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Determination of Heavy Metals Content of Refined Table Salts

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Abstract: Table salt (NaCl) is one of the most commonly employed food additives. Since most of salt used around the globe comes from mines, it is expected that heavy metals contamination might be a concern for table salt. In this study, the levels of mercury, arsenic, lead, cadmium, iron, tin and copper in samples of refined table salt were determined. The contents of investigated heavy metals were found to be in the range of 0.14-0.65 μg/g for mercury, 0.01-0.5 μg/g for arsenic, 0.01-5.8 μg/g for lead, 0.01-0.4 μg/g for cadmium, 1.5-37 μg/g for iron, 0.1-2.8 μg/g for copper and 0.38-65 μg/g for tin. The results were compared with the literature values and the legal limits.

Key words: Heavy metals · Salt · Mercury · Lead · Arsenic · Cadmium

INTRODUCTION

Many elements which are present in food, such as iron and copper are essential for human life since they play an important role in biological systems. These elements can also produce toxic effects when their intake is excessively elevated. Other elements like mercury, arsenic, lead and cadmium are non-essential elements, as they are toxic, even at low concentrations [1-3]. Trace metals have a unique property of accumulation over a period of time along a food chain. Metals that are deposited in the environment may accumulate in the food chain and cause ecological damage and also poses threat to human health [4-6]. These health concerns are quite considerable. For example, cancer, damage to the nervous system has all been documented in humans as a result of metal consumption [7]. Therefore, environmental and toxicological studies have prompted interest in the determination of toxic elements in food and food additives.

Table salt (NaCl) is one of the most commonly employed food additives. In addition to impart salty flavor, it is commonly used as a flavor enhancer and also as a preservative to inhibit the growth of spoilage and pathogenic bacteria. For example, salting of cheese by immersion in brine is a common industry practice which improves taste and also as a preserving agent. Since most of salt used around the globe comes from mines, it is expected that heavy metals contamination might be a concern for table salt. The strong and consistent correlation reported between the intake of salt and salted food and the incidence of stomach cancer and other pre-cancerous lesions. This could be attributed to the possible contamination of salt with heavy metals especially arsenic [8]. Due to the daily consumption of table salt, any contamination, even at low levels could create health risks to the consumers. Therefore, the concentration of heavy metals in table salt should be rigorously controlled, considering the participation of this ingredient in the food preparations for humans [9]. There is limited information on heavy metal levels of table salts in the literature. In this study the levels of mercury, arsenic, lead, cadmium, iron, tin and copper in samples of refined table salt marketed in Iran are reported.

MATERIALS AND METHODS

Apparatus: A Prospector GBC 932 AA atomic absorption spectrophotometer equipped with a deuterium background corrector was used for the determination of heavy metals. The operating parameters for working elements were set as recommended by the manufacturer.

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Lead and cadmium concentrations were determined by a graphite furnace atomic absorption spectrophotometer. Iron and copper were determined by direct aspiration of the sample solutions into the air-acetylene flame and tin was determined in NO_2-acetylene flame. Mercury and arsenic were analyzed using hydride generation atomic absorption spectrophotometer. The blanks and calibration standard solutions were also analyzed in the same way as the sample solutions [3].

Reagents: All the plastic and glassware was cleaned by soaking in a 10% (v/v) nitric acid solution for 15 min and then rinsed with deionized water before use. All reagents used were of analytical reagent grade. The standard stock solutions used for calibration were produced by diluting a stock solution of 1000 mg/l of the given element supplied by Sigma-Aldrich. The working solutions were freshly prepared by diluting an appropriate aliquot of the stock solutions using 10% HNO_3 [3].

Sample Preparation and Digestion: Refined table salt samples were purchased from popular supermarkets in Iran. Two grams of the samples were dissolved in 6 ml of concentrated HNO_3. The sample solutions were placed at room temperature for 24 h. The solutions were heated up to 130°C for 4 h before adding 3 ml of perchloric acid and heating up to 250°C. A blank digest was carried out in the same way. All metals were determined against aqueous standards. The recoveries of the metals were determined by spiking the samples with various concentrations of heavy metals which were then taken through the digestion procedure. These spiked samples were analyzed for the metal concentrations in the same way as the sample solutions [10].

RESULTS AND DISCUSSION

Samples of refined table salt were analyzed for mercury, arsenic, lead, cadmium, copper, iron and tin content. The levels of investigated heavy metals are presented in table 1. All the metal concentrations were determined on a dry weight basis. The recoveries of spiked samples were in the range of 92-104 % for mercury, 93-101 % for arsenic, 94-99 % for lead, 92-102 % for cadmium, 97- 101 % for copper, 96-103 % for iron and 95-101 % for tin. Good recoveries of spiked samples demonstrate the accuracy of the methods used.

Mercury was detected in 20 % of the samples tested. The concentration of mercury in these samples varied from 0.14-0.65 μg/g. In another report from Iran, the mean concentration of mercury in table salt samples was 0.021 μg/g. The maximum permitted level of mercury in food grade salt is 0.1 μg/g according to the codex legislation [11] and 0.05 μg/g according to the Iranian food standards [12]. Mercury interferes with the architecture of the developing brain, disrupting microtubule assembly [13] and interfering with the temporal sequencing of cell adhesion molecules that guide neuronal migration and connections [14].

In the present study, cadmium was detected in 16.6 % of the samples and it was in the range of 0.01-0.4 μg/g. In two other reports from Iran, the mean concentration of this element in table salts was 0.024 μg/g [15] and 0.65 μg/g [10]. According to Soylak *et al.* [16], the concentration of cadmium in 53 % of the refined and unrefined table salt samples from Turkey, Egypt and Greece was below 0.14 μg/g and the highest cadmium level was 0.30 μg/g. The concentration of cadmium in table salt samples from Brazil has been reported in the range of 0.01-0.03 μg/g by Amorim and Ferreira [9]. The maximum cadmium level permitted for salt is 0.5 μg/g according to the codex legislation [11] and 0.2 μg/g according to the Iranian food standards [12]. Cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage and reproductive deficiencies.

Lead is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adults [17]. The maximum permitted level of lead in food grade salt is 2.0 μg/g according to the codex legislation [11] and 1.0 μg/g according to the Iranian food standards

Table 1: Concentration of heavy metals (μg/g) in refined table salt samples. Data represent the mean of three replicates.

	Minimum	Maximum	Average	Iranian Food Standards	Codex Standards
Mercury	0.14	0.65	0.327	0.05	0.1
Lead	0.01	5.8	2.728	1.0	2.0
Cadmium	0.01	0.4	0.122	0.2	0.5
Arsenic	0.01	0.5	0.2664	0.5	0.5
Iron	1.5	37	8.774	10.0	-
Copper	0.1	2.8	1.288	2.0	2.0
Tin	0.38	65	26.371	-	-

[12]. In our study, lead was detected in 33.3 % of the samples and it was in the range of 0.01-5.8 μg/g. According to the previous reports from Iran, the mean concentration of this element was 0.87 μg/g [10] and 0.43 [15]. Lead contents in the literature have been reported in the range of 0.5-1.64 μg/g in refined and unrefined table salt samples from Turkey, Egypt and Greece [16] and 0.03-0.10 μg/g in samples from Brazil [9]. The Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives [18] has suggested a provisional tolerable intake of 400±500 μg cadmium per week for man; the quantity of mercury to be tolerated in human food is 0.3 mg per week and, for lead, a weekly intake of 3 mg. The maximum concentration of lead which is permitted in prepared foods specifically intended for babies or young children is 200 μg/kg.

It was reported previously that the table salt samples from Iran contained 0.094 μg/g arsenic averagely [15]. In this study, arsenic was detected in 36.6 % of the samples tested. The concentration of arsenic in these samples varied from 0.01-0.5 μg/g. According to the codex legislation [11] and the Iranian food standards [12], the maximum permitted level of arsenic in food grade salt is 0.5 μg/g. We observed iron and copper in 93.3 and 86.6 % of the samples, respectively. They were in the range of 1.5-37 μg/g for iron and 0.1-2.8 μg/g for copper. In another report from Iran, the mean concentration of iron and copper in table salts were 15.30 μg/g and 1.21 μg/g, respectively [10]. According to the codex legislation [11] and the Iranian food standards [12], the maximum permitted level of copper in food grade salt is 2 μg/g. The level of copper in table salts has been reported in the range of 0.17-0.47 μg/g by Soylak *et al.* [16]. Copper is essential for good health but very high intake can cause adverse health problems, such as liver and kidney damage [2]. Iron is a mineral essential for life and for our diets. Although considered a trace mineral, diets lacking in iron can contribute to the deficiency condition known as anemia. The maximum permitted level of iron in food grade salt is 10 μg/g according to the Iranian food standards [12]. While, no comparative date for tin content of table salts was found in the literature, this element was detected in 20 % of the table salt samples in our study and it was in the range of 0.38-65 μg/g.

In conclusion, the mean concentrations of mercury and lead in refined table salt samples were found to be above the legal limits. The contamination may be reduced by performing more suitable methods for purification and refining the salts.

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