have negative effects (Sabir *et al.*, 2003). To ensure the safety of the products, it is crucial to test raw meat for harmful metals. Therefore, the current study's objective was to estimate the amount of metal present in camel meat, liver, and kidney. Pb, Cd, Ni, and Cr were the hazardous metals that were measured. The public health significance of the tested metals was also discussed.

MATERIALS AND METHODS

Collection of samples

Ninety samples of muscle, liver, and kidney (30 of each) were taken from camels chosen at random. Samples were taken right after the slaughter at the central abattoir in Zagazig. Sampling procedures were done during December 2022 to March 2023. All of the animals were healthy, active, and disease-free. Until extraction and measurement, sample tissues for metal analysis were maintained at -20ºC in plastic falcon tubes.

Sample preparation and extraction

Determination of heavy metals

The amount of lead, cadmium, chromium, and nickel (mg/Kg) in the analyzed samples of camel meat and offal was calculated on the basis of wet weight.

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Cleaning techniques (AOAC, 2006)

Equipment cleaning is a crucial step in preventing contamination with the element being analyzed. To ensure that all the equipment was free of metal, glassware and vessels were carefully cleaned with deionized water, submerged in hot, dilute HNO3 (10%) for 24 hours, rinsed many times with deionized water, and then left to dry. The digesting vessels were also immersed in water and soap for two hours before being repeatedly cleaned with tap water. Once with distilled water, once with a solution of 250 ml deionized water, 200 ml concentrated HCl, and 80 ml hydrogen peroxide, and once with 10% HNO_3. In reality, every container was carefully cleaned with deionized water and allowed to air dry in an incubator to remove any contaminants or dust.

Technique for digestion (Tsoumbaris and Papodoulou, 1994)

In order to accurately determine the presence of lead, cadmium, chromium, and nickel residues, 1 g of each sample was macerated with a sharp scalpel and digested with 10 ml of a digestion solution (60 ml of 65% nitric acid and 40 ml of 70% perchloric acid in a screw-capped tube).

Throughout the heating period, the digesting tubes were shaken ferociously every 30 minutes. To ensure that the materials were completely digested, the tubes were then allowed to cool to room temperature, diluted with 1 ml deionized water (30%), and then heated in a water bath at 70ºC. All organic matrixes have been destroyed at this point.

Deionized water was used to dilute each tube to a volume of 25 ml, and Whattman filter paper No. 42 was used to filter the digest. After being collected in Pyrex glass test tubes with polyethylene film caps, the filtrates were maintained at room temperature until their lead, cadmium, chromium, and nickel contents were determined.

Preparation of blank and standard solutions (Shibamoto and Bjeldanes, 2000)

The Flame Atomic Absorption Spectrophotometer (VARIAN, model AA240 FS, Australia) operator handbook served as the basis for the instrument techniques used for numerous analyses. However, blank and standard solutions were made in the same way and with the same chemicals as those used for wet digestion.

Nitric acid and H_2O_2 were used to make the blank solution, which was then diluted with deionized water and filtered. The value of the blank was subtracted from the final calculations in order to account for any potential metal contamination of the chemicals. Additionally, 10 parts nitric acid and 1 part H_2O_2 were used to generate standard solutions with pure certified metal standards at various strengths.

Analysis

By using a Flame Atomic Absorption Spectrophotometer (VARIAN, Australia, model AA240 FS), the digest, blanks, and standard solutions were aspirated, and their lead, cadmium, chromium, and nickel concentrations were measured. The device has an automatic sampler, a digital absorbance readout, and a concentration readout that can function under the circumstances as advised by the instrument instruction (Table 1).

Measuring the quantity of heavy metal residues

The concentration of lead, cadmium, chromium, and nickel was determined using the following equation, and metal absorbency was directly recorded from the digital scale of AAS:
Where, C = R x (D/W),
C stands for lead concentration (mg/kg wet weight)
R is the digital scale reading for the AAS.
D is the prepared sample's dilution.
W stands for sample weight.

Additionally, the amount of each heavy metal in the blank solution was computed and deducted from each sample that was examined.

Statistical analysis

The Tukey-Kramer HSD difference test (JMP) (SAS Institute, Cary, NC, USA) was used for statistical comparisons (p 0.05).

RESULTS AND DISCUSSION

Table 2 provides a summary of the study's findings. Worldwide, camel meat is regarded as a good source of animal protein, vitamins, and necessary trace minerals. Camels that have been exposed to heavy metals through food or environmental pollution. Toxic heavy metals are problematic because they accumulate in human and animal bodies and aren't eliminated by cooking (Jankeaw *et al*., 2015). In addition to mutagenicity and carcinogenicity, such as lead and cadmium, there are many types of toxicity, including hepato-, nephro-, immunotoxicities, and CNS abnormalities (Klassen *et al*., 1986). Biologically important substances including structural proteins, enzymes, and nucleic acids can bind to toxic heavy metals and prevent them from performing their normal roles in cells (Emsley *et al*., 2011).

The mean detectable levels of lead (Pb) in the camel samples used in the current study were 0.11±0.03 mg kg, 0.47±1.18 mg kg, and 0.7±0.13 mg/kg, respectively (Table 2). These variations in lead amounts in the fresh meat and edible offal samples under examination were statistically significant ($P<0.05$). Specifically, liver and kidney samples from camels acquire the most Pb residues. According to Ahmed Al-perkhdri (2021), the kidney recorded the highest concentration of lead, reaching 8 ppm, than muscle and liver of camel. The kidney was shown to have the highest quantity of this metal, at 0.7±0.13 mgkg, compared to muscle and liver. The fact that muscles had the lowest quantities (0.11±0.03 mg kg), however, indicates that Pb enters the body through water and food. According to EOS. (2010), the acceptable permitted

Table 1. The used gas and lamp characteristics of the used atomic absorption Spectrometry.

Condition	Lead	Cadmium	Chromium	Nickel
Lamp wavelength (nm)	217.0	228.8	357.9	232
Lamp current (m/amp)	5.0	4.0	7.0	4.0
Slit width (nm)	1.0	0.5	0.2	0.2
Used gas	A-AC	A-AC	A-AC	A-AC*

A-AC*= Air/Acetylene

limit for lead in fresh camel meat is 0.1 mg/kg, and it is 0.5 mg/kg for offal. Lead levels in camel muscle were 0.11 mg/kg, which is less than the results reported by Abdel Basset *et al.* (2014), who claimed that the mean lead concentration for muscles is 0.71 mg/kg. It is also less than the results reported by Badis *et al.* (2014), who claimed that the mean lead concentration in Algeria is 2.01 ppm, although it is more than the levels found by Sharkawy *et al.* (2002)(0.06 ppm). As a result, environmental conditions, the kind of pasture, and the extent of industrialization all affect the quantities of hazardous metals in meat (Kadim *et al.*, 2013). High blood pressure, anaemia, kidney disease, and mental retardation are just a few of the illnesses that lead can severely affect numerous organs and cause. Because of their propensity to affectively absorb lead and their developmental delays, young children are particularly risky (Kocak *et al.*, 2005).

In the camel muscles, liver, and kidneys that were tested, the mean detectable levels of cadmium (Cd) were 0.13±0.04 mg/kg, 0.43±0.12 mg/kg, and 0.85±0.34 mg/kg, respectively (Table 2).

The highest amount of cadmium was found in the kidneys of camels, which had a concentration of 0.85±0.34 mg/kg. This finding is consistent with the idea that the kidneys serve as an animal's primary organ of storage (García-Fernández and Sánchez-García, 1996). As tiny molecular compounds containing -sh groups, the excretory mechanism for such metals was poorly developed in vertebrates and was unable to handle high levels of such metal contaminations (Pompe-Gotal and Crnic, 2002).

The detectable levels in this study do not exceed the acceptable limits for cadmium, according to the legal norm (0.05 mg/kg) in meat, (0.5 mg/kg) in offal except kidney and suggested by EOS (2010). Our study's findings were higher than those noted by Abdel Baset *et al.* (2014), who noted that kidney, liver, and muscle each contained 0.69 mg/kg, 0.25 mg/kg, and 0.12 mg/kg of the substance, respectively. However, these results were lower than those reported by Darwish *et al.* (2019), who said that the amount of cadmium in the kidney is 1.83 mg/kg, 2.18 mg/kg, and 0.29 mg/kg.

Cadmium is widely dispersed in the environment and is present in almost all plants, animals, and foods. Long-term phosphate fertilizer application and acid rain both significantly increase the quantity of cadmium in the soil (Busceme *et al.*, 1997). High quantities of these hazardous metals are present in the water that camels consume from contaminated sources and graze in (Nwude *et al.*, 2010).

The Food and Agriculture Organization (FAO, 2011) stated that the nickel standard for food goods is 0.5 mg/kg. This result is in opposition to a study by Bala *et al.* (2014) that found significant Ni concentrations in the kidney and liver (0.77 mg/kg and 0.94 mg/kg, respectively). Ni concentrations were higher in the kidney samples than the liver. This is consistent with the findings of Iwegbue (2008), who found that the kidneys had higher nickel concentrations (0.16 mg/kg) than the liver (0.10 mg/kg). Our study's findings diverge from those made by Farooq (2016), who estimated that meat had 8.2–24 g/kg of nickel. The results of our investigation revealed that the levels of 0.1±0.03 mg/kg, 0.16±0.54 mg/kg, and 0.23±0.05 mg/kg in the muscle, liver, and kidney, respectively, are within acceptable ranges (Table 2). Sabeeh (2017) also discovered nickel in camel meat and determined that its concentration was 0.10.008mgkg, which is consistent with our findings and within allowable limits.

Cadmium replaces Zinc and therefore disturbs the normal function of several enzymes, thus more zinc is needed to counteract the toxicity of that hazardous metal (Abd El-Salam *et al.*, 2013; Darwish *et al.*, 2015; Elhelaly *et al.*, 2022).

According to WHO/FAO (2011), 1 mg/kg is the standard value for chromium, thus our results showed that all samples fell within acceptable ranges. For example, Table 2 shows that the chromium levels in muscle, liver, and kidney were 0.21 mg/kg, 0.25 mg/kg, and 0.25 mg/kg, respectively. And this concurs with the findings of Farooq (2016), who reported that their samples had lower chromium concentrations than the reference value. Additionally, Richard *et al.* (2014) found that the amount of chromium in beef was 0.48 mg/kg, although our findings were lower. Additionally, Okareh and Oladipo (2015) discovered a mean Cr concentration in the kidney that was greater than our study's findings at 2.3 to 2.99 mg/kg. According to Oliveira (2012), chromium is typically included in stainless steel anti-corrosive agents in tanks, pipes,

Table 2. Mean values of heavy metals concentrations in muscle, liver and kidney (mg\kg) of camel.

Metal		Muscle	Liver	Kidney
Lead	Lead (mg\kg)	0.11± 0.03^{b}	0.47±1.18^{a}	0.7±0.13^{a}
	MPL (mg\kg)[1]	0.1	0.5	0.5
Cadmium	Cadmium (mg\kg)	0.13±0.043^{c}	0.43±0.12^{b}	0.85±0.34^{a}
	MPL (mg\kg)[1]	0.05	0.5	0.1
Nickel	Nikel(mg\kg)	0.1±0.03^{a}	0.16±0.54^{b}	0.3±0.05^{a}
	MPL (mg\kg)[2]	0.5	-	-
Chromium	Chromium (mg\kg)	0.1±0.45^{b}	0.21±0.11^{a}	0.25±0.07^{a}
	MPL (mg\kg)[2]	1.0	1.0	1.0

[1]MPL: Maximum permissible limit stipulated by E.O.S (2010)
[2]MPL: Maximum permissible limits of F.A.O (2011)
SE: Standard Error of mean
Values within the same row carrying different superscript letter are significantly different at $P< 0.05$.

Table 3. Potential health hazards associated with lead, cadmium, nickel and chromium.

Metal	Adverse health effects	Reference
Lead	Death, cancer risk, Neurological disorders, and organ damage	Darwish *et al.* (2016)
Cadmium	Itai –itai disease, kidney dysfunction, bone softening, and cancer risk	Thompson and Darwish (2019)
Nickel	Allergic dermatitis, diarrhea, abdominal pain, abdominal swelling, and stomatitis	Picarelli *et al.* (2011)
Chromium	Dermatitis, ulcers, respiratory illness, and alteration in iron metabolism	Kornhauser *et al.* (2002)

and chemicals used to cure wood. This showed that the excessive use of chrome-band utensils was to blame for the high quantities of chromium that had been found. When compared to nickel, cadmium, and lead, chromium is at least the metal that is the most environmentally stable and exists in a variety of oxidation states, as demonstrated by Zayed and Terry (2003).

The variations in environmental contamination and the grazing of animals on tainted soil, food, and water are the main causes of the discrepancies in metal-accumulation patterns between this study and other studies for other researches from other parts of the world. Furthermore, according to Komsta--Szumska and Chmielnicka (1983), inter-species variations in metal accumulation and animal age may be ascribed to variations in xenobiotic metabolizing enzymes and metal detoxifying capacities.

According to Jarup and Akesson (2000) and El-Ghareeb *et al*. (2019), the liver and kidney of the camel play a significant role in the metabolism and detoxification of xenobiotics, which may explain the higher amount of hazardous metals in these organs compared to the muscles.

In general, ingestion of food of animal origin that contaminated with heavy metals is linked to several adverse health effects (Table 3) that vary from dermatitis, kidney failure, abdominal pain, alterations in several enzyme functions, and iron metabolism to cancer risk, organ damage, and even death.

CONCLUSION

The findings of this study demonstrated that even at lower detection levels, heavy metals like cadmium and lead are significantly more abundant in the kidney and liver of camels than in the meat. As a result, while the meat of animals grazing in contaminated pasture with heavy metals may be safe for human consumption, the liver and kidney should be discarded if levels are higher than allowed because the toxic metals appear to bioaccumulate in these tissues.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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