Study on the Stability of Iodine Content in Commercial Iodized Salt in Sudan

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Dedication

To my parents and brothers …

To my friends and colleagues…

To all who encourage and push for tenacity ring in my ears…

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I would like to express my deeply sincere thanks to my supervisor Dr. Mohammed Osman Babiker for his invaluable help and constant encouragement. I am most grateful for his teaching and useful advices.

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Abstract

Iodine deficiency disorders are recognized as a major global public health Problem. Iodine is a key regulator of the body's basic metabolic activity and insufficiency of this micronutrient can lead to enlargement of the thyroid gland (goiter) as well as physical and mental disorders in both adults and children. it is possible to root out this problem by universal salt iodization. (WHO) and International Council for Control of Iodine Deficiency Disorders (ICCIDD) recommend that the amount of added iodine should be 20-40 mg/kg of salt. iodine readily sublimes at high temperatures, iodate is typically used due to its better resistance to oxidation. The aim of this study was to determine iodine concentration in iodized salt and its stability under different storage conditions. Four samples of iodized salt(three of which were collected from the market of Hassahissa (1.Alrashed , 2. Riyadh and Zad) and the fourth sample was prepared in the local laboratory) were subjected to storage in the laboratory cupboard and exposure to direct sunlight for several days . An iodometric titration method was used for analyzing the iodine content of the salt samples. The Initial iodine(mg/kg) for all Samples were (17.20, 37.48, 56.88, 38.81) Respectively, these results showed high and low levels of iodine, with some values closer to the reported values indicated on the labels. The Initial iodine obtained from the analysis for sample two and sample four was very close to that of the value on the label while those of sample one and sample three were quite different from that on the labels. The actual availability of iodine from iodated salt at the consumer level can vary widely due to a number of factors, including the variability in the amount of iodine added during production and storage. All samples retained the iodine content after storage in laboratory cupboards for five weeks, except sample four which showed a decrease in iodine content after five weeks. All the salts after the exposure to sun light decreased in iodine concentration during the period of storage. The losses do not occur readily when salt samples are stored in cool, dry and dark places away from direct sunlight. It is recommended that to encourage and support the production of iodized salt, raise of the quality control standards procedures and storage the salt under appropriate conditions.

دراسة عن ثبات محتوي اليود في الملح التجاري المعالج باليود في السودان

آمنة علم الدين حسن عبد المجيد

ملخص الدراسة

الاضطرابات الناجمة عن نقص اليود تمثل مشكلة عالميه كبرى للصحة العامة. اليود هو المنظم الرئيسي للنشاط الايضى في الجسم ونقصه قد يؤدى إلي تضخم الغدة الدرقية(جويتر) وكذلك الاضطرابات الجسدية والعقلية في كل من البالغين والأطفال. فمن الممكن القضاء على هذه المشكلة عن طريق إضافة اليود إلي الملح. منظمة الصحة العالمية والمجلس الدولي لمكافحه اضطرابات عوز اليود توصى أن كمية اليود المضافة يجب أن تكون 40-20 ملجم/ كجم من الملح. اليود يتبخر بسهولة في درجات الحرارة العالية وعادة ما تستخدم الايودات نظرا لمقاومتها العالية للأكسدة. الهدف من هذه الدراسة تحديد تركيز اليود في الملح المعالج باليود وثبات اليود في ظل ظروف التخزين المختلفة مثل خزانة المختبر والتعرض لأشعه الشمس المباشرة لعدة أيام.تم جمع أربعة عينات من الملح المعالج , ثلاثة منها تم جمعها من سوق الحصاحيصا (1. الرشيد ,2. الرياض و زاد) وحضرت العينة الرابعة في المختبر. تم استخدام طريقة المعايرة الأيودومترية لتحديد محتوى اليود في عينات الملح. وكانت نسبة اليود الابتدائية (ملجم / كجم) لجميع العينات (17.20 ,37.48 ,56.88 ,38.80) علي التوالي وأظهرت هذه النتائج مستويات عالية ومنخفضة من اليود مع بعض القيم أقرب إلي القيم المذكورة في الديباجة . نسبة اليود الابتدائية التي تم الحصول عليها من تحليل العينتين الثانية والرابعة قريبة جدا من القيم علي الديباجة بينما العينتين الأولي والثالثة أظهرت قيم مختلفة تماما. وهذا الاختلاف يعزى لعدة أسباب منها الاختلاف في كمية اليود المضاف وظروف التخزين. جميع العينات احتفظت بمحتوي اليود بعد التخزين في خزائن المختبر لمدة خمس أسابيع ما عدا العينة الرابعة والتي انخفض تركيز اليود فيها . وانخفض تركيز اليود في جميع العينات بعد التعرض لأشعة الشمس خلال فترة التخزين. ونلاحظ أن الخسائر لا تحدث بسهولة عندما يتم تخزين عينات الملح المعالج باليود في أماكن باردة وجافة ومظلمة بعيدا عن أشعة الشمس. أوصت الدراسة بتشجيع ودعم إنتاج الملح المعالج باليود, ورفع معايير إجراءات مراقبة الجودة وحفظ الملح تحت الظروف المناسبة.

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CHAPTER ONE

INTRODDDUCTION AND LITERATURE REVIEW

1.1 Introduction:

Iodine is an element that is needed for the production of thyroid hormone. The body does not make iodine, so it is an essential part of your diet. If we do not have enough iodine in our body, we cannot make enough thyroid hormone. (American Thyroid Association, 2007).

Iodine deficiency affects humans at every stage of life and leads to several severe disorders. Iodine deficiency is the leading cause of brain damage, enlargement of the thyroid hypothyroidism, mental retardation in infants and children whose mothers were iodine deficient during pregnancy, endemic goiter, cretinism, dwarfism, muscular disorders, spontaneous abortions, and stillbirths (Verma and Raghuvanshi, 2001).

In the 1990s, 1.6 billion people, one third of the world's population, was at risk for iodine deficiency disorders (IDD), Universal Salt Iodization (USI), the primary strategy to prevent IDD, was adopted in 1993. In 1998, nearly 60% of world's edible salt was iodized and there was a significant decrease in number of children born at risk of IDD. By 2000, 70% of households in developing countries used iodized salt (Kiwanis, 2000).

UNICEF has declared that 85 million children will be born free of iodine deficiency disorders (IDD) this year. Because of the global effort to wipe out IDD it is now estimated that more than 70% of the world has access to iodized salt, the most practical vehicle for providing iodine in the diet (Kiwanis, 2011).

Universal salt iodization is the recommended intervention for preventing and correcting iodine deficiency .In the past, recommendations for iodine levels in salt were made on the assumption that, from producer to consumer, iodine losses from iodized salt were commonly between 25% and 50%, and that average salt intakes were commonly between 5 and 10 g/person/day. Substantial experience has been gained in the last decade in implementing universal salt iodization and assessing its impact on iodine deficiency disorders (IDD). A major achievement is the spectacular reduction of IDD in countries that have implemented universal salt iodization (Geneva, 1994).

1.2 literature review:

1.2.1 Iodine:

Iodine is a non-metallic, dark-gray/purple-black, lustrous, solid element. Iodine is the most electropositive halogen and the least reactive of the halogens even if it can still form compounds with many elements. Iodine sublime easily on heating to give a purple vapour. Iodine dissolves in some solvents, such as carbon tetrachloride and it is only slightly soluble in water.

http://www.lenntech.com/periodic/elements

Table (1-1): physical properties

Atomic number	53
Atomic mass	126.904 g.mol -1
Electro negativity according to Pauling	2.5
Density	4.93 g.cm-3 at 20°C
Melting point	114°C
Boiling point	184°C
Vanderwaals radius	0.177 nm
Ionic radius	0.216 nm (-1) ; 0.05 nm (+7)
Isotopes	15
Electronic shell	[Kr] 4d10 5s25p5
Energy of first ionization	1008.7 kJ.mol -1
Standard potential	+ 0.58 V (I2/ I-)
Discovered	Bernard Courtois in 1811

http://www.lenntech.com/periodic/elements

1.2.2 Sources:

Iodine is found in the form of iodides in seawater and in the seaweeds which absorb the compounds. The element is found in Chilean saltpeter and nitrate-bearing earth (caliche), brackish waters from salt wells and oil wells, and in brines from old sea deposits. Ultrapure iodine may be prepared by reacting potassium iodide with copper sulfate.

Table (1-2): Iodine content of common foods:

Food	Iodine content (µg per 100g)
Oysters	160
Sushi (containing seaweed)	92
Tinned salmon	60
Bread (made with iodized salt)	46
Steamed snapper	40
Cheddar cheese	23
Eggs	22
Ice cream	21
Chocolate milk	20
Flavoured Yoghurt	16
Regular milk	13
Tinned tuna	10
Bread (without iodized salt)	3
Beef, pork, lamb	<1.5
Tap water (varies depending on site)	0.5-20.0
Apples, oranges, grapes, bananas	<0.5

1.2.3 Uses:

One of the most important uses of iodine is prevention of thyroid problems as iodine is a vital mineral for our body which is necessary for the synthesis of thyroid hormones. Iodine, in form of silver iodide is used in photography. Here, are some more uses of iodine related to the human body, medical uses and some other uses.

1.Radiation Exposure:

Potassium iodine has been used to help individuals exposed to radiation by reducing the harmful accumulation of radioactive substances in the thyroid. However, It has been said that nascent Iodine may be 4-7 times more effective than potassium iodide and is much safer to use.

2. General Use as a Sterilizing Agent:

Almost all sterilization products for the body have iodine. It is a wonderful wound cleaner, and has even been used to purify water in tablet or liquid form.

3. Preventing Goiter:

Irritation of the throat area and thyroid gland is known as a “goiter”. To prevent this condition, it is suggested to take the daily recommended amounts of a nascent iodine supplement to boost overall thyroid health.

4. Boosting Metabolism:

Due to improper thyroid function, metabolism of the body may slow down. Supplementing with nascent iodine may help ensure the smooth functioning of the thyroid gland, which in turn helps regulate the metabolism. It can also aid the body in keeping warmth, steadying the heart rate, maintaining a health body weight, and promoting overall digestive health.

5. Harmful Organisms:

A nascent iodine solution can be used to assist the body in fighting off harmful organisms. Using an iodine tonic as a throat gargle is also helpful for a cough. Iodine also acts as an expectorant of mucous from the common cold and other respiratory ailments.

6. Breast Health:

Much research is currently being conducted on the role of iodine in breast health and overall shape and function. Similarly, iodine is a key mineral in mother’s milk, and is passed on to children for their proper growth and development. However, most nursing mothers are extremely deficient in Iodine.

7. Ovarian Health:

Again, much research confirms the link between a lack of iodine and ovarian problems, such as cysts, and reproductive ability.

8. Neurological Health:

Children can suffer from mental illness and disabilities due to a lack of iodine. It is important that mothers supplement with this micronutrient as a preventative measure.

9. Vaginitis:

Iodine douches have been used to reduce vaginal irritation, itching and discharge associated with chronic yeast imbalances.

10. Eye Health:

Iodine is commonly used as a treatment for a number of different eye conditions. It is also a natural protectant against UVB radiation.

11. Skin and Hair Health:

Iodine is a common aid for skin conditions, such as acne, as well as hair loss. The healthy development of skin, teeth, nails and bone are all related to normal iodine levels.

12. Powerful Antioxidant:

Iodine is just as important as vitamin C in terms of antioxidant activity. Specifically, it is a strong antioxidant for the blood (Human Health Fact sheet, 2005).

1.2.4 Role of iodine in human body:

Iodine is a chemical element required for good health, as it has several roles in the body. Iodine is needed to make thyroid hormones and promote a healthy pregnancy, as well as to prevent a number of conditions. Because foods don't naturally contain much iodine, salt is fortified with iodine. It's estimated that iodized salt is used regularly by about half the U.S. population, according to Medline (Brownstein, 2008).

1.2.4.1 Role of iodine in Thyroid Function:

The thyroid gland can't function without iodine because it's needed to make thyroid hormones. Insufficient iodine can cause an enlarged thyroid gland. This unsightly swelling in the front of the neck is known as a goiter. Insufficient iodine can also affect thyroid function by causing hypothyroidism, or an under active thyroid. Symptoms include fatigue, weight gain and depression. Thyroid function is important for fertility, as well iodine deficiency leading to low levels of thyroid hormones can cause women to stop ovulating, leading to infertility (Brownstein, 2008).

1.2.4.2 Role of iodine in Normal Metabolism:

Iodine is needed for the normal metabolism of cells. Metabolism is the process of converting food into energy. Insufficient iodine can slow down the body's metabolism, which can result in weight gain. "Because thyroid hormones regulate metabolism and growth, when production of these hormones is slowed or stopped due to iodine deficiency, your metabolism can become sluggish, (Brownstein, 2008).

1.2.4.3 Role of inorganic and organic forms of iodine as an antioxidant:

Iodine is one of the most abundant electron-rich essential elements in the diet of marine and terrestrial organisms. It is transported from the diet to the cells via iodide transporters. Iodide, which acts as a primitive electron-donor through peroxides enzymes, seems to have an ancestral antioxidant function in all iodide concentrating cells from primitive marine algae to more recent terrestrial vertebrates. Thyroxin and iodothyronines have an antioxidant activity too and, through denominate enzymes, are donors of iodides and indirectly of electrons. Thyroid cells phylogenetically derived from primitive gastro enteric cells, which during evolution of vertebrates migrated and specialized in uptake and storage of iodo-compounds in a new follicular “thyroidal” structure, for a better adaptation to iodine-deficient terrestrial environment. Finally, some anima land human chronic diseases, such as cancer and cardiovascular diseases, favored by dietary antioxidant deficiency (Brownstein, 2008).

1.2.4.4 Iodine and delayed immunity:

Iodine was and is sometimes used therapeutically in various pathologies where the immune mechanism is known to play a dominant role. It has in fact been administered to patients with tubercular glaucomatous, lepromatous, syphilitic and msycotic lesions where it facilitates cure. Iodine may also be used in Villanova-Panol Panniculitis, in erythema nodosum, in nodular vasculitis, erythema multiform and Sweet's syndrome. Oral iodine is also very effective in the lymphatic-cutaneous form of sporotrichosis. (Brownstein, 2008)

Table (1-3): Recommended Iodine intake:

Age group		**Recommended iodine intake**
Infants	Up to 4 months (estimate)	40 µg / day
	4 months to 12 months	80 µg / day
Kinder	1 to under 4 years	100 µg / day
	4 to under 7 years	120 µg / day
	7 to under 10 years	140 µg / day
	10 to under 13 years	180 µg / day
	13 to under 15 years	200 µg / day
Adolescents and adults	15 to under 51 years	200 µg / day
	51 years and older	180 µg / day
Pregnant women		230 µg / day
Breastfeeding mothers		260 µg / day

1.2.5 Iodization Level:

During the past few years the minimum goal of iodine fortification has been set at 150 µg/day per person. Many countries aim at much higher levels. Iodine is normally introduced as the iodide or iodate of potassium, the actual iodine addition levels to salt is based on the average per capita salt consumption and anticipated losses of iodine during distribution. Specifically, Mannar and Dunn (1995), based on their earlier experience, recommended that the addition level be based on the assumption of 50% iodine loss between iodization and consumption. ICCIDD/WHO/ UNICEF (WHO 1990) have described desirable average levels of iodine in salt at various points in the salt distribution chain, taking into account level of salt intake, climatic conditions and packaging. World Health Organization (WHO) and ICCIDD recommend that the amount of added iodine should be 20-40 mg/kg of salt (Diosady *et. al.,* 1998).

1.2.6 Iodine Stability:

Elemental iodine readily sublimes and is then rapidly lost to the atmosphere through diffusion. Potassium iodide is less stable than potassium iodate, as it can be oxidized to elemental iodine by oxygen or other oxidizing agents, especially in the presence of impurities, such as metal ions and moisture, which catalyze the reaction. Potassium iodate may be reduced to the elemental iodine by a variety of reducing agents in the salt, such as ferrous ions. Moisture is naturally present in the salt, or is abstracted from the air by hygroscopic impurities such as magnesium chloride. The pH of the condensed moisture on the salt is very much influenced by the type and quantity of impurities present, and this affects the stability of the iodine compounds. Elevated temperatures increase the rates of iodine loss.

The levels and types of impurities, moisture content and pH of salt produced for human consumption vary widely depending upon the source and production process. Salt is produced from sea water, rock salt deposits and lake sediments, by solar evaporation of brines and dry or solution mining of rock salt deposits. Refining processes range from simple washing methods to large-scale mechanized vacuum evaporation systems which require trained operators and rigorous quality assurance.

As a result, the salt which is available for iodization may contain, in addition to sodium chloride, impurities such as mud and organic matter, salts of magnesium, calcium, carbonates and sulphates, insoluble matter and moisture.

Physically, grains may range from large crude crystals, white or off-white in colour of varying size (5-25 mm) to a refined, dry uniform-grain powder.

Based on the chemical properties of salt aimed at human consumption, losses of iodine were not unexpected, and there have been numerous published and unpublished studies on iodine stability in salt during the past 75 years. A review of this literature showed that iodate is superior to iodide in terms of stability as a fortificant in salt. Published evidence of the stability of iodine, added in the form of iodate without stabilizers, is relatively meagre, but indicates iodine losses ranging from around 5% to 66% after 12 months.

Conditions of packaging and storage, such as humidity and temperature also affect the final iodine content of the salt, yet these factors were not always clearly defined in earlier studies. Sample sizes and reproducibility of results were not always reported, making it more difficult to asses the statistical significance of results.

Salt blocks, iodized with potassium iodate, exposed to wind, rain, and sun under typical Canadian conditions lost up to 33% of iodine after 8 weeks (Davidson *et. al.*, 1951).

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. He recommended that iodate be used under adverse conditions such as found in developing countries where the salt being iodized is crude, unprocessed and usually not dried sufficiently.

Arroyave, *et. al*. (1956) showed that potassium iodate, mixed with calcium carbonate, was stable when added to crude local sea salt stored in hemp fibre sacks. After eight months at ambient temperature and relative humidity between 70% and 84%, an average of 3.5% of the added iodine was lost. There was no significant migration of iodine within the sacks, likely due to iodate's low solubility.

study by Chauhan *et. al.,* (1992) compared iodine stability over 300 days in common salt iodized with iodate, packed in 5 kg solid HDPE bags or left in open heaps. RH varied from 41 to 83% (median value 52%) with temperatures between 30-39 00. Both the salt packed in HDPE bags and in the open lost 9-10% of the added iodine within the first month, after which values remained practically constant. In a second experiment, when heated to 120°C, salt in a covered Petri dish lost up to 57% of added iodine after only 3 hours.

Other evidence of the magnitude of iodine losses from iodized salt come from studies assessing the efficacy of stabilizing compounds in local salt. Findings from control samples (without stabilizers) suggest considerable variation in iodine stability in spite of differences in experimental design.

Ranganathan, *et. al.,* (1986) found that coarse salt iodized with iodate at "normal" room temperature and humidity showed iodine losses of 20% after 12 months, while samples stabilized with calcium carbonate lost no iodine over an 18- month period.

In a later study analyses of five types of Indian salt (including powder and crystal) iodized with iodate showed losses of 28-51 % after 3 months, 35-52% after 6 months, and up to

66% after 12 months. Losses from powder salt appear lower. No information was given available on packaging. Findings demonstrate the utility of the use of sodium carbonate as stabilizer (Ranganathan, in press)

Iodine losses from refined solar salt packed in open 1kg plastic film bags, heated to 130C for 2.5hr.to simulate drying, and stored at ambient temperature were reported to be 5.7% after 12 months and 11% after 3 years (Zigong Institute, 1992).

Although the literature, and North American practice indicate that the iodine loss is reduced by stabilizers, such as carbonates, these are not used in most developing countries, and thus we chose not to use them in this study.

1.2.7 Methods of determination of iodine:

Many methods are used in the analysis of iodine these methods include the following:

1. kinetic spectrophotometric methods (Ni and Wang 2007).
2. liquid-liquid micro extraction by high-performance liquid chromatography-diode array detection (Gupta *et al.,* 2011).
3. gas chromatography– mass spectrometry (Das et al. 2004).
4. using polymer membrane selective for molecular iodine (Bhagat et al. 2008).
5. Iodometric Titration (De Maeyer et al. 1979).

1.2.8 method of choice:

In this study iodometric titration method will be used because it requires simple and inexpensive experimental setup and is of considerable scientific interest. Most of the techniques are complex and involve sophisticated instruments and complex procedures.

1.2.9 Iodometric Titration:

The principle is that iodine is liberated by adding sulphuric acid to a solution of iodized salt, Iodine liberated is titrated with sodium thiosulphate solution. The amount of thiosulfate used is proportional to the amount of free iodine liberated from the salt. Starch is added as an external (indirect) indicator of this reaction and reacts with free iodine to produce a blue colour. 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 occurs with further titration, indicates that all remaining free iodine has been consumed by thiosulfate.

1.2.9 Objectives of the Study:

1. determination of the iodine content in different types of iodized salt.
2. effect of sun light on the stability/ loss of iodine in different types of iodized salt.

CHAPTER TWO

MATERIALS AND METHODS

2.1 Materials:

2.1.1 Samples:

Four samples of iodized salt were used in this work, three of which were collected from the market of Hassahissa, the remaining one was prepared in the laboratory. All samples contain iodine in the form of potassium iodate.

Salt is iodized by the addition of fixed amounts of potassium iodide or iodate as either dry solid or an aqueous solution at the point of production. The dry mixing method was found to be the best process, because it showed the least amount of iodate loss and require no heating. The iodized salt sample was made by mixing potassium iodate (0.034gm) with 500gm edible salt for 10-15 min, until visual homogeneity was achieved. Samples were then divided into equal portions and exposed to different storage conditions which included storage in laboratory cupboards and exposure to direct sunlight.

Table (2.1): Iodized salt samples

Salt	Company name	Manufacture date	Eexpiry date
1	Alrashed salt port Sudan	Jan. 2014	Jan. 2016
2	Riyadh food K.S.A	May 2013	May 2015
3	Zad salt K.S.A	Nov. 2013	Nov. 2015
4	Was prepared in the lab	April 2014	

2.1.2 Apparatus:

Analytical balance, Distillation Equipment.

2.1.3 Glassware:

Beakers, Volumetric flask, spatula, funnel, pipette, conical flask, Dropper, Measuring Cylinder, Burette and Stand.

2.1.4 Chemicals:

- Sulfuric Acid
- Potassium Iodide
- Potassium iodate
- Sodium Thiosulphat
- Starch-
- Distilled Water

2.2 Methods:

2.2.1 Preparation of Standard solutions and reagents:

- Sodium thiosulphate (0.005 M):

1.24g sodium thiosulphate were dissolved in distilled water and diluted to 1litre .

- Sulfuric acid (1M):

Approximate 5.50 ml of concentrated sulfuric acid were added drop wise into a 90 ml distilled water.

- Potassium iodide (10%):

10g potassium iodide were dissolved in distilled water and diluted in 100 ml .

- Potassium iodate(0.00083 M):

0.18g Potassium iodate were dissolved in distilled water and diluted to 1litre .

- Starch (1%):

1.0g of starch were prepared a slurry in 50 ml water. Added this slurry slowly to 50ml of boiling water. A freshly solution was prepared every time.

2.2.2 Standardization of Sodium Thiosulphate solution:

The sodium Thiosulphate solution is to be standardized with Standard Potassium iodate solution to determine its exact molarity. 0.005 M thiosulphate solution were placed in a burette. Pipetted out 25 ml of 0.00083 M standard potassium iodate solution in a conical flask. Added 2 ml of 1M H_2SO_4 and 5 ml of 10% KI solution. Titrated the solution against sodium thiosulphate till the solution became pale yellow in colour. To this, 1 ml starch were added . The solution turns deep purple. Added thiosulphate solution drop by drop from the burette till the purple colour completely disappears.

Molarity of Thiosulphate is calculated as follows :

Volume of KIO_3 (V1) x molarity of KIO_3 (M1) x 6 = Volume of $Na_2S_2O_3$ (V_2) x molarity of $Na_2S_2O_3$ (M_2)

$$\text{Molarity of Sodium Thiosulphate} = \frac{V_1 \times M_1 \times 6}{V_2}$$

2.2.3 Test for iodate:

25 ml solution 1% starch, 25ml solution 10% KI and 1ml H_2SO_4 , placed a small amount of the salt to be tested added two drops of the test reagent. If iodate is present the salt will immediately turn grey/blue and remain this colour for several minutes before turning brown.

2.2.4 Determination of Iodine content in the salt:

10g of salt were dissolved in 50 ml distilled water. Then added 2 ml of 1 M sulfuric acid and 5 ml of 10% potassium iodide to it. After shaking, the solution will turn to a yellow colour. Closed the flask with stopper and kept the flask in the dark for about 10 minutes. Removed the samples from the dark and was titrated against the sodium thiosulphate solution until it turns into a very light yellow colour (pale yellow). Subsequently, added a few drops (1-5 ml) of 1 % starch solution. The solution was turn into a deep purple colour. Added thiosulphate drop by drop from the burette until the solution became colourless and noted the final reading.

$KIO_3 + 5KI + 3H_2SO_4 \; \text{----->} \; 3K_2SO_4 + 3I_2 + 3H_2O$

$KI + I_2 \; \text{------>} \; KI_3$

$2Na_2S_2O_3 + I_2 \; \text{------->} \; 2NaI + Na_2S_4O_6$

2.2.5 Calculation:

The iodine content of the sample in parts per million was calculated by the formula:-

$$\text{Iodine Content (ppm)} = \frac{V \times 100 \times 1000 \times 0.127 \times M}{6}$$

Where:

V: The Volume of Thiosulphate used (burette reading)

100 : For converting burette reading for 1000gm of salt

1000: For converting gms of iodine to milligrams

0.127 : The weight of Iodine equivalent to 1ml of normal sodium thiosulphate solution

M: Molarity of sodium thiosulphate solution

6 : To arrive at the value of 1 atom of iodine liberated

CHAPTER THREE

3.1 Results and Discussion

The stability of iodine compounds in salt is important for two reasons. First, it is necessary to ensure that iodize salt carries the actual amount of iodine stipulated by medical authority, Individuals and peoples for whom iodized salt is intended as a goitre preventive must receive the effective quantity in their daily in take of salt, and not some thing less. Secondly regulation governing the sale of iodized salt must be framed in fairness to manufactures under statutory obligation to provide iodized salt of a certain standard.

Table (3.1): storage of iodine in laboratory cupboards

No of sample	Concentration according the label of the product(mg/kg)	Initial iodine(mg/kg)	%of original iodine remaining after storage				
			1weak	2weak	3weak	4 weak	5 weak
1	20-40	17.20	100%	100%	100%	100%	100%
2	20-40	37.48	100%	100%	100%	100%	100%
3	25-35	56.88	100%	100%	100%	100%	100%
4	40	38.81	100%	100%	100%	100%	98.85%

Salt samples analysed at the beginning showed high and low levels of iodine, with some values closer to the reported values indicated on the labels. The first iodine value obtained from the analysis for sample two and sample four was very close to that of the value on the label whiles those of sample one and sample three were quite different from that on the labels. I think the different in the first iodine value obtained from the analysis and those values in the label to one of the following reasons, the variability in the amount of iodine added during production, its uneven distribution within the batches or bags produced due to poor mixing and due to losses in distribution or during storage. Generally, some values were comparable to the recommended iodization levels of 20-40 mg/kg of salt as given by (WHO) and ICCIDD(1998). All samples retained the iodine content after storage in laboratory cupboards for five weeks, except sample four there is decrease in iodine content after five weeks , I believe that this decrease resulted from the presence of moisture in edible salt. Samples stored in the cupboard showed slight decreases in the variation of iodine during the period of storage suggesting that losses do not occur readily when salt samples are stored in cool, dry and dark places away from direct sunlight due to the absence of heat and moisture as well as less air.

Table(3.2) : Effect of sun light on loss of iodine from salt

No of sample	concentration according the label of the product	Initial iodine(mg/kg)	%of original iodine remaining after storage				
			1weak	**2weak**	**3weak**	**4 weak**	**5 weak**
1	**20-40**	17.20	100%	100%	100%	100%	97.44%
2	**20-40**	37.48	100%	100%	100%	100%	98.83%
3	**25-35**	56.88	100%	100%	100%	100%	99.24%
4	**40**	38.81	100%	100%	100%	98.85%	97.72%

All the salts after the exposure to sun light decreased in iodine concentration during the period of storage. The decrease in iodine content varied with storage conditions and percentage lost also varied with the individual samples. Salts that were exposed to direct sunlight lost greater portions of the added iodine. This result can be attributed to the presence of heat at such high temperatures causing elemental iodine to readily sublime which is then lost to the atmosphere due to the high volatility of the element. The effect of temperature on the iodine levels suggest that heat affects the rate of iodine losses as rapid decreases were registered at higher temperatures. Cooking loss could be a major reason for high Iodine Deficiency Disorders.

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3.2 Conclusion:

The results of this study shows that the iodated salts confirmed that the actual iodine available vary from the point of production to when it is consumed. Length and choice of storage greatly affects the iodine levels in salts. cupboard conditions are best storage conditions as only little losses occurred within the period of storage while that exposed to the sun shows higher portions of iodine were lost when the salt is subjected to high temperatures and heat. A cool and well ventilated storage system reduces the amount of iodine lost.

3.3. Recommendations:

It is recommended to encourage and support the production of iodized salt and to provide strategies for providing information, education and communication, which aims to improve knowledge about the disorders of iodine deficiency and raise the standards of quality control procedures and keeping the salt under appropriate conditions.

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