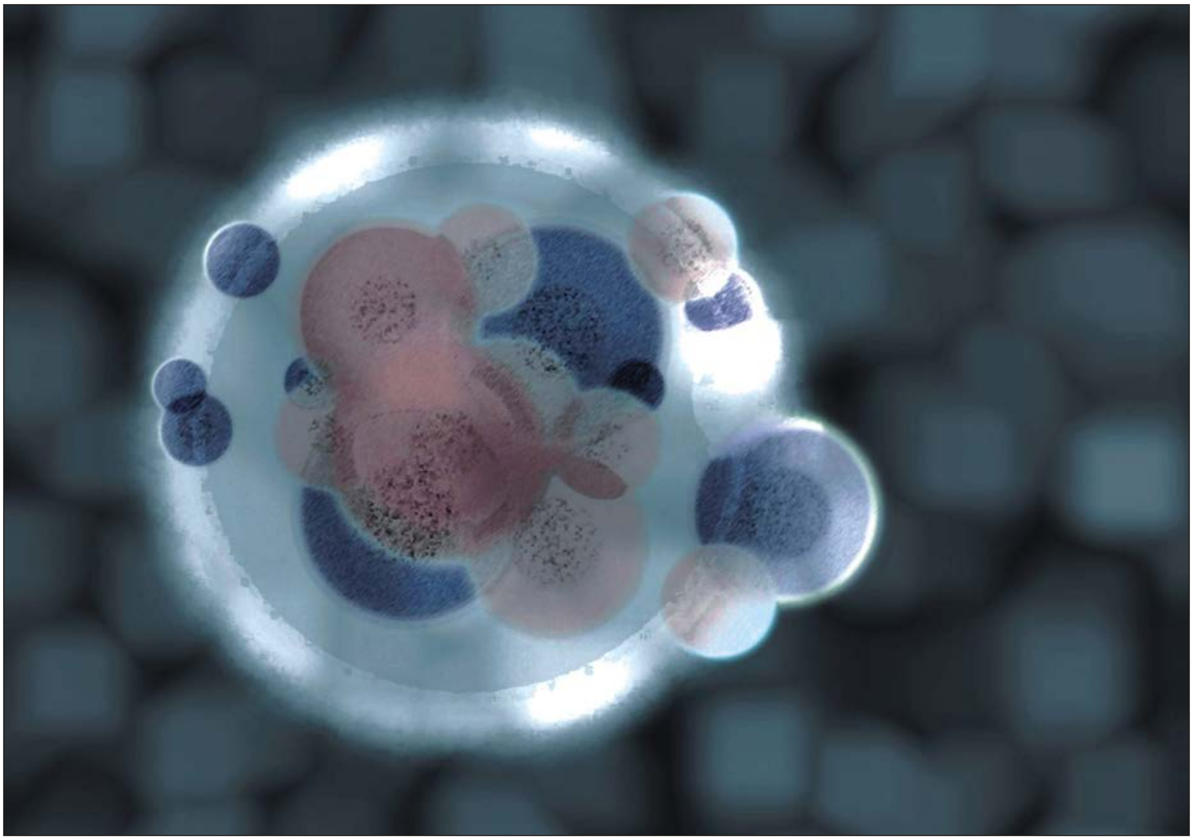

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Determination of Trace Metal Contaminants in Edible Salts in Tehran (Iran) by Atomic Absorption Spectrophotometry

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Abstract: In this research the concentration of some trace elements such as Pb, Cd, Zn, Fe, Cu and Al in edible salts were determined. The study was carried out on 60 samples of kitchen salts and table salts (a fine-ground, refined and crystallized rock salt with nearly pure 95% or greater sodium chloride). The packed salt samples were collected from retail market in Tehran City and analyzed by flame atomic absorption spectrophotometry for Lead (Pb), Cadmium (Cd), Zinc (Zn), Iron (Fe), Copper (Cu) and Aluminum (Al). The mean and standard deviation of Pb, Cd, Zn, Fe, Cu and Al in kitchen salts were 1.59±0.90, 0.91±0.32, 6.02±2.54, 17.8±6.11, 1.24±0.90 and 5.82±0.61 mg kg^{-1}, respectively. Also, the mean and standard deviation of Pb, Cd, Zn, Fe, Cu and Al in table salts were 0.86±0.52, 0.65±0.34, 6.5±4.86, 15.3±5.95, 1.21±0.79 and 5.60±0.75 mg kg^{-1}, respectively. It was concluded that the levels of some toxic metals in some investigated Iranian packed edible salts were exceeded the maximum allowable concentrations of metals recommended by the Codex Alimentarius Commission and Iranian Institute of Standards and Industrial Research.

Key words: Trace metals, contaminants, table salt, kitchen salt, edible salts, atomic absorption spectrophotometry

INTRODUCTION

A case of environmental pollution confronted very frequently and threatening food safety is due to heavy metals. As a result of soil, atmosphere, underground and surface water pollution, foods and beverages are getting contaminated by heavy metals. The effect of environmental pollution on contamination of foods and on their safety for human consumption is a serious global public issue and widely addressed (Alegria *et al*., 1990; Ahmed *et al*., 2000; Moffat and Whittle, 1999). Lead (Pb) is present in the environment because of air, soil and water pollution. Major sources of lead are exhaust fumes from vehicles, industrial gases and liquid effluents, some phosphate fertilizers and pesticides. Cadmium (Cd) may increase in the biosphere due to emissions from batteries, coatings, electroplating steel and cast iron, pigments, plastic stabilizers constituent of low melting or easily fusible alloys, electronic and optics and solder for aluminum, reactor control rods, hardener for copper and catalysts. Moreover, it is presented as a contaminant in phosphatic fertilizer and sewage sludge and is dispersed by mining activities (Hu, 2002; Mahindru, 2004). Trace heavy metals are significant in nutrition, either for their essential nature or their toxicity. Toxic metals set up conditions that lead to inflammation in arteries and tissues, causing more calcium to be drawn to the area as a buffer, contributing to hardening of the artery walls with progressive blockage of the arteries and osteoporosis. In general, heavy metals have no function in the body and can be highly toxic. They are systemic toxins with specific neurotoxic, nephrotoxic, fetotoxic and teratogenic effects. Several reports have focused on residues of numerous heavy metals in food stuffs (Cabrera *et al*., 1995; Liobet *et al*., 1998; Jahed Khaniki and Zazoli, 2005; Jahed Khaniki *et al*., 2005). Copper and zinc are known to be essential and may enter the food materials from soil through mineralization by crops, food processing or environmental contamination. The toxicity of them is due to excessive intake. The largest amount of trace elements found in human body has been absorbed via food. Salt is a biological necessity of human life and it is added to most of food. It is necessary for the body to produce digestive acids, stimulate the liver and helps get rid of

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gas. Besides enhancing taste, salt acts as an antimicrobial or microbiological control agent. It contributes to certain chemical reactions that create a wide variety of food characteristics (Kuntz, 1994).

There are two forms of packed edible salt for using in food and cooking in market of Iran. A kind of packed salt is table salt. It is a fine-ground, refined and crystallized rock salt with nearly pure (95% or greater) sodium chloride. Fourteen salt refinery plants exist in Iran that they produce 350 million kg refined salt per year. The other kind of packed salt obtains from grinded rock salt and it has not been refined and it is packed as kitchen salt. Most salt manufactured in Iran comes from underground deposits, although some comes from solar evaporation of saline sea water. Edible salts can be contaminated to heavy metals because it is one of the most ubiquitous food ingredients around. Some studies of heavy metals in salt had previously been conducted in Iran (Ovji, 1994; Poorrasoul, 1998; Hamshahri Organization, 2006). The city of Tehran was selected for this study because there was no whole information available on the occurrence of trace metal contaminants in edible salts. This study seeks to investigate and measure the levels of Pb, Cd, Zn, Fe, Cu and Al in packed edible salts of Tehran City in order to improve of salt quality.

MATERIALS AND METHODS

Sample collection: Sixty packages of kitchen and table salts with one kg weight were collected from retail market at different places of Tehran City in 2005. Packed salt samples were sent to laboratory and they were analyzed by flame atomic absorption spectrophotometry for trace metals-Lead (Pb), Cadmium (Cd), Zinc (Zn), Iron (Fe), Copper (Cu) and Aluminum (Al).

Flame conditions for the AAS measurements of Pb, Cd, Zn, Fe, Cu and Al: The Atomic absorption spectrometric analysis of Pb, Cd, Zn, Fe, Cu and Al was performed using at least two standard solutions for each metal. Flame conditions are given for Pb, Cd, Zn, Fe, Cu and Al in Table 1.

Sample examination: For lead, cadmium, zinc, iron, copper and aluminum analysis edible salt samples were left to air dry before examination. They stored in high density polyethylene bottles, 100 mL capacity, with screw caps. Bottles were pre washed with nitric acid, rinsed with deionized water, dried and tested for contamination by leaching with 5% nitric acid. The bottles contained no metal liners that can contaminate the samples.

Sample extraction: One gram of salt samples was precisely weighed in test tubes and 3 mL of nitric acid were added to each tube and tubes were allowed to remain over night at room temperature, protected from dusts. Tubes were heated up to 130°C for 4 h using a metal block thermostat unit. Tubes were left to cool down before 2 mL of nitric acid and 0.7 of perchloric acid and 43 mL distilled water were added to each tube. A programmable circuit was used to raise temperature up to 230°C within 33.5 h. The clear wet ash in each tube was dissolved in 2 mL of distilled water and tubes were stored until flame atomic absorption spectrophotometry was performed. The samples were analyzed by atomic absorption spectrophotometer (ALPHA 4, Chem Tech Analytical Co. England) using an air and nitrous oxide-acetylene flame. The certified standard reference material (Alpha-Line, Chem Tech Analytical, Ltd., England) was used to check the accuracy and the analytical values were within the range of certified values. All the recoveries of the metals studied were over 95%. All the concentration of the metals is expressed in mg kg^{-1} in dry weight.

Statistical analysis: The index was used for correlations between the specimens and metal levels. ANOVA analysis was made between kinds of consumption edible salt in Tehran City and a multiple regression between kinds of consumption edible salt and the amount of the different lead and cadmium, aluminum, iron, zinc and copper metals. All the statistical method were done using the software SPSS, version 11.5. Analysis of variance ANOVA was employed after logarithmic conversion when necessary to detect significant differences among means.

RESULTS AND DISCUSSION

Trace heavy metal concentrations obtained from this study are summarized in Table 2. Both kinds of edible salts showed the high content of Pb and Cd. Pb and

Table 1: Flame conditions for the AAS measurements of Pb, Cd, Zn, Fe, Cu and Al (Flame Atomic Absorption Spectrophotometer-ALPHA 4, Chem Tech Analytical Co. England)

Elements	Wave length (nm)	Slit	Lamp current (mA)	Gain	Oxidant	Acetylene flow	Berner height	Sensitivity (µg mL^{-1})	Detection limit (µg mL^{-1})	Calibration range at 1 scale Exp. (µg mL^{-1})
Lead (Pb)	217.0	3	4	8	Air	2.4	6	0.12	0.004	0.4-40
Cadmium (Cd)	228.8	3	2	7	Air	2.1	7	0.02	0.002	0.05-5
Zinc (Zn)	213.9	2	4	8	Air	13.5	7	0.009	0.006	0.002-2
Iron (Fe)	248.3	1	8	8	Air	3.3	6	0.05	0.05	0.1-10
Copper (Cu)	324.7	2	5	5	Air	1.8	7	0.03	0.0001	0.1-10
Aluminum (Al)	309.3	2	3	6	Nitrous oxide	13.2	4	0.8	0.02	2-200

Table 2: Content of trace heavy metals in packed edible salts (mg kg^{-1})

Kind of salt	N	Pb	Cd	Zn	Fe	Cu	Al
		(Mean±SD)					
Table salt	30	0.87±0.53*	0.65±0.34*	6.50±4.86	15.30±5.96	1.21±0.80	5.60±0.75
Kitchen salt	30	1.60±0.90*	0.91±0.32*	6.02±2.54	17.80±6.12	1.24±0.91	5.82±0.61

*$p<0.05$

they were lower in table salt than kitchen salt. The highest content of Pb was showed in kitchen salt with 2.50 mg kg^{-1} dry weight ($p<0.05$). Also, Cd content was lower in table salt than kitchen salt. Among the most collected edible salts, kitchen salt contained more Cd about 1.23 mg kg^{-1} dry weight, whereas the table salt contained lower Cd about 0.31 mg kg^{-1} dry weight, all $p<0.05$. The mean and standard deviation of Al content in table salt and kitchen salt were 5.60±0.75 and 5.82±0.61 mg kg^{-1} dry weight, respectively. Greater amount of Al was found in kitchen salt.

The mean and standard deviation of Zn, Fe and Cu contents in table salt were 6.50±4.86, 15.30±5.96 and 1.21±0.80 mg kg^{-1} dry weight, respectively. Also, the mean and standard deviation of Zn, Fe and Cu contents in kitchen salt were 6.02±2.54, 17.80±6.12 and 1.24±0.91 mg kg^{-1} dry weight, respectively. Distributions of Pb, Cd, Cu and Al in different types of edible salts indicated that Al had the highest levels among other trace heavy metals in kitchen salt.

Peerawat *et al.* (1998) reported that natural salt have some impurity and they must be reduced or eliminated by means of the appropriate purification procedure. The levels for Al, Pb, Fe, Cu, Cd and Zn were 0.6, 2, 0.1, 0.2, 0.1 and 0.2 mg L^{-1} in natural salt samples in Thailand, respectively. Trace elements are fairly widespread in the environment and edible salts may contaminate to some of them. They can enter to human body by ingestion of edible salts. The intake of heavy metals by human through salt ingestion depends on their food habits. The levels of lead and cadmium in this study have a significance differences in table salt and kitchen salt. The level of lead in table salt was less than 1 mg kg^{-1}, but the level of lead in kitchen salt was more than 1 mg kg^{-1}. The level of cadmium is more than 0.2 mg kg^{-1} in both salts. The level of heavy metals obtained from this study is less than heavy metal levels were reported by Poorrasoul (1998).

The Codex Alimentarius and Institute of Standards and Industrial Research of Iran have established the maximum permissible concentration of metals in food grade salt. The levels of the toxic metals in various edible salts are presented in Table 3 (ISIRI, 2006, Codex Alimentarius Commission, 2001). The levels of lead and cadmium in kitchen salt are more than maximum limits of heavy metals in food grade salt of Iranian standard. According this standard, food grade salt does not contain contaminants in amounts and in such form that may be harmful to the health of the consumer. In particular the maximum limits of lead and cadmium shall not be exceeded more than 1 and 0.2 mg kg^{-1}, respectively. This study showed that the levels of lead in table salt and kitchen salt is less and the levels of cadmium in both are high than codex standard. According the codex standard, food grade salt may not contain contaminants in amounts and in such for that may be harmful to the health of the consumer. In particular the maximum limits shall not be exceeded 2 mg kg^{-1} for lead and 0.5 mg kg^{-1} for cadmium. Ovji (1994) reported that the salt of Maharloo Lake has contaminated with heavy metals. The levels of arsenic, lead, copper and iron in salt is 1.8-3.2, 5.1-6.9, 2.85-4.51 and 11.43 mg kg^{-1}, respectively. These heavy metals are higher than the maximum allowance in food grade according to standard of Iran.

Table 3: Maximum limits of heavy metals in edible salts (mg kg^{-1})

Elements	Codex standards	Iranian standards
Copper	2	2
Lead	2	1
Cadmium	0.5	0.2
Iron (Fe III)	-	10

At present study, the levels of copper, iron and zinc were determined in table salts and kitchen salts. They are naturally found in the body and they are essential to human health. They normally occur at low concentrations and are known as trace metals. Copper levels was less than maximum limits by Codex alimentarius and Iranian standard for food grade salt. Onianwa *et al.* (2001) reported that the levels of copper and zinc in edible salt are 2.04 and 2.13 mg kg^{-1}, respectively. The level of copper and zinc at mentioned study is higher and less than present study, respectively. Excess copper interferes with zinc, a mineral needed to make digestive enzymes. Too much copper also impairs thyroid activity and the functioning of the liver. The World Health Organization (WHO) suggests that 10-12 mg day^{-1} may be the upper safe limit for consumption. The iron levels of tested salt samples were higher than maximum limits of Iranian standard for food grade salt. This problem can be related to add ferrocyanide (Calcium ferrocyanide or Sodium and Potassium ferrocyanides) to food grade salt as an anti-caking agent in edible salts at during salt processing. Another trace element is Aluminium that can find in edible salts. The level of aluminum was high and it was more than 5 mg kg^{-1} in both of salts. It may be related to add sodium aluminosilicate and Calcium aluminium silicate as an anti-caking agent at during salt processing.

CONCLUSIONS

Kitchen salt samples are unacceptable as a food grade salt because they have some heavy metals more than permitted limit. Some of heavy metals in table salt is high and it recommended to use a suitable method for clarification and purification at during salt processing. Also, based on results obtained in this study, it can be concluded that the levels of some toxic metals in some edible salts investigated exceed the maximum allowance concentrations of metals recommended by the Codex Alimentarius and Standards and Industrial Research Institute of Iran. It is important at this stage to further investigate the levels of these toxic metals in other food commodities consumed by the different age groups and to assess the public health risks arising from the presence of these toxic contaminants in foods consumed by the population of Tehran City.

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