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IODINE CONTENT IN THE MARKETED PRODUCTS OF IODIZED SALT: A DESCRIPTIVE STUDY IN SOUTHERN SRI LANKA

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ABSTRACT

Background: Monitoring of the iodization programmes is crucial not only to ensure that the salt contains sufficient amount of iodine but not excessive amounts that lead to adverse health consequences. Countries usually recommend minimum standards for the iodine content of salt at the production level, but less frequently establish standards at the consumer level. Sri Lankan standards recommended salt should have 15.0-30.0 ppm of fortified iodine at the retail level.
Objective: To assess the iodide content in crystal and table (powder) salt preparations for the human consumption in Southern Sri Lanka.

Methods: Commercially available packets of both crystal and table salt were purchased from randomly selected permanent (57 retail shops and 24 supermarkets) and temporary (8, weekly fairs) shops and analyzed for the iodine content. Information on the storage conditions, the shelf life of the samples was also recorded.

Results: There was a total of 89 packets of salt which comprising of crystal (n=30) and powder (n=59) packets belonged to 42 different brands (15 and 27 brands for crystal powder salts respectively). Over 74% of packets had one year and the remainder (26%) had 18 to 24 months of shelf life. The median iodide level of the total sample was 20.40 ppm (range 0.0 to 73.81 ppm) whereas the median iodide level of crystal salt was 18.89 ppm (range 3.70 to 73.81 ppm) and table salt was 21.63 ppm (range 0.0 to 41.24). It was revealed that 21(23.6%) packets of salt (11 crystal and 10 table salts respectively) had iodide levels below 15.0 ppm and 11(12.4%) packets of salt (4 crystal and 7 table) had iodine level above the recommended range of 30.0 ppm. Altogether 22 (52.4%) brands did not have iodine levels within the recommendations and in fact, one powder salt packet did not contain a detectable amount of iodide.

Conclusions: Establishing a precise sustainable monitoring system of salt iodization at the production level is important in maintaining iodine nutrition at the optimum level.

Key words: Iodine deficiency, salt iodization, Sri Lanka, monitoring salt iodization.

BACKGROUND

Iodine Deficiency Disorders (IDD) remains a significant public health problem throughout the world. The World Health Organization (WHO), United Nations Children's Fund (UNICEF) and International Council for Control of Iodine Deficiency Disorders (ICCCIDD) have recommended Universal Salt Iodization (USI) as a safe, cost-effective and sustainable public health strategy to ensure sufficient intake of iodine by all (1). Salt iodization is a remarkably cost-effective and on average, the one-time increase in cost is only 3-5 cents per person per year - a price so low that even consumers in the least developed countries would barely notice it (2). Two forms of iodine preparations are used for salt iodization: 'iodide' and 'iodate', usually as the potassium salt (3). Iodate is much more stable than iodide and is the preferred fortificant. Today, nearly 70% of the salt made for humans and livestock cons-umption in the world is iodized (2). UNICEF estimated that less than 20% of households in the developing world were using iodized salt in the early 1990s and this level had been increased to 70% by the year 2000 (4).

Iodine is an essential component for the production of thyroxine in the thyroid gland. Chronic iodine deficiency alters thyroid function, resulting in low circulating thyroxin concentrations leading to hypothyroidism and long-standing stimulation of the thyroid gland by the associated elevation of thyroid stimulating hormone leads to a goiter with time. Salt iodization has shown to be a successful and a cost effective way of providing daily iodine requirement of an individual. It is estimated that about 68% of households worldwide have access to iodized salt at present (5). However, sustainability of the salt iodization programmes has become a major issue for many countries with IDD (6). Though salt iodization theoretically increases the daily intake of iodine, improper storage and usage may restrict the achievement of this goal (7). As such, monitoring of IDD prevention and control programmes is crucial to ensure that iodized salt consumption is effective in reducing the deficiency while preventing excessive intake that may lead to adverse health consequences (1).

Monitoring of iodized salt program occurs at three levels: the producer, the retailer, and the consumer level. Recommendations have been made for the standards of iodine content in salt at the producer level. In 1995, the government of Sri Lanka launched "Universal Salt Iodization" (USI) programme. With the strong private-public partnership and financial and technical support from external development partners, the Ministry of Health intensified the USI. In order to legalize the implementation of salt iodization programme, the government has passed a law that regulates the production and distribution of iodized salt in the country. This was incorporated into the Food Regulation Act, which came into effect in July 1995 (8). Regulation under this act prohibited the production, distribution and sale of non-iodized salt for human and livestock consumption. The iodine content of salt at the retail level was specified to be within 25.0-50.0 ppm in 1996 in the legislation. In 2005, this law revised highlighting the minimum level of 15.0 ppm and the maximum of 30.0 ppm of iodine content in salt (9). However, the quality of the salt iodization was a matter of concern. The objective of this study was to assess the quality of the salt iodization in the South of Sri Lanka.

METHODS

The study obtained approval from the Ethical Review Committee of the Faculty of Medicine, University of Ruhuna and was carried out in Galle district of Sri Lanka. Commercially available packets of salt (both crystal and powder forms of different brands) were purchased from randomly selected permanent (57 retail shops and 24 supermarkets) and 8 temporary shops (weekly fairs) in the district. The storage conditions including exposure to the sunlight, and whether stored on the floor or on the shelves were noted. Once the packets were brought to the laboratory, they were stored in a cool dry place until analysis. The manufacturing & expiry dates were noted and the shelf life was calculated. Further, information available on the packets regarding the iodine preparation and the content were documented. Whether those products received the Sri Lanka Standards (SLS) certificate was also noted.

The salt samples were analyzed in triplicate from each packet for the measurement of iodine content using iodometric titration method recommended by WHO/UNICEF/ICCIDD (1) at the iodine contamination free laboratory of the Department of Biochemistry, Faculty of Medicine Galle, Sri Lanka. Analysis of the iodine content of the samples was carried out before the expiry date indicated in each sample. The reaction was carried out in two steps. In the first step, the liberation of free iodine was done by the addition of H_2SO_4 and excess potassium iodide (KI) was added to help solubilize the free iodine, which is quite insoluble in pure water under normal conditions. Secondly, the titration was done with sodium thiosulfate and in this step, free iodine is consumed by sodium thiosulfate. The amount of thiosulfate used was proportional to the amount of free iodine liberated from the salt. Starch was added as an external (indirect) indicator to this reaction. Starch reacted with free iodine and produced a blue colour and when added towards the end of titration (i.e. when only a trace amount of free iodine is left) the loss of blue colour, or end-point, which occurred with further titration, indicates that all remaining free iodine has been consumed by thiosulfate. The concentration of iodine in salt was calculated based on the mean titrated volume (3 burette readings) of sodium thiosulfate using the following formula.

$$\text{mg/kg (ppm) iodine} = \frac{\text{titration volume in ml} \times 21.15 \times \text{normality of sodium thiosulfate} \times 1000}{\text{salt sample weight in g}}$$

Data analysis was done using the Statistical Package for Social Science (SPSS, version -15, Chicago, USA) software. General tabulations including frequency distribution were used to describe the data. Chi-square tests and the median test were used to compare different groups/variables.

RESULTS

There were 89 salt samples comprising 30 of crystal salt and 59 of powder (table salt) belonged to 42 different brands (Table 1). From the 42 brands, 15 brands were of crystal salt and 27 brands were of powder forms. Out of these 42 brands, 25 were found in all 3 types of shops (supermarkets, retail shops, and weekly fairs). In these 25 brands, more than one sample belonged to different batches were available. From each of the other 17 brands, we were able to collect only one sample during this study period. The retail shops were the commonest source where 64% of brands were available. The presence of powder salt (66%) was more than that of crystal salt (34%) in the market. The salt packets were stored on the floor by 46% of vendors and more over exposed to sunlight in 18% of the shops. As indicated on the packets, over 74% of samples had one year of shelf life and the remainder (26%) had 18 to 24 months of shelf life.

The overall median iodide level of the total sample was 20.41 ppm (range 0.0 to 73.81) whereas the crystal salt had a median of 17.77 ppm (range 3.70 to 73.81) and powder salt had 21.15ppm (range 0.0 to 41.24). Although the median iodine level was

Table 1: Characteristics of salt usage & the type[1]

	Salt type		Chi test[2]
	crystal (n=30)	powder (n=59)	
Place of purchased			
Retailed shops	20 (22.5)	37 (41.6)	
Super markets	7 (7.9)	17 (19.1)	
Weekly fair	3 (3.4)	5 (5.6)	0.52; p=0.85
Exposure to sunlight			
Yes	7 (7.9)	10 (11.2)	
No	23 (25.8)	49 (55.1)	0.63; p= 0.47
Shelf life			
<365	22 (24.7)	53 (59.6)	
>365	8 (9.0)	6 (6.7)	4.08; p=0.04
Period of storage			
<90	18 (20.2)	34 (38.2)	
>90	12 (13.5)	25 (28.1)	0.05; p=0.83
Place of storage			
Shelf	15 (16.9)	33 (37.2)	
Floor	15 (16.9)	26 (29.1)	0.28; p=60

1results presented as n (%)
2 Chi squared test comparing groups and the one tailed p value

found within the specified range (15.0-30.0 ppm), our analysis revealed that 21(23.6%) samples (11 crystal and 10 powder salt) had iodide levels below 15.0 ppm and one powder salt sample did not even contain a detectable amount. On the other hand, 11(12.4%) samples (4 crystal and 7 powder) had iodine level above the upper limit of recommendation.

Out of the 42 different brands, 22 (52.4%) did not have the iodine levels within the recommendations and only 2 brands had obtained the standard certificate from the Sri Lanka Standard Institute i.e., SLS certification. From the total number of samples, only 64% of samples (15 crystal and 42 powder salt) had the iodine levels within the specified range.

There were 17 instances (including all 8 weekly fairs) where the salt packets were exposed to direct sunlight. The median iodide content of these samples was 19.25ppm (range 5.60 to 25.60). The iodine content in samples obtained from weekly fairs was low (median level of crystal salts was 11.32ppm (range 9.0; 18.3) and powder salts 19.25ppm (range 5.60; 25.60) respectively) when compared with samples from other permanent shops (median iodine level in crystal salt was 20.41ppm (range 3.70; 73.80) and powder salt 22.52ppm (range 0.0; 41.2) respectively.

The majority of salt producers (75 out of 89 samples) have indicated that it expired within a year of production. The iodine content in samples, which were analyzed within 3 months (90 days) of production had higher iodine content (median iodine level in crystal salt was 18.51 (range 3.7; 73.8) ppm and the powder salt was 22.79 (range 0.0; 41.24) ppm) when compared with samples stored more than 3 months (median iodine level in crystal salt was 17.34 (range 4.5; 33.1) ppm and powder salt was 20.83 (range 4.8; 36.7) ppm).

DISCUSSION

The iodine concentration recommended for salt can vary in different countries, depending on the particular climatic conditions and the dietary habits of that particular population. In Sri Lanka, the estimated per capita consumption of salt is about 15g per day (10) and the recommended iodine concentration of salt at the retail level is 15-30 ppm. Considering the expected loss in iodine through the production site to the household (20%) and due to cooking (20%) prior to salt consumption, it is expected to have a level of 55ppm at the production level (11). However, the iodine level of 36% of the samples and 52.4% of brands in the local market were not within the recommendations.

The salt producers are expected to comply with the industry and health standards recommended by the Ministry of Health. Although there were many salt producers in this part of the country (42 brands), the majority (52.4%) were not maintaining recommended industry standards and only two brands had obtained the SLS quality assurance certificate. This highlights the inadequacies in the monitoring and regulations of salt iodization process at industry levels in Sri Lanka.

Inadequate iodine content in salt could be due to defective iodization at the production level, inappropriate mixing prior to package, incorrect packaging, or deterioration of iodine in salt due to long term exposure to excessive moisture and heat, mainly in tropical and subtropical countries. A previous study in Sri Lanka has reported a varying level of iodine (5.3 to 418.0 ppm) in iodized salt at the retail level (12). Our study demonstrated that 23.6% of the salt samples had sub-optimal iodine concentration of iodine and 3 products negligible amount of iodine suggesting a significant (>50%) loss of iodine in salt from the point of production till the consumption. This shows that integrity of the salt products and the need for maintaining proper industry and marketing standards.

The iodization programme is considered to have achieved its objective when more than 90% of households consume iodized salt, containing recommended iodine concentration (13). According to a national survey, Sri Lanka achieved this goal in 2005 as it was revealed that 91.2% of households consumed iodized salt (14). However, a study done in 2010, revealed that only 69.4% of salt samples at household level contained an adequate iodine concentration (>15 ppm) in Sri Lanka (15). Our study also demonstrated a similar figure (64%) suggesting a deterioration of iodization programme over the past few years. Similar figures were demonstrated in a national survey on iodized salt consumption in Malaysia (16), where more than 90% of the households were using salt containing iodine as tested using Rapid Test Kit, only 24.7% were consuming adequately iodized salt, having an iodine level of 20-30 ppm. In contrast, 71.1% of households were consuming iodized salt at the recommended level of 15 ppm or more in a Coverage Evaluation Survey in 2009, in India (17). These data highlights the challenges face by the regional countries in achieving the goal of salt iodization.

When iodide is exposure to excess oxygen and carbon dioxide, it slowly gets oxidizes to metal carbonate and elemental iodine which then get evaporated (18). Storage beyond 2 months aggravates loss of iodine from the salt due to different environmental conditions during storage and distribution (19). This might be due to the effect of physical or environmental factors like moisture content of the salt, humidity of the atmosphere, light, heat, and weather conditions. Usage of packed salt at the household level has significantly improved the availability of iodine in iodized salt. A study conducted in Canada showed that iodine content of the salt remained constant and its distribution remained uniform for many months when the salt was packed and kept dry, preferably in a cool place and away from strong light (20). Another study done in Iraq showed that the packed salt was better iodized compared to non-packed salt (21) due to the good transportation system, storage, and keeping it in a suitable environmental condition. Our study revealed that the exposure to sunlight and storing on the floor (i.e., weekly fairs) resulted in low iodine content. It was expected that good packaging and the package itself may act as a sunlight shield. Therefore, the less iodine content of the products may be due to the defect in package as well as defective iodination at the production level.

CONCLUSIONS

A significant number of salt products in Sri Lanka do not have the recommended levels of iodine. Although iodization of salt is compulsory by law, it appears to be not well monitored and a proper monitoring system at the production level to assess iodine concentration appears important. Results emphasize the necessity of tight regulation of salt production to ensure the quality of their products. Implementation of a system to carry out regular market surveys is also important to assess the quality of the salt products at the retail level.

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