



CHEMICAL EVALUATION OF SOME SELECTED METAL COMPOSITION IN EDIBLE SALT

De Zoysa H P E¹

Industrial Technology Institute, 363, Bauddhaloka Mawatha, Colombo 07, Sri Lanka¹

hpedezoysa@gmail.com

Mahatantila K²

Industrial Technology Institute, 363, Bauddhaloka Mawatha, Colombo 07, Sri Lanka²

kushani@itit.lk

S D M Chinthaka³

Department of Chemistry, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka³

sdmchin@sjp.ac.lk

M N A Mubarak⁴

Industrial Technology Institute, 363, Bauddhaloka Mawatha, Colombo 07, Sri Lanka⁴

mnam@iti.lk

ABSTRACT

It is important to assess the quality of salt as salt is the most used food additive worldwide. Determination of metallic elements of salt samples which were purchased from retail outlets of Ambalangoda were done by Inductively Coupled Plasma Mass Spectrometry. All the samples complied with SLS 79: 2014 (Food Grade Salt Granular Form) and SLS 80: 2014 (Food Grade Salt powdered Form) with respect to arsenic, cadmium and copper as arsenic and cadmium levels were lesser than 0.5 mg/kg and copper levels of samples were lesser than 2.0 mg/kg. However, two samples did not comply with above standards as lead content was greater than the maximum limit (2.0 mg/kg). One sample contained 0.4 mg/kg of mercury content which was four times greater than maximum limit for mercury (0.1 mg/kg). Beryllium, Cobalt, Selenium, Silver, Rubidium, Cesium, Thallium, Uranium, Vanadium, Zinc and Gallium were lesser than 0.1mg/kg in salt samples that were tested. Concentration of Aluminum, Manganese, Strontium, Barium and Nickel varies from <0.1 to 18.7, <0.1to 4.8, <0.1to 45.3, <0.1 to14.6 and <0.1to2.9 mg/kg consecutively. Although exact reason is not clear,all samples except one sample contained a higher amount of strontium content with respect to that of other metals. Even though minute in quantity, chromium is available in 82% of the samples which were tested. Helium mode of ICP MS seems to be a reliable method to analyze metals in salt as percentage of recovery is in between 80% to 120% for most of the metals tested.

KEY WORDS: Salt, Heavy Metals, Icp-Ms, Quality

Corresponding Author: De Zoysa H P E , Email: hpedezoysa@gmail.com

1. INTRODUCTION

Salt has been a common commodity and household staple for thousands of years. It is considered that salt production dates back from 6000 BC. Salt is the common name given to sodium chloride (NaCl), and it plays various roles in food preparation. For example, salt makes food acceptable during food processing, preserves food by retarding the growth of spoilage microorganisms, gives proper texture to foods, regulate the rate of fermentation in food processing, and strengthens gluten in bread. Sodium chloride is an essential constituent for human body functions, such as maintenance of osmotic balance in cells, transmission of nerve impulse signaling, hydration etc. (Munteanu et al., 2011).

Salt can be prepared by mining from salt deposits or by evaporation. Sea salt consists of about 98% of NaCl with remaining 2% constituted by trace elements such as iron, magnesium, sulfur, iodine, potassium, magnesium, calcium, zinc, nickel, chromium, cadmium, manganese, copper, cobalt etc. (Mohammad N. et al., 2013). Irrespective of the source of origin, there is a high probability for the occurrence of toxic substances such as heavy metals in salts. Heavy metals are required for both plants and animals in small quantities, but they are harmful when present in excessive amounts (Morris et al., 2008). Heavy metal contamination in food even at relatively low concentrations can cause adverse health effects. Since edible salt is the most used food additive worldwide, any contamination of salt could be easily spread within entire community.

Therefore, it is extremely important to know the salt quality in terms of essential and non-essential metals as it is one of the basic food items used in daily routine by all the people.

Considering the above facts, it is essential to conduct a thorough scientific research to check the occurrence and to quantify essential and non-essential metals in salt which leads to take meaningful actions to generate awareness within Sri Lankan community.

2. METHODOLOGY

Ten retail outlets of Ambalangoda were selected to collect samples. Packets of salt from different brands were randomly chosen from each of the selected retail outlets. During selection of samples, both granular form and powdered form samples were purchased from each retail outlet. From every brand of salt, two packets from one batch were purchased. In total, seventeen samples from different batches of seven brands of salt including both granular and powdered salt were analyzed. Among the selected samples, there were ten crystal samples and seven powdered samples. Sealed plastic packets of salt brands were bought in 400 g, 500 g, 900 g, and 1 kg quantities. The anonymity and confidentiality of salt brands was maintained by the use of codes during analysis of samples.

Samples were labeled and transferred to the laboratory of Industrial Technology Institute and stored in 25 ± 2 °C, without allowing expose to sunlight until analysis was completed. Corn and quartering was done to obtain a representative sample to carry out analysis.

As to SLS 79: 2014 (Food Grade Salt Granular Form) and to SLS 80: 2014 (Food Grade Salt powdered Form), moisture content was determined in salt samples by drying approximately 10 g of the sample at 140°C to 150°C for at least 4 hours.

To prevent the occurrence of contamination from the glassware, prior to sample preparation, all the volumetric flasks of 50 mL were washed by laboratory detergent, following rinsing in water, and they were soaked in 10% nitric acid overnight. Then they were rinsed with distilled water. The volumetric flasks were finally washed with 1% nitric acid and then with ultrapure water immediately just before the preparation of samples. When preparing salt samples for the analysis of metal composition, 0.5 g of salt from the homogenized samples was accurately weighed by using a calibrated analytical balance. Salt was dissolved in ultrapure water by thoroughly shaking

the glass volumetric flasks of 50 mL after stoppered. To each volumetric flask, high purity analytical grade (AristAR[®]) nitric acid was added to obtain a solution with the acid strength of 6%. Volumetric flasks of 50 mL were filled to the mark with ultrapure water. Reagent blank was prepared by using ultrapure water and high purity analytical grade (AristAR[®]) nitric acid.

Recovery study was carried out for the quality assurance of data. For that two samples of spiking solutions of 0.2mg/kg were prepared. One sample was prepared by using a known weight of AnalaR NORMAPUR grade sodium chloride and to other sample known weight was added from randomly selected granular salt sample. These solutions were spiked by the addition of 2mL from the 10 mg/kg certified reference material which consisted of multi elements. Determination of metallic elements presence in salt solutions was done by using Agilent 7900 ICPMS (High matrix introduction, Helium mode). Calculation of metal content was done on dry basis. For the preparation of calibration curve, 10 mg/kg multi element standard and a solution of 6% (V/V) nitric acid which was prepared by using high purity analytical grade (AristAR[®]) nitric acid and ultrapure water was used. The standard series which was prepared consisted of 1µg/kg, 10 µg/kg, 50 µg/kg, 100 µg/kg and 200 µg/kg. All the data were analyzed using SPSS version 17.1. One tailed T test was used for the determination of difference in levels of metals and metal profile in powdered and crystal salt samples. P < 0.05 was considered as significant differences.

3. RESULTS

The minimum detection limit for metal ions is 0.1mg/kg. All the samples, except one sample in which strontium content was lesser than 0.1mg/kg, contained a higher amount of strontium content with respect to other metals. Among the salt samples in which strontium was present, the lowest observed value for strontium was 6.13 mg/kg and the highest observed value was 45.3 mg/kg. Even

though minute in quantity, chromium was available in 14 samples out of 17 samples which were tested.

In the salt samples which were analyzed, Beryllium (Be), Cadmium (Cd), Cobalt (Co), Selenium (Se), Silver (Ag), Rubidium (Rb), Cesium (Cs), Thallium (Tl), Uranium (U), Vanadium (V), Zinc (Zn), Gallium (Ga) were lesser than 0.1mg/kg levels.

Arsenic and cadmium levels of the samples were lesser than 0.5 mg/kg and the copper content of the samples were lesser than 2.0 mg/kg respectively. Lead content of the two samples of two different brands were greater than 2mg/kg. From the samples analyzed, 41% of salt samples contained lead below 2 mg/kg. One salt sample, which was granular in nature, contained 0.4 mg/kg of mercury content. Variation of concentration of metals in salt samples that were analyzed is shown in table 01.

Table 01 –Types of metal verses variation in concentration in different brands of granular and powdered salt samples.

Type of metal	Average concentration of metal in powdered samples / (mg/kg)	Average concentration of metal in granular samples / (mg/kg)	Range of concentration / (mg/kg)
As	<0.1	0.03±0.1	<0.1 – 0.3
Cr	0.21±0.1	0.16±0.3	<0.1- 0.9
Al	1.33±2.4	2.64±5.9	<0.1- 18.7
Mn	0.54±0.7	1.41±1.9	<0.1- 4.8
Cu	0.22±0.6	0.15±0.5	<0.1- 1.6
Sr	14.94±6.9	26.23±13.8	<0.1- 45.3
Ba	3.19±5.1	3.62±4.7	<0.1-14.6
Pb	0.03±5.1	0.51±0.1	<0.1-2.5
Ni	0.41±1.1	0.35±0.8	<0.1- 2.9
Hg	<0.1	0.04±0.1	<0.1- 0.4

There is no any significant variation in between the metal contents in powdered salts and granular salts ($P > 0.05$).

In addition to that, there was no any significant variation in the metal profile in powdered salts and granular salts ($P > 0.05$).

In both spiked solutions which were prepared by using AnalAR NORMAPUR grade sodium chloride and a randomly selected sample of edible common salt, percentage of recovery was in between 80% to 120% of Aluminum (Al), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), Silver (Ag) and Vanadium (V) .. Correlation of coefficient for each and every metal was calculated. Among the metals, Arsenic and Aluminum, Arsenic and Mercury and Aluminum and Mercury consist of a correlation of coefficient closer to 1. Moreover, Chromium and Nickel and Manganese and Lead have a correlation coefficient which is closer to 0.7

4. DISCUSSION

As to SLS 79: 2014 (Food Grade Salt Granular Form) and to SLS 80: 2014 (Food Grade Salt powdered Form) maximum limits available only for Arsenic as As, Cadmium as Cd, Lead as Pb, Mercury as Hg, Copper as Cu are 0.5, 0.5, 2.0, 0.1 and 2.0 mg/kg consecutively.

Therefore, all the samples are complied with respective standards with respect to arsenic, cadmium and copper. But three samples do not comply with SLS standards for salt due to presence of higher level of lead and mercury.

ISO standards for food grade salt, granular type and crystal type or codex standards have not established maximum allowable limits for metals except for lead, cadmium, mercury and arsenic.

Out of the seventeen samples which were tested, two crystal samples of two different brands do not comply with above mentioned standards as lead

content of those samples are greater than the maximum limit (2mg/kg). Lead content may be high in salt due to sea pollution; sea water which was used in preparation of salt may contain higher concentration of lead. Moreover, salts of lead may easily precipitate along with sodium chloride. Lead accumulates in the body. Data published in literature indicates that excessive intake of lead, even in minute quantities causes harmful effects on different systems and organs such as central and peripheral nervous system, gastrointestinal tract, muscles, kidneys etc.

Cadmium accumulates in kidneys and has a long biological half-life in humans of 10–35 years. Moreover, cadmium is a well-known carcinogen. In all the samples which were analyzed, cadmium content is lesser than mg/kg level. Hence, salt seems to free from potential toxicity with respect to cadmium.

International agency for research on cancer has categorized chromium and mercury as carcinogens. One crystal sample consists of mercury which is four times higher than the maximum allowable limit for mercury by above standards. Therefore, it is important to continuously monitor the level of mercury presence in salt. It is equally important to pay attention to the level of chromium in salt as 14 samples consist of chromium. Although the level of chromium is minute, there is a high possibility to cause chronic toxicity of chromium via salt as salt is consumed in everyday by Sri Lankan consumers.

Inorganic arsenic is considered as a carcinogen which causes cancers in the skin, lungs, liver and bladder. Lower level exposure can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, and damage to blood vessels. Arsenic content in salt samples that were tested is lesser than 0.5mg/kg, and salt samples comply with SLS specifications with respect to arsenic. Therefore, salt does not act as a source of arsenic. But it is important to evaluate the quality of salt Island wide via a comprehensive

study, with respect to arsenic prior to reaching such conclusion.

The highest value of barium presented in tested samples is 14.6 mg/kg. Barium is not known to be carcinogenic or mutagenic. Short term excessive exposure can cause vomiting, abdominal cramps, diarrhea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, muscle weakness and hypertension. According to the regulatory limits which were established by United States Environmental Protection Agency for drinking water, the maximum allowable limit for barium is 2.0 parts per million (ppm). Although there is a maximum limit available for Barium to be present in water, there is no such maximum allowable limit for barium with respect to salt. It is important to evaluate the level of barium in edible salt as maximum barium concentration observed in edible salt is seven times greater than that of maximum allowable limit for barium in drinking water.

According to literature, prolonged excessive exposure of silver causes argyria, a condition in which skin and hair are heavily discolored by silver in the tissues, there is no any associated health risk of silver with respect to salt as silver is not detected in mg/kg quantities in any of the samples which were analyzed.

Since most of the samples contain a higher amount of strontium, it is important to further study about the significance of strontium content and also the concentration of radioactive strontium proportion of the edible salt. Problems with bone growth may occur in children eating or drinking unusually high levels of strontium, especially if the diet is low in calcium and protein. Radioactive strontium may cause cancer as a result of damage to the genetic material in cells. As to the agency for toxic substances and disease registry of United States department of health and human services, an increase in leukemia over time was reported in individuals in one foreign population who

consumed relatively large amounts of ^{90}Sr and other radioactive materials due to usage of river water contaminated by a nuclear weapons plant. Although the cause which makes strontium concentration to become high in salt is not clear, the reason could be that strontium may easily precipitate by forming salts along with sodium chloride. Additionally, strontium content may be high in sea water which is used for the production of salt.

Since the correlation of coefficient of Arsenic and Aluminum, Arsenic and Mercury and Aluminum and Mercury is closer to 1, it could be concluded that there is a strong correlation for the presence in salt is available within those metals. Even though the exact reason is not clear, this may be due to similar chemical properties of the cations of these metals.

As Chromium and Nickel and Manganese and Lead have a correlation closer to 0.7, it could be concluded that moderate correlation is available within these metals in salt samples.

Since percentage of recovery is in between 80% to 120% of most of the metals analyzed, it could be recommended that high matrix introduction, Helium mode of ICPMS is a good method to analyze metals in salt.

5. CONCLUSION

High matrix introduction, Helium mode of ICPMS is a good method to evaluate and quantify metals in salt. (This statement is valid if recovery studies have been done for all the metals analyzed)

It is essential to analyze salt quantitatively for the presence of heavy metals as salt is universally consumed. Although salt samples which were analyzed comply with SLS standards with respect to Cadmium, Copper and Arsenic, 17% of total samples do not comply with SLS standards for salt due to presence of higher level of lead and mercury. Therefore, it is important to assess salt quality with respect to heavy metals since salt is one of the commonly consumed ingredient every day.

Since chromium is present in most of the samples, it is important to determine the chromium content even though SLS specifications for salt have not given any upper limit for chromium.

It is important to assess the concentration of radioactive strontium level of salt as most of the samples consisted of considerably higher levels of strontium.

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