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DETERMINATION OF ESSENTIAL ELEMENTS IN COMMERCIAL INFANT FOODS BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

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ABSTRACT

Eating habits are important determinants of health conditions during childhood. Commercial infant food is an important part of the diet for many babies. As such it is necessary that such food contain sufficient amounts of essential elements. Inadequate complementary feeding is a major cause of high rates of malnutrition throughout the world. Commercial infant food is classified into four different stages: Stages 1 and 2 are adequate for babies older than 6 months, but new flavors and food are introduced in stage 2; Stage 3 is offered to 8 month old babies; Junior Stage is recommended to children over 1 year old. In this study, essential elements: Ca, Cl, Co, Cr, Fe K, Mg, Mn, Na, Se and Zn were determined in commercial infant food samples by Instrumental Neutron Activation Analysis (INAA). Twenty-seven infant food samples were bought in stores around São Paulo city during 2011. These samples were freeze-dried and homogenized before analysis. The powdered samples were irradiated in the IEA-R1 nuclear research reactor of IPEN-CNEN/SP. For validation of the methodology, INCT MPH-2 Mixed Polish Herbs and NIST-SRM 1577b Bovine Liver reference materials were analyzed. Most of the concentration results were below the World Health Organization´s recommended daily intake for infants from 6 to 12 months old. These low essential element concentration results in commercial infant foods obtained in our study indicate that infants should not only be fed with commercial baby foods.

1. INTRODUCTION

Breast milk is recognized as the most complete and most suitable food for the health growth and development for babies and infants. The World Health Organization (WHO) recommends exclusive breastfeeding up to six months of age. After this age, WHO recommends the introduction of complementary foods and maintenance of breastfeeding up to two years old [1-2].

After six months, complementary foods become essential in the baby´s development as these foods are responsible for additional provision of energy, proteins, vitamins, and minerals. Breastfeeding should be continued even after the introduction of complementary foods, since it provides protein with high biological value as well as energy needs of infants [3].

Before six month, infants that are not feeding with breast milk can suffer damage to their health with risk of diarrhea, respiratory infections and malnutrition. On the other hand, if the introduction of complementary food in the infant diet is delayed, it can lead to growth retardation and nutritional deficiencies with serious damage to health of children [4].

Complementary foods play a critical role in providing adequate quantities of many minerals. Inadequate complementary feeding is a major cause for high prevalence of malnutrition in developing countries. Some elements may be a potential health risk when consumed above the tolerable levels of intake for an extended period [5].

The first two years are considered critical for the infant because in this period growth faltering and malnutrition can occur which can in turn affect the great cognitive development which also occurs in this period. Good nutrition and cognitive stimulation have both synergic effect on infant growth and development [6].

Complementary feeding must be adequate so that the complementary foods provide quantity, frequency and consistency adequate in accordance with the needs of the growing infant. A variety of foods must be consumed to meet the infant nutritional needs, but breastfeeding has to be maintained [7]. The infant diet is adequate when foods provide energy, proteins, and micronutrients enough to supply the infant nutritional needs. They also have to be safe, free of any contamination, not salty or spicy, and easily edible [8].

The importance of an adequate diet in this period is essential in the prevention of infant morbidity, including malnutrition and overweight. The linear growth deficit acquired in childhood can usually hardly never be reversed after two years. Thus, to achieve optimal feeding for most infants must be an important point of the global strategy to ensure food safety of a population [4].

Inadequate complementary foods is a major cause of the very high prevalence of malnutrition in the developing world, and emerging data suggest that this may have long-term implications for growth, development, and health [9].

Malnutrition is associated with delays in motor and mental development, as well as increased morbidity and mortality. For example, a number of micronutrients required for optimal growth are also essential to specific and non-specific immune functions [10].

Normally the complementary food is introduced between 6 to18 months and constitutes an increasing part of the infant dietary intake. In the last years, there has occurred an increasing consumption of industrialized food, especially in infant diets.

There are no published data on essential element content in commercial infant foods marketed in São Paulo city. The objective of this study was to determine essential elements Ca, Cl, Co, Cr, Fe, K, Mg, Mn, Na, Se and Zn content in commercial infant foods by Instrumental Neutron Activation Analysis.

Instrumental neutron activation analysis (INAA) was employed for the precise and accurate element determination, since it is a powerful technique for the direct analysis of solid food samples without dissolution, thus eliminating the possibility of contamination. The technique also provides low detection limits for many inorganic constituents. Moreover, the quality control and quality assurance of the technique is also maintained through the use of certified reference material (CRM) [11].

2. EXPERIMENTAL

2.1 Description of the commercial infant foods

Commercial infant foods are divided into four different stages, according to the age of children, composition, flavors and textures. The first stage that could be offered as soup to babies after six months allows that babies to discover the food. Thus these foods are composed only by one type of fruit. Stages 1 and 2 are adequate for babies older than 6 months, but new flavors and foods are introduced in stage 2. The third stage is offered to 8 month old babies and these foods will be responsible to stimulate the babies to chew. So, in the third stage some food comes in pieces and not only in the form of porridge. Finally, the last stage, called junior, is designed to provide nutrition for growth and development of children as well as their adaptation to normal diets. Therefore, foods will have flavors similar to those offered during family meals. Table 1 shows the types of commercial infant foods found in the market of São Paulo city.

Table 1. Types of the commercial infant foods

Commercial baby foods	Flavor	Age
Stage 1	One fruit	Older than 6 months
Stage 2	Two fruit, fruit and milk, salt soup	Older than 6 months
Stage 3	Salt soup	Older than 8 months
Junior Stage	Salt soup	Older than 12 months

2.2 Sample Preparation

In this study, twenty-seven commercial infant foods of the 1, 2, 3 and Junior stages were analyzed.

All samples were collected in the form of porridge. The infant food samples were coded and removed from their containers to polyethylene vials, previously cleaned with deionized H_2O and 10% HNO_3 solution. The samples were then stored in a refrigerator at -4 ºC to maintain the product in adequate conditions.

The samples were freeze-dried during 15 hours in a freeze-dryer Modelyo D (Thermo-Electron Corporation) at -51°C and 49µbar. After the lyophilization process, the samples were ground and homogenized in a domestic blender, which was adapted with titanium blades. The percentages of water weight loss during this process varied from 78.6 to 87.7%. Table 2 describes the commercial infant food samples analyzed with their codes used in this study.

Table 2. Compositions of the commercial infant food samples

Sample (codes) and Stages	Composition
1-a (Stage 1)	Plum
2-a (Stage 1)	Cashew
3-a (Stage 1)	Apple
4-a (Stage 1)	Passion fruit
5-a (Stage 1)	Grapes
1-b (Stage 2)	Banana with milk
2-b (Stage 2)	Guava with milk
3-b (Stage 2)	Assorted Fruits
4-b (Stage 2)	Tropical fruits
5-b (Stage 2)	Apple and banana
6-b (Stage 2)	Mango with pear
7-b (Stage 2)	Peach with milk
1-b (Stage 2)	Meat with vegetables
2-b (Stage 2)	Bean soup with vegetables and beets
3-b (Stage 2)	Chicken with vegetables and noodles
4-b (Stage 2)	Egg yolk with meat and vegetables
5-b (Stage 2)	Vegetables with chicken breasts
6-b (Stage 2)	Meat with vegetables and parsnip
7-b (Stage 2)	Turkey breasts with vegetables and rice
1-c (Stage 3)	Bean soup, meat and rice
2-c (Stage 3)	Vegetables and meat
3-c (Stage 3)	Chicken breasts with vegetables
4-c (Stage 3)	Noodles, meat and vegetables
1-d (Stage Junior)	Spaghetti Bolognese
2-d (Stage Junior)	Chicken Risotto
3-d (Stage Junior)	Mince
4-d (Stage Junior)	Stroganoff with rice

2.2 Preparation of Standards

Standards of Ca, Cl, Co, Cr, Fe, K, Mg, Mn, Na, Se and Zn were prepared from appropriate dilutions of their Spex Certiprep stocks solutions. Aliquots (25 – 100 μL) taken from such solutions were pipetted on small sheets of Whatman 40 filter paper and dried under infrared lamp. Standards of Cl were dried overnight on desiccators. After drying, these filter papers were placed into clean polyethylene bags.

2.3 Neutron Irradiations

About 0.1 g of freeze-dried commercial infant food sample weighed in polyethylene bags were irradiated together with element standards for 20 seconds under a thermal neutron flux of 6.6 x 10^{12} cm^{-2} s^{-1} at the IEA-R1 nuclear research reactor of IPEN-CNEN/SP. In these conditions the elements Cl, K, Mg, Mn and Na were determined.

About 0.2 g of freeze-dried commercial infant food sample weighed in polyethylene bags were irradiated together with element standards for 8 hours under a thermal neutron flux of 4.5×10^{12} cm^{-2} s^{-1} at the IEA-R1 nuclear research reactor of IPEN-CNEN/SP. In these conditions the elements Ca, Co, Cr, Fe, Se and Zn were determined.

Gamma-ray activities of the irradiated samples and element standards were measured with a POP TOP model H Ge detector from EG&G ORTEC with 20% efficiency and 1.9 keV resolution at 1332.49 keV peak of ^{60}Co. The detector was coupled to an electronic system composed of multi-channel analyzer, source of high tension, amplifier and a compatible microcomputer. The gamma-ray spectrum was analyzed using the VISPECT2 software. Table 3 and Table 4 present the nuclear data of the radioisotopes used in this study.

Table 3. Nuclear data for the radioisotopes determined by INAA [12]

Radionuclides	Half-life	Gamma-ray keV	Counting time
^{38}Cl	37.29 min	1642	300 s
^{42}K	751 min	1525	1800 s
^{27}Mg	9.45 min	843	300 s
^{56}Mn	154.80 min	846	1800 s
^{24}Na	900 min	1368	1800 s

Table 4. Nuclear data for the radioisotopes determined by INAA [12]

Radionuclides	Half-life	Gamma-ray keV	Decay time	Counting time
^{47}Ca	4.54 d	1297.09	5 d	7200 s
^{60}Co	5.27 y	1173.2	10 – 15 d	50000 s
^{51}Cr	27.7 d	320.08	10 – 15 d	50000 s
^{59}Fe	44.5 d	1099.25	10 – 15 d	50000 s
^{75}Se	119.77 d	264.66	10 – 15 d	50000 s
^{65}Zn	243.9	1115.55	10 – 15 d	50000 s

3- RESULTS AND DISCUSSION

Instrumental Neutron Activation Analysis (INAA) was applied to determine eleven essential elements (Ca, Cl, Co, Cr, Fe, K, Mg, Mn, Na, Se and Zn) in twenty-seven commercial infant food samples. To assess the accuracy and precision methodology two certified reference materials (CRMs) INCT MPH-2Mixed Polish Herbs and NIST-SRM 1577b Bovine Liver were also analyzed. Table 5 presents the experimental results obtained with the certified values. The results agreed with the certified values, resulting in relatively good precision and accuracy.

Table 5. Concentration of elements in certified reference material

Element	Mixed Polish Herbs (INCT-MPH-2)				Bovine Liver (NIST 1577b)			
	This study (Mean±SD)[a]	RSD[c] (%)	ER[d] (%)	Certified values	This study (Mean±SD)[b]	RSD (%)[c]	ER[d] (%)	Certified values
Ca µg/g	10842 ± 241	2.2	0.39	10800 ± 700	<LD	-	-	116 ± 4
Cl µg/g	2790 ± 136	4.9	1.8	2840 ± 200	2797 ± 234	8.3	0.61	2780 ± 60
Co ng/g	225 ± 16	7.1	7.1	210 ± 25	249.1 ±7.0	2.8	0.36	(250)[b]
Cr µg/g	1.692 ± 0.068	4.0	0.12	1.69 ± 0.13	-	-	-	-
Fe µg/g	487 ± 36	7.4	5.9	(460)[b]	185.2 ± 8.2	4.4	0.54	184 ± 15
K µg/g	19176 ± 1083	5.6	0.40	19100 ± 1200	9486 ± 764	8.1	4.8	9940 ± 20
Mg µg/g	2944 ± 68	2.3	0.82	2920 ± 180	575 ± 52	8.9	4.5	601 ± 28
Mn ng/g	188.1 ± 9.7	5.2	1.5	191 ± 12	10.28 ± 0.89	8.7	2.2	10.5 ± 1.7
Na µg/g	346.7 ± 7.0	2.0	0.94	(350)[b]	2217 ± 136	6.1	9.2	2420 ± 60
Se ng/g	-	-	-	-	728 ± 25	3.4	027	730 ± 60
Zn µg/g	33.3 ± 1.6	4.8	0.60	33.5 ± 2.1	128.4 ± 8.2	6.4	0.79	127 ± 16

[a]Mean and Standard Deviation of eight determinations ;[b]Values in parenthesis indicate informative values; [c]RSD%: Relative standard deviation;[d]ER%: Error relative; <LD: Limit of detection

A direct comparison of the results of the present study with the literature data is not straightforward due to the different infant product characterization adopted in other studies.

Despite of this fact, the results obtained are discussed and compared with data previously reported by Khalifa and Ahmad [13], Zand *et al* [14] and proposed guidelines issued by Anvisa [15] and FAO/WHO [16]. The concentrations of Cl, K and Mn elements obtained in the commercial infant foods analyzed are lower than those reported by Khalifa *et al*. [13] and by FAO/WHO guidelines [16].

The concentrations of Fe, Ca and Mg are lower and the Na concentrations are higher than those reported by Zand *et. al.* [14] . The concentration of K is similar to that reported by Zand *et al* [14].

Proper complementary infant feeding is crucial for their proper development, so low level of essential elements can have adverse effects on infant development and can also decrease immunity [13,16].

Table 8. Levels of essential elements concentration *in natura* commercial infant food samples

Sample	Ca (µg/g)[a]	Cl (µg/g)[a]	Co (ng/g)[a]	Cr (ng/g)[a]	Fe (µg/g)[a]	K (µg/g)[a]	Mg (ng/g)[a]	Mn (ng/g)[a]	Na (µg/g)[a]	Se (ng/g)[a]	Zn (µg/g)[a]
1-a	129±11	41.7± 4.0	6.22±0.60	49.8±4.2	2.74±0.26	1563±125	61.0±6.0	0.890±0.079	52.1±4.4	5.32±0.55	0.877±0.083
2-a	48.5±3.2	58.9±5.4	4.27±0.41	51.6±4.5	1.72±0.15	780±62	61.8±5.6	0.923±0.062	32.7±2.5	3.44±0.35	1.032±0.088
3-a	77.4±3.1	22.17±0.87	3.86±0.28	38.7±2.7	1.12±0.11	825±45	27.8±1.9	0.422±0.036	32.6±2.7	< LD	0.441±0.015
4-a	60.5±5.6	143±13	4.57±0.38	22.1±1.7	1.40±0.07	1247±87	88.4±8.7	1.71±0.11	30.9±2.3	< LD	1.748±0.031
5-a	62.9±5.8	22.9±1.8	2.84±0.24	105.2±5.8	2.51±0.24	981±72	37.9±2.8	0.834±0.040	29.2±1.7	2.93±0.28	0.587±0.044
1-b	1209±107	766±74	5.59±0.50	51.91±0.86	4.88±0.46	2131±135	154±13	2.42±0.18	212±18	5.32±0.47	3.35±0.19
2-b	1314±129	611±49	7.66±0.71	147±11	5.04±0.49	1830±111	105.4±9.0	1.25±0.11	255±22	7.16± 0.45	3.51±0.34
3-b	52.6±5.2	61.1±5.5	5.09±0.50	64.1±1.6	2.68±0.11	945±87	42.8±4.1	0.436±0.039	33.0±3.0	12.2±1.0	0.512±0.034
4-b	73.4±7.0	194±14	4.70±0.34	56.8±5.6	1.74±0.15	1358±107	113.5±9.9	5.34±0.47	19.1±1.6	12.1±1.1	0.806±0.061
5-b	82.3±3.6	132.2±9.6	3.95±0.33	77.1±6.8	2.02±0.19	1083±34	74.0±6.7	0.951±0.080	45.2±3.8	10.1± 1.0	0.790±0.026
6-b	97.1±9.4	23.1±1.9	5.31±0.48	37.7±3.7	1.51±0.14	1218±113	63.5±4.3	1.049±0.094	13.4±1.2	< LD	0.739±0.048
7-b	1582±155	476±21	6.19±0.60	25.9±2.3	3.87±0.35	1546±86	76.7±7.4	0.854±0.071	214±19	< LD	3.34±0.30
1-c	103.6±9.5	1005±65	9.37±0.61	31.7±2.7	5.27±0.40	2179±127	124±11	0.691±0.055	530±49	11.83±0.96	10.59±0.51
2-c	86.9±8.3	1212.2±8.7	16.6±1.4	55.2±1.6	4.85±0.47	2168±138	145±14	0.98±0.10	629±51	18.0±2.3	9.31±0.88
3-c	99.1±1.0	1202±21	12.2±1.1	22.65±0.93	4.25±0.34	2338±223	117±11	0.810±0.077	584±53	17.01±0.13	2.70±0.15
4-c	83.4±4.5	1281±49	4.26±0.34	41.3±3.6	4.03±0.37	2227±62	111.2±6.9	0.712±0.064	576±50	17.4±1.7	2.75±0.20
5-c	229±21	1182±112	9.73±0.91	35.7±1.3	4.01±0.35	2013±169	149±13	2.32±0.19	554±51	20.7±1.0	6.41±0.35
6-c	111.6±6.9	1094±90	7.46±0.47	61.37±0.54	3.97±0.38	1934±65	95.7±8.6	0.590±0.056	576±53	25.6±1.7	7.76±0.72
7-c	129±12	1013±96	10.21±0.59	25.84±0.26	2.09±0.18	1762±96	108±10	0.708±0.068	588±53	8.00±0.51	2.88±0.14
1-d	172±13	1727±134	15.5±1.3	110.2±9.2	6.74±0.63	2181±211	159.9±9.8	1.33±0.13	861±79	18.51±0.98	2.17±0.17
2-d	90.5±4.6	1523±89	4.99±0.48	155.3±6.7	5.37±0.49	2784±250	125.4±9.0	1.096±0.093	959±53	11.23±0.88	7.65±0.43
3-d	110.1±8.6	1806±147	4.42±0.41	83.5±7.1	3.25±0.29	2171±202	123±12	0.62±0.50	945±47	19.8±1.0	2.87±0.21
4-d	97.7±7.6	1814±134	7.33±0.72	66.7±4.7	6.03±0.50	1884±167	95.9±8.8	0.823±0.072	845±50	8.36±0.44	9.01±0.47
1-e	92.2±8.4	2962±246	9.07±0.82	84.1±7.7	26.7±1.9	2753±235	73.8±2.3	0.939±0.083	1019±77	4.68±0.40	9.04±0.54
2-e	98.7±9.5	3525± 125	10.2±1.0	190.5±9.8	27.2±2.3	3543± 190	182±10	0.901±0.078	1335±124	9.76±0.89	9.71±0.80
3-e	435±40	4121± 368	8.26±0.77	105.1±9.0	22.2±2.2	2653± 245	124.5±3.0	0.850±0.063	1630±131	17.7±1.7	3.38±0.29
4-e	678±67	3663± 326	9.12±0.86	117.7±4.6	29.0±2.4	3646± 194	109.4±8.3	0.847±0.063	1373±110	22.9±1.1	8.83±0.77

[a]Mean and Standard Deviation of 3 determinations <LD: Limit of detection

Table 9. Mass of the essential elements by commercial baby food pots (Average ± standard deviation)

Sample	Mass of food in each pot	Ca mg	Cl mg	Co µg	Cr µg	Fe µg	K mg	Mg mg	Mn µg	Na mg	Se µg	Zn µg
1a	120g	15.4±1.2	5.00±0.48	0.747±0.072	6.00±0.50	329±31	188±15	7.32±0.72	106.8±9.5	6.26±0.52	0.638±0.063	105±10
2a	120g	5.82±0.38	7.07±0.65	0.513±0.048	6.20±0.54	206±18	93.6±7.4	7.41±0.67	110.7±7.4	3.91±0.30	0.413±0.041	124±11
3a	120g	9.28±0.37	2.66±0.10	0.463±0.034	4.64±0.32	134±13	99.0±5.5	3.34±0.23	50.7±4.3	3.91±0.32	-	53.0±1.8
4a	120g	7.26±0.67	17.2±1.6	0.548±0.046	2.65±0.20	167.7±8.4	150±10	10.6±1.0	205±14	3.71±0.28	-	209.8±3.7
5a	120g	7.55±0.70	2.74±0.22	0.341±0.029	12.62±0.69	301±29	117.7±8.7	4.55±0.34	100.0±4.8	3.51±0.20	-	70.5±5.2
1b	120g	145±13	92.0±8.9	0.671±0.061	6.23±0.10	586±55	256±16	18.4±1.6	290±22	25.4±2.2	0.638±0.056	402±22
2b	120g	158±15	73.3±5.9	0.919±0.085	17.6±1.3	605±59	220±13	12.7±1.1	149±13	30.6±2.7	0.86±0.054	421±40
3b	120g	6.31±0.62	7.33±0.65	0.611±0.059	7.70±0.19	321±13	113±10	5.14±0.49	52.3±4.7	3.97±0.36	1.46±0.12	61.4±4.1
4b	120g	8.81±0.83	23.2±1.6	0.564±0.041	6.81±0.67	208±18	163±13	13.6±1.2	640±57	2.29±0.19	1.45±0.13	96.8±7.3
5b	120g	9.44±0.94	15.9±1.2	0.473±0.039	9.30±0.83	243±22	129.9±4.0	8.88±0.80	114.1±9.6	5.42±0.46	1.25±0.084	94.8±3.1
6b	120g	11.7±1.1	2.78±0.23	0.638±0.057	4.53±0.44	180±17	146±14	7.61±0.51	126±11	1.61±0.14	-	88.7±5.8
7b	120g	190±19	57.1±2.5	0.749 ±0.067	3.11±0.27	464±42	186±10	9.20±0.89	102.4±8.6	25.7±2.3	-	401±37
1c	115g	11.9±1.1	115.5±7.5	1.079±0.071	3.64±0.31	607±45	251±15	14.3±1.3	79.5±6.3	60.9±5.6	1.36±0.11	1,217±59
2c	115g	9.99±0.84	139.4±1.0	1.91±0.16	6.35±0.18	557±54	249±16	16.6±1.6	113±11	72.3±5.9	2.07±0.20	1,070±102
3c	115g	11.40±0.12	138.2±2.4	1.39±0.12	2.60±0.11	489±39	269±26	13.5±1.3	93.1±8.8	67.1±6.1	1.957±0.015	310±17
4c	115g	9.59±0.52	147.3±5.6	0.489±0.039	4.75±0.42	464±43	256.1±7.1	12.79±0.79	81.9±7.4	66.2±5.8	2.00±0.19	316±22
5c	115g	26.3±2.4	136±13	1.12±0.11	4.11±0.15	461±40	231±19	17.1±1.4	266±21	63.7±5.9	2.38±0.12	737±40
6c	115g	12.83±0.79	126±10	0.858±0.054	7.057±0.062	456±44	222.4±7.4	11.00±0.99	67.8±6.4	66.3±6.1	2.93±0.20	892±83
7c	115g	14.8±1.4	116±11	1.175±0.068	2.972±0.029	240±20	203±11	12.4±1.2	81.4±7.8	67.6±6.1	0.921±0.059	331±16
1d	170g	29.2±2.2	294±23	2.64±0.22	18.7±1.5	1,145±108	371±36	27.2±1.7	226±21	146±13	3.15± 0.17	369±30
2d	170g	15.39±0.78	259±15	0.849±0.082	26.4±1.1	914±83	473±42	21.3±1.5	186±16	162.9±8.9	1.91±0.15	1,300±72
3d	170g	18.7±1.5	307±25	0.752±0.071	14.2±1.2	553±49	369±34	20.8±2.0	104.7±8.5	160.7±8.0	3.36±0.17	488±36
4d	170g	16.6±1.3	308±23	1.25±0.12	11.33±0.79	1,024±85	320±28	16.3±1.5	140±12	143.6±8.5	1.421±0.075	1,532±80
1e	250g	23.0±2.1	741±62	2.27±0.21	21.0±1.9	6,677±473	688±59	18.45±0.57	235±21	255±19	1.17±0.10	2,259±136
2e	250g	24.7±2.4	881±31	2.58±0.22	47.6±2.5	6,797±577	886±48	45.4±2.6	225±20	333±31	2.44±0.22	2,429±199
3e	250g	109±10	1,030±92	2.07±0.19	26.3±2.3	5,556±552	663±61	31.12±0.75	213±16	408±33	4.42±0.44	844±72
4e	250g	170±17	916±81	2.28±0.21	29.4±1.1	7,247±599	912±49	27.3±2.1	212±16	343±27	5.71±0.28	2,208±193
RDA/AI	**-**	**270 mg/day[a]**	**570 mg/day[a]**		**5.5 µg/day[a]**	**11,000 µg/day[b]**	**700 mg/day[a]**	**75 mg/day[a]**	**600 µg/day[a]**	**370 µg/day[a]**	**20 µg/day[a]**	**3,000 µg /day[b]**

a): Stage 1 (b) Stage 2 sweet taste (c) Stage 2 salty taste (d) Stage 3 (e) Stage Junior [a] RDA [b] AI

As of the sixth month, many nutrients that a child needs should be provided by complementary feeding. Thus, it is important that foods offered to infants are nutritionally rich. Table 8 shows that the concentrations of the elements determined by INAA *in natura*. Table 9 shows the mass of the nutrients present in each individual pot. The results showed that only Fe, K and Zn present values near the adequate ingestion values for the Junior stage. For the other elements of the study the values were far below the recommended daily intake provided by the Institute of Medicine (IOM) [17].

The lack of some nutrients can result in lifelong consequences for the child. Exact amounts of magnesium, sodium, potassium and magnesium are needed to regulate various cellular pumps and membrane ion channels. These elements control the passage in and out of cells of the materials that regulate the transmission of nerve impulses and muscle contractions. Magnesium deficiency is rare. This element is required for normal parathyroid function. Low magnesium levels may alter calcium and phosphorus homeostasis. As with magnesium, sodium deficiency is rare too [18].

As can be observed from the results obtained, commercial infant foods do not meet the daily intake requirements of the most essential elements determined. Therefore these results should be taken into account for the safe and healthy nutritional development of the baby. In view of the above, it is important that a child continues to be breastfed or be fed with infant formula a long with complementary baby foods.

4. CONCLUSIONS

The results of this study showed that the most essential element levels in different commercial infant food samples marketed in São Paulo city were lower that the WHO recommendations. Since the nutritional quality of these foods are low they can be considered poor, and thus commercial infant foods should not replace breast feeding, but complement it. These foods are not able to meet the child´s daily nutritional needs. These preliminary data encourage further study to determine other essential elements in a variety of commercial baby foods available in the markets of Brazil.

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REFERENCES

1. World Health Organization: *"***Complementary feeding***"*, http://www.who.int/nutrition/topics/complementary_feeding/en/index.html (2012).
2. M. C. A Santos, *Alimentação no Primeiro Ano de Vida: hábitos de aleitamento e de diversificação alimentar*, Licenciatura em Ciências da Nutrição, Universidade Atlântica, Barcarena, Portugal (2010).
3. J. E. Arimatea, L. M. C. Castro, S. Rotenberg,"Feeding Practices of Children Under one Year Old: guidelines for health professionals and the Health Ministry Recommendation. Ceres", *Nutrição e Saúde*, **v. 4**, n. 02, pp. 65-78 (2009).
4. R. C. P. Pelegrin, "*O Cuidado com a Alimentação de Crianças Menores de Um Ano na Perspectiva Materna"***.** Dissertação de Mestrado, Universidade de São Paulo, Ribeirão Preto (2008).

5. R. Melo, K. Gellein, , L .Evje, T. Syversen, "Mineral and trace elements in commercial infant Food". *Food and Chemical Toxicology*, **v.46**, pp.3339-3342 (2008).
6. M. Arabi, E. A. Frongillo, R. Avula., N. Mangasaryan,. "Infant and Young Child Feeding in Developing Countries", *Child Development*, **v. 83**, n. 01, pp. 32-45 (2012).
7. WHO- World Health Organization. Global strategy for infant and young child feeding: the optimal duration of exclusive breast-feeding. Fifty-fourth World Health Assembly., Genova (2001).
8. E. R. J. Giugliani, C. G. Victora, "Complementary Feeding", *Jornal da Pediatria*, **v.76**, Supl. 03, pp. 253-262 (2000).
9. K.F. Michaelsen, H. Friis, 'Complemenary Feeding: A Global Perspective'**.** *Nutrition***,** **v.14**, n. 10, pp. 763-766 (1998).
10. J.E. Kimmons, K.G. Dewey, E. Haque, J. Chakraborty, S.J.M. Osendarp, K.H. Brown, "Low Nutrient Intakes among Infants in Rural Bangladesh Are Attributable to Low Intake and Micronutrient Density of Complementary Foods" *Journal of Nutrition*, **v.135**, pp.444-451(2005).
11. M. A. Gouveia, M. I. Prudencio, "New data on sixteen reference materials obtained by INAA". *Journal of Radioanalytical Nuclear Chemistry.*, **v. 245**, pp.105-108 (2000).
12. IAEA International Atomic Energy Agency. "Pratical aspects of operating a neutron activation analysis laboratory", IAEA- TECDOC-564 (1990).
13. A. S. Khalifa, D. Ahmad, "Determination of key elements ICP-OES in commercially available infant formulae and baby foods in Saudi Arabia", *African Journal of Food Science*, **v. 4,** n. 07, pp. 464-468 (2010).
14. N. Zand, B. Z. Chowdhry, F. B. Zotor, D. S. Wray, P. Amuna, , F. S. Pullen, "Essential and trace elements content of commercial infant foods in the UK", *Food Chemistry*, **v. 128**, pp. 123-128 (2011).
15. ANVISA:"Regulamento Técnico sobre Ingestão Diária Recomendada (IDR) para Proteína, Vitaminas e Minerais**"**, http://www4.anvisa.gov.br/base/visadoc/CP/CP%5B8989-1-0%5D.pdf (2004).
16. FAO/WHO "Vitamin and mineral requirements in human nutrition"**,** Geneva, http://apps.who.int/iris/bitstream/10665/42716/1/9241546123.pdf (2002)
17. Institute of Medicine (IOM), "*Food and Nutrition Board. Dietary References Intakes",* National Academic Press, Washington D.C. (2001*).*
18. R. Silverman, J. Brauer, "*Minerals: The Complete Guide to Nutrition in Primary Care***"**, Cap. 12, p. 249-274, Ed. Blackwell (2008).