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Full Length Research Paper

Determination of key elements by ICP-OES in commercially available infant formulae and baby foods in Saudi Arabia

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Health risk for infant and toddler is a serious threat in the presence of many key elements in baby foods and infant formulas. Manufactures are important part of the diet for babies. We have analyzed various essential Ca, Na, Mg, Fe, Cu and Zn and non essential elements Al, As, Cd, Hg, Pb, Sb and Sn in 56 samples, collected in different area of Riyadh, Saudi Arabia. Essential elements were analyses and observed the result according to the guidelines proposed by European Union legislation (ECC regulation). Non essential elements were comparable with the set limit by international pediatric guideline of infant formulas. Mercury (Hg) was not detected in any samples whereas Pb and Cd were detected in almost all samples with mean range of 5 ug cd /l and 5 ppm. Sb and Sn were analyzed in 59 and 23% samples in the range of 0.04 and 0.054 ppm. Rusks and biscuits type of food showed a little higher concentration of some elements. Daily intake of elements was calculated on the basis of information specified by the manufacturers of different branded formula and baby food on the containers.

Key words: Infant formula, baby food, toxic elements, Pb, Cd, Cu, Fe.

INTRODUCTION

Apart from the beast milk, infant formula has a special role to play in the diets of infant because they are the major source of nutrients (Bermejo et al., 2000; FDA, 1997). Some time breast feeding is not sufficient or after six months feed, then complimentary feeding become necessary (Monte and Glugillans, 2004). Many brands of infant formulae are designed to provide required nutrients as recommended diet intake (RDI) of minerals for infants and toddlers (WHO/UNCEF, 1998). Some elements may constitute potential health risk if consume above the RDI values. The composition of commercial infant formulae and baby foods can be very different from the foods that make up the diet of the general population and therefore information is needed on the levels of many metals and elements in these food groups. Recently rice based food is becoming important factor of daily intake in baby foods (Matusiewicz, 2003). Baby foods and formulae deserve high priority in plan aimed at sound child health, irrespective of cultural or religious considerations. Many elements can be present in foods naturally, or through human activities, such as processing, storage, farming activities and industrial emission (Fein and Falci, 1999; Clemens and Mercurio, 1981). Significant variations of some elements in different brands of infant formulae have been reported in USA, UK and in other countries (Ikem et al., 2002). Literature reveals that some toxic elements are also present (Ozturk and Yilmaz, 2000) which enters into food chain through processing (Hurrell et al., 1989). Some time added intentionally with additives on formula resulting excess of toxicity (American Academy of Pediatrics, 1996b; Fernandez-Lorenzo et al., 1999). It is well established that Pb, Cd, As, Al, Sn, Hg are

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toxic and babies are more sensitive to these metals than adults and more chance of these metals to enter in the human body (Bermejo et al., 2000; Schumann, 1990). While WHO/UNICEF (1998). Fe, Cu, Zn, Na, Ca, Mg are essential (Kashan et al., 2003), but can be toxic when taken in excess. Therefore, it has been classified like, low iron or iron-fortified and based on whether they contain less or more than 6.7 mg/L of formulae and infant baby foods (American Academic of pediatrics, 1999b,). Iron fortified formulas in the USA are up to 12.7 mg/L and within the range up to 0.2-0.5 mg/L in Europe (Rodrigues et al., 2000). To control baby food World Health Organization and Food Agriculture Organization issued some guidelines to produce infant formula commercially (FAO/WHO, 1999). Since there is inadequate information about some elements in infant foods and formulae, especially in cereal based food in Saudi Arabia. The study was carried to determine and compare the levels of both the essential and non-essential elements in the main types and brands of infant foods and formulae available on sale in the Saudi Arabian market and to allow an assessment of infants' exposures from these elements in these foods formulae. The daily intake of some elements was also estimated in the study.

SAMPLING

Different branded infant formulae and baby foods from different area of Riyadh region and pharmacies were purchased in 2009 in Riyadh, Saudi Arabia. A pool of samples was prepared by combining portion of each brand. An aliquot of this pooled sample was divided in to three portions and each was analyzed separately.

SAMPLE DIGESTION AND ICP-OES (ION COUPLED PLASMA-OPTICAL EMISSION SPECTROMETRY) ANALYSIS OF SAMPLES

The cleaning procedures for the sample containers, microwave vessel, glassware for standard and ICP sample for metal determination was performed as per the procedure recommended by American Public Health Association (1998) with slight modifications. In brief, all the containers were washed with metal free non-ionic detergent solution, rinsed with several times with any element free double distilled demonized water prior to use. Between 0.3 - 0.5 g sample of formula was placed into Teflon bomb and digested with 7 mL Nitric acid on the microwave work station. The condition of microwave was set as temperature 25 - 170℃ for 10 min and 170℃ for another 10 min at 1000 W, followed by immediate ventilation at room temperature for 20 min. The acid digested samples were diluted with 10 mL ultra pure water in 10 mL volumetric flask. All samples were analyzed in triplicates by ICP-OES (GBS- Integra; Australia) and hydride generator system was used for Hg and AS analysis. Instruments operating parameters for ICP-Integra was shown in Table 2.

METHOD VALIDATION

For the precision and accuracy of the method, a standard whole powdered milk purchased from National Institute of Standard and Technology (NIST) Gaithersburg, MD, USA. The milk standard, mixed reagent and individual elements' standard 100 mg/mL were procured from Sigma, Co. (USA) and were analyzed routinely for the purpose of accuracy. Recovery assays were satisfactory, ranging from 96 to 103.8%. Limit of detection and precision of all elements were calculated. Ultra pure water of noted resistance was used in all the process (Bronsted Co. UK). Nitric acid and HCL were of spectroscopic grade (Merck Germany), Standard Solution of Al, AS, Ca, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Pb, Sb, Sn and Zn were prepared by dilution of 1 mg/ mL. Fluka (Kamica, Switzerland) of each metal.

RESULTS AND DISCUSSION

Fifty six baby food samples, based on their ingredients were categorized into five types of foods as shown in Table 1. Infant formula - Type1, follow-On formula – Type 2, cereals based formula - Type 3, rusks and biscuits - Type 4 and fruits and vegetable extracts as Type 5. The mean concentration of each element from all five types of samples analyzed was shown in Table 3. All the results obtained were discussed and compared with data from previously reported by Ikem et al. (2002) and proposed guidelines issued by WHO/UNECEF (1998). The concentrations of essential elements such as Ca, Na, K, Mg, Fe, Cu, Zn and Cr, were analyzed, and concentrated on the highest levels in all five types of foods. Calcium was determined highest (710.77 ± 132.00) in type 2, followed by potassium (589.39 ± 103.75) Type-2, magnesium (66.52 ± 4.96) Type-3, sodium (333.0 ± 92.29) Type-3, Iron (13.01 ± 7.6) Type-3, zinc (3.57 ± 0.853) Type-1, manganese (0.97 ± 0.45) Type-3 and copper (0.508 ± 0.408) from Type-1, respectively. The levels of essential elements determined were little higher when compared with previous report by Ikem (2002) and guidelines proposed by European Community Legislation and International Pediatrics Organization based on the infant requirements. It has to be noted that, these elements are added during manufacture of formulae and baby foods to achieve the adequate levels of essential elements according to ECC-regulations, (ECC Regulation, 96 ECC (1996) as amended. Chromium is also an essential element if fortified within the allowed range 0.006 to 0.037 ppm in formulae. Chromium level detected in almost all the samples observed in the present study, which is an indication of manufactures' special designed in baby foods to complete the requirements. The balance amount of essential elements plays an important role in the metabolism of lipid, carbohydrate, protein and insulin (Kobla and Vople, 2000). Proper complimentary feeding of infants

Table 1. Infant formulas packaging and their characteristics.

Type	Sample characteristics	Package type
	Powder, milk based, fortified with iron, since birth	Tin
Type -1	Powder, Milk based, lactose free, since birth	Tin
	Powder milk, alphas protein rich, iron fortified	Tin
	Powder, Milk based, fortified with iron, after six months	Tin
Type-2	Powder, milk based, iron added with long chain fatty acid	Tin
	Powder Milk based with iron and follow on after 6 months	Tin
	Cereal with milk based, wheat, honey and Rice	Tin
Type-3	Rice based with vegetables fortified with iron	Tin
	Cereal with oat and wheat	Tin
	Biscuits after six months with minerals and vitamins	Paper box
Type-4	Solid food as rusk , digestible easily	Tin
	Biscuits crushed with vitamin and minerals	Paper Box
	Pulp of fruits and vegetables mixed	Glass bottle
Type-5	Pulp carrot and apple with vitamin	Glass bottle
	Fruit paste of carrot, apple and guava	Glass bottle

Table 2. Instruments operating conditions (ICP-Integra) applied for metals determination.

Parameters	Conditions
RF power (emission intensity)	1200 W
Nebulizer type	Concentric
View height	8 mm
Gas (as 600 kpa)	Argon
Auxiliary gas (250 kpa)	N2
Plasma gas flow	10 L/min
Auxillary gas flow	0.5 L/min
Nebulizer flow	0.5L/min
PMT volts	600 V
Sample flow	0.9 ml/min
Pump speed	15 rmp
Stabilization time	15 s
Flush time	15 s
Auto integration	10 s
Rinse time	5

is crucial for their proper development, low level of essential elements has adverse effects and decrease immunity. Cereal based food showed a higher concentration of Ca, Cu, Fe, Cr in comparison of infant milk formula but were found within the limit and not exceeding the required upper limit set by EC Regulation 446/2001. Our finding shows that all five types of baby foods (Table 3) were commercially prepared to full fill the infants' need of nutrients as required by WHO/UNICEF (1998).

On the other hand, the presence of non essential elements such as Al, As, Cd, Hg, Pb, Sb and Sn (Table 3) were calculated and compared to other researchers' and foods and formulae. The metal, lead was detected in most of the samples as shown in Table 3, with mean value of 0.018 ± 0.002 in infant formulae (Type-1) followed by 0.037 (Type-4), 0.023 (Type-3), 0.015 (Type-5) and 0.005 ppm in (Type-2). On the other hand, values

Table 3. Mean concentration of multi-elements in different brands of formulas and baby food (Mean ± S.D).

Elements	Formula brands-since birth (infant formula) (N = 19)	Formula brands-follow on-formula (N = 8)	Cereals based food (N = 5)	Rusts and elements biscuits (N = 9)	Fruits and vegetable paste (N = 15)
Al (ppm)	1.944 ± 1.09	1.60 ± 1.55	9.88 ± 7.77	5.83 ± 3.60	6.45 ± 3.89
AS (ppm)	0.089 ± 0.022	0.08 ± 0.015	0.17 ± 0.035	0.71 ± 0.042	0.137 ± 0.029
Ca (mg/100 g)	445.47 ± 179.72	710.77 ± 132.2	551.38 ± 70.71	491.122 ± 136.0	19.77 ± 14.41
Cd (ppm)	0.007 ± 0.005	0.002 ± .0001	0.018 ± 0.003	0.007 ± 0.002	0.002 ± 0.001
Cr (ppm)	0.037 ± 0.055	0.050 ± 002	0.08 ± 0.08	0.06 ± 0.05	0.07 ± 0.05
Cu (mg/100 g)	0.508 ± 0.408	0.386 ± 0.107	0.18 ± 0.06	0.271 ± 0.236	0.052 ± 0.07
Fe (mg/100 g)	6.58 ± 3.203	8.299 ± 2.94	13.01 ± 7.61	10.935 ± 3.35	1.46 ± 1.07
Hg (ppm)	nd	nd	nd	nd	nd
K (mg/100 g)	402.47 ± 80.96	589.39± 103.75	408.22 ± 02.64	116.02 ± 51.93	69.63 ± 28.78
Mg (mg/100 g)	53.53 ± 10.47	62.87 ± 23.847	66.52 ± 4.96	42.0 ± 33.83	12.76 ± 7.23
Mn (mg/100 g)	0.09 ± 0.011	0.125 ± 0.176	0.97 ± 0.45	0.648 ± 0.75	0.198 ± 0.343
Na (mg/100 g)	275.65 ± 75.86	318.40 ± 91.56	333.05 ± 92.29	179.61 ± 131.5	45.62 ± 64.24
Pb (ppm)	0.018 ± 0.002	0.005 ± 0.001	0.023 ± 0.003	0.037 ± 0.016	0.015 ± 0.025
Sb-ppm	0.0418 ± 0.008	0.024 ± 0.006	0.051 ± 0.015	0.031 ± 0.06	0.033 ± 0.026
Sn (ppm)	0.054 ± 0.037	0.328 ± 0.086	0.197 ± 0.046	0.227 ± 0.076	1.92 ± 1.205
Zn (mg/100 g)	3.57 ± 0.853	3.55 ± 1.33	2.46 ± 0.654	1.54 ± 1.59	0.51 ± 0.68

Nd = not detected; N= no. of sample analyzed.

obtained were within the limit for lead in infant formulae of 0.02 ppm in EC Regulation 446/2001 as amended, for other infant food limit range from 0.05 to 0.03 ppm. Hence, none of the infant formulas, foods exceeded the limit of lead in this study. However, the presence of lead in infant food is of great concern since infants are very sensitive to its toxic effects. Childhood exposure to lead may induce suppression of mental capacity or retardation the set limits of international pediatric guidelines for baby which causes a high negative association between lead exposure and children's intelligence quotient (Schwartz, 1994). Cadmium (Cd) was analyzed in all the samples except in 'follow-on formula (Type-2)' but none of the sample exceeded the 5 µg Cd/L as set limit according to EC Regulation by American public Health Association (1988) and Kiely (1997). However, cadmium was more observed in cereals based samples as compared to other baby foods. Cadmium is also a matter of concern due to its carcinogenic effect and can lead to kidney dysfunction (International Programmed on Food Safety, 1992). It is very clear entrance of lead and cadmium in cereal based food may lead through water or ingredients were used in preparation during processing.

Aluminum was detected in most of the samples with mean concentration 1.94 ± 1.09 in infant formulae type-1, followed by 1.60 ± 1.5 (Type-2), 9.88 ± 7.7 (Type-3), 5.83 ± 3.60 (Type-4) and 6.45 ± 3.89 (Type-5) respectively. These findings were consistent with the result reported in earlier by Sahin et al. (1995). Aluminium may cause strong effects including dysuria, discomfort, cataract and neurotoxicity (Klassen, 1990), if intake is more than recommended values. The highest concentration of Al (7.855 ppm) in cereal based baby food is a matter of concern (Table 3). This high amount could be due to bad practices during manufacturing or packaging. Antimony (Sb) was detected in 33 samples (59%) but generally at low concentration with mean value 0.042 ± 0.008 ppm in different infant foods. The highest value (0.051 ppm) was obtained in Type-3 food was consistent with other study (Rowels, 2003). Mercury (Hg) was not detected in any of the samples. Tin (Sn) only was detected in 13 samples (23%) only at a very low concentration with mean value of 0.054 ± 0.037 ppm in infant formulae followed by 0.328, 0.197, 0.227 and 1.92 ppm in baby food Types 2, 3, 4 and 5, respectively. The values were below the set limit of Tin in food regulation 1992, Food London and EC proposed 50 mg/Kg. Daily intake were also calculated in the study of toxic elements on the basis of information specified by the manufacturers of different branded containers. Each infants consume 840 mL formulae / per day (average body weight 6 - 8 Kg and 6 -12 month old infant. Thus, the daily consumable formulae would be 112 g powder of infant formulae according to manufactures. Assuming daily intake 100 - 112 g/day with average body weight of 7.0 kg (Tripathiet al., 1999), the daily intake of Aluminium were computed 217 µg followed by As (9.96), Sb (4.68) Sn (6.08) Cr (0.67) Pb (2.01) and Cd (0.78) µg/day, respectively. The estimated intake of Al was lower than daily tolerable intake as recommended tolerable intake of Al of 1000 ug/Kgbw/day (WHO, 1989).

Similarly the daily intake of lead and cadmium were estimated below the FAO/WHO joint committee (2001) on food additives recommendation of 25 µg/kg body weight and 70 µg/kg body weight, but little above the reported by Kazi et al. (2010). In the present study, It was observed that 'follow-on formula (Type-2)' identified as free of contamination whereas other types showed considerable variations, especially in cereals, rusks and biscuit categories (Types-3), which is a matter of serious concern and investigation. Metals such as Al, As, Ca, Cu Cr Sb and Pb were little higher when compared with the study reported earlier (Ikem et al., 2002). It needs a special attention and general awareness among public about selection of food intake among infants. This variation could be attributed to the different manufacturing practices, quality of raw materials and packaging containers used by infant food manufacturers' specially cereal based food products for babies. However, our findings were within the limits of guidelines purposed by EC, Regulation (2000) and FDA administration (1997).

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