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VARIATION OF IODINE AND CADMIUM IN *TYPHA LATIFOLIA* AND COMMERCIAL SALTS FROM BUSIA IN KENYA

By

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ORIGINAL RESEARCH ARTICLE

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Abstract: ***Background to the study:*** *Table salt is a vital food additive needed for adding flavor, pickling, to preserve, curing fish and meat and for tanning. It is an essential ingredient used in baking and cooking to suppress bitterness, improve the tastes, and preserve food. Table salts have additives such as iron used to prevent anaemia and iodine used to prevent goiter. Most of the salt used around the world comes from mines and plant material that tend to be present in soils contaminated with heavy metals. Cd, Fe and Pb are some of the heavy metals found in the environment. Iodine is an essential trace element for human nutrition. The safe dietary intake of iodine as recommended by the World Health Organization (WHO) is 100* $\mu g\ day^{-1}$ *for children and 150* $\mu g\ day^{-1}$ *for adults. Iodine is necessary for synthesis of* T_3 *and* T_4 *hormones by the thyroid gland. Insufficient iodine leads to iodine deficiency symptoms and disorders like goiter, mental retardation, extreme fatigue and depression which are collectively referred to as iodine deficiency disorders (IDD). The fortification of salt with iodine is an efficient, economical, and steady way of ensuring sufficient iodine ingestion.* ***Objectives:*** *Effect of storage time on the iodine and cadmium concentration in Typha Latifolia reed salt and two selected commercial table salts (Ken salt and Sea salt) from Busia in Western Kenya has been investigated.* ***Methods:*** *Iodometric titration and Inductive Coupled Plasma – Atomic Emmision Spectroscopy were used to determine the concentration of iodine and cadmium respectively.* ***Results:*** *Amount of iodine in the salt is affected by the storage time. The average amount of iodine in mg/ kg of salt, measured every after 15 days for a period of 90 days was in the ranges: indigenous T. latifolia salt (868.0 mg/kg – 385.0 mg/kg); sea salt (214.4 mg/kg - 100.8 mg/kg); ken salt (236.88 mg/kg - 186.12 mg/kg). The percentage loss of Iodine in the salt was highest in T. latifolia reed salt (55.68 %) followed by Sea salt (52.99 %). Ken salt lost 16.67 % of Iodine during the storage time. Amounts of cadmium in mg/ kg of salt, measured every after 15 days for a period of 90 days was in the ranges: indigenous salt (96.5 mg/kg - 32.92 mg/kg); ken salt (20.06 mg/kg - mg/kg); potassium iodate (2260 mg/kg - 2732.52 mg/kg). Amount of cadmium in mg/ kg of salt were in the ranges: indigenous T. latifolia salt (9.65 mg/kg – 17.32 mg/kg); sea salt (32.92 mg/kg – 34.98 mg/kg); ken salt (20.06 mg/kg - 46.52 mg/kg); potassium iodate (2260 mg/kg – 2328 mg/kg). This study provides strong evidence that the amount of iodine reduces over time in the salts. Commercial salts lost smaller percentage of Iodine than reed salt. This could be attributed to the presence of stabilizers in commercial salts. T. latifolia salt had higher levels of Iodine during the first 15 days of production. Therefore, it will be worth recommending consumption of small amount of salt within the first 15 days after production when the concentration of iodine is high or stabilizers can be added to the salt if it is to be used for a longer period of time. This should be done in line with the World Health Organization recommended levels of iodine for human consumption. Consumption of small amount of the salt will minimize the uptake of harmful impurities such as Cadmium. There was no significant change in the levels of Cadmium in the salts with time. However, the levels of Cadmium should be monitored during salt production to ensure the salt is safe for human consumption.*

Key words: ***Cadmium, Iodine, Storage, Time, and Concentration***.

Introduction

Table salt is a frequently used food additive which has a unique place in food consumption. It is an important additive which has been used from prehistoric times for flavoring, pickling, preservation, curing fish and meat and for tanning (Ukwo and Edima, 2016). It is a vital ingredient in baking and cooking used to suppress bitterness, improve the tastes, and preserve food. Salt plays an important role in the processes of digestion (Al-Rajhi, 2014). Refined salt, which is commonly used at present, is chiefly sodium chloride. It is a form of table salt which has been extracted and treated with chemicals to precipitate most impurities (Cheraghali *et al*., 2010). The quantity and the type of impurities present vary widely in the table salt (Diosady and Mannar, 2000). Table salts have additives such as iron used to prevent anaemia and iodine used to prevent goiter (Ukwo and Edima, 2016). Most of the salt used around the world comes from mines and plant material that tend to be present in soils contaminated with heavy metals. Due to this, heavy metals contamination may be a concern for table salt (Cheraghali *et al., 2010*). Cadmium, Iron and Lead are some of the heavy metals which are found in the environment as a result of human activities and geological processes. Table salt is obtained from solid rock deposits or by evaporation of lakes, sea water, oceans, underground brines and salt springs (Ukwo and Edima, 2016). Salts from plants may be produced by burning plants parts which are rich in potassium (Wangila *et al*., 2013).

The plants used for preparation are mostly waste parts of cultivated plants like stems of maize, millet, sorghum and some widespread plants like *Hygrophila* species. Also pawpaw or banana false trunk is used to produce plant salt (Wangila *et al*., 2013). The salt is also obtained from solid rock deposits or by evaporation of lakes, sea water, oceans, underground brines and salt springs (Ukwo and Edima, 2016). The physical and chemical composition of salt produced from different sources such as rock deposits, evaporation of lakes, sea water oceans, underground brines and salt springs or plant material varies usually depending upon the composition of the raw material, the levels of pollution in the immediate environment of the salt source and the technique used during manufacturing. Natural salts sometimes can be extracted from seawater by freezing or by evaporation (Siulapwa and Mwambugu, 2015). Today most of the refined salt is obtained from rock salt which is either mined conventionally or through injection of water (Cheraghali *et al*., 2010). The table salt obtained is then processed and purified to remove contaminants. Anti-caking agents such as Sodium aluminosilicate or Magnesium or Calcium carbonate are added to the salt to make it free flowing (Ukwo and Edima, 2016). Different types of salt vary in their mineral content, giving each salt a distinctive flavor (Al-Rajhi, 2014). The lowest permitted NaCl content in salt is 97 % w/w according to codex legislation (Siulapwa and Mwambungu, 2015).

Iodine is one of the essential trace elements for human nutrition. Iodine is an essential micronutrient which is needed at all stages of life with fetal life and early childhood being the most critical phases of requirement (Ahad and Ganie, 2010). Major portion of iodine is concentrated in the thyroid gland.

The safe dietary intake of Iodine according to the World Health Organization (WHO) is 100 μg day^{-1} for children and 150 μg day^{-1} for adults (Kulkarni *et al*., 2013). It is required for the synthesis of the thyroid hormones. The thyroid has two hormones namely L-thyroxinetetraiodothyronine (T_4) and L-triiodothyronine (T_3) (Miot *et al*., 2010). The T_3 and T_4 hormones control metabolism processes and biochemical reactions in the body, including those which are responsible for the mental and physical growth (Jabbour, *et al*., 2015). Both T_3 and T_4 hormones influence metabolism process, brain development, breathing, heart and nervous system functions, body temperature, strength of the muscles, skin dryness, menstrual cycles, weight, and cholesterol levels (Fardousi, 2012). The store of iodine in the human body is the thyroid gland. Inadequate iodine intake results in iodine deficiency symptoms and disorders like goiter, mental retardation, extreme fatigue and depression which are jointly referred to as iodine deficiency disorders (IDD). According to Zimmermann (2013), iodine is broadly but not uniformly dispersed in the earth's environment. A large amount of iodide is found in the oceans, soil and water of the coast. It is found in most soils, and is taken up by plants which are in turn eaten by animals and humans. Effects of glaciations, flooding, and leaching into soil during the Ice Age have resulted in the variable geographic distribution of iodine (Leung *et al.*, 2012).The fortification of salt with iodine is an efficient, economical, and steady method of ensuring sufficient iodine ingestion. Though, for this process to be effective, it should reach the vulnerable members of the society; the pregnant women and children and also the salt used should be adequately iodized (15–40 ppm iodine content). The amount of iodine added to salt during the process of fortification needs to account for the losses of iodine during transport and storage and should be regularly monitored by government agencies (Lowe, 2015).

Research has shown that even after fortifying salts, iodine is still not available if not insufficient as a result of contamination related chemical reactions and the losses during packaging and repackaging of the salt (Diosady and Mannar, 2000. The actual availability of iodine present in iodized salt at the consumer level can vary extensively because of a number of factors such as: unevenness in the mass of iodine added when iodizing, poor mixing which can result in non-uniform distribution of Iodine in the batches or bags of table salt produced and instability of iodine in the salt. These factors affect the quantity of iodine that is finally available for consumption (Diosady and Mannar, 2000). According to Kumma *et al*., (2018), inadequately iodised salt is used by the consumers due to the use of unpackaged salt, prolonged exposure of the salt to the sun light, presence of impurities and water moisture in the salt, presence of insufficiently iodised salt, heating and processing of food. Potassium iodate which is commonly used for iodisation of salt in tropical regions has a higher resistance to oxidation than potassium iodide, however iodate salt lose iodine over time, (Laar and Pelig-Ba 2013) It is for this reason that the investigation of the effect of storage time on Iodine and Cadmium impurities in prepared salts is being undertaken.

Cadmium is a rare but widely dispersed element, found naturally in the environment. It is mainly found in the earth's crust. It is a rare but widely dispersed element, found naturally in the environment, (Agency for Toxic Substances and Disease Registry 2013). It is mainly found in the earth's crust. In industries, cadmium is an inevitable by-product of zinc, copper and lead extraction. After application of manure and pesticides cadmium enters the environment through the ground. About a half of the cadmium is released into rivers through weathering of rocks and some cadmium is released into air during forest fires and volcanoes. Municipal and Industrial wastes are the major sources of cadmium pollution. Surface waters containing excess of cadmium per liter have possibly been polluted by industrial wastes from plating works, metallurgical plants, plants manufacturing cadmium pigments, cadmium-stabilized plastics, textile operations, or nickel–cadmium batteries, or by effluents from sewage treatment plants. Presence of cadmium in vegetation arises from the deposition of cadmium-containing aerosols directly on plant surfaces and by absorption of cadmium through roots. Plants vary in tolerance to cadmium in soil and in amounts they accumulate (Ghinwa *et al*., 2009).

Biology, Chemistry of *Typha latifolia* Reeds

Typha latifolia plants have broadleaf cattail. It is an aquatic growing perennial plant. The plant has shown usefulness against Staphylococcus aureus and Escherichia colidue to secondary metabolites which are the active sources of valuable drugs such as Glycoside, Tannin, Saponin, Steroid, and Alkaloid present in the reeds (Wangila, 2017). The broadleaf of the reeds are combined with oil and used as dressings on wounds and sores. Their pollen grains are diuleric, astringent, haemostiasis, emmenagogue, refrigerant sedative and vulnerary (Wangila 2017). The dried pollen grains are anticoagulant, but when the pollen grains are roasted with charcoal they become homeostatic. It is used internally in treatment of hemorrhages, kidney stones, postpartum pain, painful menstruation, abnormal uterine bleeding, abscesses and cancer of lymphatic system (Wangila, 2017). Its stem has been in use for the treatment of whooping cough, while the roots of Typha *latifolia* reeds are diuretic, refrigerant and tonic. *Typha latifolia* reeds are shown in the figure 1 below.

Figure 1 *Typha latifolia* reed plants
Source: https: goo.gl prota4u.org

Flowers are used for the treatment of some ailments such as, Amenorrhea cystitis, abdominal pains vaginitis and dysuria. Young flowers heads are eaten for treatment for diarrhoea. Its seeds are used as a dressing on scalds and burns (Wangila, 2017)

Research has shown that *Typha latifolia* reed species can store heavy metals such as iron, manganese, magnesium, cadmium and Zinc in their tissues, (Hazra, Avishek and Pathak, 2015).

Purpose of the Study

The purpose of this study was to determine the effect of storage time on the levels of iodine and cadmium in *Typha Latifolia* reed salt and two selected commercial table salts; ken salt and sea salt obtained from Busia County in the year 2007 in Western Kenya. This was an attempt to fill in the knowledge gap regarding the suitable storage time for the salts from the time of production to the time of consumption when the level of iodine is sufficient to prevent goiter and other iodine deficiency disorders. It will also give the knowledge on the effect of storage time on the levels of cadmium which is one of the contaminants in the salts, which might interfere with the suitability of the salts in supplying the micro nutrients needed by human beings.

Materials and Methods

Study area

This study was carried out in Busia County of Western Kenya, where the locals are still using reed salt besides the commercially available refined salt, in the year 2017. The County is divided into six administrative divisions, namely Nambale, Butula, Funyula, Budalangi, Township and Matayos. Matayos division was randomly selected for this study. Busia district in

Western region covers an area of 1,261.3 km^2, 137 km^2 of which is part of Lake Victoria basin. Busia lies at 1220 m above sea level, has a rainfall range of 1300-1800 mm falling under lower midland agro ecological zone (AEZ), (Wangila *et al.*, 2013).

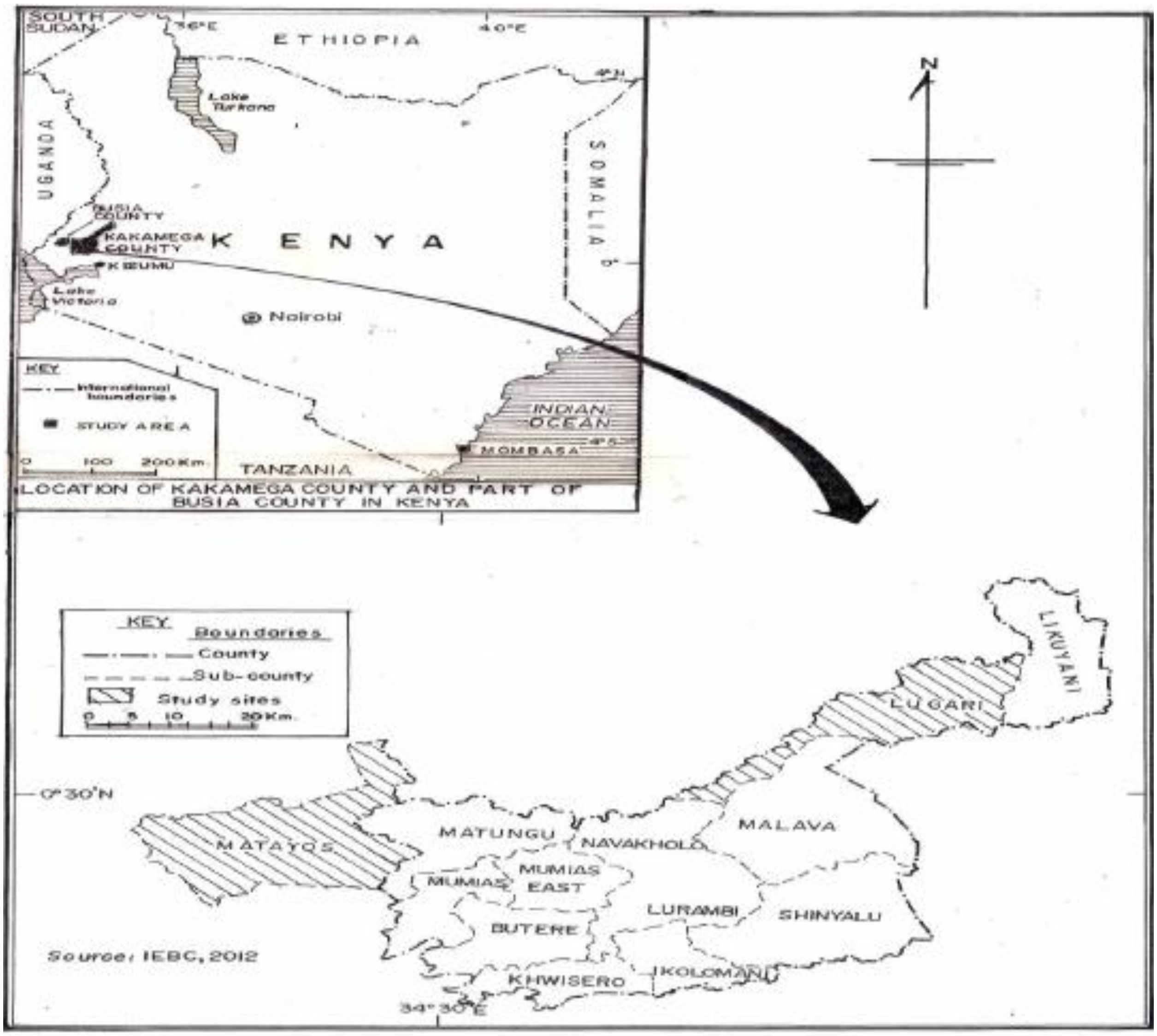

Figure 2: Busia County Map (Source: Wangila *et al*,. 2013)

Sample collection

Reed salts

A sample of mass 20 kg of Typha Latifolia reed plant samples were collected at full growth stage from randomly selected sampling points at Ululo in Busia region of Western Kenya. The samples were collected randomly along Shiinda river. Quadrats measuring 5 m by 5 m were randomly mapped out from each sampling site, with five sampling spots at a distance of 5 m from each other within each quadrat. Reed Plant samples were randomly harvested using a stainless steel knife. Plants were collected from each sampling sites of Ululo along river Shinda in Busia region and stored in the open area to dry for 10 days. The reed salt was prepared on site by burning the dry reeds to obtain ash. Five litres of water was added to the ash and filtered using a perforated plastic can. The filtrate was exposed to evaporation to dryness, in a steel open pan to obtain the reed salt. The salt samples weighing 500 g were collected and packed in well labeled low density polyethylene bags, and taken to the laboratory for analysis. (Wangila et al., **2013)**

Commercial table Salts

A sample with a mass of 500 g of the Ken salt and Sea salt was obtained from local distributors in Matayos sub- County during the period of sampling in March, 2017. The salts were transferred to well label low density polyethene bags, sealed and transported to the laboratory for analysis.

Sample Preparation and preservation

Salt samples were passed through a 2 mm-mesh sieve to obtain 2 mm particle size which was used without pre-grinding. Salts containing larger particles than this were ground with pestle and mortar and passed through a 2 mm-mesh sieve. Sieved samples were stored in labeled low density polyethylene containers.

Six samples of 20 g each of the reed salt were weighed and packed in well labeled LDPE bags and the levels of iodine and cadmium measured within a period of 3 months at an interval of 15 days using the iodometry and Inductive Coupled Plasma-Atomic Emission Spectroscopy methods respectively. The procedure was repeated for the commercial salts and a cadmium spiked sample of KIO_3, used in the control experiment.

Chemicals and Reagents

All chemicals and reagents were of analytical grade obtained from Kobian manufacturers. A series of standard solutions were prepared as per the standard methods according to Rosen (2011), by appropriate dilution of the respective stock solutions. In general, reagents of the highest purity were used whereas for iodometry, fresh reagents were prepared and used.

They included: 0.04M Sodium Thiosulphate, Potassium Iodate, 10.00 % Potassium Iodide, Starch, 0.60 % HCl, 3.00M HCl and Cadmium Chloride.

Glass ware and preparation of Reagents

De-ionized water was used for dilution of reagents, preparation of both the samples and the working standards. All glassware and apparatus were cleaned by soaking in detergents for 24 hours and rinsed with de-ionized water. Then they were soaked in 10 % HNO_3 for 24 hours, rinsed with de-ionized water and oven-dried at 110 °C. The standard solutions of the analytes for calibration were produced by diluting the respective stock solutions of 1000 mg/L of the given element.

Sample Analysis

Iodine analysis

Iodine was determined using iodometric titration as described by Jabbour *et al.*, (2015). Concentration of iodine in salt was calculated basing on the volume of the $Na_2S_2O_3$ used. Moles of $Na_2S_2O_3$ reacted was calculated according to the formula shown below;

$$\text{Moles of } Na_2S_2O_3 = \text{volume used in litres} \times 0.04$$

Sodium thiosulphate reacts with iodine according to the equation shown below
$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$
Mole ratio of $Na_2S_2O_3$ to moles of all iodide ions =1: 1, hence concentration of iodide ions can be determined.

Cadmium analysis
Analysis of cadmium was done using Inductive Coupled Plasma-Atomic Emission Spectroscopy as described by Al-Rhaji (2014). The analysis was done using ICP-AES spectrometer Shimadzu type ICPE 9000 (Kyoto Japan). Salt sample solution was prepared and spiked with 0.07 ppb of Cd $^{2+}$ and introduced to the pump which delivered the sample to the nebulizer. The intensity of the photons emitted at a selected frequency of 226 nm was used to determine the concentration of the Cadmium in the salt. All results were recorded in table 1 below.

Data Analysis
Analysis was done using SPSS version 21. All analysis was carried out basing on three replicates. Means of the concentrations of iodine and cadmium in salts was calculated and compared. Regression analysis was used to investigate the effect of storage time on the Iodine and Cadmium concentration in *Typha Latifolia* reed salt and selected commercially available table salts from Busia region. Multiple comparisons were used to explain how differences arise.

Results and Discussion

The effect of storage time on Iodine levels and Cadmium levels was investigated in *Typha Latifolia* reed salt and two commercial salts (Ken salt and Sea salts) over a period of 90 days (0, 15, 30, 45, 60, 75 and 90 days), in order to determine whether the levels of Iodine and Cadmium differed over time. Information in this section was based on the concentration of Iodine and Cadmium in mg/kg of salt in *Typha Latifolia* reed salt, Ken salt, Sea salt and potassium iodate spiked with Cadmium, which was used as a control in the experiment. The levels of Iodine and Cadmium from day 0 to day 90 are presented in **Table 1** below. Where are the error margins in these results.

Table 1: The Concentration of iodine and cadmium from day 0 - 90 in mg/ kg of salt.

Element	Days	Indigenous salt	Sea salt	Ken salt
Iodine	0	868.51±0.002	214.32±0.002	236.85±0.001
	15	930.60±0.021	169.20±0.001	321.46±0.001
	30	535.80±0.003	129.72±0.0012	152.28±0.013
	45	479.40±0.0013	163.56±0.014	214.32±0.002
	60	377.80±0.001	124.08±0.002	197.40±0.0017
	75	434.28±0.013	107.16±0.002	197.40±0.002
	90	417.36±0.002	101.52±0.001	199.20±0.002
Cadmium	0	9.650±002	34.94±0.0021	20.06±0.0021

	15	11.00±0.002	4.333±0.001	2.42±0.002
	30	31.55±0.002	34.53±0.0017	20.29±0.0021
	45	9.75±0.0013	29.44±0.0023	20.96±0.001
	60	9.75±0.0014	29.67±0.002	20.16±0.003
	75	9.65±0.001	34.94±0.002	16.83±0.002
	90	9.74±0.001	32.97±0.002	9.74±0.001

There was a significant interaction between concentration of Iodine in salts (indigenous salt, Ken salt and Sea salt) and storage period (Days) as confirmed in **Table 2** with the P value < 0.001.

Table 2. The Two-Way ANOVA for Variation of concentration of Iodine in *T. latifolia* salt, Kensalt, Sea salt and Potassium iodate.

Source of variation	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	99.545[a]	27	3.687	64.869	0.000
Intercept	279.790	1	279.790	4.923E3	0.000
Days	12.878	6	2.146	37.764	0.000
Salt	73.722	3	24.574	432.377	0.000
Salt * Days	12.944	18	0.719	12.653	0.000
Error	3.183	56	0.057		
Total	382.518	84			
Corrected Total	102.727	83			

a. R Squared = 0.969 (Adjusted R Squared = 0.954)

Since the interaction term was significant, there was no need to investigate the storage period and the concentration of iodine in indigenous, Ken salt and Sea salt separately. There was a clear distinction after every 15 days in average concentration of Iodine. Days 0 and 15 of storage period had higher concentrations of Iodine for indigenous, Ken salt and Sea salt and as compared to the other storage periods with the following trend on iodine levels indigenous salt > Ken salt > Sea salt. Indigenous *T. latifolia* reed salt had higher concentrations of iodine during this storage period. Generally, the initial levels of iodine in the salts were higher than recommended iodization levels of 40-50 ppm as given by the WHO, (1994).

From the results, it was also observed that: The concentration of iodine in the reed salt was steadily decreasing over the storage time period. According to Wangila *et al.*, (2016), this trend can be attributed to instability of iodine in the salt.

The concentration of Iodine in indigenous salt reduced as the storage time increased. The concentration of Iodine in Indigenous salt was the same on days 0 and 15 but greater than the concentration observed on 30, 45, 60, 75, and 90 days period. In particular, the concentration of iodine gradually decreased from day 0 to day 45 then remained steadily constant up to day 90. However, this concentration of iodine appeared relatively low on day 60 (377.8 mg/kg).

The concentration of Iodine in Sea salt reduced over the storage time period. It was established that there was no significant change in concentration of Iodine in Sea salt from Day 0 to Day 45, but the levels decreased from Day 60 to Day 90.

The levels of Iodine in all the salt samples generally reduced over the storage period. However, the pair wise comparisons, indicates that there was no significant difference between the concentration of Iodine on day 60 and 75, and 90 in indigenous salt. Hence, the concentration of iodine in indigenous salt appeared to change over the storage period from Day 0 to Day 45. The pair wise comparisons indicated that the levels of iodine in indigenous salt was higher on Day 45 than Day 60 however, the concentration of Iodine was the same on Day 45, 75, and 90. Therefore, the significant difference in the concentration of Iodine in the indigenous salt between day 45 and 60 does not bear any practical importance. The pair wise comparisons in indicated that there is significant difference in the concentration of iodine in Ken salt on Day 0, 15, 30, but there is no significant difference in concentration of Iodine on Day 30, 45, 60 and 90. It means these salts can be stored and used for 90 days.

Multiple comparisons for the samples indicated that for the indigenous salt, amount of iodine remained constant for the first 15 days then reduced up to day 60 and remained constant up to day 90. The percentage loss of iodine during the storage period was 55.68 %. The results was in agreement with the findings of Laar and Pelig-Ba (2013) who observed that the length and choice of storage greatly affects the iodine levels in salts for either iodated or non-iodated and found out that iodine losses over the period ranged from 10 % to 100 %. High percentage; 42.11 % of iodine was lost during the first 60 days. This was in agreement with the findings by Wangila *et al*., (2016), who found that *T. latifolia* salt lost more of the iodine present in the salt during the first two months of storage. It is thought that the absence of stabilizers coupled with the presence of moisture and impurities contributed to the high losses in iodine. The percentage loss of iodine in Ken salt was 16.67 %. This finding was in agreement with the findings by Jabbour *et al.,* (2015) who observed that the iodine loss for the commercial salts iodized with iodate, and kept in impermeable container and stored away from sunlight was 16.17 %.

The percentage loss of iodine in sea salt, was higher than the loss in ken salt. This could be attributed to the difference in the composition of sea salt and composition of Ken salt, however the multiple comparisons done on the commercial salts indicated that there was no significant loss of iodine in the commercial salts hence the amount of iodine was fairly constant in the commercial salts. This could be attributed to the presence of stabilizers in the commercial salts (Laar and Pelig-Ba, 2013). Percentage loss of iodine in potassium iodate was 78.58 %. The loss of iodine in potassium iodate was high. This could be due to the absence of stabilizers. The trend of the concentration of Iodine highest in T. latifolia salt followed by

Indigenous salt and Ken salt then sea salt, which had the lowest concentration of iodine across the 90 days storage period.

Considering Cadmium using the Two-Way ANOVA results in **Table 3** the p-value for the test for a significant interaction between storage period and salts was 0.176. This p-value was greater than 5 %, therefore there was lack of evidence of a significant interaction between the levels of cadmium in salts and storage period (Days).

Table 3. Two-Way ANOVA for Variation in concentration of Cadmium with time in the salts (*T. latifolia*, Ken salt, Sea salt, on concentration of Cadmium present.

Dependent Variable: Cadmium

Source	Type III Sum of Squares	df	Mean Square	F	P-value.
Corrected Model	1705.408[a]	26	65.593	1.212E4	0.000
Intercept	636.572	1	636.572	1.176E5	0.000
Days	.118	6	.020	3.646	0.004
Salt	1646.372	3	548.791	1.014E5	0.000
Salt * Days	.128	17	.008	1.394	0.176
Error	.292	54	.005		
Total	2237.696	81			
Corrected Total	1705.700	80			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

Since the interaction term was insignificant, there was need to carry out further tests concerning the presence of the main effect of storage time on the levels of cadmium in the salts. The null hypothesis of no effect of storage period (Days) on the concentration of Cadmium was tested. The p-value (0.004) was less than 0.05 so the null hypothesis was rejected. There was no significant difference in the concentration of Cadmium between the seven storage periods. This shows that cadmium levels in salts does not reduce with time.

The null hypothesis of no effect of salts on the concentration of Cadmium was tested. The p-value (< 0.001) was less than 0.05 so the null hypothesis was rejected. There was a significant difference in the concentration of Cadmium between the four salts.

All the 28 treatments (each combination of storage period and salts) were examined to determine the differences in concentration of Cadmium present. From multiple pair wise comparisons, it was established that the concentration of Cadmium remained the same in indigenous salt, sea salt, ken salt and potassium iodate over the storage period. Results indicated that the concentration of Cadmium was similar in indigenous salt and commercial salts but higher in Potassium Iodate. Also, the concentration of Cadmium appeared to be relatively constant over the storage period, regardless of the salt type.

In general, the cadmium levels seemed to remain constant across storage period in Indigenous salt, Sea salt and KIO_3. However for Ken salt, the cadmium levels were the same from days 0 to 75 except on day 15 where the cadmium concentration level was significantly lower. This could be attributed to non-uniform distribution of cadmium in Ken salt crystals. Ken salt had significantly more cadmium on the 90th day than both indigenous and sea salts.

Higher levels of cadmium could be attributed to non-uniform distribution of the impurity in the salt, (Diosady and Mannar, 2000).

Conclusion and Recommendations

Conclusion

This study provides strong evidence that the amount of iodine reduces over time with levels higher during the first 15 days of production in indigenous salt. Therefore, it will be worth recommending consumption of this salt within the first 15 days after production when the concentration of iodine is high. This should be done in line with the World Health Organization recommended levels of iodine for human consumption, in order to reduce the burden of thyroid pathologies among the residents of Busia region in Western Kenya reported by Idda *et al*,. 2011.

Recommendations

Consumption of small amounts of indigenous salt in order to minimize intake of harmful heavy metal impurities within the first 15 days after production when the concentration of iodine is high is recommended, or stabilizers should be added to the salt to reduce the rate of loss of iodine, if the salt is to be used for 90 Days. There is need to find out the effect of the impurities in *T. latifolia* reed salt on the levels of iodine in the salt.

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