Evaluation of Toxicity Potentials of Heavy Metals in Camel Milk from Selected Farms in Yobe State, Nigeria

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***Abstract*: The consumption of camel milk is gaining popularity due to its medicinal and dietary properties. Camel milk has also become the major requirement of daily diets, particulary among the vulnerable groups like the infants, school going children and the old persons. The concentrations as well as the toxicity potentials of some selected heavy metals were evaluated. The concentrations of heavy metals (Zn, Fe, Cu, Co, Ni, Pb, Cd and Cr) in camel milk obtained from four different farms (Gaidam, Waro, Yusari and Yunusari of Yobe State, Nigeria) were determined using Atomic Absorption Spectrophotometric Technique. The levels (ppm) of zinc, iron, copper, cobalt, nickel, lead, cadmium and chromium were respectively found to be in the range of 4.38 (Gaidam farm) to 4.88 (Waro farm), 0.20 (Waro farm) to 0.60 (Gaidam farm), 0.74 (Yunusari farm) to 1.34 (Waro farm), 0.02 (Gaidam and Waro farms) to 0.04 (Yunusari farm), 0.27 (Yunusari farm) to 0.80 (Waro farm), 0.02 (in all the four farms), 0.012 (Gaidam farm) to 0.018 (Yusari farm) and 0.013 (Yunusari farm) to 0.02 (Gaidam and Waro farms). Comparison of the observed values with permissible limits revealed that the values are less than or equal to their corresponding permissible limits. The observed toxicity potentials of all the heavy metals indicated values that are less than 1.00 in all the farms except in Gaidam and Waro farms where their corresponding chromium toxicity potentials are 1.00 in each case. The observed values were subjected to One-Way Analysis of Variance (ANOVA) and the Least Significant Difference (LSD) test. The variations in the levels of lead, cadmium and chromium were found to be statistically the same ($P \geq 0.05$), whilst the variations in the levels of zinc, iron, copper, cobalt and nickel were statistically not the same ($P < 0.05$). Based on the observed toxicity potentials, it is therefore evident that consumption of camel milk samples from all the farms is safe for human consumption.**

***Keywords*: Camel milk, permissible limits, toxicity potentials, heavy metals, Analysis of Variance and Least Significant Difference.**

I. INTRODUCTION

Among the various contaminants, heavy metals are directly associated with health challenges in human beings. Increased industrial and agricultural activities led to increase in the levels of metals such as iron, manganese, zinc, copper, aluminium, lead, chromium, mercury and nickel in air, water and soil [1]. The metals are absorbed and accumulated in the tissues of plants. These environmentally unfriendly pollutants have direct deadly effect on humans, as they are present in body tissues. The milk of animals contain some vital elements such as sodium, potassium, magnesium, phosphorus, chlorine and some trace elements like zinc, iron, copper, chromium, lead, nickel and cadmium as well as protein [1].

Heavy metals pollution can cause a lot of risk due to their bioaccumulation, toxic effect and continuity in different forms of food chain [2]. When lactating animals become exposed to high levels of heavy metals, such animals can amass the heavy metals in their milk and when man consumes the milk, this can cause serious health challenges [3]. Camel milk is known for its dietary and medicinal properties. It is considered to have anti-diabetic, anti-cancer and hypo-allergic properties [4][5]. The high content of its unsaturated fatty acid is responsible for its overall dietary quality [6][7]. The low quantity of β-caserin and lack of β-lactoglobulin are associated with the hypo-allergic property of camel milk [7]. The consumption of milk and milk products has increased in recent years since they have become the main requirement of daily diet, particularly for the vulnerable groups like the school going children, infants and the old persons [8].

The concentration of heavy metals in the environment is increasing as a result of anthropogenic activities [9]. Heavy metals pollution has received the attention of researchers all over the world, possibly due to their harmful effects on living organisms [10]. Some heavy metals are essential to both plants and animals at trace levels. Heavy metals that are essential to plants are copper, iron, molybdenum, cobalt and zinc, while those that are essential to animals are nickel, tin and chromium. Heavy metals such as mercury, lead and cadmium are not essential to either animals or plants. The concentrations of individual metals in living tissues must be very low and maintained within narrow limits in order to allow the optimum biological performance of most living organisms [10]. The levels of heavy metals in the environment greater than the permissible limit can be destructive to all living species. Intake of such heavy metals through ingestion, inhalation or by any other means can lead to health problems and complications such as cancer, damage to nervous system and consequently death [11]. This study is aimed at determining the levels of heavy metals in camel milk from selected farms in Yobe state, Nigeria and to also evaluate the toxicity potentials of the heavy metals.

II. MATERIALS AND METHODS

2.1 Materials

In preparing the solutions, chemicals of analytical reagent grade purity and distilled water were utilized. All the glass and plastic wares used were thoroughly washed with detergent solution, 5.00 % ($^{v}/_{v}$) trioxonitrate (V) acid, rinsed with water and the solutions that were used in them. The apparatus were then allowed to dry [12]. Buck Scientific Atomic Absorption Spectrophotometer Model 210-VGP was used for the determination of heavy metals in camel milk.

2.2. Methods

2.2.1 Sampling of Camel Milk

Camel milk samples were purchased from four different farms located in Gaidam, Waro, Yusari and Yunusari of Yobe State, Nigeria. The sampling process was done during the hand milking of the lactating female camels. The milk samples were separately collected in capped-polyethylene containers, labelled and stored in a refrigerator in order to prevent the milk samples from fermenting.

2.2.2 Digestion of Camel Milk

Milk sample (50.00 cm^3) was measured into a 250 cm^3 beaker and 10.00 $cm^3$of concentrated trioxonitrate (V) acid was added. The beaker and its content were moderately heated at 80 ^oC on a hot plate until brown fumes of the decomposed acid were observed [13]. Heating was continued until the volume reduced to about 10.00 cm^3. After cooling the digest, 20.00 cm^3 of water was added, filtered using Whatman Filter Paper Number 1 into a 100 cm^3standard flask and water added to capacity. The analyte solution was then transferred into screw-capped polyethylene bottles and labelled appropriately.

2.2.3 Determination of Heavy Metals in Camel Milk Samples

The levels of some selected heavy metals (Zn, Fe, Cu, Co, Ni, Pb, Cd and Cr) in the various analytes were determined at their respective wavelengths using Buck Scientific Atomic Absorption Spectrophotometer (AAS) Model 210-VGP.

2.2.4 Spiking of Camel Milk Samples with Standard Solutions of Some Metals

Some heavy metals were below the detection limit of the AAS. The camel milk sample were separately spiked with standard solution of such metals, followed by treatment as in sections 2.2.2 and 2.2.3 respectively.

2.2.5 Evaluation of Toxicity Potentials

The toxicity potential of each of the heavy metals studied was determined. Toxicity potential (T) was evaluated using:

$T = \frac{c_x}{c_m}$, where

c_x = concentration of pollutant and

c_m = threshold limit or maximum permissible limit based on standard [14]

III. RESULTS AND DISCUSSION

3.1 Results

The concentrations of zinc, iron, copper, cobalt, nickel, lead, cadmium, and chromium respectively determined in camel milk samples purchased from four different farms (Yusari, Yunusari, Gaidam and Waro) of Yobe State are presented in Table1

Table 1: Concentration of Heavy Metals (ppm) in Camel Milk Samples

Elements	Yusari	Yunusari	Gaidam	Waro
Zn	$4.59^b \pm 0.13$	$4.46^c \pm 0.13$	$4.38^d \pm 0.13$	$4.88^a \pm 0.13$
Fe	$0.40^c \pm 0.09$	$0.47^b \pm 0.09$	$0.60^a \pm 0.09$	$0.20^d \pm 0.09$
Cu	$0.87^c \pm 0.33$	$0.74^d \pm 0.33$	$1.08^b \pm 0.33$	$1.34^a \pm 0.33$
Co	$0.03^a \pm 0.00$	$0.04^a \pm 0.00$	$0.02^b \pm 0.00$	$0.02^b \pm 0.00$
Ni	$0.73^a \pm 0.21$	$0.27^c \pm 0.21$	$0.40^b \pm 0.21$	$0.80^a \pm 0.21$
Pb	$0.02^a \pm 0.00$	$0.02^a \pm 0.00$	$0.02^a \pm 0.00$	$0.02^a \pm 0.00$
Cd	$0.018^a \pm 0.00$	$0.013^a \pm 0.00$	$0.012^a \pm 0.00$	$0.015^a \pm 0.00$
Cr	$0.018^a \pm 0.00$	$0.013^a \pm 0.00$	$0.02^a \pm 0.00$	$0.02^a \pm 0.00$

Values are mean ± Standard Error of the Mean (n = 3). Values on the same row with different superscript letters are significantly different as revealed by one-way ANOVA and least significant different test ($p < 0.05$), while those same superscript letters are significantly the same ($p \geq 0.05$).

3.2 Discussion

The levels of zinc in camel milk samples as depicted in Table 1 spread from 4.38 (Gaidam sample) to 4.88 ppm (Waro sample) with 4.46 ppm (Yunusari sample) and 4.59 ppm (Yusari sample) falling in between the two extreme observed values. The observed values are lower than reported literature zinc level (5.16 ppm) determined in camel milk sample [15] and also lower than 5.01 ppm zinc in cow milk sample [16].

The observed values are however higher than 3.77 ppm of zinc found in raw milk in a rural area [17]. All the observed zinc values are lower than 6.00 ppm permissible limit [18]. The toxicity potentials of zinc in the camel milk samples from the various farms investigated were found to be Waro (0.81), Yusari (0.77), Yunusari (0.74) and Gaidam (0.73) respectively. This therefore shows that the camel milk samples are safe for human consumption. This is because toxicity potentials greater than one (1.00) are out of specification and therefore not acceptable. Table 2 shows that statistical significant differences ($p < 0.05$) exist between the concentrations of zinc found in all the farms.

Table 2: Treatment Means Difference of Zinc in Four Different Camel Farms ($LSD_{0.05} = 0.0032$)

	Waro: 4.88	Yusari: 4.59	Yunusari: 4.46	Gaidam: 4.38
Waro: 4.88		0.29	0.42	0.50
Yusari: 4.59			0.13	0.21
Yunusari: 4.46				0.08

Zinc is a trace element that is essential for human health. It plays a vital function in the immune system and it is an anti-oxidant in vivo. Deficiency of zinc can lead to birth defects [19][20].

The concentrations of iron determined in all the milk samples of Yobe State ranged from 0.20 ppm (Waro sample) to 0.60 ppm (Gaidam sample). The levels of 0.40 pm (Yusari sample) and 0.47 ppm (Yunusari sample) are in between the two observed concentrations of iron. The concentration of 0.60 ppm of the iron found in camel milk sample of Gaidam was found to be the highest. This could be because of food and water in which the animals feed on. All the experimental values are higher than reported literature value of 0.08 ppm of iron determined in camel milk sample [15]. The concentrations of iron in the present study are below the permissible limit of 4.00 ppm [18]. The toxicity potentials of iron in this study ranged from 0.05 (Waro sample) to 0.15 (Gaidam sample) with 0.10 (Yusari sample) and 0.12 (Yunusari sample) falling in between. This therefore indicates that the analytes are safe for human consumption. Significant differences ($p < 0.05$) were found to exist in the observed iron values in the camel milk samples from various farms (Table 3).

Table 3: Treatment Means Difference of Iron in Four Different Camel Farms ($LSD_{0.05} = 0.012$)

	Gaidam: 0.60	Yunusari: 0.47	Yusari: 0.40	Waro: 0.20
Gaidam: 0.60		0.13	0.20	0.40
Yunusari: 0.47			0.07	0.27
Yusari: 0.40				0.20

Long time over-consumption of iron can cause hemosiderosis (a condition characterized by large deposits of iron storage protein hemosiderin in the liver and even some tissues). Chronic toxicity can result into arthritis, fatigue, gut damage, aggressive behaviours, cardiovascular diseases, anorexia, increased oxidative stress, cancer, liver damage and weight loss [21].

Table 1 shows that the level of copper ranged from 0.74 ppm (Yunusari sample) to 1.34 ppm (Waro sample) with 0.87 ppm (Yusari sample) and 1.08 ppm (Gaidam sample) falling in between the observed extreme values. The experimental values of copper are higher than reported literature value of 0.07 ppm copper in camel milk sample [15], but lower than the threshold limit of 2.00 ppm [18]. The observed toxicity potentials of copper were found to be Waro (0.67), Gaidam (0.54), Yusari (0.44) and Yunusari (0.37) respectively. Based on the experimental values, threshold limit and the toxicity potentials, it is therefore evident that the camel milk samples investigated are safe for human consumption. The levels of copper in the camel milk samples were found to be statistically not the same ($p < 0.05$) as shown in Table 4.

Table 4: Treatment Means Difference of Copper in Four Different Camel Farms ($LSD_{0.05} = 0.23$)

	Waro: 1.34	Gaidam: 1.08	Yusari: 0.87	Yunusari: 0.47
Waro: 1.34		0.26	0.47	0.87
Gaidam: 1.08				0.61
Yusari: 0.87				0.4

Copper is an essential element that promotes the activity of certain enzymes in the body and it is also involved in haemoglobin synthesis, bone and elastic tissue development as well as in the normal functioning of the central nervous system[22].

The levels of cobalt found in all the camel milk samples studied spread from 0.02 ppm (Gaidam and Waro samples) to 0.04 ppm (Yunusari sample) with 0.03 ppm (Yusari) falling in between the concentrations of the metal determined. The highest level of cobalt (0.04 ppm) was observed at Yunusari sample, while the lowest level (0.02 ppm) was observed at Gaidam and Waro samples respectively. All the observed values are less than 0.05 ppm threshold limit [18]. The corresponding toxicity potentials of cobalt based on the sampling locations are Yunusari (0.80), Yusari (0.60), Gaidam (0.40) and Waro (0.40) respectively. Since all the toxicity potentials are less than 1.00, it therefore shows that the camel milk samples are safe for human consumption. Table 5 revealed that statistical significant differences ($p < 0.05$) exist only in the levels of cobalt in camel milk samples from Yunusari, Gaidam and Waro respectively.

Table 5: Treatment Means Difference of Cobalt in Four Different Camel Farms ($LSD_{0.05} = 0.012$)

	Yunusari: 0.04	Yusari: 0.03	Gaidam: 0.02	Waro: 0.02
Yunusari : 0.04			0.02	0.02
Yusari: 0.03				
Gaidam: 0.02				

Cobalt is an essential component of vitamin B-12. It can accumulate to toxic concentrations in the pancreas, liver, kidney, heart, skeleton and the skeletal muscles [23]. Cobalt can also form tumors in animals and is a likely human carcinogen.

The concentrations of nickel (ppm) as determined in camel milk samples ranged from 0.27 (Yunusari sample) to 0.80 (Waro sample) with 0.40 (Gaidam sample) and 0.73 (Yunsari sample) falling in between the lowest and highest observed nickel values. Comparatively, these observed values are higher than not detected nickel values in cow milk samples from Kawo, Malali, Kakuri and Kudendan of Kaduna State of Nigeria [24]. The values in the present study are lower than the permissible limit of 1.00 ppm [18]. The toxicity potentials of nickel in the analytes from the various farms are Waro (0.80), Yusari (0.73), Gaidam (0.40) and Yunusari (0.27) respectively. These facts revealed that all the analytes are fit for human consumption. Statistical significant differences ($p < 0.05$) in the levels of nickel in the various analytes were found to exist (Table 6).

Table 6: Treatment Means Difference of Nickel in Four Different Camel Farms ($LSD_{0.05} = 0.016$)

	Waro: 0.80	Yusari: 0.73	Gaidam: 0.40	Yunusari: 0.27
Waro: 0.80		0.07	0.40	0.53
Yusari: 0.73			0.33	0.48
Gaidam: 0.40				0.13

Nickel is essential to many living organisms, but high levels are harmful [25]. It is vital in hormone as well as lipid metabolism and as an activator of some enzymes and can be involved in glucose metabolism [26]. High levels of nickel can be toxic.

The levels of lead in all the sampling locations were found to be 0.02 ppm. The observed values of nickel in all the farms compares fairly well with 0.025 ppm of nickel in camel milk [15]. The observed values are lower than the threshold limit of 0.20 ppm [18]. Evaluation of the toxicity potentials of lead in all the farms indicated a numerical value of 0.10. This therefore points to the fact that man can safely consume the camel milk samples from all the farms. Statistically, all the observed values of lead (0.02 ppm) are significantly the same ($p \geq 0.05$). High levels of lead can cause irreversible brain damage (encephalopathy), seizure, coma and death if not treated immediately. Kidney problem, chronic and acute nephropathies are features associated with lead toxicity [27].

The levels of cadmium determined in camel milk samples spread from 0.012 ppm (Gaidam sample) to 0.018 ppm (Yusari sample) with 0.013 ppm (Yunusari sample) and 0.015 ppm (Waro sample) falling in between the lowest and highest experimental cadmium levels. The observed values are lower than 0.163 ppm of cadmium determined in fresh cow milk [28]. The levels of cadmium obtained in the present study are lower than the permissible limit of 0.02 ppm [18]. The toxicity potentials of cadmium in the test solutions are 0.90 (Yusari), 0.75 (Waro), 0.65 (Yunusari) and 0.60 (Gaidam) respectively. The observed toxicity potentials of cadmium in the various samples is an indication that the milk samples are fit for human consumption. The observed values are statistically the same ($p \geq 0.05$) as shown in Table 1. Cadmium is responsible for the outbreak of osteomalacia disease due to food poisoning [29]. Cadmium exposure can cause renal dysfunction, bone degeneration, liver and blood damage [30] and it is a toxic metal, which is carcinogenic [31].

Table 1 shows that the level of chromium determined in the camel milk samples ranged from 0.013 ppm (Yunusari sample) to 0.02 ppm (Gaidam and Waro samples). Yusari sample (0.018 ppm) fell in between the lowest and highest observed values of chromium. The experimental values of chromium in the present study compares well with the levels of chromium (0.013 ppm and 0.175 ppm) found in cow milk samples of Mumbai, India [32]. The observed values of chromium are in good agreement with 0.02 ppm permissible limit of chromium [18]. The corresponding toxicity potentials of chromium spread from 0.65 (Yunusari sample) to 1.00 (Gaidam and Waro samples). Yusari sample had a toxicity potential of 0.90 that fell between the extreme toxicity potential values. Based on the toxicity potential values obtained, it therefore shows that man can safely consume the camel milk samples. The experimental values of chromium are statistically the same ($p \geq 0.05$) as seen in Table 1. Chromium is an essential trace mineral that can improve insulin sensitivity as well as enhance protein, lipid and carbohydrate metabolism [33]. The main symptom of chromium deficiency is impaired glucose tolerance, which can lead to reduced insulin production and action.

IV. STATISTICAL ANALYSIS

All the observed values were subjected to standard error of the mean and One-Way Analysis of Variance (ANOVA). Observed values that were found to be significantly different were subjected to Least Significant Difference test ($p < 0.05$) in order to determine where the statistical significant difference lies. Values that were statistically different are depicted in Tables 2 – 6.

V. CONCLUSION

The results of heavy metals determined in camel milk samples collected from four different farms of Yobe State indicated that all the metals were present at different concentrations. The levels of all the metals determined in all the analytes were less than or equal to their corresponding permissible limits. The observed toxicity potentials of all the heavy metals revealed values that are less than 1.00 with the exception of Gaidam and Waro samples in which their corresponding chromium toxicity potentials are 1.00 in each case. Toxicity potentials that are greater than 1.00 are regarded as being out of specifications and hence unacceptable. Based on the present study, it is therefore evident that consumption of the camel milk from all the farms will not pose any health threat to the consumers.

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