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Determination of Heavy Metal Levels in Edible Salt

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Background: Edible salt is the most commonly used food additive worldwide. Therefore, any contamination of table salt could be a health hazard.
Objectives: The present study aimed to determine the levels of heavy metals in table and bakery refined salts.
Materials and Methods: Eighty-one table refined salt samples and the same number of bakery refined salt samples were purchased from retail market in the province of Hamadan, Iran. The levels of lead (Pb), cadmium (Cd), mercury (Hg), copper (Cu), and iron (Fe) were determined using atomic absorption spectroscopy method.
Results: The levels (mean ± SD, μg/g) of Pb, Cd, Hg, Cu, Fe in table refined salt samples were 0.852 ± 0.277, 0.229 ± 0.012, 0.054 ± 0.040, 1.25 ± 0.245 and 0.689 ± 1.58, respectively. The results for the same metals in bakery refined salt samples were as follows (mean ± SD, μg/g): 22 ± 0.320 for Pb, 0.240 ± 0.018 for Cd, 0.058 ± 0.007 for Hg, 1.89 ± 0.218 for Cu, and 8.75 ± 2.10 for Fe. Heavy metal concentrations were generally higher in bakery refined salt.
Conclusions: The results obtained in the present study were compared with the literature and legal limits. All values for these metals in the table and bakery refined salts were lower than the permitted consumption level defined by Codex (2 μg/g of Pb, 0.5 μg/g of Cd, 0.1 μg/g of Hg, and 2 μg/g of Cu).

*Keywords:*Cadmium; Lead; Heavy Metals; Mercury; Sodium Chloride

1. Background

Trace elements or heavy metals are widely present in the earth's crust, air, water and food. Heavy metal contamination of food is a great concern for human health because of their toxicity and even at relatively low concentrations can cause harmful effects. Although these effects have been known for a long time, exposure to heavy metals exists and is even increasing in some countries (1, 2).

To limit the possibility of food poisoning by trace elements, the highest allowable concentrations of them are determined (3). Human may expose to heavy metals through inhalation and dermal contact; however, contaminated food and drink are the major exposure path in most people (4).

Edible salt is biologically necessary because it provides two important macro elements of sodium and chlorine for human body. Furthermore, it improves food taste, could serve as a preservative, and elongates shelf life. Generally, salt is the most additive used in food industry (2).

Salt might be contaminated by various chemical substances in different amounts and forms that may harm the consumers' health. Some studies showed that heavy metals are found in edible salt (2, 5-9). Therefore, the concentration of heavy metals in table salt should be rigorously controlled.

Table refined salt (fortified by iodine and used for home cooking), and bakery refined salt (used in production of bread and is free of iodine) are two types of edible salt supplied in Iran.

2. Objectives

The aim of this study was to determine lead (Pb), cadmium (Cd), mercury (Hg), copper (Cu) and iron (Fe) content of table and bakery refined salt samples consumed in the province of Hamadan, Iran and to compare their values with the standards established for human health. According to Iran standard, the maximum permitted levels of heavy metals in salt are 1 μg/g of Pb, 0.2 μg/g of Cd, 0.05 μg/g of Hg, 2 μg/g of Cu, and 10 μg/g of Fe (10).

Implication for health policy/practice/research/medical education:
The levels of lead, cadmium, mercury, copper, and iron in edible salt consumed in Hamadan province were significantly lower than the permitted level prescribed by Codex Alimentarius Commission (Codex) and Institute of Standards and Industrial research of Iran (ISIRI). Among heavy metals, lead (Pb) was at higher concentration in all analyzed samples whereas mercury (Hg) was at the lowest level. Although heavy metal level in edible salt was low, we advise to routinely check their level in edible salt.

3. Materials and Methods

3.1. Sampling

Eighty-one table and 81 bakery refined salt samples from 26 commercial brand (three samples from each brand) were purchased from retail market in the province of Hamadan, Iran. Twenty-five gram of each sample was used for analysis.

3.2. Reagents and Solutions

All materials of the study were obtained from Merck, Darmstadt, Germany. Solutions were prepared with double-deionized water. The calibration curve was established using standard solutions prepared in 1 mol HNO3 by dilution from 1000 mg/L stock solutions. The calibration standards were not submitted to the preconcentration procedure. Approximately, 0.1% solution of Dy2O3 was prepared freshly by dissolving dysprosium (III) oxide (Merck, Suprapur grade) in small amounts of nitric acid and diluted to 50 mL with double distilled water. Nitric acid (65%) (Used for preparing of diluted acid solution) was Suprapure grade from Merck.

3.3. Analysis of Table and Bakery Refined Salts

Graphite furnace atomic absorption spectroscopy (model AA240 G, Varian, Inc.) was used for measuring heavy metals (Pb, Cd, Cu, and Fe) in edible salt samples. The procedure applied by Soylak et al. (2008) and Peker et al. (2007) was used to determine heavy metals in all salt samples (8, 11).

In brief, 2.0 g of salt sample was dissolved in 20 mL of distilled water. After adding 1.0 mg of dysprosium, precipitates of dysprosium hydroxide were formed and ammonia was used to adjust the pH of the solution (pH = 11). The tube is slowly and carefully shaken for several seconds and then allowed to stand for 10 minutes. The precipitate is centrifuged at 3000 rpm for 10 minutes and the supernatant is discarded. A small precipitate adheres to the bottom of the tube. Then, 1 mL of 1 M HNO3 is added to dissolve the precipitate. The final volume was completed to 2.0 mL with distilled water. An aliquot of 100 μL of the solution was introduced into graphite furnace atomic absorption spectroscopy for measurement of Pb, Cd, Fe and Cu. Hg was measured by using cold vapor atomic absorption spectrophotometry (12).

3.4. Statistical Analysis

All data were analyzed using SPSS version 17.1. One-sample t test was used for determination of the difference between levels of heavy metals in refined or unrefined salt samples and maximum limits levels permitted in codex standard. Difference between mean of heavy metals in table and bakery refined salt samples was compared by independent t-test. $P < 0.05$ was considered as a significant difference.

4. Results

Table 1 shows the heavy metal contents obtained from analysis of table refined salt samples based on dry weight. Contents of Pb, Cd, Hg, Cu, and Fe in table refined salt were lower than that of in bakery refined salt, however, there were no significant differences between the two salt groups in Cd and Hg. Concentrations of Pb, Cu and Fe were significantly higher in bakery refined salt ($P < 0.05$).

5. Discussion

Several researchers reported the presence of trace elements in the salt (2, 5-9). Lead is one of the most toxic heavy metals that accumulates in the body and data published in literature indicates that its excessive intake harm different systems and organs such as central and peripheral nervous system, gastrointestinal tract, muscles, kidneys, and hematopoietic system (13). The maximum permitted level of lead in food-grade salt is 2.0 μg/g according to the Codex legislation (14) and 1.0 μg/g according to the Iranian food standards (10).

In our study, Pb content of table and bakery refined salt samples were 0.852 μg/g and 1.22 μg/g respectively, which is between Codex and the Iranian code. In another report from Iran, Pb concentration was 2.728 μg/g (range 0.01-5.8 μg/g) and in salt samples from Tehran, lead content was 0.87 μg/g (4) and 0.438 μg/g (2). Pourgheysari et al.

Table 1. Contents of Pb, Cd, Hg, Cu and Fe in Table and Bakery Refined Salts [a]

	Mean ± SD		Range		Iranian Food Standard	Codex Standards
	Table Salt	Bakery Salt	Table Salt	Bakery Salt		
Pb, μg/g	0.852 ± 0.277 [a]	1.22 ± 0.320 [b]	0.430-1.520	0.45-1.870	1.0	2.0
Cd, μg/g	0.229 ± 0.012 [a]	0.240 ± 0.018 [a]	0.110-0.650	0.090-0.900	0.2	0.5
Hg, μg/g	0.054 ± 0.040 [a]	0.058 ± 0.007 [a]	0-0.170	0.25-0.180	0.05	0.1
Cu, μg/g	1.25 ± 0.245 [a]	1.89 ± 0.218 [b]	0.96-2.08	1.05-2.41	2.0	2.0
Fe, μg/g	6.89 ± 1.58 [a]	8.75 ± 2.10 [b]	4.1-9.87	5.3-11.2	10.0	-

[a] Means in the same row having the different letters are significantly different at $P < 0.05$.

(2007) in Isfahan reported lead content to be 0.57 μg/g in refined salt and 0.61 μg/g in unrefined salt (7). In the literature, it was reported in the range of 0.5-1.64 μg/g in refined and unrefined table salt samples from Turkey, Egypt and Greece, and 0.03 μg/g from Brazil (8).

In our study, mean Cd concentrations found in table and bakery refined salts were 0.229 and 0.240 μg/g, respectively. These values are comparable with the values reported in other studies. In Turkey, Cd content found in refined and unrefined salt was < 0.14-0.3 μg/g and 0.14-0.21 μg/g, respectively. In other countries such as Brazil, Egypt, and Greece, Cd concentration in table salts were reported in a range of 0.01-0.03 μg/g, 0.18-0.22 μg/g and 0.18-0.19 μg/g, respectively (8). Other researchers in Iran have shown that Cd amount in salt was more than our results. In a survey in Tehran, Cd content in bakery and table salt were 0.91 and 0.65 μg/g, respectively (6).

At low concentration, copper and iron are essential for human health; however, high levels of these elements are toxic (15, 16). Despite the positive effects of optimal levels of copper, harmful effects may occur if the threshold level is exceeded. Wilson's disease (hepatolenticular degeneration) is one of the diseases linked to the excess copper in the body. It results from dysfunction of the copper transmission, which occurs due to the lack of suitable enzyme to catalyze the process of copper deletion from detached bonds with albumins and binding to ceruloplasmin. The condition leads to neuron degradation, liver cirrhosis, and occurrence of colorful rings on the cornea (17, 18).

Our results are consistent with the previous studies on the content of toxic and essential metals in recrystallized and washed table salt in Shiraz, Iran (5). In conclusion, all values for toxic metals were significantly lower than the permitted values set by Codex and Iran standards. Lead was generally at higher concentration in all analyzed samples whereas mercury was at thelowest level. In comparison, analyzed heavy metal contents of table refined salt were generally higher than that of bakery refined salt.

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Authors' Contributions

Study concept, design, and supervision: Aliasghar Vahidinia, Iraj Salehi, Ali Heshmati; acquisition, analysis, and interpretation of data, and drafting of the manuscript: Ali Heshmai.

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