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Research Article

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Study of the effect of storage conditions on stability of iodine in iodized table salt

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ABSTRACT

Iodine is a key regulator of the body's basic metabolic activity and insufficiency of this micronutrient can lead to goiter as well as physical and mental disorder in both adults and children. Iodine deficiency is the world's most prevalent, yet easily preventable, cause of brain damage. The addition of a small, constant amount of iodine to the salt that people consume daily is all that is needed. The main aim of this study was to compare storage conditions effects on iodine content in different commercial iodized table salt products available in local market and as a secondary goal to study the stability of the most two common compounds of iodine used in salt iodization around the world in different storage conditions. The highest loss from original iodine content from iodized salt with either iodate or iodide occurred from storage in exposure to sunlight followed by storage in humidity, while storage in Perfect conditions in opaque, impermeable container at opaque lockers away from light and humidity showed greater iodine stability. Potassium iodate *showed more stability than potassium* iodide *under Accelerated (sunlight and humidity) and long - term stability* conditions *(Perfect storage conditions away from light and humidity). Iodine loss percentage was reduced in case of iodate to 30.07%, 26.67%, and 16.17% in the mentioned storage conditions whereas in case of iodization with iodide the percentage was 52.5%, 47.5% and 35%.*

Key words: iodized salt, table salt, iodine stability, potassium iodide, potassium iodate.

INTRODUCTION

Iodine is one of the most essential trace elements for human life. Although very small amount of iodine is required by the human body ,but it has a critical role as a key component of thyroid hormones T3, or triiodothyronine, and T4, or thyroxine with iodine involving 65% and 59% of their weights, respectively. These hormones are responsible for many of the metabolic and biochemical reactions in the body, including those responsible for the mental and physical growth. [(1)]

Inadequate production of thyroid hormones caused by Iodine deficiency called iodine-deficiency disorders (IDD) can cause enlargement of the thyroid gland, also known as goiter. When iodine deficiency is severe, endemic goiter and cretinism, mental retardation, decreased fertility rate, increased infant mortality and other serious problems can occur.[(2)(3)(4)]Iodine requirements are increased 50% during pregnancy. Iodine deficiency during pregnancy can cause maternal and fetal hypothyroidism and impair neurological development of the fetus.[(5)(6)(2)]

Yet iodine deficiency still considers the most common cause of preventable mental impairment worldwide. [(7)]

Recognizing the importance of preventing IDD, the World Health assembly adopted in 1991 the goal of eliminating iodine deficiency as a public health problem and in 1993 World Health Organization WHO and the United Nations International Children's Emergency Fund UNICEF officially have recommended universal salt iodization (USI) as the main and most cost- effective strategy to control IDD. [(7)]

WHO/UNICEF/ICCIDD (International Council for Control of Iodine Deficiency Disorders) recommends that iodine is added at a concentration of 20–40 mg iodine per kg salt, dependent on local salt intake. [7][8] Iodine can be added to salt in the form of potassium iodide or potassium iodate. Because potassium iodate has higher stability than does potassium iodide in the presence of salt impurities, humidity, and porous packaging ,it is the recommended form in tropical countries and those with low-grade salt.[1][7]The purpose of the present work was to assess the stability of iodine content in table salt.

EXPERIMENTAL SECTION

The effect of both light and moisture in the stability of iodine in iodized salt where studied on Three different commercial iodized table salt products **A**, **B** and **C** were purchased from supermarket in Syria.

Accelerated and long-term stability conditions have been applied on 36 samples of iodized table salt with potassium iodate. All containers have been preserved at room temperature 25ºC ± 2 and divided into four equal groups as follows:

Group **1** stored in transparent impermeable container exposed to sunlight , group **2** stored in opaque impermeable container exposed to sunlight and group **3** stored in opaque open container exposed to high humidity, while group **4** stored in optimal storage conditions in opaque, impermeable container in opaque lockers away from light and humidity.

All containers stored for six month. Iodine content from each product has been determined monthly using

iodometric titration.
The reaction mechanism includes two steps:
1. Liberation of free iodine from salt.
2. Titration of free iodine with thiosulfate in presence of starch as an external indicator. [7]
The research was conducted between November 2013 to April 2014 at the laboratory of the department of Analytical and Food Chemistry, University of Damascus.

●SOLVANT & CHEMICALS:
Sodium thiosulfate
Sulfuric acid
Potassium iodide
Ultra-pure water was used for the experiments.

●MEASURMENT OF IODINE CONTENT:
■The iodine content of iodized salt with potassium iodate samples was measured using an iodometric titration. At first salt should be thoroughly mixed to ensure that the iodine is homogeneously distributed in the salt. 10g iodized salt is weighted and dissolved in 50ml distilled water. Once the salt is dissolved in the measured amount of water, sulfuric acid 2N(1–2 ml) and potassium iodide 10% (5 ml) is added to the salt solution, which in the presence of iodine will turn yellow. The reaction mixture is then kept in a dark place for 5 to 10 minutes to reach the optimal reaction time, before titrated with sodium thiosulfate using starch (2 ml) as indirect indicator. The concentration of iodine in salt is calculated based on the titrated volume of Sodium thiosulfate according to the formula mentioned below:[9] [10]

mg/kg (ppm) iodine = titration volume in ml x 21.15 x normality of sodium thiosulfate x 1000 / salt sample weight in g.

■while the iodine content in iodized salt with iodate determined using an iodometric titration; iodine content in iodized salt with iodide measured according to British pharmacopeia titration as follow:
Once the salt is dissolved in the measured amount of water, add 40 ml of hydrochloric acid to 20 ml of the solution then titrate with 0.05M potassium iodate until the color change from red to yellow. Add 5mlchloroform and continue titration, shaking vigorously until chloroform layer is decolorized.

RESULTS AND DISCUSSION

The main focus of the present study was iodine stability determination in iodized salts with potassium iodate or iodide. Iodine content in table salt brands A, B, and C which iodized with potassium iodate measured before storage were (39.13 , 43.36 & 49.7) ppm ,respectively. In total, 36 salt samples were analyzed, three samples from each

stored brand in four different conditions were measured and the average titrated volume has been taken. The procedure repeated again every month for six months. Results were as following:

Table (1) Iodine concentration (PPM) in iodized table salt with potassium iodate A after stored for six months

Time (days)	Accelerated stability conditions			Long-term stability condition
	Transparent impermeable container exposed to sunlight	Opaque impermeable container exposed to sunlight	Opaque open container exposed to high humidity.	Opaque, impermeable container in opaque lockers away from light and humidity.
0	39.13	39.13	39.13	39.13
25	35.95	37.01	34.89	38.07
56	32.78	33.84	33.84	35.95
84	31.73	32.78	30.67	34.89
109	29.61	31.73	29.61	34.89
140	28.55	29.61	27.49	33.84
171	25.26	27.49	26.44	32.78

Table (2) Iodine concentration (PPM) in iodized table salt with potassium iodate B after stored for six months

Time (days)	Accelerated stability conditions			Long-term stability condition
	Transparent impermeable container exposed to sunlight	Opaque impermeable container exposed to sunlight	Opaque open container exposed to high humidity.	Opaque, impermeable container in opaque lockers away from light and humidity.
0	43.36	43.36	43.36	43.36
25	39.13	41.24	38.07	42.3
56	37.01	38.07	37.01	40.19
84	35.96	37.01	35.96	38.07
109	33.84	35.96	34.89	37.01
140	32.78	34.89	34.89	35.95
171	30.67	33.84	32.87	34.89

Table (3) Iodine concentration (PPM) in iodized table salt with potassium iodate C after stored for six months

Time (days)	Accelerated stability conditions			Long-term stability condition
	Transparent impermeable container exposed to sunlight	Opaque impermeable container exposed to sunlight	Opaque open container exposed to high humidity.	Opaque, impermeable container in opaque lockers away from light and humidity.
0	49.7	49.7	49.7	49.7
25	46.53	47.59	45.47	48.65
56	44.41	45.47	43.35	47.59
84	42.3	43.36	41.24	45.47
109	40.19	41.24	40.19	45.47
140	39.13	40.19	38.07	44.41
171	37.01	40.19	38.07	43.35

So iodine loss percentage from iodized table salt with potassium iodate after stored for six months in accelerated and long term stability conditions was:

Table (4) iodine loss percentage from iodized table salt with potassium iodate after stored for six months

salt	Transparent impermeable container exposed to sunlight	Opaque impermeable container exposed to sunlight	Opaque open container exposed to high humidity	Opaque, impermeable container in opaque lockers away from light and humidity
A	35.4%	29.7%	32.4%	16.2%
B	29.3%	22%	24.2%	19.5%
C	25.5%	19%	23.4%	12.8%
Average	**30.07%**	**23.57%**	**26.67%**	**16.17%**

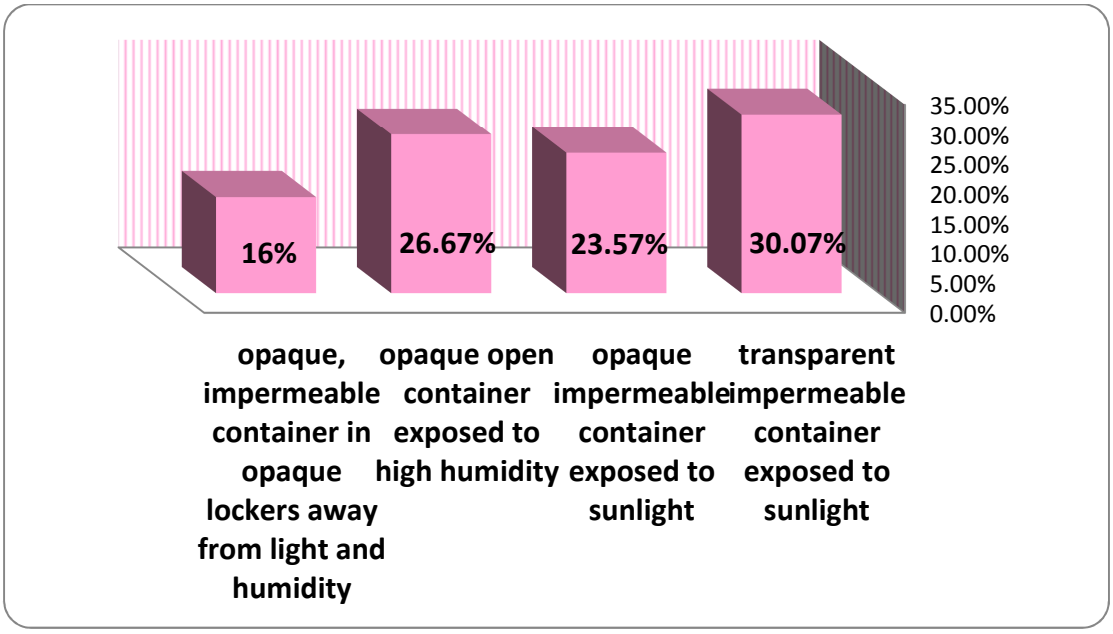

Figure (1) Storage condition effect on iodine loss percentage in table salt iodized with potassium iodate after six months

The second aim from the present work was to compare the stability of the most two common compounds of iodine used in salt iodization around the world in different storage conditions which are iodate and iodide.

Considering the use of potassium iodide is not available for salt fortification in many countries, iodized salt with potassium iodide was prepared manually.

Iodine content in iodized salt with potassium iodide measured before storage was (0.65) PPM after adding 0.65g potassium iodide to 1 kg of non-iodized salt. The procedure repeated again every month for six months. Results were as following:

Table (5) potassium iodide concentration (PPM) in iodized table salt with potassium iodide after stored for six months

Time (days)	Accelerated stability conditions			long-term stability condition
	transparent impermeable container exposed to sunlight	opaque impermeable container exposed to sunlight	Opaque open container exposed to high humidity.	Opaque, impermeable container in opaque lockers away from light and humidity.
0	0.65	0.65	0.65	0.65
25	0.581	0.6142	0.5976	0.6308
56	0.5146	0.5644	0.5478	0.5976
84	0.4482	0.5312	0.4814	0.5644
109	0.3984	0.4648	0.4316	0.5146
140	0.3486	0.4316	0.3818	0.4648
171	0.3154	0.3818	0.3486	0.4316

So iodine loss percentage from iodized salt with potassium iodide under storage conditions was**:**

Table (6) iodine loss percentage from iodized table salt with potassium iodide after stored for six months

transparent impermeable container exposed to sunlight	opaque impermeable container exposed to sunlight	opaque open container exposed to high humidity	opaque, impermeable container in opaque lockers away from light and humidity
52.5%	**42.5%**	**47.5%**	**35%**

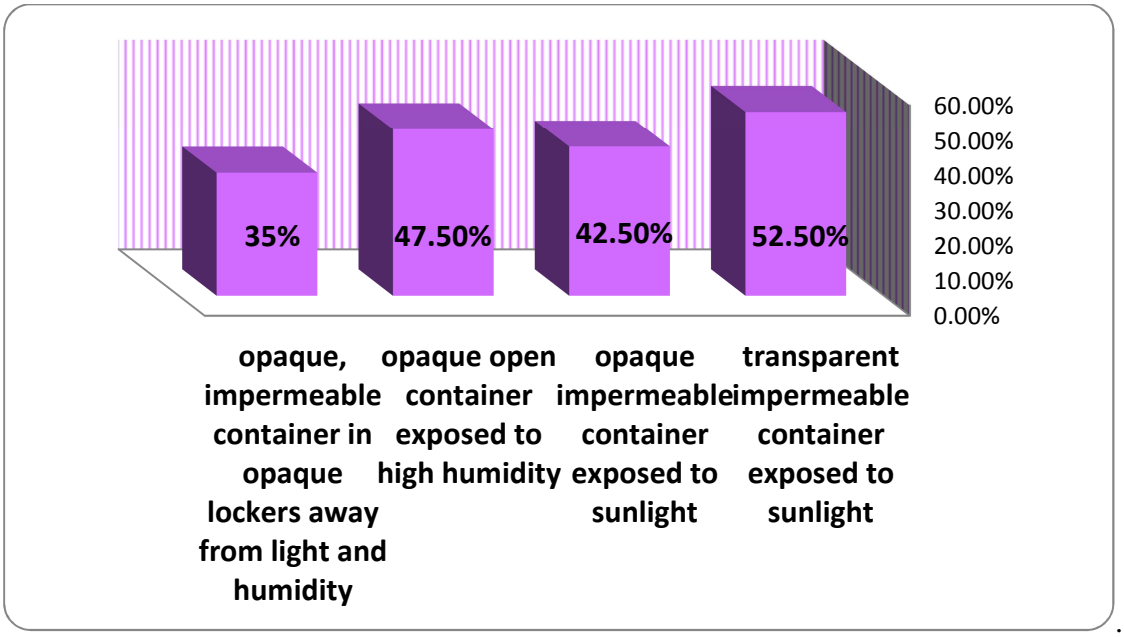

Figure (2) Storage condition effect on iodine loss percentage in table salt iodized with potassium iodide after six months

As stability comparing between of the most two common compounds of iodine used in salt iodization in same storage conditions we find:

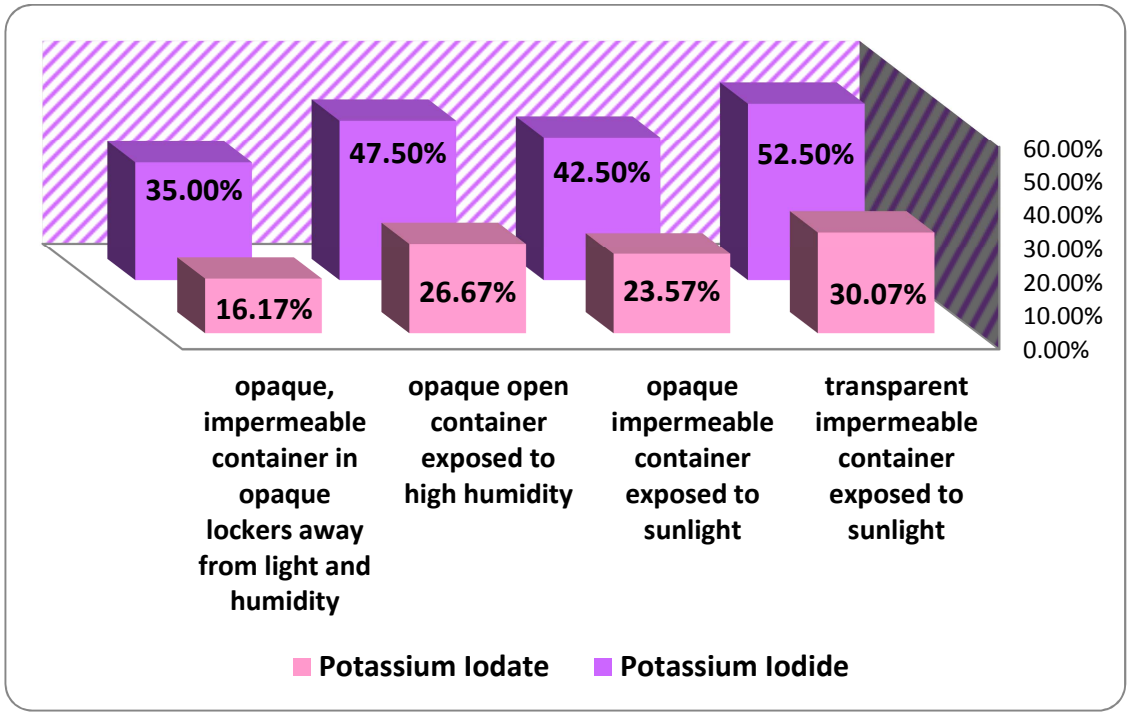

Figure (3) Iodine content loss percentage from iodized salt with potassium iodate and iodide respectively after six months

The purpose of this study was to assess the effects of storage conditions on the stability of iodine in iodized table salt products which fortified with potassium iodate or iodide.

Length and choice of storage greatly affects the iodine levels in salts.

Among the three selected Accelerated stability conditions, the effect of sunlight in particular showed the highest loss in iodine levels from the original iodine content in iodized salt with iodate (30.07%)or iodide (52.5%) followed by

high humidity which resulted in considerable loss of iodine content (ranging from 26.67% in case of iodate to 47.5% with iodide).

The perfect storage conditions whereas iodized salt preserved away from sunlight exposure and high humidity reduces the amount of iodine loss and showed greater iodine stability (16.17% in case of iodate and 35% with iodide).

In the stability compartment of the most two common compounds of iodine used in salt iodization iodate and iodide; potassium iodate showed more stability than potassium iodide under both accelerated and long – term stability conditions.

These results Coincided with the following studies:

●A comprehensive review of the literature by Kelly (1953) concluded that the stability of iodine in salt is determined by (i) the moisture content of the salt and the humidity of the atmosphere (ii) light, (iii) heat (iv) impurities in the salt (v) alkalinity or acidity (vi) the form in which the iodine is present. He concluded that the iodine content will remain relatively constant if the salt is packed dry with an impervious lining, and kept dry, cool, and away from light.[(11)]

●Diosady L.L. and his colleagues (1997) studied the stability of iodine in iodized table salt and found that moisture plays critical role in the stability of iodine.[(12)]

●In a later study Laar C and K.B. Pelig-Ba (2013) found the Salts storage greatly affects the iodine levels in salts be it iodated or noniodated. [(13)]

CONCLUSION

In this study, we evaluated storage conditions effects on iodine loss in iodized salt products which iodized with potassium iodate or iodide. Our results showed that storage condition had noticeably effect on iodine content stability, and to ensure the effectiveness of local salt iodization programs we should determine iodine losses from iodized salt under local conditions of packaging and storage.

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