

REVIEW

Factors involving in fluctuation of trace metals concentrations in bovine milk

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Abstract: Milk makes a significant contribution to human diet through provision of macronutrients, vitamins and minerals. The exact composition of milk varies with species among domestic animals according to their neonatal needs. It is recognized that imbalance in the quantity of minerals and trace elements is a serious health hazard especially for infants. Many studies reported the fluctuation in the level of metals in milk due to the influence of several factors such as geographical and exposure to environmental pollution caused by anthropogenic activity. Amongst all sources, industries take lion's share to alter the metal content in milk. The importance of different nutritional and toxic metals in milk from different geographical areas is discussed.

Keywords: Bovine milk, toxic metals, industrial and sewerage drains, geographical factors.

INTRODUCTION

Metals differ from other toxic substances in that they are neither created nor destroyed by humans. Metals are redistributed in the air, water, soil and food through geological, biological and anthropogenic pathways (Beigjer *et al.*, 1986). Mineral nutrients are involved in the most fundamental process of life (Hui, 1992). They are inorganic elements that maintain their structure throughout the processes of digestion, absorption and metabolism, and play critical roles in virtually all aspects of human health and function. On the basis of body requirements the two categories of minerals in our diets are the major minerals (>100mg/day) and the trace minerals (<100mg/day). Amount of major minerals present in the human body is greater than 5g; in contrast, trace minerals exist in the human body is less than 5g. Major minerals include Ca, P, Na, K, Cl, Mg while trace minerals include Fe, Zn, Cu, Mn, F, Cr, Mo, Se and I (Thompson, 2009). These trace metals are responsible for many pernicious effect on human health as immunodepression and skin diseases (zinc and copper contamination), neurological disorders (manganese), or blood disorders (iron) have been experienced (Konuspayeva *et al.*, 2009).

Milk is an excellent source of Ca, P and Mg and exhibit correlation with caseins (Sikiric *et al.*, 2003; Hui, 1992). It is well known that casein has tendency to absorb the nonessential metal ion (Mishra *et al.*, 1998). Amongst the 92 elements Pb, Hg and Cd are familiar as contaminants and inevitable in food since their wide spread industrial relevance or their presence in earth crust have resulted in

their becoming a persistent and ubiquitous contaminant in the environment involving in food chain and pose injurious effect on consumer health (Birghila *et al.*, 2008; Patra *et al.*, 2008). Hence Pb and Cd assessment is imperative in favor of producing better quality meal (Florea *et al.*, 2006; Pavlovic *et al.*, 2004). Low level of these elements is toxic as well and creates hazardous risk (Mahaffey, 1977, Santhi *et al.*, 2008).

The exact composition of milk varies from species to species depending on the requirement of their neonates. For example, buffalo milk contains a higher level of organic part (casein, albumin and globulins) and minerals like Ca, Mg, and inorganic phosphates in comparison to cow's milk (Iqbal *et al.*, 2011). An investigation reported by Enb *et al.*, (2009) demonstrated that buffalo milk is richer in essential metals (Fe, Cu and Zn) content and non-essential metals (Pb and Cd) than the cow's milk. Nonetheless, level of Cu and Mn was found to be higher in cow's milk compared to buffalo's milk.

Industrial areas particularly close to cattle colonies cause disorder in the concentration of minerals in milk due to broad exposure of the heavy metals that is clearly provide evidence in recent study done in Challawa, industrial areas of Nigeria where higher metal levels recorded in cow's milk than previous study and also the WHO permissible limits (Ogabiela *et al.*, 2011). In contrast, the milk produced in the areas of Croatia, which have lower industrial load exhibited the balanced levels of essential elements and less contaminated by non essential elements (Sikiric *et al.*, 2003).

Sewerage drains leads to higher accumulation of heavy metals in milk as well wherever cattle farms raised close

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proximity. The related factor recorded in the milk of cattle and goat in Faisalabad city, where Cd, Cr, Ni, Pb, As and Hg concentrations were estimated greater than the most reported literature concentrations (Aslam *et al.*, 2011). Significant differences in the level of heavy metals (Cd, Cr, Ni and Pb) in milk samples of polluted and unpolluted areas of Faisalabad city was reported by Farid and Baloch, (2012). Another study provides clear evidence that lead free cattle feed (water and fodder) limits the lead concentration in milk at a safer level (Sahayaraj and Ayyadurai *et al.*, 2009).

Geographical factors also pose impact on the levels of some elements of cow's milk such as aluminum, titanium, manganese, gallium, selenium, germanium, and cobalt show higher concentration in Lower Silesian as compared to Upper Silesian, Poland region, nevertheless some elements (Zn, Ba, Cu, Cr, V, Ni, As, Mo, Pt, Sb, Au, Hf, Ce, U, Re, Tl, Ru, Rh, Ir, Ta, Be) maintain their concentrations and do not show wide variation in different geographical circumstances (Dobrzanski *et al.*, 2005).

Environmental pollution is a causative factor of high toxic metal content in milk via soil, water and animal feed (Qin *et al.*, 2009). Soil and water pollution are the chief factors of increased levels of Pb and Cu in bovine milk available for the consumption of natives in Northern Nigeria due to dense traffic and occurrence of industries (Jigam *et al.*, 2011). Higher levels of heavy metals in cattle milk in Neyveli, India were reported by Ramamurthy and Thillaivelavan, (2005). The major cause of this was the polluted air through flying ash in the region due to coal fired power plant.

Processing of milk, pasteurization and sterilization creates imbalance in the mineral content (Ayar *et al.*, 2008). A considerably higher amount of Cd was estimated in packet milk available in Erbil, Iraq as compared to the fresh milk; the trend was found for essential metals vice versa (Hassan, 2009).

Lead

Lead, which is chemically identical to calcium, is excreted into milk to a considerable extent (Klaassen, 2001). Chemically identical divalent essential metals such as iron, calcium and zinc are replaced from some of their metabolic sites by lead and disabled to perform their functions. For example, lead competes with iron in heme, but then cannot act as an oxygen carrier; similarly, lead competes with calcium in neurons, but cannot signal messages from nerve cells (Whitney *et al.*, 2005). Whereas milk, fasting, low levels of calcium, vitamin D and iron have been shown to increase lead absorption in laboratory animals (Mudgal *et al.*, 2010). Effluence of the environment with lead is a global dilemma. Combustion of gasoline with tetraethyle lead (TEL) as an anti-knocking additive and exhaust into the atmosphere and

creates lead toxicity in the vicinity of roads, earth, atmosphere, water and vegetation (Burguera and Rondon, 1987).

Lead does not break down in the environment and this potent neurotoxin can harm the nervous system, reproductive complications and kidney failure especially in young children. Children under the age of 6 and unborn fetuses even with low blood level of lead are particularly vulnerable to nervous system impairment, low IQ, shortened attention span, hyperactivity, hearing damage and various behavioral disorders (Miller *et al.*, 2009; Whitney *et al.*, 2005).

Cadmium

Cadmium is toxic when increased into the environment in high concentration. Its toxic effects may originate when the industrial sludge meets the rivers and also the wide usage of phosphate fertilizers in the fields (Venugopal and Luckey, 1978). Cd is an identical metal to Zn, located just below the Zn in periodic table and makes compounds in the oxidation state II. Being similar, it replaces to Zn (II) from the active site of zinc- dependent enzymes and proteins, which in turn lose their biological activities. A widely occurring pollution caused by Cd was manifested in a malady called "itai-itai" disease and it causes a symptom of severe osteoporosis (Ochiai, 2011). In addition, it is concerned in high blood pressure, prostate malignancy, mutations and fetal death (Perry *et al.*, 1979; Pitot and Dragan, 1996). The foremost path of access of cadmium to the organs of an individual is the digestive system and intestinal assimilation. Vegetation acquires cadmium from irrigation water only in the form of activated Cd ion past discharge since the sorption compound or commencing soil solution (Smirjchkova *et al.*, 2005).

Iron

The human body contains approximate 2 to 4 g iron (~38 mg iron per kg body weight for women and ~50 mg per kg body weight for men). Above 65% of body iron found in hemoglobin, up to approximate 10% is found as myoglobin, ~1% to 5% is found as part of enzymes and the residual body iron is found in the blood (Gropper *et al.*, 2005).

Bovine milk contains a very low amount of Fe (Jigam *et al.*, 2011) and far too much protein for infant consumption, to and high casein content makes it much harder for the infant to digest and absorb (Thompson, 2008). Excess feeding of breast milk or formula may limits the infant intake of iron-rich food, causing milk anemia that can affect a child's energy level, attention span and mood (Perween *et al.*, 2011;Thompson, 2009).

Copper

Copper is widely distributed in nature and is nutritionally essential element. Daily intake of copper in adults varies

Table 1: Comparative levels (ppm) of the essential/nonessential elements in bovine milk of different cities in the World

City	Cadmium	Lead	Iron	Copper	Zn	References
Mumbai, India	0.012-0.013	--	0.540-44.275	--	--	Zodape <i>et al.</i> , 2013
Ogbomoso, Nigeria	0.0021	0.003	--	--	--	Tona <i>et al.</i> , 2013
Addis Ababa, Ethiopia	0.100	0.998	1.213	--	4.923	Dawd <i>et al.</i> , 2012
Sarab, Iran	0.004	0.065	--	--	--	Dizaji <i>et al.</i> , 2012
Malekan, Iran	0.005	0.142	--	--	--	Dizaji <i>et al.</i> , 2012
Meyaneh, Iran	0.001	0.182	--	--	--	Dizaji <i>et al.</i> , 2012
Ahar, Iran	0.002	0.012	--	--	--	Dizaji <i>et al.</i> , 2012
Ramallah, Palestine	0.022-0.057	0.93	3.2-12.91	0.62-0.85	--	Abdulkhaliq <i>et al.</i> , 2012
Erbil, Iraq	0.004	--	0.271	0.190	1.080	Hassan, 2009
Chennai, India	--	0.06	--	--	--	Sahayaraj and Ayyadurai <i>et al.</i> , 2009
Constanta, Romania	0.004	0.12	0.72	0.17	0.98	Birghila <i>et al.</i> , 2008
Alexandria, Egypt	0.001	0.1431				Hafez and Kishk, 2008
Jeddah, Saudi Arabia	0.004	0.003	0.41	0.04	0.94	Kinsara & Farid, 2007; Farid <i>et al.</i> , 2004
Silesia, Poland	--	--	--	0.065-0.089	3.085-3.163	Dobrzanski <i>et al.</i> , 2005
Calabria, Italy	0.000	0.001	--	0.001	2.016	Licata <i>et al.</i> , 2004
Mumbai, India	0.000	0.001-0.003	--	0.043-0.195	1.77-4.23	Tripathi <i>et al.</i> , 1999

Table 2: Comparative levels (ppm) of the essential/nonessential elements in bovine milk of different cities of Pakistan

City	Cadmium	Lead	Iron	Copper	References
Faisalabad	0.171- 0.122	23.240-16.704	--	--	Aslam <i>et al.</i> , 2011
Karachi	--	--	3.30	--	Perween <i>et al.</i> , 2011
Lahore	0.07-0.08	--	0.56-0.62	0.13-0.21	Hussain <i>et al.</i> , 2010
Hyderabad	0.044-0.056	0.047-0.055	--	--	Kazi <i>et al.</i> , 2009
Karachi	--	--	--	0.260	Perveen <i>et al.</i> , 2005

between 0.9 to 2.2mg while in children has been estimated to be 0.6 to 0.8mg/day, the copper content in human body ranges from 50 to 150 mg. It exists in the body in two oxidation states Cu^{1+} and Cu^{2+} (Gropper *et al.*, 2005). The main form of copper used in mineral-fortified food products is copper sulfate; other bioavailable and water soluble forms of copper include cupric chloride, cupric acetate and copper carbonate (Baker, 1999). In human and rats, large amount of iron intake decreases the absorption of copper (Yu *et al.*, 1994; Snedeker *et al.*, 1982; Finely and Cerklewski 1983). It has been shown that milk supplies a little quantity of Cu (Jigam *et al.*, 2011). A significantly lower absorption was found in infants fed on formulated fortified products with iron (10.8 ppm iron) as compared to that infants fed without fortified formula providing only 1.8 ppm iron (Haschke *et al.*, 1986).

Zinc

Zinc is found in all body organs, most notably the liver, kidney, muscle, skin and bones. Zinc appears to be a part of greater number of enzyme systems than the rest of the trace minerals combined. It may affect the activity of several enzymes attached to plasma membranes, including alkaline phosphatase, carbonic anhydrase and

superoxide dismutase, among others (Bettger, 1993). Zinc deficiency results in wide spectrum of clinical effects depending on age, stage of development, and deficiencies of related metals. Zinc deficiency was first characterized by Prasad (1983) in adolescents with growth failure and delayed sexual maturation (Jigam *et al.*, 2011), pellagra, and iron and folate deficiency. Zinc deficiency in the newborn may be manifested by dermatitis, loss of hair, impaired healing, susceptibility to infections, and neuropsychological abnormalities. Other chronic clinical disorders such as ulcerative colitis and the malabsorption syndrome, chronic renal disease and hemolytic anemia are also associated with zinc deficiency (Ryan-Harshman and Aldoori, 2005; Klassen, 2001).

CONCLUSION

Drinking milk may play an extremely important role in detoxification of Pb before its penetration in the muscles. Increased levels of other trace metals also may cause a number of diseases and harmful effects. Therefore, standardization and detection of deleterious levels of metals (essentials and non-essentials) in milk is necessary before human consumption.

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