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Taha et al.: Monitoring Heavy and Trace Metals in Selected Children's Food
**MONITORING HEAVY AND TRACE METALS
EXISTING IN SELECTED CHILDREN'S FOOD**

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ABSTRACT

High or low levels of essential and trace elements in foods typically eaten by children (potato chips, "karate" [a crispy puffed corn paste], biscuits and cakes) may cause significant health problems. In this study, the amounts of 13 elements (Ca, Cd, Co, Cu, Cr, Fe, K, Mg, Mn, Na, Ni, Pb and Zn) were estimated in samples collected from supermarkets in Aswan City, Upper Egypt. Food samples included, 28 kinds of potato chips, 44 kind of karate, 15 kind of biscuits and 13 kind of cakes. One hundred samples were analyzed. The results showed that potato chips have the highest level of Cu, K, Mg, Na, and Pb, but they have low level of Ca. On the other hand, karates have the highest Na concentrations. Also, biscuits and cakes have high Pb levels. It is strongly recommended that the food industry in Egypt pay more attention in supplying and in technological management of snack food products to avoid the exposure of children to dangerously high or low levels of elements.

Chemical estimation of heavy and trace element levels in human diets and their components provide the best indication of intake levels in relation to minimum needs and toxic potential. Food is a common source of trace metals, which accumulate to toxic levels in different tissue of the human body and cause damage to many systems (renal, cardiovascular, gastrointestinal, endocrine, nervous, etc.) (Reilly, 1991). In recent years, determination of trace elements in clinical and biological materials and foods has been of considerable interest because of the well-documented toxic effects of some of these elements on intrinsic mechanisms regulating vital biological processes (Shang and Hong, 1997). For other elements, trace amounts of various elements are necessary for proper nutrition of the human body.

Presence of elements in food can be naturally occurring, or may result from numerous industrial operations, where various chemicals are used at different stages in production and processing of food. In both the preservation and processing of foods, many substances are used to prevent spoilage, promote binding properties, enhance flavor and nutritive value, and act as antioxidants or coloring agents, etc. (Gracey, 1986). Metals may also contaminate a food source by a leaching process between the food and its container (Hagstad and Hubber, 1986). The risk of deficiencies or toxicities of trace elements and attendant pathologies are dependent on a number of factors including the daily dietary intake, amount of minerals in food consumed, technological treatment of the products, presence of substances that limit or increase the bioavailability of minerals, and the physiological state and overall health of the consumer (Barbra et al, 1992). Because of great sensitivity of the developing tissue and organs of young children toward

METHODS

FOOD SAMPLES COLLECTED

Samples of 28 kinds of potato chips, 44 kinds of karate, 15 kinds of biscuits and 13 kinds of cakes were purchased from supermarkets in Aswan City, Upper Egypt.

Samples Digestion

Using the methods of Tinggi, et al. (1997), triplicates of five grams of dried samples were accurately weighed and transferred to 150-ml conical flasks. A mixture of strong acids, HNO₃ –H₂SO₄ (12:2 ml) was added. The samples were then left at room temperature overnight to avoid the vigorous fuming of NO₂ during heating. Glass funnels were inserted into the flasks for refluxing. The presence of H₂SO₄ was added to prevent the solution from drying out with increasing temperature. The digestion was continued until the appearance of white fumes of SO₃. The entire procedure was repeated for a blank containing the same amount of acid mixture without samples. Digested solutions were then heated to near dryness, dilute HCl was added and the solutions were heated again, cooled and transferred to a measuring flask, and deionized water was added to make the solution amount equal to 25 ml.

Materials

All chemicals used were of A.R grade (99.99 percent) and purchased from BDH, Aldrich Sigma and/or Merck. Certified atomic absorption spectroscopic standard solution (1mg/ml) for calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), lead (Pb) and zinc (Zn) were purchased from BDH, UK. Working solutions were prepared by appropriate dilution of the stock solutions. Tomato leaves (TOL) and Orchard leaves (OL) biological standard, were also used to assure certified results.

Apparatus

A recording flame atomic absorption spectrophotometer, Solar, model 969, digital, direct readout of the concentration was used for estimating Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb and Zn levels in the monitored samples.

Statistical Analysis

Descriptive statistics were calculated on the levels of trace minerals, including mean, median, triplicate-mean, standard error of the mean, standard deviation, minimum value and maximum value. These values were compared with the Recommended Daily Allowance (RDA) or Estimated Safe and Adequate Daily Dietary Intakes (ESADDIs).

RESULTS AND DISCUSSION

The mean elements concentration (triplicates) obtained from analysis of samples under study are recorded in Table 1. The descriptive statistical analysis is presented in Table 2.

Calcium (Ca):

Calcium, the major cation of bone, is needed in an increased amount during periods of growth or during new bone formation. The RDA (Recommended Daily Allowance) for children from one-10 years of age is 800 mg (Alper, et al., 1995). Biscuits and cakes have relatively higher Ca content (Table 3) than the other foods sampled which is probably due to the high Ca content in their collected ingredients. Karate has the lowest Ca content, which may be due to the low Ca contents in corn, especially after milling. All analyzed samples were under the recommended daily allowance for Ca. Results of other international studies agree with the current study. Ikem, et al. 2002, stated that the mean Ca content in some infant formula samples purchased from Nigeria, U.K. and the U.S.A. ranged from $344 + 53.1$ to $700 + 138$ $\mu\text{g}/\text{ml}$. Also, Turkish bread has low Ca content, which ranged from $19 + 0.84$ to $43 + 1.7$ $\text{mg}/100$ g (Dagliouglu and Tuncel, 1999). Calcium concentration of yogurts collected from Turkey ranged from $1.276 + 0.127$ in cherry flavored yogurt to $1.544 + 0.438$ g/kg in yogurt (Orak, et. al, 1998).

Cadmium (Cd):

Cadmium is virtually absent from the human body at the moment of birth and is accumulated with upgrowth in body tissues. Toxic levels of cadmium cause kidney failure (Gracey and Collins, 1992). Even low level exposure to Cd causes accumulation in the tissue over time and may lead to hypertension, testicular atrophy, and may induce prostate cancer, renal dysfunction, bone changes and anemia (WHO, 1980). The maximum permissible limit of Cd in food is 0.05 mg/kg (Egyptian Organization for Standardization 1993). Cadmium was found in levels above the maximum permissible limit in biscuits and cakes in this sample, but were below those reported by Marzec et.al., (1998), who reported Cd content in some Polish-made confectioneries (e.g., biscuits, waffles and cream sandwiches) ranged from 0.05 to 0.14 mg/kg . Results are also compatible with those reported by Abdou and Korashy (2001), where the Cd content ranged from $0.0 + 0$ to $0.17 + 0.36$ mg/kg for milk and milk product samples collected from Egypt. Those recorded by El-Prince and Abdel-Mohsen (2001) and Eklund and Oskarsson (1999), for some infant food is similar to samples in the present study.

Cobalt (Co):

Cobalt is a main component of vitamin B12. It plays an important role in the metabolism of iron and in the synthesis of hemoglobin. Chronic cobalt deficiency in humans is one of the main risk factors for cardiovascular disease and vitiligo (Qiu, 1979; Sun, 1984 and Zhang, 1996). In the current sample, potato chips had the highest cobalt content. Murthy et al., (1971) found the total Co intake for children in U.S.A. varies from 0.30

composites, the highest content being in waffles (76 ng/g), pancakes (74 ng/g) and potato chips (70 ng/g). Ma, et al., (2000) estimated the Co content in spinach, flour and tea to be 3.10, 1.85 and 2.17 ug/g, respectively.

Simpkin, et.al, (2000) found that Co content ranged from 0.001 to 0.003 ug/g in most Australian juice sampled at different location. Mohammed, (2000), found that high level of Co content present in some kinds of dates in Saudi Arabia such as Lubana, Balah, Helwa and Al-Ahsaa, which have 0.74, 0.55, 0.84 and 0.41 mg/kg, respectively.

Chromium (Cr):

Chromium is recognized as an essential trace element for humans, and is involved in insulin function (Offenbacher and Pi- Sunyer, 1988). The safe intake range of Cr is estimated as 50-200 x10³ ng in United States for adults (Alper, et al., 1995). The biscuits analyzed in the current study had the highest Cr content, which may be due to the high Cr content in the components used for baking the biscuits. Chromium levels in the samples under study are higher than those reported by Tinggi, et al.,(1997) where they estimated the Cr content in biscuits with cream, cakes with chocolate, sone, muesli bars and roasted potatoes, and were found to have 23 + 2.7, 30.5 + 6.7, 42.2 + 10.2, 423 + 10 and 19.0 + 2.2 ng/kg, respectively. Caroli, et al.,(1999) found the Cr content in honey ranged from 1.03 to 3.93 ng/g.

Copper (Cu):

Copper is considered an essential mineral for the function of certain enzymes (Grandjean, 1986). Copper is involved in respiration and synthesis of hemoglobin. It plays a vital role in the production of the skin pigment melanin. Copper is used in the treatment of anemia because it works with iron in the development and maintenance of red blood cells and the protein hemoglobin (Kirschman, 1996). Children should have a daily intake between 1.0 and 1.5 mg/day (Alpers, et al., 1995). Potato chips in the present study have the highest Cu concentration and exceed the maximum daily intake for children. That may be attributed to the use of copper acetate and copper monohydrate as fertilizer for crop production (Alloway, 1995). The results are similar to those reported by Marzec, et al., (1998), where copper content ranged from 0.55 to 5.65 mg/kg in some Polish-made confectionery products, e.g., biscuits, waffles and cream sandwiches. El-Prince and Abdel- Mohsen, (2001) estimated the Cu content in some infant foods and found levels of 1.59 + 0.26 mg/kg. Results of the present work are compatible with those in Turkish bread, where Cu levels ranged from 1.7 + 0.1 to 3.9 + 0.2 mg/kg (Dagliglu and Tuncel, 1999). On the other hand, the results found in this study are less than the estimated copper content (0.36 + 0.4 to 0.72 + 0.11 ug/ml) in some infant milk collected from Nigeria, U.K. and U.S.A. (Ikem, et al., 2002). Saad, et al., (2001), measured the level of copper in farm bulk milk collected from Ismailia and EL-Sharkia Governorates and found that the Cu levels decrease as lead levels increase. These findings are similar to those reported by Evans (1971) and El-Hoshy, et al., (1994).

Iron (Fe):

Iron deficiency is a serious health problem affecting a large proportion of the world's population (Macphail and Bothwell, 1992). Food fortification programs are a cost effective mean for reducing the prevalence of iron deficiency (Yip, 1997). While iron deficiency is often associated with other vitamin and mineral deficiencies, most notably with zinc deficiency in children resulting in anemia, dwarfism and hypogonadism (Alpers, et al., 1995), chronic iron overload in humans results in hepatocellular damage and fibrosis (Doyle, et al., 1993). In the present study, biscuit samples had the highest iron content, however most samples were below the recommended daily intake of 10mg/kg (WHO, 1980). Presence of iron in food may be attributed to the addition of iron using fortification (Alper, et al., 1995 and Sari, et al., 2001). Results of the present investigation are similar to those recorded for Polish-made confectionery products, e.g., biscuits, affects and cream sandwiches, where Fe contents ranged from 7.0 to 56.5 mg/kg (Marzec, et al., 1998). In addition, results agree with those recorded by El-Prince and Adel-Mohsen (2001). Iron content in powdered infant milk collected from Nigeria, U.K., and U.S.A., was relatively lower, and ranged from 2.98 to 16.7 ug/ml (Ikem, et al., 2002). Also Turkish bread had low iron content, ranging from 6.0 to 22.5+ 0.4 mg/kg (Dagliglu and Tuncel, 1999). The obtained results are higher than those recorded by both Dagliglu and Tuncel, 1999) and Ikem, et al., (2002).

Potassium (K):

Potassium is the major intracellular cation along with sodium and calcium. It is responsible for maintenance of normal electric potential across cell membranes. Average intake of K ranged from 780 to 1600 mg/day for infant and children (Alpers, et al., 1995). Potato chips in the current samples had the highest potassium level compared to other samples under investigation but no sample exceeded the maximum daily intake amount. The obtained result was lower than results recorded by Orak, et al., (1998) for yogurt and cheese collected from Turkish markets, whereas results were similar to those reported for infant formulae and milk powders in New Zealand (Hua, et al., 2000).

The mean potassium level in cow milk obtained from different cities in Turkey was 1.43 g/kg. Different companies produce those milk samples in Turkey. The highest levels of potassium in coca flavored milk samples (2.04 ± 0.32 g/kg) occurred because of adding the mineral (Orak, et al., 2000). The Lazio honeys had average potassium content of approximately 472 ug/g which is similar meant to that reported for Spanish honey (Conti, 2000).

Magnesium (Mg):

Extracellular magnesium, important in neuromuscular transmission, is a component of bone matrix and is an essential cofactor in many enzyme reactions including oxidative phosphorylation and nucleic acid synthesis. All enzymatic reactions that involve ATP (Adenine Tri Phosphate) require Mg (Alper, et al., 1995). The daily intake for up to one-year of age is 60 mg, and is 80 mg for children ages one-three years, 120 mg for ages four-six years and 170 mg for seven-10 years. Potato chips have the highest Mg content (mean 1583.4 mg/kg), far more than the samples of karate, biscuits and cakes. The

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waffles and cream sandwiches samples. The obtained results are higher than recorded by Ikem, et al., (2002) for infant milk, and similar to those reported by Orak (1998) and (2000).

Manganese (Mn):

Mn is one element capable of causing permanent brain damage and/or personality disorders (James, 1985). Mn intoxication in man is more important than deficiency. The provisional safe intake is 2-5 mg for adult (Alpers et al., 1995). Potato chips have the highest Mn content than the other foods, but no samples exceeded the allowance values. Results were lower than those reported by Marec, et al., (1998) for some Polish-made confectionery products, e.g., biscuits, waffles and cream sandwiches. The obtained results are similar to those reported by Tinggi et al., (1997) for biscuits and cakes (cream, chocolate, sone and muesli bar). On the other hand, infant formula had low Mn content as reported by Ikem, et al., (2002) and Hua, et al., (2000).

Sodium (Na):

Sodium is the most abundant intracellular cation responsible for the osmolarity and ionic balance of the extracellular fluids and the electrochemical gradients of nerve axions for electrical impulses to be transmitted (Spallholz, et al., 1999). The 1989 Recommended Dietary Allowances Publication listed an estimated minimum requirement for Na of 500 mg daily for individuals 18 years of age (Spallholz, et al., 1999). Karate samples had the highest Na content (14501 mg/kg) followed in decreasing order by potato chips, cakes and biscuits. All samples under investigation exceeded the maximum RDA values for Na. This may be attributed to extensive amounts of sodium salt (NaCl) added to these products to increase palatability of the snacks. The results reported in this study are similar to those obtained by Orak, et al., (1998) and Daglioglu ad Tuncel, (1999).

Nickel (Ni):

Ni is present in all human tissue, evidence for its homeostatic cellular control (Gammelgaard and Jons, 1995). Nickel is a component of enzyme urease. The human intake of nickel varies between 170 and 700 ug /day (Spallholz, et al., 1999). Biscuits and cakes have higher Ni concentration than the other samples, but no sample exceeded the recommended daily intake. Results were similar to those reported by Marzec et al., (1998), but higher than those reported by Ikem, et al., 2002 for infant milks. The mean concentration of nickel in potato chips was 63 ug/kg during period 1988-92 and 50 ug/g during the period 1992-97 in Denmark (Larsen, et al., 2002) where other types of food had Ni content ranged from 14 to 225 ug/kg during period 1992-97.

Lead (Pb):

The presence of lead in food is of great concern since children are very sensitive to its toxic effects. Childhood exposure to lead may induce suppression of mental capacity,

Taha et al.: Monitoring Heavy and Trace Metals in Selected Children's Food, and may lead to mental retardation and aggressive behaviors (Falomir, et al., 1999; Borden et al., 1997) and there is high association between lead exposure and children's intelligence quotient (Schwartz, 1994). The PTWI (Provisional Weekly Intake) of lead was 0.025 mg/kg for children as a maximum allowance value (FAO / WHO, 1993). High Pb levels were found in the samples under investigation, especially in biscuits and potato chips. The high Pb content in those samples may be attributed to the lead content in raw material which reflect in turn the nature of soil in which it was grown, and/or due to the contamination of samples with Pb during the different industrial steps (i.e. preservation and/or processing) where different substances are employed to prevent spoilage, promote binding properties, enhance flavor antioxidants and coloring agents. The obtained results are higher in Pb than those reported by Marzec, et al., (1998); EL-Prince and Adel-Mohsen, (2001); Ikem, et al., (2002) and Caroli, et al., (1999), but similar to those recorded by Abdou and Korashy (2001).

Zinc (Zn):

Zn is an essential element playing a wide variety of biochemical roles in vivo, and its deficiency or excess could affect children's development (Baht and Moy, 1997). Zn deficiency can intensify Cd accumulation and toxicity (Brzoska and Moniuszko-Jakoniwuk, 2001). All samples under investigation were within the recommended values of 10 mg/day, (Alper, et al., 1995). The obtained results are similar to those reported by Marzec, et.al, (1998) and El- Prince and Abdel-Mohsen, (2001).

CONCLUSIONS

As noted by Sandstead (1997), the major exposure of humans to toxic elements occurs principally through their normal food supply. Most of the elements (Co, Cr, Fe, Mn, Ni and Zn) in food products commonly eaten by children and analyzed in the present work were within the corresponding values of their nutritional requirement levels. Many food samples had higher Pb & Na content and lower Ca content than the recommended daily intake. Potato chips had high concentration of Cu, Mg ad Na and Pb; karate had high concentration of K and Pb; biscuits had high concentration of Cr, Mn and Pb; and cakes had high concentration of Pb and low levels of Zn. It is strongly recommended that the food industry in Egypt pay more attention in supplying and in technological management of snack food products to avoid the exposure of children to dangerously high levels of toxic elements, and chronically low levels of necessary elements.

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Samples	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb
Chips	286.7	0.053	0.298	3.98	3.82	18.07	15402	1583.4	4.178	8684	0.518	0.650
Snack	201.6	0.044	0.169	4.68	0.680	17.46	3304.8	366.7	1.887	13542	0.371	0.558
Biscuit	301.1	0.096	0.202	5.58	1.815	27.14	5515.2	328.3	3.956	4173	1.461	0.828
Cakes	438.7		0.126	4.39	0.737	13.92	2398.6	200.3	3.53	6365.2	0.673	0.386

Table 2 : Descriptive Statistics for Foods Under Study

Elements	No.	Mean	Median	Tr Mean	St Dev	Se Mean	Minimum	Maximum
Ca	100	307.27	249.52	290.35	196.32	45.6	33.9	973.7
Cd	100	0.0482	0.00	0.1752	0.071	0.029	0.00	0.85
Co	100	0.199	0.1651	0.1787	1309	0.0285	0.00	0.65
Cr	100	4.659	3.696	4.723	2.279	0.452	0.395	9.59
Cu	100	1.763	1.296	1.560	0.973	0.2117	0.044	6.87
Fe	100	19.146	16.62	18.73	6.81	1.836	6.13	62.66
K	100	6655	6172	6553.2	3143.2	726	1181	20401
Mg	100	619.72	444.1	555.35	317.15	70.32	71.7	2870
Mn	100	3.387	2.963	4.28	1.642	0.393	0.784	9.34
Na	100	81911	6800	7460	3084.5	675.5	2031	20103
Ni	100	0.756	0.6966	0.7319	0.3993	0.090	0.0	2.76
Pb	100	0.605	0.5435	0.5803	0.4159	0.0907	0.01	1.99
Zn	100	6.125	6.031	6.373	2.22	0.492	2.12	14.89