The Effect of Storage Conditions on the Levels of Iodine in Iodized Salt

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Abstract: This study determined the percentage loss of iodine from salt samples kept in different storage containers commonly used in homes in Freetown, Sierra Leone. Local salt was purified by dissolution in distilled water, concentration by evaporation on a sand bath followed by crystallization, vacuum filtration and solar drying. The purified salt was iodized in the laboratory using two methods: humid and dry mixing method. The salt was then kept in four different containers of the kinds used in most homes for storage of salt in the country. The iodine content of the salt was determined on a weekly basis and the percentage loss of iodine with time was recorded. Of the four storage containers used (yellow plastic cup, transparent mayonnaise bottle, milk tin and transparent plastic bag), the yellow plastic cup turned out to be the best as the rate of loss of iodine was least and no corrosion took place as was observed in the case of the milk tin. Moreover both method of iodization (dry and humid), show some measurable loss of iodine with the passage of time.

Keywords: iodization, iodine loss, stability, consumption, Sierra Leone

Introduction:

Iodization of salt is recognized globally as a key measure to control iodine deficiency. Sierra Leone, in its food and nutrition security policy plan 2012-2016, has set a goal to reduced iodine deficiency (ID) in school children by 20% by 2016 through universal salt iodization; she hoped to achieve this objective through increase availability of iodized salt among households (1). As the most effective and generally legislated intervention measure, policy on salt iodination has being implemented. The government of Sierra Leone has legislated that all salt imported into the country should contain a minimum of 35ppm of iodine at entry or production (1). In order to guarantee an adequate consumption of iodine from iodized salt, the concentration of iodine in salt needs to be checked at the production, distribution, marketing and household levels. This is necessary because iodine stability in salt and levels of iodization are queries of vital importance, not only to salt producers but to national planners as it will help in policy rectification and enforcement.

The problems associated with the loss of iodine from iodized salt have been reported earlier by many scholars (1-3, 4, 5-8). However such studies has never been done in Sierra Leone, thus this study is the first to address such issue. The climate in Sierra Leone is tropical and humid all year, with high temperature ranging from 17 °C (63 °F) to 41 °C (106 °F) with the average annual temperature of around 27 °C (81 °F) [2]. With these prevailing conditions of high temperature and humidity, loss of iodine from iodized salt can be severe if the salt is not properly stored between production and actual consumption. Consequently the required amount of iodine needed for complete eradication of iodine deficiency (IDD) through consumption of iodized salt would not be met.

The stability of iodine in salt is affected by many factors among which are the storage conditions of the salt, sunlight, moisture content, impurities etc. [3-6]. It is commonly observed that solutions of potassium iodide become yellow or brown with age. The brown color is due to the formation of free iodine from the decomposition of potassium iodide. This reaction, being photochemical in nature will proceed at a faster rate upon exposure of the solution to sunlight, consequently accelerating the decomposition [4-6]. Previous study reveal that a greater percentage of salt consumed in Freetown has iodine concentration less than 35ppm even though salt imported into the country by regulation should contain at list 35ppm [7].it may be inferred that the iodine concentration of salt are mostly considerably reduced before been finally consumed.

Salt is iodized by the addition of fixed concentration of potassium iodide or iodate either in the form of a dry solid or aqueous solution during production. The availability of iodine in iodized salt at the consumer level can differ over a wide range owing to the:

- Actual compound used to iodized the salt
Unevenness in the concentration of iodine within batches and individual packages;
- Quantity of iodine added in the salt during iodization,
- Iodine losses due to environmental conditions, salt impurities, moisture content and packaging conditions during storage and distribution;
- Iodine losses owing to food processing/cooking at household level.

In order to determine the approximate concentration of iodine to be used in iodization of salt for policy implementation, raising awareness of the public about the essence of consuming iodized salt and it proper handling at household level, knowledge on the losses of iodine occurring between time of iodization and consumption is essential.

The purpose of this study is to determine percentage iodine losses on weekly basis from iodized salt samples kept in different storage containers commonly used in homes, so as to evaluate the effect of storage condition on the concentration of iodine in iodized salt and to establish the most appropriate container for it storage.

Material and Method

Purification and Iodization of Local Salt:

Local salt in Sierra Leone is known to be contaminated with insoluble matter and it lacks iodine. The salt was purified by dissolution in double distilled water followed by filtration under vacuum. The filtrate containing sodium chloride and other soluble salts was concentrated by evaporation over a sand bath and the salt allowed to crystallized slowly in air. Purified salt was spread in an open and shallow wooden box and dried in the sun for five days, and was iodized in the laboratory using two methods: humid method and dry mixing. In the humid method, salt in a plastic bowl was sprayed with an aqueous solution of KIO₃ followed by hand mixing. In the dry mixing method, a premix was prepared by mixing the salt with dry KIO₃ in a ratio of 10:1. The premix was then sprinkled, by hand, over the salt in a plastic bowl followed by hand mixing. All salt samples were iodinated to 40-50ppm as recommended by WHO. Salt samples were then kept in four different closed containers of the kinds used in most homes for storage of salt. The containers were closed to prevent circulation of air in the sample as it is believed to hasten loss of iodine. The iodine content of the salt was determined on weekly basis to monitor the rate of loss of iodine from the salt.

Determination of iodine content of salt samples.

The iodine fortificant most commonly used in salt these days is potassium iodate. The method of iodine determination employed in this study therefore involved the determination of iodine produced when IO₃⁻ oxidizes excess I⁻. The I₂ produced is determined by volumetric titration with standard thiosulphate solution.

1. 50 g of salt sample was accurately weighed in a clean dry beaker. This was dissolved in boiled, double distilled water and transferred quantitatively into a 250 cm³ volumetric flask and then made up to the mark.

2. 50 cm³ of this solution was pipetted into 250 cm³ Erlenmeyer flask; 1.0 cm³ of 2.0 mol dm⁻³ H₂SO₄ was added, followed by 5.0 cm³ of 10 % KI (the solution turned yellow). The flask was stoppered and put in a dark cupboard for 10 minutes.

3. The micro burette was rinsed and filled with the 0.01024 mol dm⁻³ thiosulphate solution.

4. After the elapse of 10 minutes the Erlenmeyer flask was removed from the dark cupboard and its contents titrated with the thiosulphate solution.

5. The titration was repeated with other 50 cm³ aliquots until concordant titres were obtained. The average titer value was calculated.

6. The average titer values were then converted to iodine concentration (in ppm) of the salt samples using a standard conversion table.

Results:

Table 1 and 2 show the percentage loss of iodine in each container on a weekly basis and figures 1 and 2 represent a comparison of the rates of loss of iodine from the four different containers from salt iodinated by the two different methods. It should be noted that there is no result for week 6 for salt sample in Milk Tin container. This is so because the sample was contaminated with rust from the container as it is a metal based container.
TABLE 1: Percentage Weekly Average Loss of Iodine by Salt Iodinated Using Humid/Spray Method

<table>
<thead>
<tr>
<th>Storage Duration (Weeks)</th>
<th>Transparent Mayonaise Glass Bottle</th>
<th>Yellow Plastic Cup</th>
<th>Milk Tin</th>
<th>Transparent Plastic Bag</th>
</tr>
</thead>
<tbody>
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<td>6</td>
<td>15.8</td>
<td>10.4</td>
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TABLE 2: Percentage Weekly Average Loss of Iodine by Salt Iodinated Using Dry Method

<table>
<thead>
<tr>
<th>Storage Duration (Weeks)</th>
<th>Transparent Mayonaise Glass Bottle</th>
<th>Yellow Plastic Cup</th>
<th>Milk Tin</th>
<th>Transparent Plastic Bag</th>
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<td>6</td>
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Figure 1: comparison of the rates of loss of iodine from the four different containers for salt iodinated by the humid/spray method
Discussion:

From the data which have been given it is evident that iodized salts show considerable variation in the degree to which they retain their iodine when stored in different containers. Results show that irrespective of the container in which the iodized salt was stored and the method of iodization (dry or humid), some measurable loss of iodine was observed in all the samples with the passage of time. It should be noted that even when iodized salt is kept in the most perfect conditions, loss of iodine still occurs. Sunlight and humidity only accelerate the process. Moreover there were no stabilizers added to minimize the loss of iodine with passage of time. This suggests that in iodization of salt for the elimination of IDD, addition of stabilizer such as sodium hexametaphosphate (SHMP) is worthwhile. Study by Diosady et al. showed remarkable reduction of iodine loss from salt stabilized with SHMP [5].

The highest rate of decrease was recorded in the first few weeks of storage for iodized salt stored in yellow plastic cups and milk tins (10.2% iodine loss for salt iodinated by humid/spray method and 7.6% for salt iodinated by the dry method) compared with the percentage loss from the transparent plastic bag (11.3% iodine loss for salt iodinated by humid/spray method and 10.3% for salt iodinated by the dry method) and transparent recycled mayonnaise bottle (accounting for 10.5% iodine loss for salt iodinated by humid/spray method and 11.7% for salt iodinated by the dry method) compared with the percentage loss from the yellow plastic cup (7.3% iodine loss for salt iodinated by humid/spray method and 8.9% for salt iodinated by the dry method) and the recycled milk tin (10.2% iodine loss for salt iodinated by humid/spray method and 7.6% for salt iodinated by the dry method). This difference in rate of loss of iodine can be explained in terms of the chemical process in which IO$_3^-$ is broken down into I$_2$ and subsequently lost physically by evaporation. The decomposition of IO$_3^-$ is accelerated by light and, to some extent, the moisture content of the salt [8].

For all salt samples (salt iodinated by both the dry and humid methods), the average percentage loss of iodine was higher in the transparent plastic bag (accounting for 11.3% iodine loss for salt iodinated by humid/spray method and 10.3% for salt iodinated by the dry method) and transparent recycled mayonnaise bottle (accounting for 10.5% iodine loss for salt iodinated by humid/spray method and 11.7% for salt iodinated by the dry method) compared with the percentage loss from the yellow plastic cup (7.3% iodine loss for salt iodinated by humid/spray method and 8.9% for salt iodinated by the dry method) and the recycled milk tin (10.2% iodine loss for salt iodinated by humid/spray method and 7.6% for salt iodinated by the dry method). This difference in rate of loss of iodine can be explained in terms of the chemical process in which IO$_3^-$ is broken down into I$_2$ and subsequently lost physically by evaporation. The process is photochemical and the rate increases with increase in light intensity. In the case of the yellow plastic cup and milk tin the salt samples were completely cut off from light. However a major disadvantage of the use of the milk tin as a
Storage container is that it tends to rust and contaminate the salt, as a result of increase moisture absorption which also has a negative effect on the iodine content of the salt. The yellow plastic cup and the milk tin provides a strong barrier against light, it should have been expected that they should have lost iodine at the same rate. But this is not the case here as the milk tin has a greater percentage loss of iodine than the yellow plastic cup, see figures 1 and 2. There is evident that the rate of moisture penetration in the milk tin was higher as the nature of the lid is one which cannot be tightly closed once it has been open. This is why milk tins are mostly sealed first with aluminum foil before closing with the lid to prevent moisture absorption and retention. The effect of moisture, high humidity and sunlight on the loss of iodine has been studied by many scholars [12-14]. All these studies came up with the finding. That moisture, high humidity and sunlight hasten the loss of iodine from salt. Iodine retention in three types of iodised salt (powdered salt, white crystal and brown crystal salt) was assessed at 15 days interval using common storage containers (glass jar with lid, plastic jar with lid, earthenware pot with lid, cut open salt packet etc.) by Jayashree et al, 2000 [13]. Lowest percentage loss of iodine irrespective of type of salt was noticed in intact salt packet (2.18%) [13]. This was so because the intact salt packet was able to prevent the salt from most of the factors such as moisture, light etc. affecting salt iodate content.

**Conclusion:**
Storage of salt in an effective moisture and light barrier container such as colored polymeric containers (yellow plastic cup), leads to significant reduction in iodine losses. The results indicate that, better storage, is critical to the stability of iodine in salt. The loss of iodine in the salt samples established that the actual iodine available in salt varies from the point of production to the end user. Duration of storage and choice of storage container greatly affects the iodine levels in salts. Rate of loss of iodine was found to be faster in the case of the transparent mayonnaise bottle and transparent plastic bag as compared to the yellow plastic cup and milk tin. This is a pointer to the possible photochemical nature of the process involved in the loss of iodine. Of the four storage containers used in the study, the yellow plastic cup turned out to be the best as the rate of loss of iodine was least and no corrosion took place as was observed in the case of the milk tin. Moreover both methods of iodization (dry or humid), show some measurable loss of iodine with the passage of time.

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