Estimation of Metal Contents in Different Varieties of Milk Available in Karachi City

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Summary: Milk is generally considered as nutritionally balanced food for human beings of all age groups. It contains different type of metals and the concentration of metal contents varies with the variety of milk. The presence of metals may be natural or due to contamination. Therefore, in order to have an assessment of the dietetic intake of metals by consumers, sodium, copper, manganese and chromium were studied in different varieties of powder milk, fresh milk and processed milk, available in the markets in Karachi city. The range of content of sodium, copper, manganese and chromium was found to be (492-1366) mg/l, (0.227-0.652) mg/l, (0.044-0.102) mg/l and (ND-0.028) mg/l respectively. The results are discussed with reference to WHO Guidelines and data on metal contents in infant formula milk in USA, UK and Nigeria.

Introduction

Mineral and trace elements occur in the human body in the form of inorganic ions and salts or as constituent of organic molecules, such as proteins, fats, carbohydrates and nucleic acids. In the light of their nutritional value, these metals may be divided into (i) essential metals, like Na, K, Ca, Cu, Zn and Mn and (ii) unessential metals like Hg, Pb, Al, Sr, Cd and As [1]. The deficiency or presence in excess quantity of essential metals in human diet may result in a variety of ill effects on the consumer. Therefore it is important to know about the level of heavy metals contents in different types of foodstuff being consumed by human being in daily life.

Milk is one of the most commonly consumed food items. It is considered as one of the nutritionally balance food, as it contains vitamins, protein and minerals in colloidal form and there is no adequate substitute of this food. Cows, goats, buffalos and camels were domesticated centuries ago and their milk is used as diet by the people of all ages throughout the world. It contains different types of metals; the concentration of metal contents varies with the variety of milk. The caloric value and contents of high quality protein are significant. Minerals present in milk include calcium, sodium, potassium, magnesium and inorganic phosphate. Trace elements in milk, important in human nutrition, include chromium (glucose tolerance factor), zinc (insulin, enzyme cofactor), iron (hemoglobin), cobalt (in vitamin B12), copper (enzyme co-factor) and manganese (hypocholestrol) [2].

Infant formulas are liquids or reconstituted powders fed to infants and young children and serve as a substitute for human milk. Apart from breast milk, infant formula milk have a special role to play in the diets of infants, because infant formula milk are the major sources of nutrients for infants and a unique source of food during the first six months of life [3, 4].

The production of sterile milk of long keeping quality by continuous flow process at ultra high temperature (UHT) for short time, followed by aseptic packaging has been actively studied during the last two decades and accepted for liquid milk processing [5]. UHT process is one of the best ways of sterilization in which storage life of milk is increased to several months. However looses in nutrients have been observed to some extent during heating process of milk [6]. In this study two the most commonly used brands of tetra paks were selected.

Copper deficiency imparts the release of iron into the plasma and also produces defects in the structural stabilization, whereas copper in excess may result in Wilson's disease or hepatolenticular degeneration [7]. Manganese, essential for normal body

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structure, reproduction, normal functioning of central nervous system and activation of numerous enzymes is widely distributed throughout the body, with the largest concentration in the mitochondria of soft tissues especially in lever, kidney, and pancreas [8]. Sodium is the principle cation of the extra cellular fluid [9] and an excess of sodium ion depresses cardiac function [7]. Chromium is considered as an essential trace element for human metabolism. The amount of chromium in the diet is of great importance as Cr is involved in insulin function and lipid metabolism [10]. Approved daily intake of chromium has not been set; however, NRC (1989) has recommended an estimated safe and adequate daily dietary intake limit of 50- 200 µg/day [11]. Therefore this study was undertaken to assess Na, Cu, Mn, and Cr contents in different varieties of milk available in Karachi City. The data generated may help in the establishment of baseline data for trace metals present in different varieties of milk and in the assessment of the impact of the concentration of metals on daily intake per individual through this source.

Results and Discussion

The mean value concentration of Na, Mn, Cu and Cr observed in three varieties of milk powder (infant formula-1, infant formula-2 and Full cream milk powder), two varieties of fresh milk (cow and buffalo milk), and two varieties of processed milk (Tetra pak-1 and Tetra pak-2) along with standard deviation value are given in Table-1. Infant feeding deserves top priority in any program aimed at sound child healthcare, irrespective of racial, communal and religious considerations. It is estimated that proper infant feeding can prevent millions of deaths occurring from infantile gastroenteritis and malnutrition. Milk is the fundamental food for infants. The most natural and best source is from breast feeding and this is greatly encouraged for the first 06 months of life and should be continued for as long as 2 years. For elite urban women, the ready made milk preparations from the market have become handy for infant feeding. In this study, the analyzed samples of Infant formula 1 and infant formula 2 are recommended for infants up to 6 months and growing children (from age of 1 respectively. The full cream milk powder is suitable for growing children as well as for adults. The Table-1 shows that the mean concentration of metals in infant formula -1, infant formula -2 and full cream milk powder for (i) Na was found to be 492, 675 and 1366 mg/l respectively, (ii) Cu, 0.601, 0.344 and 0.625 mg/l respectively and (iii) Mn, 0.055, 0.059 and 0.102 mg/l respectively. The mean concentration of sodium in cow and buffalo milk was found to be 760 and 466 mg/l respectively, Cu, 0.260 and 0.227 mg/l respectively and Mn, 0.081 and 0.085 mg/l respectively. The mean concentration of sodium in tetra pak-1 and tetra pak-2 was found to be 0.725 and 850 mg/l respectively, copper 0.283 and 0.293 mg/l respectively, Mn 0.049 and 0.044 mg/l respectively. The concentration of chromium in cow milk was found to be 0.028 mg/l, whereas in other cases the concentration of chromium was found to be below the detection limit of 0.02 ppm or not detected.

Table – 1: Mean values of metal contents in different varieties of milk studies.

S. No.	Type of sample	Sodium (mg/l± SD)	RSD %	Copper (mg/l± SD)	RSD %	Manganese (mg/l± SD)	RSD %	Chromium (mg/l± SD)	RSD %
1.	Infant formula 1	492 ± 6	1.21	0.601 ± 0.08	1.33	0.055 ± 0.002	3.63	ND	-
2.	Infant Formula 2	675 ± 20	2.96	0.344 ± 0.001	0.29	0.059 ± 0.006	6.77	ND	-
3.	Full cream milk powder	1366 ± 22.4	1.63	0.652 ± 0.002	0.30	0.102 ±0.002	2.90	BDL	-
4.	Cow milk	760 ± 19	2.58	0.260 ± 0.008	3.07	0.081 ± 0.04	7.40	0.028±0.002	7.14
5.	Buffalo milk	466 ± 14	3.00	0.227 ± 0.01	4.54	0.085 ± 0.09	5.88	BDL	-
6.	Tetra pack 1	1125 ± 28	2.48	0.283 ± 0.004	1.42	0.049 ± 0.004	6.12	ND	-
7.	Tetra pack 2	850 ± 8.7	1.02	0.293 ± 0.004	1.37	0.044 ± 0.01	2.27	ND	-

BDL - Below Detection Limit
ND - Not Detectable in ppm

Table – 2: Concentration of milk based and soy based infant formula in USA, UK and Nigeria [12].

Brand of Milk	Na (mg/l ± S.D)	Cu (mg/l ± S.D)	Mn (mg/l ± S.D)
Milk based powder formula	183±40.1	0.43 ± 0.12	0.07 ± 0.03
Soy based powder formula	232 ± 46.7	0.72 ± 0.11	0.22 ± 0.04
Milk based first liquid formula	345 ± 33.4	0.72 ± 0.16	0.093 ± 0.014
Milk based follow on liquid formula	320 ± 26.7	0.36 ± 0.04	0.069 ± 0.031

The concentration of sodium, copper and manganese in milk based and soya based infant formula in USA, UK and Nigeria, reported by Iken *et al* [12] are given in Table-2. As compared with the data reported for Na, Cu and Mn contents in infant milk in Nigeria and UK, the values obtained for the concentration of Na in infant milk is found to be higher, whereas the concentration of Cu and Mn are lower than that in UK and Nigeria.

WHO guidelines suggest a daily allowance of 2.5 mg copper for adults [4] and 500 to 1000 µg/kg body weight for infants [13]. The average daily requirement of manganese for normal physiological function is estimated to be 2-5 mg for adults [14] whereas infant consumes 2.5 – 25 µg / kg body weight per day during the first 06 months. [15]. Tripathy *et al* [16] have reported the concentration of Cu in cow and buffalo milk 57.4 and 43.2 µg/l, which is lower than the values obtained in this study.

Experimental

Sample Collection

In this study samples of three varieties of milk, (i) powder milk (infant formula-1, infant formula-2 and full cream milk powder), (ii) processed milk (Tetrapak-1 and Tetrapak-2) and (iii) fresh milk (cow milk and buffalo milk) were studied for the contamination of sodium, copper, manganese and chromium. For this purpose three samples of each variety of milk were procured from different areas and localities in Karachi city.

Digestion Procedure

50 ml of each sample of liquid milk and 2 g of each solid sample of milk powder were accurately measured and weighted respectively in the clean and dry beaker separately. Concentrated HNO_3 and $HClO_4$ were added in 1:1 ratio. Mixture was slowly digested on sand bath almost to dryness. Beakers were removed from sand bath and H_2O_2 was added and again placed the beaker on sand bath until solution became colorless. Digested samples were cooled, filtered and diluted to a standard volume labeled as stock solution and used at the time of analysis after appropriate dilutions. Blank samples were also prepared similarly under identical conditions.

Equipment, Chemical Reagents and Glass Ware

Before the analysis, the beakers, pipettes and volumetric flasks used in the analysis, were soaked for three days in 2% HNO_3 to ensure the surface clean and then washed with de-ionized water three times and dried in oven. All the chemicals and reagents used were of analytical AR grade and Deionised water was used for dilution and preparation of reagents and standards throughout the experiment. Three samples of each brand were analyzed for copper, manganese and chromium using Perkin Elmer 3001 Atomic Absorption Spectrophotometer using air acetylene flame mode with standard conditions given in Table-3. Sodium was analyzed by FES Corning 400.

Table-3: Working Parameter - Standard Condition for Perkin Elmer 3001 Atomic Absorption Spectrophotometer

S. No.	Metal	λ (nm)	SBW (nm)	Flame Gas	Lamp current mA	Minimum Detection limit (ppm)
1	Cu	324.8	0.4	A-Ac	10	0.01
2	Mn	279.6	0.4	A-Ac	7.5	0.01
3	Cr	35.93	1.3	A-Ac	7.5	0.02

A-Ac = Air Acetylene Flame

Table -4: Statistical data for the standard of elements

Element	Conc. Range ppm (x)	Absorption/ Emission range (y)	Statistical calculation Y=mx+c m	c	r^2
*Sodium	0.00-20	0.00 -100	-	-	-
Copper	0.00-1.00	0.000-0.0337	0.0327	-0.0001	0.9999
Manganese	0.00-0.50	0.000-0.0698	0.0694	0.0008	0.9999
Chromium	0.00-0.50	0.000-0.0432	0.1924	0.052	0.9997

m =slope, c = intercept, r = correction coefficient

* by Flame Emission Spectroscopy

Determination of Metals

A series of working standard solutions of each metal was prepared from stock standard solution (1000 ppm of Merck). Calibration curve drawn for all the elements by concentration verses absorbance was statistically analyzing using fitting of straight line by least square method.

The mean value concentration of Na, Cu, Mn, and Cr in each variety of milk was obtained by taking the mean of the values obtained in three sample of a given variety of milk. The data was also summarized for standard deviation.

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