International Journal of Food Science and Nutrition
ISSN: 2455-4898, Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 2; Issue 4; July 2017; Page No. 119-124

Iodine levels of commercially available iodized edible common salt varieties in Sri Lanka and recovery of iodine after cooking

[*1] RMGB Rajanayake, [2] STN Ranwatte, [3] I Wickramasinghe, [4] WAAVS Amaradivakara

[1, 4] City Analyst's Laboratory, Public Health Department, Colombo Municipal Council, Sri Lanka
[1, 2] Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka

Abstract
Iodization of salt is an effective and sustainable approach to prevent and control iodine deficiency. Currently potassium iodate and potassium iodide used for iodine fortification of edible salt. The effectiveness of salt iodization depends on the conservation of iodine in salt at various stages of the food supply chain. Cooking loss is a major reason for the failure of control of iodine-deficiency disorders by iodized salt. This study carried out to evaluate the iodine content in commercially available iodized salt varieties in Sri Lanka and to assess the recovered amount of iodine in salt during the cooking process. Iodine content was estimated using iodometric titration. The iodine content of most of the salt varieties in the market fulfills the national regulations. Retention of iodine added via salt is high when salt added after cooking.

Keywords: iodized edible common salt, iodine content, iodometry, iodine recovery

1. Introduction

Salt is a mineral that is mainly composed of sodium chloride. Salty flavour is one of the basic tastes and salt is essential for human life in small quantities. Iodine is a trace mineral and important for essential hormone development in the human body. Fortification of iodine in salt is a physiological, simple, practicable and effective way to provide iodine for iodine deficient populations. The mixing of an iodine compound with salt is a simple operation and produces no adverse chemical reactions. The addition of iodine to salt (usually as potassium iodide or iodate) does not impart any colour, taste or odour to the salt. In fact, iodized salt is indistinguishable from unionized salt [1].

Inadequate intake of dietary iodine can lead to an enlarged thyroid gland (goiter) or other iodine deficiency disorders. Most adults require 150 micrograms iodine per day. Regular consumption of iodine is essential, because large amounts of iodine cannot be stored in the body. Pregnant and breastfeeding women need slightly more iodine as they provide total iodine requirement of their babies. Iodine found in seafood, iodized salt and some vegetables. Iodine deficiency is the world's leading cause of mental retardation in children. Excess iodine intake has also symptoms similar to iodine deficiency [2]. Commonly encountered symptoms are abnormal growth of the thyroid gland and disorders in functioning and growth of the organism as a whole.

The government of Sri Lanka has put forward special attention in this regard and has taken remarkable decisions to eliminate iodine deficiency disorders from the country. Under this, it is forbidden to sell salt without iodization. According to the Food (Iodization of Salt) regulations – 2005, the iodine (I) content of salt, on dry basis, shall be not less than 15 mg/kg of the salt and not more than 30 mg/kg of the salt.

Currently two chemical forms of iodine used for iodization of salt; iodates and iodides. A major consideration in the choice of the two compounds is the purity of the salt. Iodides degraded readily in the presence of impurities, whereas the iodates remain stable in salt of lower quality. There have been four major technologies used in the addition of iodine to salt; dry mixing, drip feed addition, spray mixing and submersion [3]. Since iodine readily sublimes at ambient temperature, the effectiveness of salt iodization depends on the stability of iodine carrier. The presence of moisture, hygroscopic impurities and metal ion impurities, such as iron, accelerate the loss of iodine.

The main objective of this study is to evaluate the iodine content of commercially available iodized edible common salt varieties and to determine the occurrence of iodine degradation in the cooking process. Studying of the fluctuation of iodine content with the cooking method and studying of the variation of iodine content after adding to specific food commodities are the specific objectives of this study.

The iodine content present in iodized salt estimated using an iodometric titration. Most of the methods for determining the iodine in iodized salt involve oxidation of the iodide to iodate, acidifying, addition of potassium iodide and titration of the liberated iodine with thiosulphate.

$$5I^- + IO_3^- + 6H^+ \longrightarrow 3I_2 + 3H_2O \quad \ldots Eq\ (1)$$

In the presence of a strong acid, iodide reacts with iodate to generate iodine, as shown in the equation Eq (1).

$$I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^- \quad \ldots Eq\ (2)$$

Liberated iodine can be titrated with thiosulphate. According to the equation Eq (2), the consumed amount of thiosulphate is proportional to the amount of free iodine liberated from the salt.

2. Materials and Method

2.1 Estimation of iodine content in iodized edible common salt

Sixteen iodized salt varieties (named as A, B, C …) selected randomly from the super markets in Colombo district and retail shops in Puttlam and Hambanthota districts. Three randomly selected salt packets of same batch purchased from each variety. Out of these sixteen varieties, three were crystal salt samples and other thirteen were fine powdered table salt samples.

2.1.1 Qualitative analysis of iodized salt

Qualitative analysis carried out to elucidate the appropriate fortification of salt with iodate. Approximately 2-3 drops of the iodine test kit (Indofarma) added to ½ teaspoon of salt and the colour change had observed.

2.1.2 Quantitative analysis - Iodometric titration

For the estimation of iodine content in iodized salt samples, iodometric titration used. Accurately about 50 g of salt sample weighed and transferred into a 250 mL volumetric flask using deionized water. The sample dissolved well and made up to the mark, and 50.00 mL aliquot of the solution pipetted out into a stoppered flask. To this solution 2 mL of 2 N sulfuric acid and 15 mL of 10% potassium iodide solution added. The flask stoppered immediately, shaken well and kept in dark for 10 minutes. The liberated iodine was titrated with 0.005 N sodium thiosulphate solution, with freshly prepared starch as an external indicator [4]. The test duplicated for each sample. A blank test carried out using 50 g of AR grade sodium chloride.

The moisture content of each salt sample was determined using the oven drying technique. Approximately about 10 g of salt sample dried at 105 ^{0}C for 2 hours and the moisture content calculated using the difference of initial and final weights of the sample.

For calculating the iodine content on dry basis, the moisture content subtracted from the weight of salt taken for the iodine Estimation. Using the equations Eq (3) and Eq (4), the iodine content of salt samples calculated on dry basis as I.

$$1\ \text{mL of } 0.005\ \text{N } Na_2S_2O_3 \equiv 0.1058\ \text{mg of iodine} \quad \ldots\ldots Eq\ (3)$$

$$\text{Iodine content of Salt as I, on dry basis (in mg/kg)} = \frac{\text{Consumed volume of } Na_2S_2O_3 \text{ in mL} \times 0.1058\ \text{mg/mL} \times 1000\ \text{g/kg} \times 250}{\text{Dry weight of the salt sample in g} \times 50\ \text{mL}} \quad \ldots Eq(4)$$

2.2 Variation of iodine content of salt with the food processing method

Three cooking procedures studied as follows;

1. Addition of iodized salt after boiling food with water
2. Addition of iodized salt before boiling food with water
3. Addition of iodized salt before boiling food with coconut milk

Eight varieties of food tested with each method of cooking.

The first cooking method tested by mixing 50 g of pre boiled food sample with 50 g of specifically identified brand of salt and keeping 10 minutes in a beaker. After 10 minutes, a solution was prepared using a minimum amount of deionized water. It was introduced into a 250 mL volumetric flask and made up to the mark. An aliquot of 50.00 mL pipetted out into a stoppered flask and the iodine content estimated using the procedure given in the section 2.1.2.

For testing, the second cooking method 50 g of food sample mixed with 50 g of salt sample and boiled using 100 mL of deionized water. The same mixed well to prepare a homogeneous solution. After reaching to the room temperature, it was introduced into a 250 mL volumetric flask and made up to the mark. An aliquot of 50.00 mL pipetted out into a stoppered flask and the iodine content estimated using the procedure given in the section 2.1.2.

The third cooking method tested by boiling 50 g of food sample with 50 g of iodized salt in 100 mL of freshly prepared coconut milk and mixing well to prepare a homogeneous solution. After reaching to the room temperature, it was introduced into a 250 mL volumetric flask and made up to the mark. An aliquot of 50.00 mL pipetted out into a stoppered flask and the iodine content estimated using the procedure given in the section 2.1.2. Each test carried out in duplicate.

A blank test performed by using 50 g of food sample and 50 g of AR grade sodium chloride for each cooking method.

Recovered iodine percentage for each cooking method calculated using the equation Eq (5).

$$\text{Recovered percentage of iodine} = \frac{\text{Iodine content recovered with the food sample}}{\text{Iodine content of used iodized salt}} \times 100 \quad \ldots Eq\ (5)$$

2.3 Variation of iodine content of salt when adding to specific food commodities

For this study, fourteen food samples selected representing several food commodities such as grains, pulses, leafy vegetables, roots, stems and fruity vegetables.

Accurately about 50 g of specific food sample measured and mixed with 5 g of iodized salt sample. After 10 minutes, a solution was prepared using a minimum amount of deionized water. It was introduced into a 250 mL volumetric flask and made up to the mark. An aliquot of 50.00 mL pipetted out into a stoppered flask and the iodine content estimated using the procedure given in the section 2.1.2.

Cabbage, potatoes, dhal, rice, beans, brinjal, bitter guard and carrot boiled with deionized water and iodized salt added after reaching to the room temperature. Snake guard and spinach blanched and then iodized salt added. Cucumber, *Gotukola*, tomato and lime mixed with iodized salt at their fresh stage.

Blank tests performed using 50 g of food item and 50 g of AR grade sodium chloride, instead of iodized salt.

2.4 Statistical analysis

Results were statistically analyzed using one-way analysis of variance (ANOVA), at 0.05 probability level with MINITAB-14 software package.

3. Results and Discussion

3.1 Estimation of iodine content in iodized edible common salt

The iodine contents of the analyzed salt varieties summarized in the Table 1.

Table 1: Iodine content of the iodized salt

No	Variety	Type	Qualitative analysis using Iodine test kit	Iodine content, on dry basis as I (mg/kg)
1	A	Powder	Violet	28
2	B	Powder	Violet	24
3	C	Powder	Violet	25
4	D	Powder	Violet	27
5	E	Powder	Violet	30
6	F	Powder	No colour change	0
7	G	Powder	Light violet	16
8	H	Powder	Light violet	15
9	I	Powder	Light violet	15
10	J	Powder	Violet	22
11	K	Powder	Dark Violet	84
12	L	Powder	Violet	15
13	M	Powder	Violet	30
14	N	Crystal	Light violet	11
15	O	Crystal	Slightly violet	8
16	P	Crystal	Violet	22

According to the results, all the studied salt varieties, except 'F' illustrated a positive result for qualitative and quantitative analysis of iodine content in iodized edible common salt. In the qualitative analysis, the intensity of colour envisages the strength of iodization. It correlated with the quantitative analytical results.

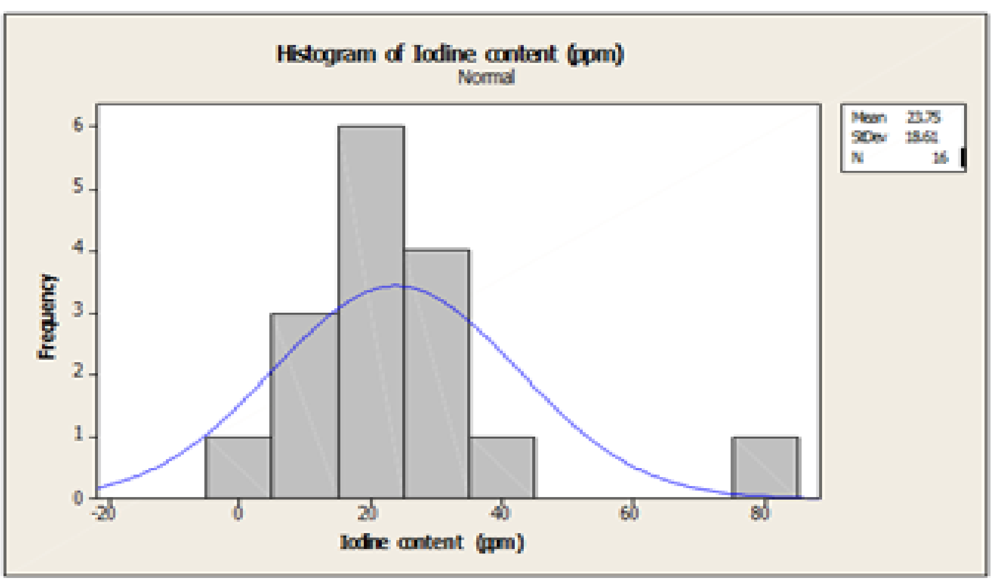

Fig 1: Distribution of iodine content in commercially available iodized salt

According to the Food (Iodization of Salt) Regulations- 2005 in Sri Lanka, the iodine (I) content of salt, on dry basis, shall be not less than 15 mg/kg of the salt and not more than 30 mg/kg of the salt. According to the study, the iodine content of the most iodized salt varieties lies within the recommended range of 15 – 30 mg/kg. However, iodine contents of some salt varieties were in both extremes. When considering the statistical analysis, the iodine content of variety 'K' is significantly higher than the maximum recommended level, while in varieties 'N' and 'O' are significantly lower than the minimum recommended level. Consumption of a high dosage of iodine may cause iodine toxicity, while the lack of monitoring of iodine nutrition can lead to iodine deficiency disorders.

To overcome both iodine Deficiency disorders and Iodine toxicity special attention should provide to monitor the method of iodization as well as homogenization. Recent research studies on urinary iodine content have shown increased levels of iodine in urine samples of studied population. This may be due to inaccurate quantification of potassium iodate during iodine fortification. Potassium iodate is an oxidizing agent and increased levels of such components could affect harmfully for human body.

3.2 Variation of iodine content of salt with the food processing method

The fluctuation of iodine content with the cooking method studied using three varieties of iodized salt, K, D and M. The selected cooking methods are the most common methods practiced among Sri Lankan population.

Table 2: Recovery percentage of iodine with the food processing method

No.	Food material	Salt variety	Recovery percentage of iodine (m/m)		
			Addition of iodized salt after boiling food with water	Addition of iodized salt before boiling food with water	Addition of iodized salt before boiling food with coconut milk
1	Cabbage	K	38	19	7
2	Potatoes	K	22	7	5
3	Beans	K	63	33	13
4	Brinjal	K	84	26	18
5	Dhal	D	76	31	14
6	Rice	D	76	37	20
7	Carrot	M	51	20	13
8	Bitter guard	M	0	0	0

According to the study, the recovery of iodine is less than 40% and 25%, when boiled with water and coconut milk respectively. The recovery of iodine is very much higher up to 84%, when adding iodized salt, after the boiled food material has come up to the room temperature. When comparing the three methods of cooking, it is clear that iodine sublimation is high with the heat treatment. The recovery of iodine, when boiling with coconut milk is much lesser than the other two methods.

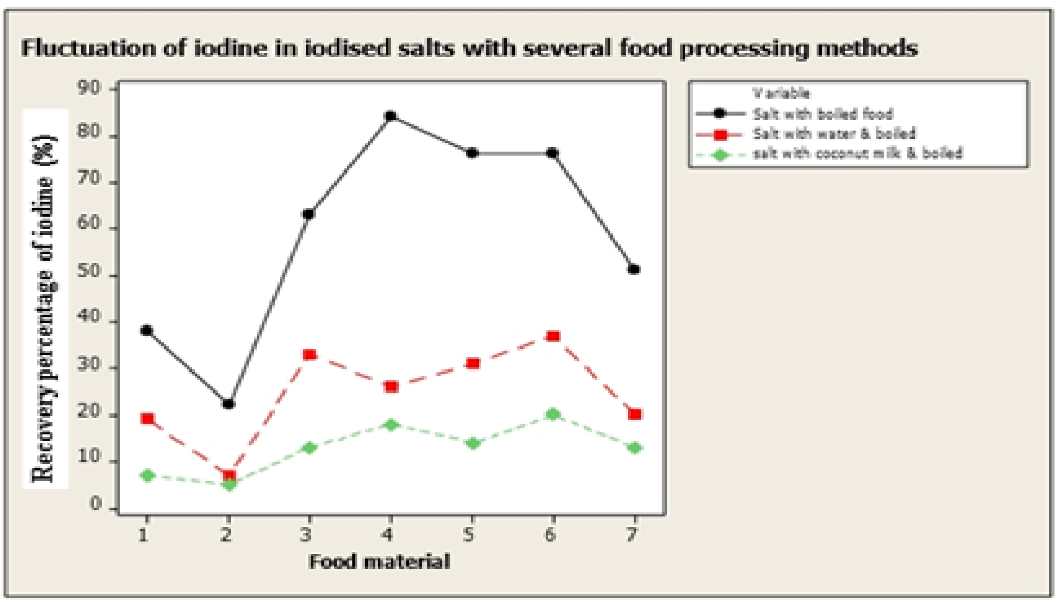

Fig 2: Variation of iodine content of salt with the food processing method

The recovery of iodine in rice is higher in second and third cooking methods, compared to other food materials. Recovery of iodine in potatoes is lesser in all three cooking methods. Food materials with high starch content illustrated a blue colour as soon as potassium iodide added. There is a contradiction of capturing all the liberated iodine from the starchy food materials as iodine trapped inside the cells, which is not accountable.

Cooking loss is a major reason for the failure of control of iodine deficiency disorders by iodized salt. Since recipes and cooking procedures vary in the different parts of the country, the time of salt addition is different and it is complicated to know the overall iodine loss during cooking.

3.3 Variation of iodine content of salt when adding to specific food commodities

The fluctuation of iodine content with the food commodities studied using three varieties of iodized salt, K, D and M. The selected food commodities are very common types among Sri Lankan population.

Table 3: Recovery percentage of iodine with the food commodity

No.	Food material	Salt variety	Recovery percentage of iodine (m/m)
1	Cabbage	K	38
2	Potatoes	K	22
3	Dhal	D	76
4	Rice	D	76
5	Beans	K	63
6	Brinjal	K	84
7	Carrot	M	51
8	Bitter guard	M	0
9	Snake guard	M	76
10	Spinach	K	52
11	Cucumber	M	92
12	*Gotukola*	K	73
13	Tomato	M	0
14	Lime	M	0

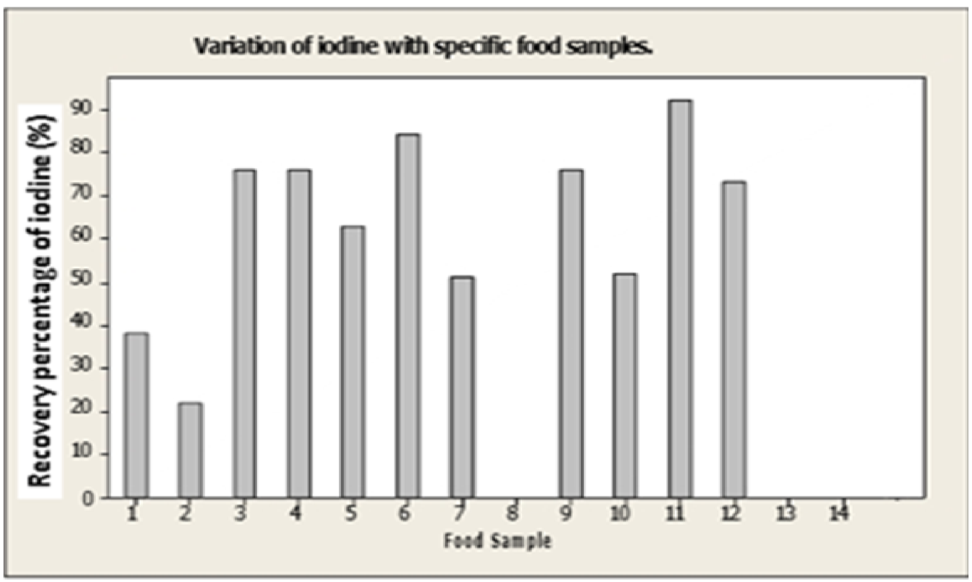

Fig 3: Variation of iodine content of salt with the food commodity

According to this study, the highest recovery of iodine observed in cucumber, which is 92%. Comparatively a high iodine recovery observed in brinjal, snake guard, rice, dhal and *Gotukola*, which is more than 70%. Cucumber and *Gotukol*a studied at their fresh stage and this may positively affect for the high recovery of iodine. There was a satisfactory recovery level in bean, carrot and spinach, which lies in between 50% and 65%. According to the results, it is clear that lime, tomato and bitter guard distroy, mask or absorb all the iodine, added with iodized salt.

It is reported that the value of dietary iodine can be reduced by vegetables from the brassica family, which includes cabbage, brussels sprouts, raw turnip, broccoli and cauliflower. This is veryfied by the study, as the recovery of iodine is relatively low with cabbage.

According to the study, it is clear that the recovery of iodine is higher when adding iodized salt for salads, instead of boiled vegetables, grains or pulses.

In this study, the recovery of iodine was estimated using 50 g of iodized salt with 50 g of the food material. However, it is not practicable to use such a high quantity of salt in our diet. The general practice is to add 1g of iodized salt into 50 g of food material to make it palatable. However, minute amount of iodine liberated from 1 g of iodized salt is hard to quantify by a titrimetric method.

Iodine found in food sources itself in minute amounts, which cannot measure quantitatively by titrimetric methods. Those trace iodine contents could be measured by spectroscopic or by radioactive methods.

4. Conclusions

According to the study, iodine content of the most iodized salt varieties available in the Sri Lankan market lies within the range of 15 – 30 mg/kg, which recommended by the national regulation. However, only few varieties have been deviated from the recommended range. According to this study, it is clear that the loss of iodine occurred due to the addition of iodized salt before cooking the food. The loss of iodine by sublimation could minimize to a significant level by adding iodized salt after the heat treatment. It is obvious that the intake of iodized salt by adding to salads such as cucumber and *Gotukola* would provide more iodine. The effect of less recovery of iodine by specific food sources such as bitter guard, lime and tomato could purge by having food with considerable recovery of iodine in the same diet.

5. References

1. Manner MGV, Dunn JT. Salt Iodization for the Elimination of Iodine Deficiency, International Council for Control of Iodine Deficiency Disorders, 1995.
2. Mason JB. Vitamins, trace minerals and other nutrients, Goldman L, Ausiello D. Cecil Medicine, 23rd edition. 2007, 1626-1639.
3. Food and Agriculture Organization, Technical consultation on food fortification: Technology and quality control report of an FAO technical meeting in Rome. 1995, 20-23.
4. SLS. Specification for Food Grade Salt (Powdered Form), Sri Lanka Standard, First Revision. 2014, 80.
5. Kelly FC. Studies on the stability of iodine compounds in iodized salt, Bull World Health Organ. 1953; 9(2):217-230.