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Amplification Titrimetric Determination of Iodine in Edible Salts Found in Local Markets in Ogun State, Nigeria

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ABSTRACT

The iodine value of randomly selected edible salts sold in local markets in Ogun State, Nigeria has been investigated using the classical amplification titrimetric method in which potassium iodide is used to amplify the concentration of iodine for effective quantitation and the results show clearly the disparity between the branded and unbranded samples. Five samples of each grade; branded and unbranded were analyzed by amplification method and results show that the iodine content of the branded edible salts range from 11.420 mg/100g to 13.96 mg/100g showing a deviation from RDA of 1.04 mg/100g to 3.58 mg/100g on the other hand, the unbranded edible salts showed iodine content in the range of 3.81 mg/100g to 7.62 mg/100g showing a deviation from RDA of 7.38 mg/100g to 11.19 mg/100g. This result clearly show the inadequacy of the locally processed edible salts and the need to fortify them with iodine to reduce the health risk associated with iodine deficiency in individuals residing in the rural areas where the access to iodized table salts may be low. The attendant health risk in consuming higher amounts of these edible salts in rural areas where access to iodized salts are often low so as to narrow the deviation from RDA may be fatal in individuals with high blood electrolyte and chronic hypertension.

Keywords : Iodate, amplification, salt, goiter, titrimetric, thyroid.

I. INTRODUCTION

Iodine, discovered by Bernard Courtois in 1811 is a rare element in the earth's crust being the 47th in relative abundance. It is a halogen and the fourth in the row of the highly electronegative p-block elements. Iodine is an essential micronutrient in human growth, Mary, Karachalacherevu and Natesan, (2011) and an essential component of thyroid hormones that is triiodothyronne (T3) and tetra iodothyronine (T4), Ahmad, Panthari, Gupta and Chandra (2012). It has an atomic mass unit 126.9g and forms an essential component of the hormones produced by the thyroid gland, Zimmermann, (2009). The World Health Organization recommendation for adequate daily iodine intake of 150 µg per day for a full grown man and non-pregnant women, non lactating women, 250 µg per day for pregnant and lactating women and a daily intake of iodine of 90 µg for children below school age (0-59 months) and 120 µg for school children (6-12 years) World Health Organization, (2007). It is expected that a population of people within a locality meet this standard iodine requirement. However, when these physiological requirements are not met in such a given population, a series of functional and developmental abnormalities grouped under the general heading of iodine deficiency disorders or IDD occur, Hetzel, (1983). Since 1991, elimination of Iodine deficiency disorders has been an integral part of many national dietary strategies, Zimmermann, Jooste and Pandav, (2008) and as such, salt iodization remains the most cost effective pathway of tackling the iodine needs of iodine-deficient populations, Engle and Black, (2007).

Iodine exists as a diatomic molecule like other halogens with a I↔I bond length of 270 nm, one the longest single bonds ever known. It has only one stable isotope (iodine - 127) whereas others are radioactive. The molecule tend to interact via the weak van der Waal or London forces and this interaction is responsible for high melting point compared to other halogens that are more compact and also diatomic (Wells, 1984). Since the atomic size of iodine is longer, the melting point is higher as the solid crystallizes as orthorhombic crystals. The crystal motif in the Hermann – Mauguin notation is Cm Ca (No 64), the Pearson symbol is oS8 being the bond dissociation energy, Wells, (1984). Elemental iodine readily dissolves in most organic solvents such as

hexane or chloroform owing to its lack of polarity but is only slightly soluble in water. However, the solubility in water can be increased by the addition of potassium iodide. Molecular iodine reacts reversibly with the negative ion generating the triiodine anion I_3^- in equilibrium which is also soluble in water. This is also the formulation as applies to some types of medicinal (antiseptic) iodine although iodine tincture is obtained by classically dissolving the elemental iodine in aqueous ethanol. The colour of solutions of elemental iodine change according to the polarity of the solvent. In non-polar solvents like hexane, the solution is violet. In moderately polar solutions like dichloromethane, the solution is dark crimson whereas in strongly polar solvents like acetone or ethanol, it appears orange or brown. This effect is as a result of formation of adducts, Maekawa, Shun-Ichiro and Nobuyuki, (2006). Iodine melts at a relatively low temperature of 113.7 °C. Iodine is an essential trace element for life and the heaviest element apart from tungsten that is commonly needed by living organisms. Thyroxines are iodine– containing hormones that make it very imperative for the wide use of iodine based or fortified cooking salts. Its main function in animals is as a constituent of thyroid hormone – thyroxine (T4) and triiodothyroxine (T3). All these hormones are made from the addition condensation products of amino acid tyrosine and are stored prior to release in an iodine–containing protein thyroglobulin, Lowe and Cunningham, (1991). Iodine can be used in clandestine synthetic application for instance, in US, the Drug Enforcement Agency (DEA) regards iodine and compounds containing iodine (ionic iodides, iodoform, ethyl iodide and so on) as reagents useful for the clandestine manufacture of methamphetamine, Jossefsson, Grunditz, Ohlsson and Ekblad, (2002). Thyroid hormones are phylogenetically very old molecules synthesized by most multicellular organisms and that even have some effects on some unicellular organisms.

Thyroid hormones play a basic role in biology acting on gene transcription to regulate the basal metabolic rate. The total deficiency of thyroid hormones can reduce basal metabolic rate up to 50%, while in excessive production of thyroid hormone; the basal metabolic rate can be increased by up to 100%, Lowe et al, (1991). T4 acts largely as a precursor to T3 which is the biologically active hormone. Iodine accounts for about 65% of the observed molecular weight of T4 and about 59% of the T3. Between 15 - 20 mg of iodine is concentrated in the thyroid tissue and the hormones but 70% of the body's iodine content is distributed in other tissues including the mammary glands, eyes, gastric mucosa in the intestines as well as the cervix and the salivary glands. Iodine enters directly in the cell of the tissue by sodium – iodine – symporter (NIS).The role of iodine in the mammary tissue is related to the fetal and neonatal development. The role in other human tissues is yet not well understood. Iodine deficiency is the leading cause of brain damage and mental retardation in the world. In addition to mental retardation, iodine deficiency causes endemic goiter, cretinism, dwarfism, mental retardation, muscular disorders, spontaneous abortions, sterilization, and stillbirths, Verma and Raghuvanshi, (2001).

There is an apparent sensitivity to iodine developed by some individuals when they are exposed to it. A tincture of iodine applied to the skin mar cause rashes while in some cases chemical burn has been observed in Betadine (a combination of Povidone and Iodine). Urticaria (Hives) can be caused by eating too much of iodine containing foods. Medical uses of iodine can cause anaphylactic shock in highly iodine sensitive patients. This is an extreme allergic reaction to an antigen to which the body has become hypersensitive following an earlier exposure. Some cases of iodine sensitivity can be formally classified as iodine allergies. The case of iodine allergies is often rare to find but their effects are considerably dangerous given the extremely widespread use of iodine based Contrast Media, McNeil, (2006). Edible salts often referred to as *"salts"* is an active flavor enhancer comprising primarily of sodium chloride and is one of the commonly eaten minerals by human beings, McNeil, (2006). In some places in Nigeria especially in the South eastern part, it exist an ore mineral *"rock salt"* in salt dooms mainly as an outcrop as well as *"salt water"* as in salt lakes. It comes to the market in so many forms as *"unrefined", "refined"* and *"iodized".* The iodization of table salt is however a feasible, inexpensive and highly effective means of getting rid of endemic goiter and other iodine deficiency disorders that have enjoyed adoption by humans in over 50 countries.

The International Council for the Control of Iodine Deficiency Disorders (ICCIDD) and the World Health Organization (WHO) has been actively supporting the extension of iodization to other countries especially where goiter still persists as a public health problem. Often times, in order to also eliminate iron deficiency at the same time, a double fortification becomes an ideal way of achieving the goal.

The iodine content of edible salts in household and retail levels before and after the introduction of the universal iodization legislation in Lesotho has been monitored, Sebotsa and Adjei, (2002). An iodometric titration method was used in analyzing the iodine content of the salt samples which gave mean values of 37 ppm in the range of 29 ppm to 48 ppm and from 31 ppm to 45 ppm in the different district examined. These values however improved dramatically after 2 years of the iodization legislation. In another development, the iodine content of selected table salts was determined spectrophotometrically at two well – defined UV absorption maxima: 288 nm and 352 nm after their conversion to I_3^- by reacting with iodine in the presence of phosphoric acid, Rosa, Fernando and Almeida, (1998). The results obtained from the spectrophotometric method compared favourably with the iodometric method. The amount of iodine in edible salts in quite little for any meaningful classical quantitation. Amplification however becomes a pathway to increase the concentration so as to ease the quantitation.

This investigation aimed at comparing the iodine content of various edible salts found in local market including the unbranded ones so as to ascertain to what extent they conform to the RDA for iodine in table salts.

II. Materials and Methods

Five branded (iodized) and five unbranded (locally processed) samples were obtained from local market in Igbesa, Ogun State Nigeria and labeled A1, A2, A3, A4 and A5; B1, B2, B3, B4 and B5 respectively. The iodine content of the salts especially the unbranded will be too low for any significant determination by titrimetric method but by careful introduction of an accurately determined concentration of potassium iodide to supply the iodine, a quantitative estimation can be carried out with appreciable accuracy. Each 5.0 g sample was dissolved in 50 mls of distilled and deionized water in a 100 ml conical flask. 5.0 ml of 1.0 M potassium iodide (KI) was carefully introduced into the conical flasks with stirring to each sample including the blank. This concentration of iodine in the potassium iodide amplifies the iodine content in the edible salt solutions. 5.0 drops of freshly prepared starch solution was added to each solution followed by 10.0 mls of bromine water. The blank was treated in like manner. 20.0 mls of sample solutions including the blank were abstracted and titrated against 0.50 M $Na_2S_2O_3$ to the first endpoint of gave blue – black colouration and then to the final end point of yellow colouration which completely disappeared shortly leaving behind a colourless solution. The iodine value was calculated as: iodine value

$$\textbf{(IV)} = \frac{\{\text{blank titre} - \text{sample titre}\} \times M\,(Na_2S_2O_3) \times 12.690}{\text{Weight of Sample}}$$

III. Result

Sample ID	Titre Value (cm^3)	Iodine Value (mg)	Iodine Value (mg/100g)	Deviation from RDI (mg/100g)
A1	4.40	0.698	13.960	1.04
A2	4.45	0.635	12.700	2.30
A3	4.50	0.571	11.420	3.58
A4	4.45	0.635	12.700	2.30
A5	4.55	0.628	12.560	2.44
B1	4.70	0.317	6.340	8.66
B2	4.80	0.190	3.810	11.19
B3	4.75	0.254	5.076	9.92
B4	4.65	0.381	7.620	7.38
B5	4.70	0.317	6.340	8.66

Blank = 4.95 cm^3 RDI for adults above 18 years = 15mg/100g

Individual	RDI µg	UIL µg	RDI mg/100g
Infants < 12 months	110	130	11.00 – 13.00
Little Children8 – 13 years	90	-	9.00
Adults Above 18 years	150	1,110	15.00 - 110.
Pregnant women	220		22.000
Lactating mothers	290	-	29.00

Courtesy: (Lyday et al, 2000). RDI: Required Daily Intake

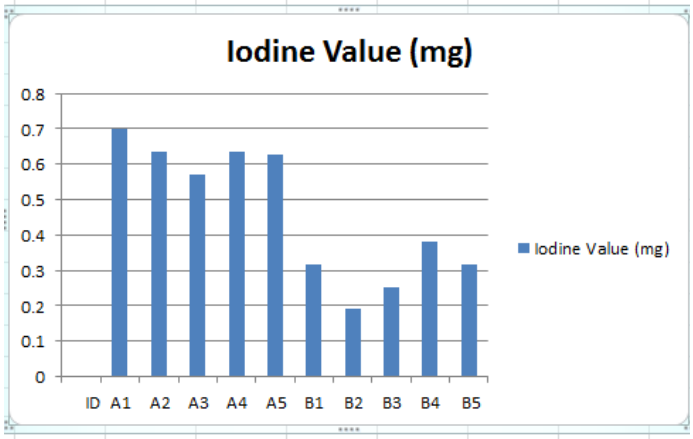

Figure 1. Histogram showing the iodine value for branded and unbranded able salt (mg)

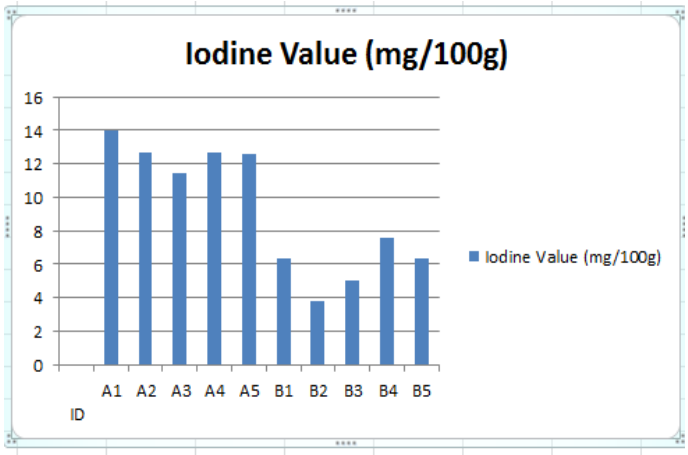

Figure 2. Histogram showing the iodine value for branded and unbranded table salt (mg/100g)

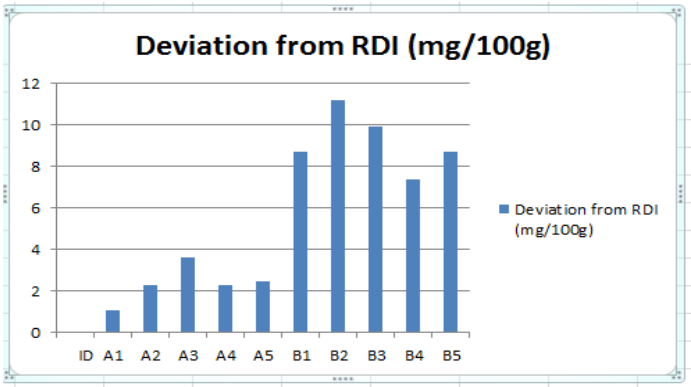

Fig. 3. Histogram showing the iodine value deviations from RDI for branded and unbranded salt (mg/100g)

IV. Discussion

The causes, prevention and cure of cretinism and goiter, which now include in the more general term iodine deficiency disorders (IDD), have been known and monitored for more than half a century; yet their total eradication remains elusive. It is obvious to our knowledge now that iodine deficiency causes broad based and irreversible effects on growth and development of foetus, neonate and child, particularly the brain justifying that a higher priority need be placed on its prevention and control now than ever before. However, results of this study that the iodine content of the selected branded edible salts range from 11.420 mg/100g to 13.96 mg/100g showing a relatively low deviation from RDA of 1.04 mg/100g to 3.58 mg/100g, while on the other hand, the unbranded edible salts showed iodine content in the range of 3.81 mg/100g to 7.62 mg/100g showing a wide deviation from RDA of 7.38 mg/100g to 11.19 mg/100g. This result clearly show the inadequacy of the locally processed edible salts which ordinarily is have limited iodine to sustain good mental and physiological development and the need to fortify them with iodine to reduce the health risk associated with iodine deficiency in individuals especially those residing in the rural areas where the access to iodized table salts may be outside the reach of the poor class or may not be deemed necessary.

Apart from diminishing the toll in human misery, the prevention of IDD would mean improved educability of children, greater productivity, and better quality of life for many millions living in the iodine-deficient regions of the world; it is now clear that iodine deficiency is a major impediment to human development, Hetzel (1993).

It becomes very necessary to educate the people within the rural areas of the immense benefits of consuming iodized table salts.

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