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HEAVY METAL CONTAMINATION OF CAMELS' MILK FROM MAIDUGURI AND ITS ENVIRONS, NIGERIA

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ABSTRACT

The safety of food items is referring to safety of its consumers. In this research work, the concentration of the metals; Co, Cu, Cr, Cd, Ni, Zn and Pb in raw camels' milk sample from Maiduguri and its environs were determined. Fresh raw camels' milk samples were collected from lactating she-camels of different age groups that were freely ranging. Collection was done in two phases, first three, six and nine-months period of calving. A total number of 50 milk samples were collected, all of which were collected during the dry season. Sample collected was analyzed using atomic absorption spectrophotometer (Shimatdzu Model AA 6200) after treatment with 5 mL of 10% HCl. The results of this study, indicate that, the concentration of Cd ranged from 0.014 – 0.019 µg/g with the highest level observed at the six-month period of lactation. The concentration of Pb ranged from 0.013 - 0.014 µg/g, with the highest concentration observed at the nine-month period of lactation. For Ni the level ranged from 0.014 – 0.035 µg/g, the highest concentration was observed at the nine-month period of lactation. Zn concentration ranged from 0.325 – 0.373 µg/g, the highest level of 0.372 µg/g was observed at the nine-months period of lactation., The concentration of Cu ranged from 0.150 – 0.471 µg/g. Cr ranged from 0 - 0.115 µg/g, the metal was found below detection limit at the three-months period of lactation and gradually increases to 0.471 µg/g at the nine-month period of lactation. The level of Co ranged from 0.131 – 0.231 µg/g, the highest level of 0.231 µg/g was observed at the first three-month period of lactation. Contamination is very minimal for the absence of high anthropogenic activity (industries or high level of traffication). Cobalt, Cr, Cu, Ni, and Zn, were found to increase with increase in the lactation period. This suggest that, the more the lactating mother gain energy to thrive and feed well, the more the level of the metals in the milk. with the exception of Cd, the metals determined in this study were all found below the maximum acceptable limits. This suggest that, camels' milk from Maiduguri and its environs are safe to take. It also indicates that, the environment is equally less or not polluted by the metals. No significant difference between the different lactation period at P = 0.05.

KEYWORDS: Environment, heavy metal, milk, pollution, soil.

INTRODUCTION

Food safety, and in particular safety of products of animal origin, is an increasingly important issue concerning human health. With increase in the consumption of products of animal origin the risk of food borne diseases of humans also increases. The raw food movement, characterized by eating raw rather than cooked food has increased the awareness of consumption of raw food. One product that is commonly distributed in raw form is milk. It has been known as nature's most complete food. However, the traditional and contemporary view of the role of milk has been remarkably expanded beyond the horizon of nutritional subsistence of infants. Milk is more of a source of nutrients for any neonate of mammalian species, as well as for growth of children and nourishment of adult humans. Aside from nutritional values, milk borne biologically active compounds such as casein and whey proteins have been found to be increasingly important for physiological and biochemical functions that have crucial impacts on human metabolism and health (Schanbacher et al., 1998; Korhonen et al., 2004; Gobbetti et al., 2007).

According to the recent statistics by the Food and Agriculture Organization (FAO), the total population of camels in the world is estimated to be about 20 million, with Somalia having the largest herd worldwide (FAO, 2008). Camels live in the vast pastoral areas in Africa and Asia and are divided into two different species belonging to the genus Camelus. Dromedary camels (Camelus dromedaries, one humped) that mainly live in the desert areas (arid), and Bactrian camel (Camelus bactrianus, two-humped) which prefer living in the cooler areas. The Bactrian species is domesticated in the East to the Northern China and in the West to Asia Minor and Southern Russia, including Mongolia and Kazakhstan (Farah, 1996).

The majority of camels are kept, among other things mainly for milk production. In the past decade or two there have been dramatic increase and growing interest in the use of camel milk for its medicinal values. This, and now its bioactive ingredients have gained significant attention of scientists from all over the world to investigate the potentials of its health benefits (Mullaicharam, 2014; Rasheed et al., 2016) Scientifically, it has been proven that camel milk ingredients are excellent for nutritional view point as it contains high proportion of anti-bacterial and anti-viral substances (El-Agamy 1992; Konuspayeva et al., 2009). Camel milk ingredients such as lactoferrin, immunoglobulins, lysozyme, B Vitamins, Vitamin C, minerals, and iron have been studied for their medicinal properties in patients with different disorders ranging from diabetes to cancer (Beg et al., 1986; Gader and Alhaider 2016). It is much more nutritious than milk from cow, buffalo, sheep, etc., as it contains low levels of fat or lactose contents, and high levels of volatile acids, especially linoleic acids and polyunsaturated acids (Gader and Alhaider 2016). It also contains high concentrations of potassium, magnesium, copper, sodium, zinc, iron, B Vitamins, Vitamin C, etc. (Farah, 1993; Gader and Alhaider 2016). Report has it that, regular drinking of camel milk makes immune system stronger as it contains series of protective proteins such as lysozyme, lactoferrin, lactoperoxidase, immunoglobulin G, and immunoglobulin A (Riechmann and Muyldermans, 1999; Mullaicharam, 2014). Camel milk lacks β-casein and other major allergens, which are present in cow milk that might prevent children from allergic disorders (Bashir and Al-Ayadhi 2014). Moreover, camel milk is an excellent source of α-hydroxy acids, which are very famous for treatment of skin disorders. Importantly, α-hydroxy acids are also frequently used by cosmetic industries for manufacturing of their products for wrinkles treatment as well as for soften of skin, and for overall improvement of the skin quality (Babilas et al., 2012).

The one humped camel (Camelus dromedarius) is multi-functional farm animal species uniquely adapted to arid and semi-arid zones. Ethiopia is home to an estimated 2.4 million camels found mainly in the arid to semi-arid regions (FAO STAT, 2011). For pastoralist and agro-pastoralist communities residing in these harsh environments, the camel represents a vital source of food, income and other services (Abbas et al., 2000; Tura et al., 2010). Dromedaries in Nigeria are concentrated in the semi-arid northern part of the country (Mohammed 2000). Pastoral groups that originate from the Niger Republic own most of the camels in northern Nigeria (Waziri et al 1999). They are the main breeders of the camel (Mohammed and Hoffmann 2006) and can be found in Borno, Yobe, Kano, Jigawa, Katsina, Sokoto, Kebbi, and Zamfara States of northern Nigeria (Mohammed 2000; Abdussamad et al. 2011). They are very reliable milkers especially during the dry seasons and drought when milk from cattle, sheep and goats is limited (Farah 2004). Milk can become contaminated in many ways. For example, if the dairy animal has mammary gland infection (mastitis) or systemic infection, the pathogen can be passed to the milk. Milk can become contaminated by the faeces of the animals and the hand of the milker usually during hand milking procedure, by using pesticides or by equipment used for milk collection and storage. It is not very common to monitor levels of contamination by toxic heavy metals in camel milk; The physical and chemical properties of camel milk are largely dependent on the quantity and quality of forage and the amount of water consumed daily (El-Agamy 2006). However, this foodstuff, like other dairy products, can be exposed to chemical risks and pollutants that are the most important chemical contaminants of heavy metals. From the nutritional point of view, the content of milk and dairy products can provide essential ingredients (Iron, Copper and Zinc) in low doses and unnecessary or toxic elements such as lead, cadmium, etc., even at low concentrations, which can lead to metabolic disturbances or serious consequences if there are unnecessary elements (Ziarati and Moslehishad, 2017).

The toxicity of excessive levels of some of these elements, such as chromium (Cr), cadmium (Cd), lead (Pb), etc., is well known (Tunegova., et al. 2016) and the presence of these metals, especially cadmium, lead and Nickel in the material Over-standard food influences to a variety of diseases, including neurological disorders, cancer, and genetic disorders (Ziarati and Moslehishad, 2017). Camel milk, like other dairy products, can be exposed to chemical risks and pollutants, which are the most important chemical contaminants of heavy metals. When livestock is exposed to high concentrations of heavy metals such as Cadmium, Nickel, Mercury, Arsenic, these metals concentrate in milk, and when they are eaten up by consumers, they will cause serious health problems (Ahmad et al., 2017) Hence, the presence of metal residues in milk has been of particular concern because milk is widely consumed by newborns and children.

Heavy metals cause many harmful effects on human health such as saturnism (lead contamination), cancer such as cadmium, (Konuspayeva et al., 2009). Long term accumulation of heavy metals via food may cause chronic effects in various organs such as heart, nervous system, liver and kidney of people. Therefore, the determination of the residual concentrations of toxic metals in milk may be a direct indicator of the health status of the milk, its consumers as well as an indirect indicator of the environmental contamination (Garba et al., 2018a). However, limited information is available on heavy metal content of camel milk under pastoral systems in the northeast region of Nigeria especially Borno -Yobe state zone. Considering the important health benefits of camels' milk. and the side effects of heavy metals, the aim of this study was to determine the level of contamination by heavy metals in camels' milk from Maiduguri and its environs, Borno state, Nigeria

MATERIALS AND METHODS

Sampling Area

Raw and fresh milk samples were collected from Maiduguri and its environs, following the browsing or grazing routes of the animals.

Sample Collection

Raw and fresh milk samples were collected randomly from apparently healthy lactating she-camels of different age groups but at three, six and nine-months period of calving. A total number of 50 milk samples were collected, all of which were collected during the dry season. Samples collected (in a labelled plastic sample bottles) were kept in a cooler containing ice blocks, transported to the Research Laboratory, Department of Chemistry, University of Maiduguri, Nigeria and stored in a deep-freezer (below 4ºC) awaiting analysis (IDF, 1992). All sample collection was done in the morning hours (6:00 - 6:30am), after every three days (Dowelmadina et al., 2014), from late March to early April 2016. The camel herds were freely and naturally ranging. They had access to water in every 6-10 days during the dry season (Evans and Powys, 1984).

Sample Preparation and Analysis

The method adopted by Garba et al. (2018a) was used for the sample preparation. Analysis of the digested milk samples for the heavy metals; lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), Cobalt (Co), Nickel (Ni), Selenium (Se) and Zinc (Zn) was carried out by atomic absorption spectrophotometer, Shimatdzu, Model, AA 6200.

Statistical Data Analysis

All statistical analyses were performed using SPSS 12 package. Statistical differences in heavy metal concentrations among the samples were detected using One-way ANOVA. Multiple comparison between the lactating period was also conducted using LSD test. A significance level of P = 0.05 was used throughout the study.

RESULTS AND DISCUSSION

The dromedary Camel (Camelus dromedarius) like any other herbivores animal grazing in arid rangelands are seasonally challenged with shortage of feed and scarcity of water, both in quantity and quality such as that of Borno state, Nigeria-Niger border. However, they are known for their ability to survive and produce milk during dry and drought periods (Moaeen-ud-din et al., 2004; Wernery, 2006). Thus, camel milk is considered one of the most valuable food sources for nomadic people in the arid and semi-arid areas and has been consumed for centuries due to its nutritional values (Kenzhebulat et al. 2000; Mal et al. 2006; Lorenzen et al. 2011). Figure 1 indicates the results for the concentration of heavy metals determined in the samples of camels' milk from Maiduguri and its environs.

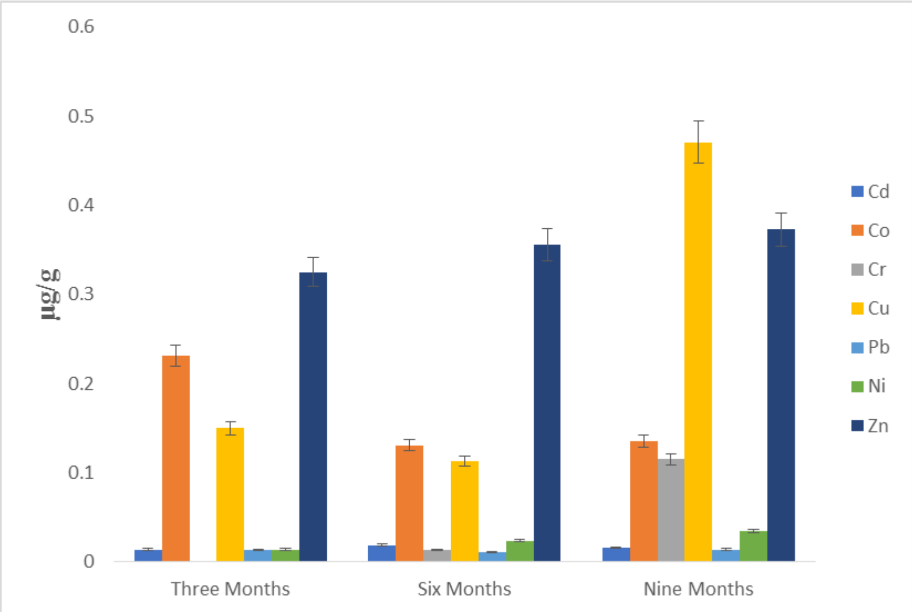

Figure 1: Concentration (µg/g) of Heavy Metals Determined in Camels' Milk from Maiduguri and its environs.

Cadmium is ubiquitous environmental contaminant arising primarily from electroplating, plastics manufacturing, mining, paint pigments, alloy preparation, and batteries. Food is the most important source of cadmium in the non-smoking, non-occupationally exposed population (Järup, 2003). The results of this study, indicate that, the concentration of Cd ranged from 0.014 – 0.019 µg/g with the highest level observed at the six-month period of lactation. No significant difference was between the different lactation period. The level of the metal observed in this study, was found higher than what was reported from Qazvin ($41x10^{-4}$ µg/g), Golestan ($53x10^{-4}$ µg/g), Semnan ($72x10^{-4}$ µg/g), Sistan-Baluchestan ($13x10^{-4}$ µg/g), Khuzestan ($41x10^{-4}$ µg/g), Bushehr ($9x10^{-5}$ µg/g) and Tehran, $14x10^{-4}$ µg/g, (Mostafidi et al., 2016). It is however, lower than what was observed in Kazakhstan (Konuspayeva et al., 2011). It also very much lower than what was observed (0.102 µg/g) by Ahmad., et al. (2017) form Khyber-Pakhtunkhwa, Pakistan. Report has it that, cadmium can induce both carcinogenic and non-carcinogenic effects on various organs including the lung, liver, kidney, bone and vascular system (Waalkes, 2003). At the cellular level, cadmium induces oxidative stress, cell proliferation and apoptosis (Tremellen, 2008; Turner and Lysiak, 2008). It is a known endocrine disruptor and reproductive toxicant (Henson and Chedrese, 2004; Cheng et al., 2011) which affects male fertility through altered function of hypothalamic-pituitary-testicular axis (Lafunte, 2013) and/or through direct gonadotoxic and spermiotoxic effects (Thompson and Bannigan, 2008). The disruption of functional structures within the blood-testis (Wong et al., 2004; Siu et al., 2009) and blood-epididymis barrier (Toman et al., 2002; Dubé and Cyr, 2013) results in impaired spermatogenesis and sperm maturation processes associated with infertility (Cheng and Mruk, 2012). Cadmium has been suggested to have some of its toxic effects by disturbing metabolism of essential metals, such as selenium. Zinc and selenium are believed to be the antagonists of cadmium toxic effects (Toman et al., 2009).

Lead (Pb) is one of the most toxic heavy metals and its level in milk and milk products is increasing day by day due to the uncontrolled urbanization and industrialization (Garba et al., 2018a). The concentration of Pb observed in this study ranged from 0.013 - 0.014 µg/g, with the highest concentration observed at the nine-month period of lactation. Lead is a major pollutant in both terrestrial and aquatic ecosystem. It is available to plant from soil and aerosol sources. Thus, when eaten up or taken through water by lactating mothers could lead to contamination of the milk. The level of lead observed in this study, is found lower than what was observed in Kazakhstan, 4.28 and 0.03 µg/g, by Konuspayeva et al. (2009) and Konuspayeva et al. (2011) respectively. It is however, higher than what was reported by Mostafidi et al. (2016) form Qazvin ($8.28x10^{-3}$µg/g) and Golestan ($6.04x10^{-3}$ µg/g) and was found below detection limit in camels' milk sample from Khyber-Pakhtunkhwa, Pakistan (Ahmad., et al., 2017). The average concentration for Pb in camel milk from Riyadh and Qassim 0.54 and 0.59 µg/g (Soltan et al., 2017) which is many folds higher than what was observed in this study.

There is no maximum limit for cadmium in the international standard (Codex Alimentarious Commission, 193-1995). Based on the standards of Food and Agriculture Organization

(FAO), World Health Organization (WHO) and Codex standard 193-2007, the determined limit for lead and cadmium is 0.02 µg/g and 0.010 µg/g, respectively. The results of this study showed that the observed concentration of lead is less than the acceptable limit whereas the level observed for cadmium in all the samples were higher than the acceptable limit. Nowadays, the probability of contamination with fuel of cars and agricultural machines and haze of industrial factories in samples can be the main source of pollution of heavy metals (Konuspayeva et al., 2011). In this study however, all the sampling sites were far from anthropogenic source of pollution, the high level of cadmium in this study therefore, could be attributed to atmospheric depositions of heavy metal suspended particulate matter in water and possible the feeds consumed.

In nature, Ni is mostly present in the form of nickelous ion, Ni^{2+}. The hydrated form as $Ni(H_2O)_6^{2+}$, is the most common form of Ni found in the soil solution. Ni also occurs in water bodies and in other atmospheres, usually in trace amounts. The release of municipal and industrial effluents significantly contributes Ni content to the soil and water but relative concentration depends on the source of effluent. Ni is added into atmosphere primarily as pollutant particle, released along with other metals from the chimneys and air flows from metallurgical sites as well as cement clinkers (Orlov et al. 2002) which ultimately settle down on the soil, water or plant surfaces. Thus, it become exposed to grazing animals. The concentration of Ni observed in this study, ranged from 0.014 – 0.035 µg/g. average of nickel camel milk in Riyadh and Qassim 1.510 and 2.100 µg/g respectively (Soltan et al., 2017). It is however, higher than what was reported by Mostafidi et al. (2016) form Qazvin ($6.9x10^{-4}$µg/g) and Golestan ($5.9x10^{-4}$ µg/g) and was found very much lower than what was found in camels' milk (0.220 µg/g) from Khyber-Pakhtunkhwa, Pakistan (Ahmad., et al., 2017) and (0.169 µg/g) reported by Nazir et al. (2015). The concentrations of Ni observed in this study are probably to a large extent the consequence of atmospheric deposition of particles. Nickel being a cofactor for a number of hormones and enzymes is considered as essential element for humans. However, the excessive intake may result in cell damage, impaired reproductive system, altered hormonal and enzymatic activities, oxidative stress and neurotoxicity. Generally, nickel and its salts do not affect the human body but in some cases, it has been recorded to cause allergic problems as it comes in contact with moist skin (Garba et al., 2018b). The maximum residual limit which according to Joint Expert Committee on Food and Agriculture and World Health Organization is 0.01mg/l (Bushra et al., 2014). This indicates camels' milk collected from the study area is not polluted with Ni and reflects good milk quality and safety of the environment.

Zinc (Zn) is an essential part of more than 200 enzymes involved in digestion, metabolism and reproduction. It is an important mineral for the maintenance of healthy skin, wound healing and is directly involved in both innate and adaptive immunity. Zinc also has antioxidant activity and helps eliminate reactive oxygen species through its role as a cofactor for the antioxidant enzyme, superoxide dismutase, SOD, (Garba et al., 2018b). The concentration of Zn observed in this study ranged from 0.325 – 0.373 µg/g. the highest level of 0.372 µg/g was observed at the nine-months period of lactation. This concentration is found many folds lower than what was reported in camels' milk (5.150 µg/g) from Khyber-Pakhtunkhwa, Pakistan (Ahmad., et al., 2017), Riyadh (1.190 µg/g) and Qassim (1.130 µg/g) reported by Soltan et al. (2017) as well as Saudi Arabia (1.480 µg/g) by Al-wabel, (2008). It is also found very much lower than what was reported from Atyrau (59.90) by Konuspayeva et al. (2009). Zn constitutes about 33 µg/g of an adult body mass and it is essential as a constituent of many enzymes involved in several physiological functions, such as protein synthesis and energy metabolism (Onianwa et al., 2001). However, high level of Zn can cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anaemia (Akther et al., 2016). The concentration of Zn observed in this study, could be attributed atmospheric deposition, the level of element in soil and water and partly due to the differences of the feeding and environmental conditions.

Copper (Cu) have numerous functions in animals and human and they are essential elements for the growth of plant. It serves as an antioxidant and helps the body to remove free radicals and prevent cell structure damage Copper (Garba et al., 2017). In this study, the concentration of Cu ranged from 0.150 – 0.471 µg/g. the highest concentration (0.471 µg/g) was observed at the nine-month period of lactation. The concentration was found to increase with increase in the period of lactation. This could be attributed to increase in the rate of feeding and restriction of the younger ones from consuming the milk periodically. The levels observed in this study, were found lower than what was observed in Saudi Arabia (1.610 µg/g) by Al-wabel, (2008), it is however, higher than 0.06 µg/g observed in milk sample form Khyber-Pakhtunkhwa, Pakistan (Ahmad et al., 2017). The highest level observed in this study however, were found very much higher than what was found in Riyadh (0.270 µg/g) and Qassim (0.180 µg/g) reported by Soltan et al. (2017). It is also higher than what was observed in Khyber Pakhtunkhwa, Pakistan (0.386 µg/g) by Nazir et al. (2015). Although what was observed in this study, at the three (0.150 µg/g) and six-months (0.115 µg/g) period of lactation were found lower than what was observed in Riyadh (0.270 µg/g) and Qassim, 0.180 µg/g (Soltan et al. 2017). It is considered that Cu concentrations between 0.1 and 0.9 µg/mL are the "normal" range in milk (Bilandžić et al. 2011). Therefore, the levels of Cu observed in this study, are within the normal range of consumption.

Chromium (Cr) is a polyvalent element, found naturally in the air, soil, water and lithosphere (Papassiopi et al., 2009). It exists in the environment in three stable oxidation states, Cr(0), Cr(III) and Cr(VI) which have different toxicities and transport characteristics (Gibb et al., 2006). Trivalent chromium Cr (III) and hexavalent chromium Cr (VI) are stable. Cr (VI) is carcinogenic and a potential soil, surface water and ground water contaminant, while its reduced trivalent form is much less toxic, insoluble and a vital nutrient for humans (Das and Mishra, 2008). Accidental or intentional ingestion or exposure to high level of Cr(VI) compounds exerts toxic effects on biological systems (Paiva et al., 2009). In this research work, the concentration of Cr ranged from 0- 0.115 µg/g. the metal was found below detection limit at the three-months period of lactation. This agrees with the findings reported by Mostafidi et al. (2016), he found Cr below detection limits in five of its area of study, however, 0.03 µg/g was observed in Qazvin which is lower than the observed levels in this study. The highest concentration of 0.115 µg/g observed in this study, was at the nine-months period of lactation. This level is however, many folds lower than what was observed in all the four regions in Kazakhstan (Konuspayeva et al., 2009). It is however, lower than what was observed in Khyber Pakhtunkhwa, Pakistan (0.08 µg/g) by Nazir et al. (2015). Reports has it that, the tolerance limit of Cr in milk is 0.3 µg/g. Although Cr and other microelements are essential to maintain the metabolic systems of human body, they can lead to poisoning at higher level (Qin et al., 2009). It can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death. Therefore, exposure across all age groups to Cr in milk is well below the tolerance limit and therefore does not raise concerns for public health.

Cobalt (Co) being a part of vitamin B12 is considered an essential element for normal human growth. However, in excess amounts it can disturb the reproductive system and thyroid glands (Nordberg et al., 2007) and is also reported as a probable carcinogenic compound by IARC, (1991). In this study, the observed level of Co ranged from 0.131 – 0.231 µg/g. the highest level of 0.231 µg/g was observed at the first three-month period of lactation. These levels however, were found very much higher than what was found in Riyadh (0.038 µg/g) and Qassim (0.075 µg/g) reported by Soltan et al. (2017).

Camel milk composition was found to be less stable than other species such as bovine. Previous findings pointed out that the variation in camel milk composition could be attributed to many factors such as analytical measurement procedures, geographical locations, feeding conditions, type of samples and breeds in addition to other factors including milking frequency, stage of lactation and parity numbers (Iqbal et al., 2001; Faye et al., 2008; Aljumaah et al., 2011). However, geographical origin and seasonal variations were found to be the most effective factors on camel milk constituents and chemical composition in production systems (Shuiep et al., 2008). According to the literature, human activities close to the sampling area influence the concentration of heavy metals in milk. Especially, traffic road intensity plays a role on lead content in cow milk (Sleiman, 2000). Trace element contaminants from fertilizers may enter the food chain via two main pathways; direct uptake by crops and translocation to harvested grains, shoots or tubers, or via pastures and inadvertent soil ingestion by grazing animals McLaughlin et al. (2000). The physical and chemical properties of camel milk are largely dependent on the quantity and quality of forage and the amount of water consumed daily (Konuspayeva et al., 2011).

CONCLUSION

In this study, the major source of pollution is atmospheric deposition brought by wind from a far place, may be across the border with Niger Republic, or even Chad. Contamination is very minimal in this study, for the absence of high anthropogenic activity (industries or high level of traffication). The concentration of the metals in the milk were found to increase with increase in the lactation period. Cobalt, Cr, Cu, Ni, and Zn, were all found to increase as the lactation period increases. This suggest that, the more the lactating mother gain energy to thrive and feed well, the more the level of these metals in the milk. However, with the exception of Cd, the metals determined in this study were all found below the maximum acceptable limits. This suggest that, camels' milk from Maiduguri and its environs are safe to take. It also indicates that, the environment is equally less or not polluted by the metals.

REFERENCES

1. Schanbacher FL, Talhouk R.S, Murray FA, Gherman LI., and Willet L.B, Milk–born bioactive peptides. Int. Dairy J., 1998; 8: 393-403.
2. Korhonen H, and Pihlanto – Leppälä A, Milk - derived bioactive peptides: Formation and prospects for health promotion. In: Handbook of Functional Dairy Products C. Shortt and J. O' Brien (eds). CRC Press, Boca Raton, FL, 2004; 109-124.
3. Gobbetti M, Minervini F, and Rizzello C. G., Bioactive peptides in dairy products In: Handbook ofFood Products Manufacturing Y.H. Hui (ed). John Wiley & Sons, Inc. Hoboken, NJ., 2007; 489-517.
4. FAO. (2008). Camel milk. Retrieved from. http://www.fao.org/ag/againfo/themes/en/dairy/camel.html.
5. Farah Z, Camel milk properties and products. St. Gallen, Switzerland: SKAT, Swiss Centre for Developments Cooperation in Technology and Management, 1996.
6. Mullaicharam AR, A review on medicinal properties of camel milk. World J Pharm Sci, 2014; 2: 237-42.
7. Rasheed N, Alghasham A, Rasheed Z. Lactoferrin from camelus dromedarius inhibits nuclear transcription factor-kappa B activation, cyclooxygenase-2 expression and prostaglandin E2 production in stimulated human chondrocytes. Pharmacogn Res., 2016; 8: 135-41.
8. El-Agamy EI, Ruppanner R, Ismail A, Champagne CP, Assaf R., Antibacterial and antiviral activity of camel milk protective proteins. J Dairy Res., 1992; 59: 169-75.
9. Konuspayeva G., et al., "Pollution of Camel Milk by Heavy Metals in Kazakhstan". The Open Environmental Pollution and Toxicology Journal, 2009; 1: 112-118.
10. Beg OU, von-Bahr-Lindststrom H, Zaidi ZH, Jornvall H., Characterisation of camel milk protein rich proline identifies new beta casein fragment. Regul Pept, 1986; 15: 55-62.
11. Gader AG, Alhaider AA., The unique medicinal properties of camel products: A review of the scientific evidence. J Taibah Univ Med Sci, 2016; 11: 98-103.
12. Farah Z, Composition and characteristics of camel milk. *Journal of Dairy Research,* 1993; 60: 603-626.
13. Riechmann L, Muyldermans S. Single domain antibodies. Comparison of camel VH and camelised human VH domains. J Immunol Methods, 1999; 231: 25-38.
14. Bashir S, Al-Ayadhi LY, Effect of camel milk on thymus and activation-regulated chemokine in autistic children: Double blind study. Pediatr Res., 2014; 75: 559-63.

15. Babilas P, Knie U, Abels C, Cosmetic and dermatologic use of alpha hydroxy acids. J Dtsch Dermatol Ges, 2012; 10: 488-91.
16. FAO STAT, Food and Agriculture Organization of the United Nations statistical databases, 2011.
17. Abbas B, Al-Qarawi A, Al-Hawas A, Survey on camel husbandry in Qassim region, Saudi Arabia: herding strategies, productivity and mortality. Mag Anim husbandry Vet Med Tropic Countries, 2000; 53: 293-298.
18. Tura I, Kuria G, Walaga HK, Lesuper J, Camel Breeding Management among the Somali, Sakuye, Gabbra and Rendille Pastoralists of Northern Kenya. Tropentag, Zurich, Switzerland, 2010.
19. Mohammed, I., Study of the integration of the dromedary in the smallholder crop-livestock production system in northwestern Nigeria, 228. Goettingen: Cuvillier Verlag, 2000.
20. Waziri M A, Shehu A A and Kwari H D, Morphological changes of spermatozoa in sperm reserve during epididymal transit in the camel (*Camelus dromedarius*). Tropical Veterinarian, 1999; 17: 135-141.
21. Mohammed I, and Hoffmann I, Management of draught camels (*Camelus dromedarius*) in crop-livestock production systems in Northwest Nigeria. Livestock Research for Rural Development, 2006; 18(1). Retrieved April 24, 2010, from http://www.lrrd.org/lrrd18/1/moha18016.htm
22. Abdussamad AM, Holtz W, Gauly M, Suleiman MS, and Bello MB, Reproduction and breeding in dromedary camels: Insights from pastoralists in some selected villages of the Nigeria-Niger corridor. Livestock Research Rural Development, 2011; 23(8): 2011. Retrieved January 12, 2017, from http://www. lrrd.org/lrrd23/8/abdu23178.htm.
23. Farah Z., An introduction to the camel. In: Farah Z. and Fischer A. (eds) Milk and meat from the camel: Handbook on products and processing. Vdf Hochschulverlag, Zurich, Switzerland, 2004; 15-28.
24. El-Agamy EI. “Camel milk”. In: YW Park and GF, Haenlein (Editors), Handbook of milk of non-bovine mammals, Oxford: Blackwell, 2006; 297-344.
25. Ziarati P, and Moslehishad M., “Determination of Heavy Metals (Cd, Pb, Ni) in Iranian and Imported Rice Consumed in Tehran”. Iranian Journal of Nutrition Sciences and Food Technology, 2017; 12(2): 97-104.
26. Tunegova M, Toman R, and Tancin V, Heavy metals environmental contaminants and occurrence in resident types of milk. Slovak. J. Anim. Sci., 2016; 49(3): 122-131.

27. Ahmad I, Zaman A, Samad N, Ayaz MM, and S. Rukh et al., Atomic Absorption Spectrophotometery Detection of Heavy Metals in Milk of Camel, Cattle, Buffalo and Goat from Various Areas of Khyber- Pakhtunkhwa (KPK), Pakistan. J Anal Bio anal. Tech., 2017; 8: 367.
28. Garba ST, Idi AM, and Muhammad ZC. Atomic Absorption Spectrophotometric Determination of Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb), and Zinc (Zn) in goat's milk. International Journal of Scientific Research Engineering & Technology (IJSRET), 2018a; 7(7): 563-571.
29. IDF Standard, Metal contamination in milk and milk products. Int. Dairy Fed. Bull., Document no. A. Doe, 1979; 37.
30. Dowelmadina I.M.M, El Zubeir IEM., Salim ADA, and Arabi OHMH, Influence of Some Factors on Composition of Dromedary Camel Milk in Sudan. Global Journal of Animal Scientific Research, 2014; 2(2): 120-129.
31. Evans JO and Powys JG, Camel husbandry in Kenya: Increasing the productivity of Ranch lands. - In: The Camelid - an all- purpose ani-ma/, Vol. l. Proceedings of the Khartoum Workshop on Camels, 1979. Scandinavian Institute of African Studies, Uppsala, 1984.
32. Moaeen-ud-Din M, Abdullah M, Javed K, and Ahmad N, Feeding behavior of camel under stall feeding. The J. Anim. Plant Sci., 2004; 14(3-4): 74-76.
33. Wernery U, Camel milk, the white gold of the desert. J. Camel Pract. Res., 2006; 13: 15–26.
34. Kenzhebulat S, Ermuhan B, and Tleuov A, Composition of camel milk and its use in the treatment of infectious diseases in human. Pp. 101 in Proc. 2nd Camelid Conf. Agroecon. Camelid Farming, Almaty, Kazakhstan, 2000.
35. Mal G, Sena DS, Jain VK, and Sahani MS, Therapeutic value of camel milk as a nutritional supplement for multiple drug resistant (MDR) tuberculosis patients. Israel J. Vet. Med., 2006; 61: 88-91.
36. Lorenzen P, Wernery R, Johnson B, Jose S, and Wernery U, Evaluation of indigenous enzyme activities in raw pasteurized camel milk. Small Rumin. Res., 2011; 97: 79-82.
37. Järup L, Hazards of heavy metal contamination. British Medical Bulletin, 2003; 68: 167–182.
38. Mostafidi M, Moslehishad M, Piravivanak Z, and Pouretedal Z, Evaluation of mineral content and heavy metals of dromedary camel milk in Iran. Food Sci. Technol, Campinas, 2016; 36(4): 717-723.

39. Konuspayeva G., et al. "Contamination of Camel Milk (Heavy Metals, Organic Pollutants and Radionuclides) in Kazakhstan". Journal of Environmental Protection, 2011; 2: 90-96.
40. Waalkes, M. P., Cadmium carcinogenesis. Mutation Research, 2003; 533: 107–120.
41. Tremellen K, Oxidative stress and male infertility- a clinical perspective. Human reproduction Update, 2005; 14: 243–258.
42. Turner TT, and Lysiak JJ, Oxidative stress: a common factor in testicular dysfunction. Journal of Andrology, 2008; 29: 488–498.
43. Henson MC, and Chedrese PK, Endocrine disruption by cadmium, a common environmental toxicant with paradoxical effects on reproduction. Experimental Biology and Medicine, 2004; 229: 283–392.
44. Cheng CY, Wond EWP, and Lie PPY, Environmental toxicants and male reproductive function. Spermatogenesis, 2011; 1: 2–13. Lafuente A, The hypothalamic-pituitary-gonadal axis is target of cadmium toxicity. And update of recent studies and potential therapeutic approaches. Food and Chemical Toxicology, 2013; 59: 395–404.
45. Thompson J, and Bannigan J, 'Cadmium: toxic effects on the reproductive system and the embryo', Reproductive Toxicology, 2008; 25(3): 304–315.
46. Wong CH, Mruk DD, Lui WY, andCheng CY, Regulation of blood-testis barrier Dynamics: and in vivo study. Journal of Cell Science, 2004; 117: 738–798.
47. Siu ER, Mruk DD, Porto CS, Cheng CY, Cadmium-induced testicular injury. Toxicology and Applied Pharmacology, 2009; 238: 240–249.
48. Toman R, Massányi P, Uhrín V, Changes in the testis and epididymis of rabbits after an intraperitoneal and peroral administration of cadmium. Trace Elements and Electrolytes, 2002; 19: 114–117.
49. Dubé, E. and Cyr DG, The blood-epididymis barrier and human male fertility. Advances in Experimental Medicine and Biology, 2013; 763: 218–236.
50. Cheng CY, and Mruk DD, The blood-testis barrier and its implications for male contraception. Pharmacological Reviews, 2012; 64: 16–64.
51. Toman R, Golian J, Šiška B, Massányi P, Lukáč N, and Adamkovičová M, Cadmium and selenium in animal tissues and their interactions after an experimental administration to rats. Slovak Journal of Animal Science, 2009; 42: 115–118.
52. Soltan ME, et al. "Effect of the environmental factors on some element contents in camel and sheep milks: A comparative study between Qassim and Riyadh regions, KSA". International Research Journal of Public and Environmental Health, 2017; 4(8): 184-192.

53. Codex Alimentarious Commission, Codex general standard for contaminants and toxins in food and feed (Codex Standard 193-1995). Rome: Codex Alimentarius Commission, 1995. Retrieved from http://www.fao.org/fileadmin/user_upload/livestockgov/documents/1_CXS_193e.pdf.
54. Orlov DS, Sadovnikova LK, and Lozanovskaya IN, Ecology and protection of biosphere under chemical pollution. Vysshaya Shkola, Moscow, 2002.
55. Nazir R, Khan M, Ur Rehman M, Masab M, Khan A, Rehman M, Khaliq A, Parveen I, and Shehnaz F, Comparative Study of Heavy Metals (Ni, Cu, Fe and Cr) in the Milk of Cattle and Humans Collected from Khyber Pakhtunkhwa, PakistanGlobal Veterinaria, 2015; 14(5): 761-767.
56. Garba ST, Mustapha BU, and Baba A, Level of Some Heavy Metals In Selected Fruits and Vegetables *International Journal of Scientific Research Engineering & Technology (IJSRET)*, 2018b; 7(6): 483-492.
57. Bushra I, Saatea A, Samina S, and Riaz K, Assessment of Toxic Metals in Dairy Milk and Animal Feed in Peshawar, Pakistan. British Biotechnol. J., 2014; 4(8): 883-893.
58. Al-Wabel NA, Mineral Contents of Milk of Cattle, Camels, Goats and Sheep in the Central Region of Saudi Arabia. *Asian Journal of Biochemistry*, 2008; 3(6): 373-375.
59. Onianwa PC, Adeyemo AO, Idowu OE, and Ogabiela EE, Copper and zinc contents of Nigerian foods and estimates of the adult dietary intakes. Food Chem., 2001; 72: 89. http://dx.doi.org/10.1016/S0308-8146(00)00214-4.
60. Akther S, Shahriar SMS, Zakir HM, and Alam MK, A Quantitative Analysis of Chromium and Zinc in Water and Raw Milk in Chittagong, Bangladesh. Journal of Scientific Research, 2016; 8(1): 93-100.
61. Garba ST, Abba AB, Abdullahi S, and Abdullahi M. The Heavy Metals (Ag, Fe, Co, Cr, Cu, Cd, Mn, Zn, Ni and Pb) in Beans (Phaseolus vulgaris) Grown in Lake-Chad Research Institute, Maiduguri, Borno State, Nigeria International Journal of Science and Engineering Investigations, 2017; 6(60): 23-29.
62. Bilandžić N, Dokić M, Sedak M, Božica S, Varenina I, and Knežević Z, et al. Trace element levels in raw milk from northern and southern regions of Croatia. Food Chemistry, 2011; 127(1): 63–66. doi: 10.1016/j.foodchem.2010.12.084.
63. Papassiopi N, Kontoyianni A, Vaxevanidou K, and Xenidis A, Assessment of chromium biostabilization in contaminated soils using standard leaching and sequential extraction techniques. Sci. Total Environ, 2009; 407: 925-936.

64. Gibb HJ, Lees PS, Pinsky PF, and Rooney BC, Lung cancer among workers in chromium chemical production. Am. J. Ind. Med, 2006; 38(2): 115-126.
65. Das AP, and Mishra S, Hexavalent chromium (VI): environment pollutant and health hazard. J. Environ. Res. Develop, 2008; 2(3): 386-392.
66. Paiva LB, de Oliveira JG, Azevedo RA, Ribeiro DR, da Silva MG, and Vitória AP, "Ecophysiological responses of water hyacinth exposed to Cr^{3+} and Cr^{6+} ," Environmental and Experimental Botany, 2009; 65(2-3): 403–409.
67. Qin LQ, Wang XP, Li W, Tong X, and Tong WJ, The minerals and heavy metals on cow's milk from China and Japan., J Health Sci., 2009; 55(2): 300-305.
68. Nordberg GF, Fowler BA, Nordberg M, and Friberg LT, In: Handbook on the toxicology of metals (3rd ed.). Academic Press Inc., USA, 2007.
69. International Agency for Research on Cancer (IARC), Cobalt and cobalt compounds. IARC, Lyon, (IARC Monograms on the evaluation of carcinogenic risks to humans), 1991; 52: 363–472.
70. Iqbal I, Gill RA, and Younan M., Milk composition of Pakistani camel (Camelus dromedarius) kept under station and farms condition. Emir Journal of Agriculture Science, 2001; 13: 7-10.
71. Faye B, Konuspayeva G, Messad S, and Loiseau G, Discriminate milk component of bactrian camel (Camelus bactrianus), dromedary (Camelus dromedarius) and hybrids. Dairy Science and Technology, 2008; 88: 607-617.
72. Aljumaah RS, Almutairi FF, Ayadi MA, Alshaikh MA, Aljumaah AM, and Hussein MF, Factors influencing the prevalence of subclinical mastitis in lactating dromedary camels in Riyadh Region, Saudi Arabia. Trop. Anim. Health Prod, 2011; 43: 1605-1610.
73. Shuiep ES, El Zubeir IEM, El Owni OAO, and Musa HH, Influence of season and management on composition of raw camel (Camelus dromedarius) milk in Khartoum State, Sudan. Tropical and Subtropical Agroecosystems, 2008; 8: 101-106.
74. Sleiman H., Atmospheric pollution: blood lead levels and car traffic pollution in Beirut. Pollut Atmos, 2000; 42: 197-221.
75. McLaughlin MJ, Zarcinas BA, and Stevens DP. et al., Soil testing for heavy metals; Commun. Soil Sci. Plant Anal, 2000; 31: 1661–1700.