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Determination of some essential metals and toxic metals in pasteurized milk samples of six different brands

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Abstract

The present study investigates the selected heavy metal concentration (cadmium and lead) and trace elements (iron and copper) in different brands of pasteurized milk available at local market of Raipur. Total six samples of pasteurized milk (based on the availability at local market) were purchased and brought to the laboratory and 20 ml of each sample were digested and absorbance of these solutions was obtained using AAS for cadmium, lead and iron and copper respectively. The analyzed metals were observed in the following decreasing order of concentration: Fe> Pb> Cd> Cu. The concentration of lead in the milk samples ranged as 0.31 to 0.40 mg/l, which is far more than the limits (0.025mg/l) given by Joint Expert Committee on Food and Agriculture and World Health Organization. Level of cadmium (0.032 to 0.041mg/l) in every sample was found low than the limits (0.057 0.071mg/l) given by Joint Expert Committee on Food and Agriculture and World Health Organization. The concentration of iron was ranged as 0.392 to 0.927mg/l. Except the sample 3 which had 0.392mg/l of iron, all the other milk samples exceed the limits (0.5mg/l) given by Joint Expert Committee on Food and Agriculture and World Health Organization. The values of copper were ranged from 0.019 to 0.049mg/l which is above the prescribed limit of copper (0.01mg/l) by JECFA (1989). It is clear from the result that except cadmium other three metals (Pb, Fe and Cu) are exceeding the permissible limits. To monitor the level of heavy metals, water used for drinking animals and forage should be regularly inspected.

Key words

Pasteurized milk, lead, cadmium, trace elements, permissible limits

Introduction

Milk is considered as a nearly complete food since it is a good source of protein, fat and major minerals. Milk and milk products are main constituents of the daily diet, especially for vulnerable groups such as infants, school age children and old age. It is an ideal source of macronutrients such as Na, K, Cl, Ca, Mg and P and micronutrients (trace elements) such as Fe, Cu, Zn, Mn, Se, I, Cr, Co, Mo, F, As, Ni, Si and B and all of them are present in milk at some concentrations (Cashman, 2006). These elements are known to be essential for normal growth. The main elements are essential for human beings in amounts >50 mg/day, while trace elements are essential in concentration <50 mg/day and their biochemical actions have been elucidated (Belitz *et al*., 2004).

Heavy metals are generally defined as metals with relatively high densities, atomic weights, or atomic numbers. Some metals like Pb, Cd and Hg do not occur naturally in the body, and their presence, usually as a result of occupational or pollution related exposure is determined to health and children are more sensitive to these metals than adults. Some heavy metals (like Cu and Fe) are essential to maintain proper metabolic activity in living organisms; others (like Pb and Cd) are non-essential and have no biological role (Ayar et al., 2009; Qin et al., 2009).

Lead and cadmium are considered potential carcinogens and are associated with etiology of a number of diseases in the cardiovascular system, kidneys, nervous system, blood and skeletal system (Nasef, 2002). Copper is required with iron for synthesis of hemoglobin. It works with many enzymes such as those involved in protein metabolism and hormone synthesis. Deficiency of copper causes low white blood cell count and poor growth. Excess intake of copper can cause vomiting, nervous system disorder and Wilson's diseases (Wardlaw and Insel, 1996). Iron is an essential part of hemoglobin, iron deficiency leads to anemia and excess iron gets deposited in the liver, heart and pancreas, where it can cause cirrhosis, liver cancer, cardiac arrhythmias and diabetes (Jane, 2012).

Material and Methods

The main aim of this study is to determine the quantity of heavy metals (Pb and Cadmium) and essential trace elements (Cu and Fe) in milk samples. Atomic Absorption Spectrometer will be used for the analysis. The obtained result will be compared with the national and international recommended levels.

Sample Collection and Preparation: Total six samples of pasteurized milk like Amul, Vachan, Gaya, Devbhog, Abis and Mother dairy (based on the availability at local market) were purchased and brought to the laboratory from local grocery stores in the commercial city of Raipur. Prior to analysis, the samples were digested according to the method of Wallace (2001). 10 ml of 69%concentrated nitric acid was added to 20 ml of the sample and the mixture was evaporated on a hot plate in a fume cupboard until the brown fumes disappears leaving white fumes. If brown fumes persist, 5 ml of 69%concentrated nitric acid and 5 ml of 30% H202 was added after cooling the sample. Then reflux the sample at 90 ^{0}C until it reduced to 2-5 ml. Subsequently, additional de-ionized water was added to make up the volume to 100 ml which was then filtered with whatman filter paper and ready for atomic absorption spectrometer (AAS) analysis using the Varian AA240 model.

Analysis for heavy metal contamination: A working solution of 100 ppm was prepared from the stock solution and serial dilutions were made from the working solution. The absorbance of these solutions was obtained using AAS at 228.8 nm for cadmium and lead at 283.3 respectively. The calibration graph was plotted and the samples were analyzed for the selected heavy metal concentration. De-ionized water was used as control.

Table 1: Experimental condition for each element

Element	Wave length (nm)	Flame	Slit width (nm)	Detection Limit (mg/L)	Optimum working range (mg/L)
Pb	283.3	A-Ac	0.1	0.05	0.5-50
Cd	228.8	A-Ac	0.5	0.002	0.02-3
Fe	248.3	A-Ac	0.2	0.02	0.06-15
Cu	324.7	A-Ac	0.1	0.010	0.03-10

Result and Discussion

The analytical results of the levels of lead, cadmium, iron and copper in different brands of pasteurized milk samples are presented in Table 2 and Fig. 1.

Table 2: Concentration (mg/L) of lead, cadmium, iron and copper in different brands of pasteurized milk samples

Samples	Pb	SD	Cd	SD	Fe	SD	Cu	SD
1.	0.35	0.010	0.034	0.007	0.691	0.033	0.019	0.001
2.	0.40	0.011	0.037	0.007	0.776	0.037	0.025	0.002
3.	0.35	0.010	0.033	0.006	0.392	0.018	0.018	0.001
4.	0.31	0.009	0.032	0.006	0.532	0.025	0.019	0.001
5.	0.42	0.012	0.041	0.008	0.757	0.036	0.033	0.002
6.	0.38	0.011	0.037	0.007	0.927	0.044	0.049	0.004

The results showed that the all the four selected elements were detected in the present milk samples (Table 2). The mean concentration of toxic heavy metals under study namely lead, copper, and iron (except cadmium) were detected more than the maximum residue limits of these elements as given by Joint Expert Committee on Food and Agriculture and World Health Organization (Table 3).

Table 3: Maximum Residue Limits (mg/l) lead, cadmium, iron and copper of milk given by Joint Expert Committee on Food and Agriculture and World Health Organization

Elements	Milk MRL* mgL-1 (JECFA 1989) [12]
Pb	0.025
Cd	0.057- 0.071
Fe	0.5
Cu	0.01

*** MRL** Maximum Residue Limits

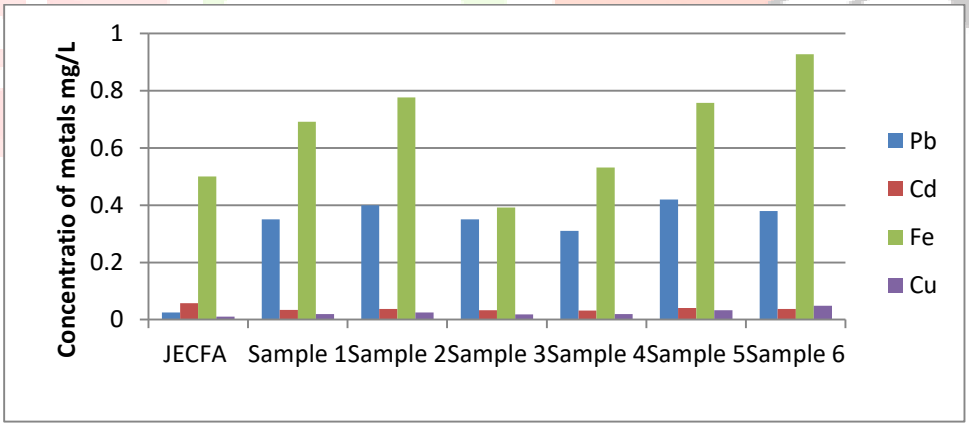

Fig. 1: Comparison of concentration of different metals (Pb, Cd, Fe and Cu) in milk sample with permissible limits of JEFA

Table 4: Concentrations of metals (µg/g) in Cow's milk from different countries compared to those of the present study

SN	Study	Country/ Milk type	Cd	Pb	Cu	Fe
1.	Enb et al (2009)	Egypt/Raw	0.086	0.066	0.0124	0.068
2.	Valiukenaiate et al (2006)	Lithuania/Raw	0.004	0.005	----	----
3.	Akpanyung (2006)	Nigeria/Powder	-----	-----	6-15	118
4.	Ayar et al (2009)	Turkey/Raw/Powder	0.017 0.024	0.103 0.054	---- ----	---- ----
5.	Qin et al (2009)	China/ Commercial Japan/ Commercial	0.004 0.001	0.035 0.012	0.017 0.23	2.21 1.51
6.	Farid et al (2004)	S. Arabia/ Commercial/ powder	0.005 0.003	0.003 0.002	0.049 0.037	---- ----
7.	Abdulkhaliq et al (2012)	Palestine/Commercial/ powder	0.036 0.054	0.20 0.93	0.62 0.66	8.23 12.91
8.	Present study (2019)	India/Pasteurized milk	0.035	0.368	0.027	0.679

In all samples analyzed, concentrations of Fe were the highest and those of Cu were the lowest. Levels of metals in milk were having the following order: Fe>Pb>Cd>Cu. However, mean Pb, Fe and Cu concentrations in milk exceed the maximum allowed limits of 0.02, 0.5 and 0.01mg/l. Table 4 shows a comparison between metal concentrations in milk samples of the present study and those reported from other countries. The results indicate that milk in the present study contains higher levels of metals than most other countries. This is obvious especially in the case of lead. The elevated levels could be related to contamination during industry processing and environmental pollution. India is an industrialized country, leaded fuel is still largely used which might be one reason for the high Pb levels recorded. In addition, processing and packaging of milk and dairy products may lead to an elevation in metal concentrations.

Cerkvenik *et al* (2000) and Bruhn and Franke, (1976) reported lead and cadmium concentrations in milk samples below the permissible limit. Similar results of very low concentrations for Pb and Cd were obtained by Sahayaraj and Ayyadurai (2009), Amponsah (2014), Birghila et al. (2008). Lower results for Cd were recorded by Enb et al. (2009), Elsayed et al. (2011), El-Bassiony et al (2016), Gidikova et al. (2016) and Tunegova et al (2016). Higher values similar to the present results were obtained by Abdulkhalequ et al. (2012), Malhat et al (2012) and Gasmalla et al. (2013). Higher results for Pb in raw cow's milk were reported by Gasmalla et al. (2013) and El-Bassiony et al (2016). Milk and dairy products become contaminated with heavy metals either through food stuff and water or through manufacturing and packaging processes (Ayar et al., 2009). The heavy metal contents vary widely due to many factors such as differences between species, characteristics of the manufacturing practices and possible contamination coming from the equipment during the process (Caggiano et al., 2005).

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