International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-7, Issue-3, March 2017

Iodine Stability in Commercial Salt Brands in Nigeria

Emmanuel J. Ekott, Ubong I. Etukudo

Abstract— **Inadequate supply of iodine in human diet has been the major causes of some public health disorders. Potassium iodate (KIO3) is the chemical form of iodine mostly added to edible salts to complement the amount gotten through diet to prevent iodine deficiency disorders. The effect of varied elevated temperatures (28 OC, 35 OC, 40 OC, 50 OC, 55OC, and 60 OC) on the stability of potassium iodate has been assessed. The studied salts brands are: Dangote salt, Mr. Chef salt and Royal salt; produced and initially fortified with 50ppm KIO3 in Nigeria. 10g of each salt brand sample was placed in different crucible and heated in an electric oven at desired temperature for 20minutes, followed by iodometric titration. The volume of sodium thiosulphate (Na2S2O3) solution consumed by the salts solution determined their iodine contents and stability. At 40 OC only 20.13% of iodine was lost by Dangote salt, therefore, it is of greater stability than Mr. Chef Salt and Royal salt that rapidly lost 36.50% and 100% of iodine respectively. This indicates that the stability of iodate varies among different salt brands. Because iodine readily sublimes and diffuses from salt with increased environmental temperature, it may decrease below 30ppm minimum bench mark stipulated by World Health Organization (WHO) to control the problems of Iodine deficiency disorders; hence, edible salts should be adequately fortified and properly preserved during transportation, storage and during use.**

Index Terms— **Iodine Stability, Salt, Potassium iodate, temperature**

I. INTRODUCTION

Iodine is an important micronutrient required by every human for good health and well-being because it ensures normal thyroid function, growth and general development. The World Health Organization (1996) informed that inadequate intake of iodine in diet has been linked to wide range of adverse health effects, commonly referred to as iodine deficiency disorders (IDDs), such as: poor mental and physical development in children and goiter in adults (Hassanien et al, 2003). Natural dietary sources of iodine are milk, vegetables, fruits, cereals, eggs, meat, spinach, and sea foods (Zimmermann, 2009); because iodine from these sources is of less concentration and not in bioavailable form, they are usually not sufficient to supply the daily requirements especially in pregnant women (Bourre and Paquotte, 2008).

Delange et al (2002) added that more than half of the world's population receives less iodine than required for developing and maintaining good health through the normal diet. The daily iodine intake by an individual is estimated by Khurana (2006) to be 500µg; daily physiological requirement by an adult is 150µg; 200µg during pregnancy and lactation period; and 40µg during neonatal period. Approximately 120µg compounds of iodine are taken up by the thyroid gland for the synthesis of thyroid hormones, which regulate some metabolic processes within the body (Pal, 2007).

Emmanuel J. Ekott, Department of Chemistry, Heritage Polytechnic, Eket, Nigeria
Ubong I. Etukudo, Department of Chemistry, Heritage Polytechnic, Eket, Nigeria

Adequate iodine intake is provided by consumption of iodized salt. Potassium iodide (KI) and potassium iodate (KIO_3) are compounds of iodine used for salt fortification because of their good iodine availability and low cost. The compounds are added either as a dry solid or an aqueous solution during production or import. Potassium iodate is preferred to potassium iodide in tropical climates due to better resistance to oxidation and stability (May et al, 1990). Also, several international organizations such as the WHO and the United Nations children's fund (UNICEF) recommend the use of potassium iodate, especially in developing countries where the salts being iodized are mostly crude, unprocessed and usually not sufficiently dried.

Diosady et el, (1998) described salt to be an excellent carrier for iodine, because it is consumed at relatively constant, well-definable levels by all people within a society, independently of socio-economic status; Probably because it is relatively cheap and adds taste to meal. However, iodized salts lose part of their iodine content by sublimation and diffusion to the environment before it is consumed. This loss is facilitated by impurities present in the salt, material used for salt packaging; environmental conditions during storage and distribution, food processing, washing, and cooking processes in the household.

Diosady et al (1998) also identified other reasons for changes in iodine levels from edible salts available to consumers to include: uneven iodine quantities added to salt during production, uneven iodine distribution within the salt batches or individual bags produced due to improper mixing, losses during transportation, selling in retail, during storage and meal preparation.

Also, light, heat; impurities in the salt, alkalinity or acidity, the chemical form in which the iodine is present, the moisture content of the salt and the humidity of the atmosphere are factors that also affect the stability of salt iodine. In 1996, the world health organization(WHO), UNICEF, and the international council for the control of iodine deficiency disorders (ICCIDD) admitted that salt loses iodine easily, as 20% of salt iodine is lost from production to a household, and another 20% is lost during cooking prior to consumption.

Bruchertseifer et al. (2003) considers the determination of iodate in salt samples as an important exercise since of the amount of iodate in the salt samples vary with environmental conditions, the nature of transport, packing conditions, and cooking methods.

May *et al* (1990) opined that Potassium iodate is more stable than Potassium iodide because the latter is usually easily oxidized to elemental iodine in the presence of oxidizing agents like oxygen, moisture and metal ions catalysts. Hence, addition of iodine to salt alongside a reducing agent such as dextrose, and a desiccant or anti-caking agent is necessary to mitigate iodine losses from edible salts.

Potassium iodide can be reduced to elemental iodine by a variety of reducing agents in salt. Moisture naturally present in salt or abstracted from the air by hygroscopic impurities such as magnesium chloride acts as the reaction medium for the decomposition of added iodate.

As in most chemical reactions, elevated temperature increases the rates of the reactions that form elemental iodine and increases the rate of evaporation of iodine from salt (Diosady et al, (1998)

Materials commonly used for packaging salt for bulk sales include paper, high density polyethylene (HDPE) of 0.15 mm thickness and low density polyethylene (LDPE) of 0.07mm thickness, other materials are woven bags made of jute, straw or high density polyethylene. The woven bags have the advantage of not absorbing water and providing a better mechanical protection for salts, because of its higher tensile strength as it is made of longer molecular chains; however, the bags allow free flow of air and water to readily penetrate to the salt (Diosady et al, (1998).

There are several analytical methods available for measuring iodine levels in salt and biological samples including urine, serum and milk. While some of these techniques are not easily applicable-because they are expensive and lack sufficient sensitivity and accuracy- they also require a high level of specialization (Gupta et al, 2011).

Most laboratories prefer the iodometric titration, as a method of choice, to measure levels of iodine because of its accuracy, relative ease to use and incurs low cost (*Jooste and Strydom*, 2010**)**. Iodometric titration involves liberation of free iodine from salt and titrating the iodine with sodium thiosulphate using starch solution as an external indicator. Iodometric titration is however time consuming and requires a trained technician and wet reagents hence, is not recommended for routine monitoring purposes. The rapid test kit (RTK), on the other hand, is for qualitative measurements. It is the most common method used to measure coverage of iodized salt in household surveys because it is affordable, easy to operate and can give immediate results to health inspectors during field spot checks *(Diosady and Mannar*, 2000).

II. MATERIALS AND METHODS

The salt samples used for this study are three different brands of salts commonly sold and consumed in Nigeria, they include: Dangote salt, Mr. Cheff salt and Royal Salt. This study aimed to assess the effect of varied high temperatures on iodine stabilities of branded table salts claimed to be initially fortified with 50ppm potassium iodate (KIO_3) during production and packed using polyethylene packaging materials by their manufacturers.

The salts were collected weekly, within two months (august and September) immediately after production and transported to the laboratory for analysis. The iodine contents of the salt samples were measured using modified iodometric titration described by Jooste and Strydom (2010**)**. The chemical and reagents used were pure and of analytical grade. They include: Sodium Thiosulphate ($Na_2S_2O_3$), Potassium iodide (KI), concentrated hydrochloric acid (HCl), sulphuric acid (H_2SO_4), starch indicator solution and distilled water.

Firstly, the salts were analyzed at room temperature (28^{O}C) and then at different elevated temperatures of 35 ^{O}C, 40 ^{O}C, 50 ^{O}C, 55^{O}C, and 60 ^{O}C. All heating were done using a portable electric heating oven. 10g of salt sample was weighed using electronic balance and transferred into a 250ml conical (Erlenmeyer) flask. 30mL distilled water was added to the flask and swirled to dissolve salt sample completely, more water was added to make volume up to 50mL. To liberate free iodine from the dissolved salt sample 1mL of freshly prepared H_2SO_4 was added. Because the liberated free iodine is insoluble in pure water, 5mL of 10% KI was added to the flask to help solubilize the free iodine as shown in equation 1.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O \quad [1]$$

The solution turned yellow indicating the presence of iodine in the salt. The flask was immediately Stoppered and put in a dark drawer for at least 10 minutes before titration. This was done to avoid any photochemical reaction that could cause iodide ions to be oxidized to iodine when the solution is exposed to light.

A titration set-up was put in place and with the aid of a clean glass funnel, 0.005M $Na_2S_20_3$ was transferred into the clean burette and its level adjusted to zero. The flask was removed from drawer, and some $Na_2S_20_3$ added from the titration burette until the solution turned pale yellow.

Few drop of approximately 2mL starch indicator solution was added; this produced a dark-purple color complex with iodine. Further titration continued until the solution became pink and finally colorless. The reaction mechanism in the titration steps is as shown in equation 2 thus:

$$2Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6 \quad [2]$$

For concordant values the salt sample was prepared and titration repeated thrice for three separate portions of the salt. The average volume of sodium thiosulfate ($Na_2S_2O_3$) consumed by each salt portion was recorded and presented in table1.The corresponding iodine concentration in ppm calculated from equation 3 derived by Srivastava (2006) thus:

$$Iodine\,(ppm) = \frac{(R \times 100 \times 1000 \times 0.127 \times N)}{6}$$

Where R = Average volume of $Na_2S_2O_3$, 100 is to convert the reading for 1000g of salt, 1000 is to convert gram of iodine to milligram of iodine, 0.127 is the weight of iodine equivalent to 1ml of normal thiosulphate solution, N is normality of thiosulphate solution (which is 0.005N); and 6 is to arrive at the value that corresponds to 1 atom of iodine liberated.

III. RESULTS AND DISCUSSION

The result of the study is presented in tables 1 and 2. At room temperature (28^{O}C) an initial iodine concentration of 50.37ppm, 46.04ppm and 10.58ppm was recorded for Dangote salt, Mr. Chef salt and Royal salt brands respectively. The initial iodine contents of the salts differ among the three brands, and also from the salt manufacturers' claims of 50ppm. These differences may be attributed to inadequate salt fortification with iodate, sublimation due to iodine instability, salt storage temperature and salt storage materials.

Table 1: Iodine levels in Salt brands at various temperatures.

Temperature ($\pm 1\ ^{O}C$)	**Dangote salt**		**Mr. Chef salt**		**Royal salt**	
	Average volume of ($Na_2S_2O_3$) consumed (cm^3)	**Iodine level (ppm)**	**Average volume of ($Na_2S_2O_3$) consumed (cm^3)**	**Iodine level (ppm)**	**Average volume of ($Na_2S_2O_3$) consumed (cm^3)**	**Iodine level (ppm)**
28	4.76	50.37	4.35	46.04	1.00	10.58
35	4.50	47.63	4.00	42.33	0.70	7.41
40	3.80	40.23	3.00	31.75	0.00	0.00
45	2.50	26.46	1.70	17.99	0.00	0.00
50	1.60	16.93	0.60	6.35	0.0	0.00
55	0.50	5.29	0.00	0.00	0.0	0.00
60	0.00	0.00	0.00	0.00	0.0	0.00

Table 2: % Iodine levels lost from Salt brands at various temperatures

Temperature ($\pm 1\ ^{O}C$)	**Dangote salt**		**Mr. Chef salt**		**Royal salt**	
	Iodine level (ppm)	**Iodine lost (%)**	**Iodine level (ppm)**	**Iodine lost (%)**	**Iodine level (ppm)**	**Iodine lost (%)**
28	50.37	0.00	46.04	7.92	10.58	78.84
35	47.63	5.44	42.33	15.34	7.41	85.18
40	40.23	20.13	31.75	36.50	0.00	100
45	26.46	47.47	17.99	64.02	0.00	-
50	16.93	66.39	6.35	87.3	0.00	-
55	5.29	89.50	0.00	100	0.00	-
60	0.00	100	0.00	-	0.00	-

Packaging materials used for Dangote salt and Mr. Chef Salt are small moisture proof polyethylene transparent bags, whereas Royal salts are packed in larger woven wool bags. The salt brands, in most cases, are exposed-to high temperature sunlight and without covering at retail sale shops in the open markets. This exposure to air and high temperature sunlight facilitates the sublimation and loss of iodine from the salts.

As temperature increased gradually a gradual but negligible loss of iodine from Dangote salt was observed. At $40^{O}C$ the iodine level of Dangote salt was 40.23ppm. However, table 2 shows that at $45^{O}C$ Dangote salt lost 50% of its initial iodine as the iodine concentration at that temperature dropped to 26.46ppm, which is below 30ppm iodine level for table salt set by the Standard Organization of Nigeria (SON) and World Health Organization (1996) to prevent iodine deficiency disorders in Nigeria.

Unlike Dangote salt, Mr. Chef and Royal salts loss their iodine at a rapid rate. At $40^{O}C$ the iodine level of Mr. Chef Salt was 31.75ppm but lost 36.50% of its initial iodine, whereas the iodine of Royal salt sublimed completely losing 100% of its iodine; Similarly, Dangote and Mr. Chef Salts lost 100% of iodine at increased temperature of $60^{O}C$. This result implies that iodized salt samples lose iodine when subjected to high temperature, and the rate of sublimation varies among different salt brands. Dangote salt is of greater iodate stability among the three salt brands studied; this may depend on the technique used for binding iodate and salt.

IV. CONCLUSION

In this study, the effect of temperature on the stability of iodine in typical salt brands produced in Nigeria has been investigated. Iodometric titration technique was used for analysis first at room temperature ($28^{O}C$), then at elevated temperatures of 35 ^{O}C, 40 ^{O}C, 50 ^{O}C, $55^{O}C$, and 60 ^{O}C.

High iodine concentration indicates greater iodate stability in salt. At room temperature Dangote, salt, Mr. Chef Salt and Royal Salts had 50.37ppm, 46.04ppm and 10.58ppm iodine levels respectively. High temperature resulted in rapid loss of iodine from Mr. Chef and Royal salts but a gradual iodine loss was noted for Dangote salt iodized with potassium iodate.

This implies that iodate in Dangote salt is of greater stability than the iodate of Mr. Chef Salt. The iodate of Royal salt is highly unstable because the salt lost all of its iodine at $40^{O}C$. Dangote salt and Mr. Chef Salts are ideal as edible salts since they are adequately fortified with iodine; but at elevated temperature beyond $45^{O}C$ they also lose valuable amount of iodine.

The findings from this study indicate that salt iodine is highly unstable at high temperature; in order to ensure that adequate iodine is consumed salt iodine testing as well as proper fortification of edible salts with iodate should be done. Also, salts should be preserved in a dry place at low storage temperature or away from direct sunlight during storage, transportation and at sales point to prevent iodine loss.

REFERENCES

[1] Bourre, J.M and Paquotte, P. (2008): Seafood (wild and farmed) for the elderly: contribution to the dietary intakes of iodine, selenium, DHA and vitamins B12 and D. *J. Nutritional Health Aging.*12 (3):186-92.
[2] Bruchertseifer, H., Cripps, R., Guentay, S. and *Jaeckel B.* (2003): Analysis of iodine species in aqueous solutions. Journal of Analytical and Bioanalytical Chemistry, 375(8):1107–1110.
[3] Delange F., Burgi H., Chenz Z. P and Dunn J. T. (2002): World Status of monitoring IDD control program. Mary Ann. Liebert Inc. 10(12):915 – 924.
[4] Diosady, L.L; Alberti, J.O; Venkatesh, M; and Fitzgerald, S (1998): Stability of Iodine in Iodized Salt used for Correction of Iodine-deficiency disorders II. Food and Nutrition Bulletin. 19 (3). The United Nations University.
[5] Dr. Srivastava, K. R. (2006) Revised Policy Guidelines On National Iodine DeficiencyDisorders Control Programme.
[6] Gupta, M; Pillai, A K V; Singh, A; Jain, A and Verma, K (2011): Salt-assisted liquid–liquid microextraction for the determination of iodine in table salt by high-performance liquid chromatography-diode array detection. *Food Chem.* 124(4):1741-1746.
[7] Hassanien, M.H; Hussein, L.A; Robinson, E.N and Preston Mercer L (2003): Human iodine requirements determined by the saturation kinetics model. Journal of Nutritional Biochemistry. 14(5):280-7.
[8] Jooste, P.L and Strydom, E. (2010): Methods for determination of iodine in urine and salt. Best Pract Res Clin Endocrinol Metab.; 24(1):77–88.
[9] Khurana I. (2006): Textbook of Medical Physiology; Endocrinal System India: Reed Elsevier. Pages: 710–715.
[10] May, W; Wu, D; Eastman, C; Bourdoux, Pand Maberly G. (1990): Evaluation of automated urinary iodine methods: problems of interfering substances identified. Journal of Clinical Chemistry. 36(6):865-9.
[11] Pal, G.K (2007): Textbook of Medical Physiology; Endocrine Physiology. India: Ahuja Publishing House.
[12] Sullivan, K. M; Houston, R; Gorstein, J and Cervinskas, J. (1995): *Monitoring universal salt iodization programs.* Atlanta, GA: Program Against Micronutrient Malnutrition.
[13] WHO/UNICEF/ICCIDD (1996): Recommended Iodine Levels in Salt and Guidelines for
[14] Monitoring their Adequacy and Effectiveness. WHO/NUT/96.13.
[15] Zimmermann, M.B (2009): Iodine deficiency. Endocrine Review, 30(4): 376–408.