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Natural Concentrations of Iodine in Common Salts Produced from Popular Lagoons in Ghana and their Potential to Eliminate Iodine Deficiency Disorders

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Abstract— *Background and objectives: Iodine deficiency is a global public health concern. This deficiency if not cured results in illness like goiter, cretinism and reduced intelligence quotient that disrupts normal physical and mental functions. The USI programme was introduced to improve household's iodine intake, in Ghana the mandatory salt iodisation law that specifies that all salts meant for consumption must be iodised has been long passed to give credence to the USI. Yet, some Ghanaian families are still deliberately or ignorantly consuming salt containing less or no iodine at all with the perception that common salt naturally contains enough iodine. Hence, this study assesses the levels of iodine in salts from popular lagoons, which are major salt producing centres in Ghana. Methods: Two hundred (200) samples of salts were collected in six (6) months from popular major salt producing lagoons, namely, Ada-Songhor, Nyanyano, Keta, Amisa and Benya lagoons. In addition, five (5) brands of packaged refined salts also sampled for their iodine for comparative analyses. Questionnaire was administered to household's women in charge of meal preparation to solicit information about preference for salt and knowledge about IDD. Statistical Package for Social Sciences (SPSS) version 16 and Microsoft Excel were used in data analysis. Results: The lagoon salt samples did not record any measurable iodine (0 ppm). Ninety-three percent of respondents were ignorant about benefits of iodised salt, whilst 50.4% prefer non-iodised salt. Conclusion: The ignorance about the absence of iodine in crude salt could influence the extent of the ignorance about benefits of iodine and preference for non - iodised salt.*

Keywords— Lagoon, Common salt, Iodine Deficiency Disorders, Survey, iodine

I. INTRODUCTION

Common salt is important for human, animal and industry. One of the sources of common salt in Ghana predominantly is the seawater, primarily consists of sodium chloride (Osborne et al., 2023)[1]. Ghana started salt production in the nineteenth century. It has been a substantial economic activity, in the major salt producing lagoon centres, namely, Ada-Songhor, Keta, Densu Delta areas, Nyanyano, Amisa and Benyah lagoons (Amadu, A.K. 2019, Atta-Quayson & Baidoo, 2020)[2,3] . National production levels are estimated around 250,000 MT annually with potential of 2-3 million Tonnes (GEPC 2009)[4].

Iodine is a necessary trace mineral received through diet or supplements because the body cannot synthesize it. It is required for the creation of thyroid hormones (De Escobar et al., 2004)[5] which control several body processes, including metabolism. Iodization, the process of iodizing salt, used to alleviate iodine deficiency. In locations where iodine shortage is a problem, iodized salt is frequently used (Chirawurah et al.,201 5)[6]. A third of the world's population lives in regions with low natural iodine levels,

necessitating interventions to guarantee a sufficient iodine supply (Doku & Bortey (2018)[7].

Globally, efforts are made to promote the consumption of iodized salt to improve iodine intake (Zimmermann, M. B. (2009)[8], through USI programme. The USI has a target of 90% household use of sufficiently iodized salt. To achieve this, a legislation was passed in Ghana requiring iodine fortification of salt meant for humans and poultry (Ghana Public Health Act. (2012)[9]. To guarantee safe usage, the Ghana Standards Authority has established standards for the iodine level in salt (Ghana News Agency (2010)[10].

This notwithstanding, there is the perception that common salt contains iodine naturally which is enough for the body's physiological processes, contrary to established fact that unprocessed salt does not contain iodine (IGN, 2019)[11]. The aim of the study is to analyse the iodine in common salt from the major salt producing lagoons in Ghana, and then assess the impact of this perception in eliminating IDD in Ghana. The results will enrich the data on IDD about Ghana, and also enable policy makers and stake holders in their decisions.

II. MATERIAL AND METHODS

2.1 Study Design and Participants

Quantitative determination of the iodine levels in the salt was by titration (WHO).

Questionnaire designed to solicit information from respondents about their knowledge on IDD and choice for salt type. One hundred and thirteen (113) respondents who were women responsible for household meal preparations were interviewed.

2.2 Study Area and Sampling

One hundred (100) packaged salt samples were obtained from shops. They were six (6) different brands and coded for analysis.

In addition, two hundred (200) samples of common salt was collected in 6 months from major salt producing lagoons across Ghana.

The locations and the coordinates are as follows:

The Ada- Songhor lagoon is located at Ada East District in the Greater Accra Region (GSS, 2010)[12] with coordinates 5.82^{O}N 0.47^{O}E (en.m.wikipedia.org)[13].

The Keta Lagoon is located at Keta Municipal District in the Volta region, the coordinates are 5º53'16"N 0º49'36"E. (en.m.wikipedia.org)[13]

Nyanyano lagoon at Gomoa East district in the Central region having coordinates 5º30'89" N 0º25'2.9"W(en.m.wikipedia.org)[13]

Amisa lagoon in the Mfantsipim district of Central region with coordinates latitude 5º12'16.49"N longitude -1º0'38.45"W. (en.m.wikipedia.org)[13]

Benya lagoon in Elmina of Komenda /Edina/ Eguafo/ Arem distrct in the Central region, latitude is 5.05º4.92"N longitude -1º 21'3.35"W. (en.m.wikipedia.org)[13]

2.3 Chemical Analysis

Samples A, B and C were subjected to chemical analysis for the presence of iodine them in the research Lab of the department of Laboratory Technology, University of Cape Coast.

Twenty grams (20g) of sample C was weighed into 250mL conical flask and stoppered. Thirty

milliliters (30 mL) of distilled water was added and swirled to dissolve. Thirty milliliters (30 ml) distilled water was added to make up 60 mL. One milliliter (1mL) of 1M H_2SO_4 and 5mL of 10% KI solution was added. The flask was stoppered and placed in the dark for 10 minutes. It was titrated against 0.01M $Na_2S_2O_3$ until the solution turned pale yellow. Two (2) mL of starch indicator solution was then added, and titration continued until the solution became colorless. This was repeated for samples A and B. (Ahiadeke et al., 2012)[14].

The qualitative analysis depended on the reaction:

$$IO_3^- + 5I^- + 6H + \rightarrow 3I_2 + 3H_2O.$$

The yellow or brown colouration indicates the presence of free iodine liberated on addition of acid, and kept in a dissolved state by potassium iodide (Doku & Bortey, 2018)[7],(University of Canterbury, College of Science. 2021)[15]. The liberated free iodine reacts with the amylose component of starch (indicator) to give the characteristic dark purple (blue - black) coloration. Addition of thiosulphate solution ($Na_2S_2O_{3\,(aq)}$) reduces excess iodine, the dark blue – black colour disappears leaving a colourless endpoint. (University of Canterbury, College of Science. 2021)[15].

The unrefined salt showed no formation of a yellow colouration from the reaction, this indicates a negative qualitative analysis, for the industrially iodated salt, a yellow coloration was observed after the initial reaction indicating the presence of iodine, hence a positive qualitative analysis.

2.4 Calculations

The equations below explain the reaction:

$$IO3^-(aq) + 5I^-(aq) + 6H + (aq) \rightarrow 3I_2(s) + 3H_2O(L). \quad (1)$$

$$I_2(s) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq) \ldots\ldots\ldots\ldots (2)$$

The number of moles of thiosulfate required for reaction with each mole of iodate in the initial salt solution was

calculated using the redox equations above, as was the average volume of thiosulfate solution used from concordant titres. (University of Canterbury, College of Science. 2021)[15]. The amount of thiosulfate, in moles, reacting was calculated first, followed by the amount of iodate in moles in the salt solution. The iodate concentration in the salt solution was obtained in mol L^{-1} , then the concentration of iodine in the salt solution was calculated, using the equation:

Iodine (I) content = iodate (IO_3^-) content × 126.9/174.9

2.5 Data Analysis

The Statistical Package for Social Sciences (SPSS) version 16.0 was used to analyze the

Data. Statistically, $p < 0.05$ was reflected as significant.

III. RESULTS

Table 1: Average Iodine Content (ppm) of Brands of Salt

Sample	Iodine content
Salt from lagoon	
Ada-Songhor	**0.0**
Nyanyano	**0.0**
Keta	**0.0**
Amisa	**0.0**
Benya	**0.0**
Crude salt from market	
A	**0.0**
B	**0.1±0.00**
C	**0.1±0.00**
D	**0.0**
E	**0.0**
F	**0.0**
G	**0.1±0.00**
Refined iodised salt	
Annapurna	**39 ± 0.01**
U2	**36.3 ± 0.02**
Crude iodised salt	
Iodised sea salt	**33.2 ± 0.01**
Ghana Standard Authority	**25-50**

Source: Bartels/Vanderpuye/Gadzekpo, Laboratory results, 2023

Table 2: Knowledge about Iodised Salt and Preference for Choice of Brand

Parameter	Respondents	Percentage, %
Benefits of iodised salt		
No idea	**105**	**93**
Improve IQ	**5**	**4**
Prevents goitre	**3**	**3**
total	**113**	**100**
Knowing salt is iodised		
Labelled as iodised	**60**	**53.1**
Assumed iodised	**53**	**46.9**
total	**113**	**100**
Preferred salt brand		
iodised	**46**	**49.6**
Non-iodised	**67**	**50.4**
total	**113**	**100**

Source: Bartels/ Vanderpuye/Gadzekpo Statistics, 2023

IV. DISCUSSION

4.1 Iodine content in lagoon salt

As shown in Table 1, all the samples from the lagoons, namely, Ada-Songhor, Nyanyano, Keta, Amisa and Benya did not record any measurable or detectable concentration of iodine, that is, zero (0) ppm of iodine content. The absence of iodine, however, suggests that the salts do not naturally contain any appreciable level of iodine, this corroborates earlier study (IGN, 2019) [11], and even though the sea contains about 2 ppm iodine content (Medeiros-Neto et al., 2016)[16]. Therefore, non-iodised salt cannot serve as a standalone remedy to fight IDD. This finding presupposes that consuming non-iodised salt do not provide iodine to combat IDD and that the perception that non-iodised salt contains iodine is false.

Moreover, results from salt samples A, B, C, D, E, F and G from various markets in Ghana also revealed the absence of iodine as shown in Table 2. Such are salts directly sold on the market from the lagoons without being iodised.

As in Table 2, for example, the 50.4% of the respondents who preferred non-iodised salt for cooking, would be deprived of the iodine required by law to fight IDD and defeat government efforts to effectively implement USI in Ghana. This could affect Ghana's grading of iodine deficiency status.

4.2 Iodine content in iodised salt

As shown in Table 2, two of the most patronized iodised salt brands in Ghana, namely, Annapourna and U2 had iodine content of 39 ± 0.01 and 36.3 ± 0.02 respectively. These concentrations are within the GSA limit of 25-50 ppm required for the maximum benefit of the consumption of iodised salt. It could be inferred that the 7% respondents could benefit from the consumption of iodised salt.

It must be emphasized that refined salt often undergoes a purification process where impurities are removed and essential micronutrients are added for fortification (Ghana Statistical Service: Ghana Demographic and Health Survey Report. (2014)[17].

Ghana, to combat iodine deficiency disorders, many countries including Ghana have implemented iodization programs, which involve adding iodine to refined salt to ensure an adequate intake of this essential nutrient.

4.3 Iodised and non-iodised salt

The difference in iodine content between the iodised and non-iodised salt sample demonstrates the effectiveness of the iodization process. Iodised salt is deliberately (Ghana Health Service/ USAID/FANTA II, 2023)[18] fortified with iodine to provide a reliable source of this micronutrient to the general population. (Ghana Statistical Service (2014)[19]. This approach helps prevent iodine deficiency, which can lead to various health problems, particularly affecting the thyroid gland. (De Escobar et al., 2004)[5] .

The WHO estimates a 20% loss from production level to household and a further 20% loss during cooking. WHO also predicts that, in order to meet an average daily requirement of 150µg iodine from an average salt intake of 10g of salt a day, iodine concentration in salt at the point of production should be within the range of 20 - 40ppm. (Doku & Bortey (2018)[7].

Households that cook meals with non-iodised salt are exposed to risks of Iodine Deficiency Disorders.

4.4 The survey

4.4.1 Benefits of iodised salt consumption

Out of the 113 surveyed, 105 constituting 93% stated that they had no knowledge about the benefits of iodine in the salt being consumed. Such ignorance involving majority of the respondents suggests lack of iodine nutrition awareness programmes in the communities of the respondents, and therefore embolden the perception that non-iodised salt contains natural iodine.

This ignorance and perception may be attributed to factors, such as, inadequate public health campaigns, insufficient dissemination of information about iodine nutrition.(Chirawurah et al., 2015)[6] , and lack of cooperation or flow of knowledge between industry and academia.

Universal salt iodization has been one of the most effective public health interventions adopted

by WHO/UNICEF/ ICCIDD for the global eradication of iodine deficiency disorders (IDDs). (Osborne et al., 2023), GEPC (2009)[4,1]. The progress of this intervention was assessed by interviewing women in control of household diet preparations, the study revealed that 53.1% have knowledge about iodized salt, as compared to earlier studies in Hohoe in the Volta and Gushegu in the Northern regions of Ghana that recorded 59.3 and 53.5% respectively. (University of Canterbury, College of Science. 2021), Medeiros-Neto et al., 2016)[16,15]

In spite of this observation, the 53.1% does not translate into use as 50.4% prefer non- iodised salt for cooking as shown in Table 2. Such behavior may also be influenced by the perception that non-iodised salt contain natural iodine, and may eventually impact negatively on the USI programme in Ghana.

V. CONCLUSION

1. Salt samples (common salt) from all the lagoons did not contain iodine. This finding does not support the assertion that raw salt contains iodine, required to eliminate iodine deficiency disorders (IDD).

2. Raw salt (samples A- G) from these lagoons that are sold on the markets also did not record significant level of iodine. Consumption of such salts therefore does not have the potential to eliminate Iodine Deficiency Disorders (IDD).

3. Concerning the survey, majority of respondents had no knowledge about the benefits of iodised salt, while many prefer non-iodised salt.

4. Annapurna most patronized refined iodised salt in Ghana had iodine content within the Ghana Standard Authority Limit. Consumption of such could eliminate IDD.

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RECOMMENDATION

- The need for effective collaboration between industry and academia for dissemination of information, and research findings as applied to salt.
- The need for relevant agencies to intensify education on iodine nutrition, emphasizing on the negative impact of the perception that raw salt contains enough iodine to fight iodine deficiency disorders

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