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(Research Article)

Determination of some heavy metal ions concentration in fresh cow milk obtained from some herder settlements around Wukari, IBI and Tella in Taraba state

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Abstract

Nine (9) samples of fresh milk from three different breeds of cow (Nama, Red Bororo and White Fulani) were collected from Sukari, Ibi, and Tella areas in Taraba state, for the determination of the presence and concentration of Lead, Cadmium, and Chromium using AAS, as well as health assessment of the heavy metals in fresh cow milk. The results obtained are; for Sukari, the average concentration of Pb, Cd, and Cr in Nama, Red Bororo and white Fulani milks are 0.308±0.002, 0.0067±0.002, and 0.037±0.002 ppm respectively. For Ibi, the average concentration of Pb, Cd, and Cr in Nama, Red Bororo and white Fulani milks are 0.493±0.002, 0.0079±0.002, and 0.078±0.002 ppm respectively. And for Tella, the average concentration of Pb, Cd, and Cr in Nama, Red Bororo and white Fulani milks are, 0.391±0.002, 0.0073±0.002, and 0.064±0.002 ppm respectively. The results of the finding revealed that, the concentration of Pb and Cd exceeded the WHO permissible limit of 0.02 ppm for Pb and 0.005 ppm for Cd. Also, the concentration of Cr in Sukari and Ibi exceeded the WHO permissible limit and within the range of 0.1 ppm in Tella. Based on the evaluated mean concentration, Lead and Cadmium were detected at high levels in all the nine samples, while chromium was low in the samples collected from weary and Tella and equals the permissible limit in Ibi samples. Therefore, consumers of fresh cow milk from the locations under consideration are at risk of some of the health challenges associated with these heavy metals.

Keywords: Milk; Heavy Metals; WHO; Permissible Limit; Carcinogenic Risk; Nama; Red Bororo; White Fulani

1. Introduction

Milk is a whitish liquid, which are produced by mammary gland of all mature female lactating / nursing mammals. Milk is a vital component of human nutrition and its consumption has risen in recent years. Milk is an important food for people of all ages because of its high nutritional. It is considered a complete food because it contains essential nutrients including protein, essential fatty acids, lactose (or milk sugar), vitamins, and minerals in balanced proportions (Mesher et al., 2014). Milk is useful to promote growth and development of the infant mammals as it contains important nutrient in a balanced proportion (Abdelkhalek et al., 2015). Milk and milk products are an essential part of the human daily diet, and their consumption is regularly increasing, especially for vulnerable groups such as infants, school age children and old age (Enb et al., 2009).

Milk has a beneficial impact on human health. Cow's milk is vital in a healthy food intake because of its high calcium content (Ketut and Rara, 2022). Although, the chemical hazards and contaminant in cow's milk can be harmful to the health of the consumers (Licata et al., 2004). The acidity of cow's milk decreases with the increase of heavy metals concentration that is poisonous to the body (Ketut and Rara, 2022).

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Consumption of cow milk in particular, is associated with beneficial health effects beyond its pure nutritional value. Several reports indicated that dairy products could serve as vehicles for other functional ingredients, such as phytosterols (as cholesterol replacement), fatty acids (as omega-3 acids) and various kinds of probiotic bacteria (Mattila-Sandholm et al., 2002). These minerals content in raw cow milk may vary depending on several factors i.e. lactation period of cows, health conditions, seasonal variations, climatic conditions, annual feed composition and environmental contamination (Yahaya et al., 2010). Studies equally showed that low-fat milk consumption could reduce risk of arterial hypertension, coronary heart disease, colorectal cancer, and obesity (Agrawal et al., 2003; Majeed, 2005; Shabo et al., 2005).

Though cow's milk contains heavy metals in very small amounts, they become toxic during collection and processing due to alteration by different factors (Khan et al., 2014). There are potential bio-accumulative risk factors in milk including lead, cadmium, chromium, and others (Li et al., 2005). Therefore, the risk to human health posed by exposure to food-based heavy metals varies from other types of pollutants in terms of long-term exposure, the inadequacy of decomposition, non-degradability and high accumulation levels along the food chain (Maas et al., 2011).

Because of the rapid developments in industry and agriculture, the assessment of heavy metal contamination in fresh milk and its derivatives has become very important (Khalil, 2018). The advancement of industry and agriculture has resulted in the release of numerous heavy metals into the environment which is harmful to the health of both animals and humans. Animals ingest heavy metals from a variety of sources including soil, water, feed and fodder (Ankur et al., 2022).

Some heavy metals are known to be essential for human growth and development but when in excess it causes a lot of health defects in human. Cow feeds and drinks are contaminated due to exposure to the environment containing heavy metals where it is absorbed into their body, which may then enter the milk of the cow. These metals have public health effect which have been largely studied such as chronic exposure to dietary heavy metals leading to hepatotoxicity, neurotoxicity and abdominal pain with a decreasing in intellectual quotient level. This study of heavy metals concentration on raw cow milk will therefore, help to account for its usefulness in consumption or otherwise.

2. Materials and Methods

2.1. Sample Collection and Preparation

Fresh cow milks samples were collected from lactating cows grazed in the farms around Wukari, Ibi and Tella areas in Taraba state.

A total of nine samples were collected through manual milking technique from nine lactating cows at three grazing areas of Wukari, Ibi and Tella, and based on the cow's species from Ndam, White Fulani, and red Bororo cows. The collection of the milk was done by nomads in the morning, under hygienic conditions. Each of the nine samples were collected in a plastic bow washed with distilled water and transferred into a sterilized sample bottle, and were kept in a cooler containing ice block and to maintain the temperature below 4oC. The samples were immediately transported to the laboratory as soon as possible and stored in a freezer at 4oC until analysis.

In this study, the concentration of selected heavy metals such as Cadmium (Cd), Chromium (Cr), and Lead (Pb) was evaluated in fresh cow milk samples conducted at Central Laboratory, Federal University Sukari Taraba state-Nigeria.

2.2. Sample Digestion

A total of 6 mL of each sample of fresh cow milk was measured and digested with 12 mL of nitric acid and hydrogen peroxide (HNO3: H2O2 == 2:1) then it was placed on a digestor at 165oC, for a period of 1hr 30mins until a clear solution was obtained.

2.3. Determination of The Presence and Concentration of Heavy Metals in Raw Cow Milk Products

In this study, Heavy metal (Cd, Cr, and Pb) concentrations in the digested samples were evaluated by atomic absorption spectrophotometric method (Model:210VGP, Atomic Absorption Spectrophotometer, BUCK Scientific) using atomic absorption acetylene flame at wave lengths of 217.0 nm, 228.8 nm, and 357.9 nm and the lamp current of 15 mA, 10 mA, and 20 mA for Pb, Cd, and Cr respectively. After digestion, samples were filtered into a volumetric flask and diluted to 100 mL with distilled. The digested solutions were analyzed and all determinations were made versus a blank reagent (distilled water).

2.4. Health Risk Assessment

Some of the contaminants can be carcinogenic, mutagenic and maybe teratogenic to human health. Risk assessment is therefore essential to ascertain the potential health effects from doses to human of one contaminant received through one or more exposure pathways.

2.5. Estimated Daily Intake (EDI) Of Heavy Metal

To estimate the daily intake, the daily intake of metals depends on both the metal concentration in cow milk and the daily food consumption rate. In addition, the body weight of the human can influence the tolerance of contaminants. The EDI of metals was determined using the following equation (Arafa et al., 2014).

$$\mathrm{EDI} = \frac{\mathrm{DFc} \times \mathrm{MC}}{\mathrm{BW}} \qquad (1)$$

Where MC is the metals concentration, 54.79 is the daily food consumption rate (DFC) of Nigeria (NASS. 2011) and 66.5 is an average body weight of adult resident (Ogum et al., 2015).

2.6. Target Hazard Quotients (THQ)

The THQ for the local inhabitants through the consumption of contaminated milk and dairy products were assessed based on the food chain and the reference oral dose (RFDO) for each metal. Evaluating the hazard quotients (THQ) from consumption are given by;

$$\mathrm{THQ} = \frac{\mathrm{EDI}}{\mathrm{RFD}} \times 10^{-3} \qquad (2)$$

Where, EDI = estimated daily intake of metal (mg/day), RFD = Oral Reference Dose (mg/kg/BW-1). For Pb, Cd, and Cr is 0.004, 0.001 and 1.5 respectively. THQs indicate potential health risk when it is equal or higher than 1 (Hasan et al., 2022).

Target Carcinogenic Risk (TCR)

When the carcinogens are to be exposed over a lifetime, the probability of cancer of an individual can be developed (Hasan et al., 2022). The acceptable risk level ranges from 10−4 to 10-6 for carcinogens. The equation is given below:

$$\mathrm{TCR} = \frac{\mathrm{EFr} \times \mathrm{ED} \times \mathrm{EDI} \times \mathrm{CSFo}}{\mathrm{BW} \times \mathrm{AT}} \times 10^{-3} \qquad (3)$$

Where, EFR means the frequency of exposure (365 days/year), ED express duration of exposure (for adults 70 years and for children 14 years) which is the average human lifetime. BW is the average body weight (where adults 60 kg; children 27 kg), AT is the average time for carcinogens, for adults = (365 days/year × 70 years) and for children= (365 days/year × 14 years) and CSF° means the oral carcinogenic slope factor (Hassan et al., 2022), which is 0.0085 (8.5×10--3) for lead, 15 for Cd, and 0.5 for Cr mg/kg/day respectively (Helion, 2022). TCR for Pb, Cd, and Cr was calculated because they are all carcinogenic (Hassan et al., 2022).

3. Results and Discussion

3.1. Results of the level of heavy metals detected in all samples

Table 1 Concentration of Pb, Cd and Cr in raw cow milk samples from Sukari and the maximum level of concentration by world health organization (MLC by WHO standard)

Metals	Nama (ppm)	Red Bororo (ppm)	White Fulani (ppm)	Mean ±SD	MLC by WHO Standard (ppm)
Pb	0.247	0.185	0.494	0.308±0.002	0.02
Cd	0.0110	0.0073	0.0018	0.0067±0.002	0.005
Cr	0.029	0.036	0.047	0.037±0.002	0.1

Table 2 Concentration of Pb, Cd and Cr in raw cow milk samples from Tella and the maximum level of concentration by world health organization (MLC by WHO standard)

Metals	Nama (ppm)	Red Bororo (ppm)	White Fulani (ppm)	Mean ±SD	MLC by WHO Standard (ppm)
Pb	0.185	0.679	0.309	0.391±0.002	0.02
Cd	0.0018	0.0165	0.0037	0.0073±0.002	0.005
Cr	0.077	0.068	0.047	0.064±0.002	0.1

Table 3 Concentration of Pb, Cd and Cr in raw cow milk samples from Ibi and the maximum level of concentration by world health organization (MLC by WHO standard)

Metals	Nama (ppm)	Red Bororo (ppm)	White Fulani (ppm)	Mean± SD	MLC by WHO Standard (ppm)
Pb	0.247	0.370	0.864	0.493±0.002	0.02
Cd	0.0147	0.0073	0.0018	0.0079±0.002	0.005
Cr	0.163	0.033	0.039	0.078±0.002	0.1

The concentrations of heavy metals (Pb, Cd, and Cr) in raw cow's milk were reported in Tables 1, 2, and 3 respectively. The three heavy metals were all detected in the nine samples of cow milk collected from three different areas (uakari, Ibi, and Tella) of weary in Taraba state in which HNO3 and H2O2 are used for the digestion procedure (Hassan et al., 2022). And their concentrations were in the order of Pb > Cd > Cr for heavy metals in all samples. All the samples show an increasing order of concentrations. Lead and cadmium were the heavy metals detected at higher levels while chromium was at low level and almost at the range in the raw cow milk samples. The concentration of each metal can be seen in the bar chart above.

The concentration and the mean concentration of Pb in Nama, Red Bororo and white Fulani milk samples were 0.247 ppm, 0.185 ppm, 0.494 ppm and 0.308±0.002 ppm for Sukari sample, 0.185 ppm, 0.679 ppm, 0.309 ppm and 0.391±0.002ppm for Tella, and 0.247 ppm, 0.370 ppm and 0.864 ppm 0.493±0.002 ppm for Ibi, the concentration and the mean concentration of Cd in Nama, Red Bororo and white Fulani milk samples were 0.0110 ppm, 0.0073 ppm, 0.0018 ppm and 0.0067±0.002 ppm for weary, 0.185ppm, 0.679ppm, 0.309 ppm and 0.0073±0.002 ppm for Tella, and 0.0147 ppm, 0.0073 ppm, 0.0018 ppm and 0.0079±0.002 ppm for Ibi with the mean concentrations of 0.391±0.002 ppm, the concentration and the mean concentration of Cr in Nama, Red Bororo and white Fulani milk samples were 0.029 ppm, 0.036 ppm, 0.047 ppm 0.037±0.002 ppm for weary, 0.077 ppm, 0.068 ppm, 0.047 ppm 0.064±0.002 ppm for Tella, 0.163ppm, 0.033 ppm, 0.039 ppm and 0.078±0.002 ppm for Ibi.

Table 4 Values of EDI for raw cow milk in Sukari LGA

Metals	Nama	Red Bororo	White Fulani
	EDI	EDI	EDI
Pd	0.203	0.152	0.407
Cd	0.009	0.006	0.001
Cr	0.023	0.029	0.038

Table 5 Values of EDI for raw cow milk in Tella

Metals	Nama milk	Red Bororo milk	White Fulani milk
	EDI	EDI	EDI
Pd	0.152	0.559	0.254
Cd	0.001	0.013	0.003
Cr	0.063	0.056	0.003

Table 6 Values of EDI for raw cow milk in Ibi LGA

Metals	Nama	Red Bororo	White Fulani
	EDI	EDI	EDI
Pd	0.203	0.304	0.711
Cd	0.012	0.006	0.001
Cr	0.134	0.027	0.032

The estimated daily intake (EDI) of metals from raw cow milk consumption had been investigated for selected heavy metals (Pb, Cd and Cr) for adult consumers of cow milk (Sukari, Tella and Ibi) are listed in Tables 4, 5 and 6. These values were used in the calculation of target hazard quotient and target carcinogenic risk.

Table 7 Target Hazard Quotients and Carcinogenic in Sukari samples

Metals	Target Hazard Quotients			Carcinogenic Risk			
	Nama	Red Bororo	White Fulani	Metal	Pb	Cd	Cr
Pb	0.050	0.038	0.101	Nama	2.9×10-7	2.3×10-5	1.9×10-6
Cd	0.009	0.006	0.001	Red Bororo	2.2×10-7	1.5×10-5	2.4×10-6
Cr	1.5x10-5	1.9x10-5	2.5x10-5	White Fulani	6.8×10-5	2.5×10-6	3.2×106
Total THQ	0.059	0.045	0.102				

Table 8 Target Hazard Quotients and Carcinogenic in Tella samples

Metals	Target Hazard Quotients			Carcinogenic Risk			
	Nama	Red Bororo	White Fulani	Metal	Pb	Cd	Cr
Pb	0.038	0.139	0.063	Nama	2.1×10^{-7}	2.5×10^{-6}	5.3×10^{-6}
Cd	0.001	0.013	0.003	Red Bororo	7.9×10^{-7}	3.3×10^{-5}	4.8×10^{-6}
Cr	$4.2x10^{-5}$	$3.73x10^{-5}$	$2.0x10^{-6}$	White Fulani	3.6×10^{-7}	7.5×10^{-6}	2.5×10^{-7}
Total THQ	0.039	0.152	0.066				

Based on the THQ, we evaluated the non-carcinogenic risks due to consumption of raw cow milk for the adult resident and the estimated THQ values of metals are given in Tables 7, 8 and 9. From the results, all the metals showed the THQ value below the threshold value of 1 suggesting that there are no obvious health risks related to these metals associated with the consumption of raw cow milk in the study area. It is clearly observed that the values of THQ for all the metals (Pb, Cd and Cr) in all the sampling area (Sukari, Tella and Ibi) decreased in the order of: Pb > Cd > Cr.

Table 9 Target Hazard Quotients and Carcinogenic in Ibi samples

Metal	Target Hazard Quotients			Carcinogenic Risk			
	Nama	Red Bororo	White Fulani	Metal	Pb	Cd	Cr
Pb	0.050	0.076	0.177	Nama	2.9×10^{-7}	3.0×10^{-5}	1.1×10^{-5}
Cd	0.012	0.006	0.001	Red Bororo	4.3×10^{-7}	1.5×10^{-5}	2.3×10^{-6}
Cr	$8.93\text{x}10^{-5}$	$1.8\text{x}10^{-5}$	$2.13\text{x}10^{-5}$	White Fulani	1.0×10^{-6}	2.5×10^{-6}	2.7×10^{-6}
Total THQ	0.062	0.082	0.178				

The data in the Tables 7 to 9 also show the cumulative THQ (THQs) for Sukari (Ndam, Red Bororo and White Fulani) did not exceed the suggested threshold value of 1 but the THQs value had decreased in the order of: White Fulani> Nama > Red Bororo. For Tella (Nama, Red Bororo and White Fulani) decreased by order of: White Fulani>Red Bororo>Nama. For Ibi (Nama, Red Bororo and White Fulani) decreased by order of: White Fulani>Red Bororo>Ndam.

These showered that in all the sample areas, the white Fulani species are more vulnerable in reaching the suggested threshold value than other species.

The carcinogenic risk of Pb, Cd and Cr were also assessed using the target carcinogenic risk for adult consumption of raw cow milk in the samples area. The risk of cancer between the ranges of 10-4 to 10-6 is generally considered as acceptable range (Hasan et al., 2022). Therefore, it was found that the TCR of Pb Cd and Cr as shown from the Tables 7 to 9 are within the acceptable ranges which indicate that the study area is within the safe limit.

4. Conclusion

Heavy metal residues such as cadmium (Cd), lead (Pb), chromium (Cr) are some of the major contaminants in chemical hazards. Heavy metals can naturally occur in milk as a result of human activities such as industrial and agricultural processes. Polluted soils are a major source of Cd and Pb which can build up in milk through the food chain. Heavy metals have become pollutants in food for a variety of reasons resulting in a concern of health issues. Atomic Absorption Spectroscopy was used to determine the amount of heavy metal contamination in milk. This study gives an important information on the concentration of heavy metals (lead, cadmium, and chromium) in fresh cow milk. Based on the evaluated mean concentration, lead and cadmium were the toxic metals detected at high levels in all the nine samples, while chromium was the only one at low level in the samples from weary and Tella and equals the permissible limit in Ibi samples.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest related to this research paper.

References

[1] Abdelkhalek A.; Elsherbini M. and Gunbaej E. (2015). Assessment of heavy metals residues in milk powder and infant milk formula sold in Mansoura City, Egypt. Alexandria Journal of Veterinary Sciences,47: 71-77.

[2] Agrawal, R.P., Swami, S.C., Beniwal, R. (2003). Effect of camel milk on glycemic control, risk factors and diabetes quality of life in type-1 diabetes: a randomized prospective controlled study. J. Camel Pract. Res., 10: 45-50.

[3] Ankur Aggarwal, Tarun Verma and Sumangal Ghosh (2022). Heavy Metal Residues in Milk and Milk Products and Their Detection Method DOI:10.5772/intechopen. Dairy Science and Food Technology, 10500.

[4] Arafa, MS, Walaa, A, Moselhy, NE and Hassan, Y. 2014. Heavy metals and trace elements levels in milk and milk products. Food Measure. 8:381–388.

[5] Enb A, Donia MA, Abd-Rabou NS, Abou-Arab AAK, El-Senaity MH. Chemical composition of raw milk and heavy metals behavior during processing of milk products. Global Veterinaria. 2009;3(3):268-275.

[6] FAO/WHO. 2002. Codex Alimentarius-general standards for contaminants and toxins in food. Schedule 1 Maximum and guideline levels for contaminants and toxins in food, Joint FAO/WHO food standards programme. Rotterdam: Codex committee. Reference CX/FAC 02/16.

[7] Hasan, G.M.M.A., Kabir, M.H. and Miah, M.A.S. (2022). Determination of heavy metals in raw and pasteurized liquid milk of Bangladesh to assess the potential health risks. Food Research 6 (1): 233 - 237

[8] Heliyon. 2022 Sep; Non-carcinogenic and carcinogenic health risks associated with heavy metals and perycyclic aromatic hydrocarbons in well water samples from an automobile junk market in Ibadan, SW-Nigeria, National Center for Biotecnology Information. 8 (9): e10688, dio: 10.1016/j. heliyon. PMCID: PMC9526163 l PMID: 36193520

[9] Ketut I. B and Rera A. S. (2022). Heavy metals analysis (Cd, Pb, Zn, Cu, Cr) and calcium in Padang and Padang Pajang fresh cow's milk. IOP Conference series: Earth Environ. Sc.1038 01207

[10] Khan, S.; Cao Q.; Zheng Y.M.; Huang Y.Z. and Zhu Y.G. (2014). Health risk of heavy metals in contaminated soils and food crops irrigated with waste water in Beijing, China Environ. Pollut. 152 686-692.

[11] Khalil, O. (2018). Risk Assessment of Certain Heavy Metals and Trace Elements in Milk and Milk Products Consumed in Aswan Province.," J. Food Dairy Sci., vol. 9, no. 8, pp. 289–29, doi: 10.21608/jfds.2018.36018.

[12] Li, Y., McCrory, D.F., Powell, J.M., Saam, H. and Jackson-Smith, D. (2005). A survey of selected heavy metal concentrations in Wisconsin dairy feeds. Journal of Dairy Science, 88(8), 2911-2922. https://doi.org/10.3168/jds.S0022-0302(05)72972-6

[13] Licata P, Trumbetta D, Cristiani M, Giofre F, Martino D, Calo M, Naccani F (2004). Levels of toxic and essential metals in samples of bovine milk from various daiey farm in calibaria Italy. Environ. Res., 30: 1-6

[14] Maas, S., Lucot, E., Gimbert, F., Crini, N. and Badot, P.M. (2011). Trace metals in raw cows' milk and assessment of transfer to Comté cheese. Food Chemistry, 129(1), 7-12. https://doi.org/10.1016/ j.foodchem.2010.09.034

[15] Magjeed NA (2005). Corrective effect of milk camel on some cancer biomarkers in blood of rats intoxicated with aflatoxin B1. J Saudi Chem Soc., 9: 253-630. Mattila-Sandholm T, Myllärinena P, Crittendena R, Mogensenb G, Fondénc R, Saarela M (2002). Technological challenges for future probiotic foods. Int. Dairy J., 12: 173-182.

[16] Meshref A. M. S.; Moselhy W. A. and Hassan N. E.-H. Y. (2014). "Heavy metals and trace elements levels in milk and milk products," J. Food Meas. Charact., vol. 8, no. 4, pp. 381–388, Dec., doi: 10.1007/s11694-014-9203-6

[17] NASS, (2011). National Bureau of Statistics/Federal Ministry of Agriculture and Rural Development Collaborative Survey on National Agriculture Sample Survey.

[18] Ogwumu, O. D.; Amoo, S. A.; Eguda, F. Y.; Adeyefa, E. O. and Abubakar, S. (2015). A Mathematical Model for Estimating the Weight of Human Beings Using Some Anthropometric Parameters (A Case Study of Taraba State of Nigeria's Community). BJMCS, 8(2): 147-158; BJMCS.2015.152.

[19] Shabo Y, Barzel R, Margoulis M, Yagil R (2005). Camel milk for food allergies in children. Immunol. Allergy., 7: 796-798

[20] Yahaya M. I.; Ezo G. C.; Musa Y. F. and Muhamad S. Y. (2010). Analysis of heavy metals concentration in roadside soils in Yauri, Nigeria. African Journal of Pure and Applied Chemistry; 4(3):022–30.