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# Iodine, and selected goitrogens measured in some common grains from Sokoto zones, Nigeria

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***ABSTRACT***

*This study aimed to determine iodine, selected goitrogens in some grains in Sokoto. Related factors were measured in clay, loamy, and sandy soils using standard methods and reagents of analytical grade. Western zone (WZ) has highest iodine (29 ± 0.01 ppm), then Central Zone (CZ) (26 ± 0.01 ppm), and Eastern Zone (EZ) had (24 ± 0.01 ppm). Sandy soil had highest pH (6.55 ± 0.08), then clay (5.02 ± 0.06) and lastly loamy soil (4.02 ± 0.05). Organic matter was highest in clay (7.3±1.02%), loamy soil (6.0 ± 1.5%), and lastly sandy soil (6.0 ± 1.5%). Iodine in rice (25 ± 0.014ppm) was higher (P<0.05) in WZ than (17±0.016 ppm) in EZ. Iodine in maize differed significantly (P < 0.05) between WZ (28 ± 0.013 ppm) and EZ (20.0 ± 0.013 ppm). The difference (P < 0.05) in iodine level of millet in WZ (18 ± 0.012 ppm) was higher than EZ (11 ± 0.014 ppm). In sorghum, iodine level between WZ (19 ± 0.010 ppm) and EZ (12 ± 0.012 ppm) differed significantly (P<0.05). Goitrogens in studied grains are: 1.2 ± 0.04 to 8.7 ± 0.56ppm, 2.2 ± 0.04 to 5.8 ± 0.16ppm, 25 ± 0.34 to 48 ± 0.03ppm, and 30 ± 0.56 to 47 ± 0.53ppm for cyanogenic glycosides, glucosinolates, thiocyanate, and total polyphenols respectively. There was significant (p < 0.05) iodine in grains of the state. However, goitrogens found in the grains could affect people that consume low-iodine diet or goitrogen laced-diet chronically.*

***Keywords:*** *Iodine, grains, goitre, iodine deficiency, soil*

## 1. Introduction

Iodine is a vital element with 53 as atomic number, and 126.9 atomic weight and is regarded as the member of group 17 in the periodic table and $9^{th}$ in the halogens group. Iodine is a solid volatile element at room temperature. Iodine remains as an ultra-trace element existing in the earth with a presumed concentration of about 0.25mg/kg to 0.3mg/kg present mostly in rocks in some circumstances. In the soil, it was expected to have about 0.1-150ppm iodine according to studies measuring iodine levels in soils. Thereof, iodine is distributed in soils according to factors such as soil topography, rainfall, anthropogenic processes and other activities (Zimmerman et al., 2008; Fuge & Johnson, 2015).

In the current century, iodine is an essential element due its ability to participate in the making of important thyroid hormones. That is why dietary iodine is very important as depicted in Figure 1 (Lu et al., 2005; Jenzer & Sadeghi, 2017). However, the extensive applications of iodine in salt and other food materials are the current norms and led to eradication of iodine deficiency in many parts of the world. In some parts of the world (such as developed countries) there is an assumption that the iodine deficiency has been eradicated, while other places (such as developing countries) are still battling with the resurfacing of iodine deficiency prevalence (Diosady et al., 1997; Enechi et al., 2013; Ajayi et al., 2015; Appiah et al., 2020). Thus, a focus was directed significantly to the concern about the environmental sources of iodine (Zimmerman et al., 2008; Fuge & Johnson, 2015). Little amount of soil iodine is taken up by plants via the root and for upward utilization by humans through the food web (The Jivita Journal, 2012; Habib et al., 2021; Naeem et al., 2021). Therefore, it is pertinent to measure iodine in soils and the onward uptake in plant foods and the possible antinutrients (goitrogens that interfere with consumed iodine actions) and in turn possibly eliciting diseases and disorders such as goiter, miscarriage, hypothyroidism, hyperthyroidism, cretinism, brain damage (Umar et al., 2017; Abu Bashar & Begam, 2020).

Nevertheless, over the years some studies were conducted regarding iodine issues. Parable, Wisnu (2008) shows that the vegetables observed contain sufficient bioavailable iodine for human utilization after subjecting the food materials to cooking. In a Ghanaian study on compliance to iodine supplementation in salts, it was revealed that, most of the companies producing the salts are not adhering to the regulations as indicated by levels of iodine in the observed salts (Doku & Bortey, 2018). In another study on iodine content in salts in Port Harcourt, it was shown that the levels of iodine in salts decrease over the time of storage, albeit the values of iodine are sufficiently high for human utilization (Emilike et al., 2017). An observation of some fruits and vegetables for iodine contents has revealed that only few fruits and vegetables are able to accumulate the enough amount of iodine needed by the human body (Salau et al., 2011). Another reported study from Nigeria observed that, there is compliance to the appropriate iodization of commonly sold salts as revealed by the assessed salts for iodine concentrations (Moyibo, 2018). Another study reported that, uptake of little / sufficient iodine can result into iodine deficiency in humans. Likewise, uptake of enough iodine coupled with long-term uptake of goitrogens is responsible for iodine deficiency in many human subjects (Appiah et al., 2020). Certainly, thereof studies had revealed iodine issues ranging from poor iodization in natural and manufactured food materials to the instigation of iodine deficiency due to goitrogenic uptake (Katongo et al., 2017; Oladejo et al., 2018; Paz et al., 2018; Sorrenti et al., 2021; Wang et al., 2021). Therefore, the objective of this study was to determine iodine levels in (clay, loamy and sandy) soils, common grains. And also to determine the goitrogenic content of common grains across zones of Sokoto state, Nigeria.

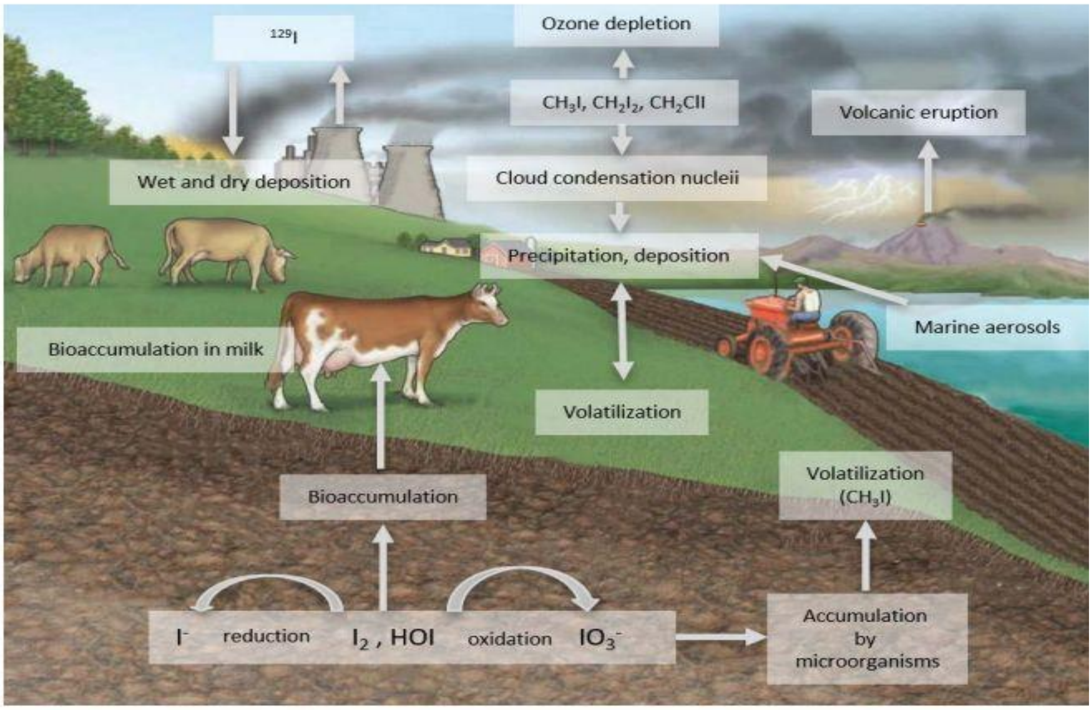


***Figure 1.*** Showing iodine cycle in the environment, Source: Ahad & Ganie, 2010

## 2. Research Methods

### *Study area*

Different grains and soil types were collected in different zones of Sokoto, Nigeria. The study was carried out in Sokoto state, Nigeria. The exact location of the study was shown by the map in the Figure 2. Sokoto State is located in the North West Zone of Nigeria between longitude 11″ 30–13″ 50 and latitude 4″–6″. It borders Niger Republic to the north and Benin Republic to the northwest, Kebbi State to south and Zamfara State to the east. It has a land mass area of about 32,000 sq km, and consists of 23 local government areas and 244 political wards. The population is predominantly rural, Muslim and consists almost entirely of Hausa/Fulani ethnic groups Sarkingobir et al. (2023).

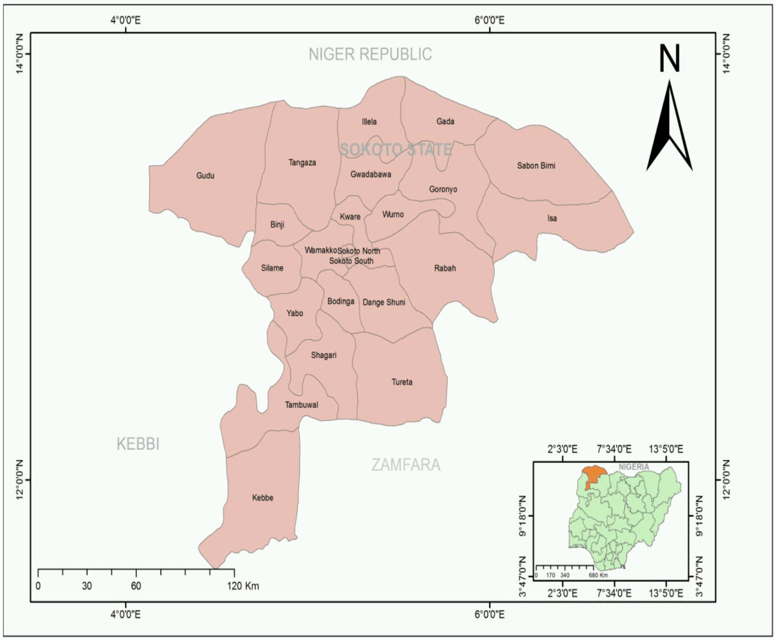


*Figure 2.* Map of the study location; Source: Sarkingobir et al. (2023).

### *Determination of iodine*

### *Principle*

Iodine content of sample was determined according to Association of Official Agricultural Chemists, AOAC (2000) by iodometric titration. Iodine is liberated by adding $H_2SO_4$ to a solution of the sample. The iodine liberated is titrated with sodium thiosulphate ($Na_2S_2O_3$) solution to form sodium iodide and sodium tetrathionate (Muleta & Kibatu, 2016).

### *Procedure*

Prior to taking a 10 g sample for analysis, the sample was thoroughly mixed in tightly sealed plastic bags to ensure that the iodine is homogeneously distributed in the sample. Ten grams (10g) of sample were dissolved in 50 ml distilled water, from which an aliquot (50ml) was analysed as mentioned in the titration step, without adjusting the concentrations of the reagents or calculation (Muleta & Kibatu, 2016).

### *Titration*

Once the sample was dissolved in the measured amount of water, sulfuric acid (1–2ml) and potassium iodide (5ml) were added to the solution. The reaction mixture was then kept in a dark place (with no exposure to light) for 5 to 10 minutes to reach the optimal reaction time, before titration with sodium thiosulphate using starch (2ml) as the indirect indicator. The solution turned deep purple. Titration was continued until the purple coloration disappeared and the solution became colourless. The concentration of iodine in sample was calculated based on the titrated volume (burette reading) of sodium thiosulphate using to the formula mentioned below

$$\text{Iodine (ppm)} = \frac{\text{Titration volume in ml} \times 21.15 \times \text{normality of sodium thiosulphate} \times 1000}{\text{Grain/soil sample}}$$

***Statistical analysis***

The descriptive statistics and one-way analysis of variance (ANOVA) were carried out at ($p<0.05$) significance level using Microsoft excel version 7.

## 3. Result

The result for this study was detailed in Tables 1-5.

*TABLE 1*. Iodine distribution in clay, loamy, and sandy soils collected from Sokoto, Nigeria

| | **Loamy soil** | **Clay soil** | **Sandy** |
|---|---|---|---|
| **Iodine (ppm)** | **25 ± 0.03** | **31 ± 0.5** | **17 ± 0.4** |
| **pH** | **4.02 ± 0.05** | **5.02 ± 0.06** | **5.60 ± 0.08** |
| **Organic matter (%)** | **6.0 ± 1.5** | **7.3 ± 1.02** | **4.4 ± 2.01** |

Key: Values are expressed as mean± standard deviation

Table 1 shows the levels of iodine, pH, and organic matter in soils collected from different zones of Sokoto state, Nigeria. The clay soil has highest iodine (31 ± 0.5 ppm), followed by loamy soil (5.60 ± 0.08 ppm), and lastly was sandy (17 ± 0.4 ppm). The factors that affect iodine bioavailability such as pH and organic matter were determined in different soils of Sokoto (Table 1). Sandy soil had the most elevated pH (6.55 ± 0.08), followed by clay soil (5.02 ± 0.06) and lastly loamy soil (4.02 ± 0.05). However, organic matter was most elevated in clay soil (7.3 ± 1.02%), loamy soil (6.0 ± 1.5%), and lastly sandy soil (6.0 ± 1.5%).

*TABLE* 2. Distribution of iodine levels in commonly consumed grains in two zones of Sokoto, Nigeria

| | **Central Zone (CZ)** | | | | **Western Zone (WZ)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Grain type** | **Sorghum** | **Rice** | **Millet** | **Maize** | **Sorghum** | **Rice** | **Millet** | **Maize** |
| **Iodine (ppm)** | **16 ± 0.012** | **21 ± 0.06** | **15 ± 0.014** | **23 ±0.015** | **19 ± 0.010** | **25 ± 0.014** | **18 ± 0.012** | **28 ± 0.013** |

Key: Values are expressed as mean ± standard deviation

*TABLE* 3. Distribution of iodine levels in commonly consumed grains in Sokoto Eastern Zones, Nigeria

| | **Eastern Zone (EZ)** | | | |
|---|---|---|---|---|
| **Grain type** | **Sorghum** | **Rice** | **Millet** | **Maize** |
| **Iodine (ppm)** | **12 ± 0.012** | **17 ± 0.016** | **11 ± 0.014** | **20 ± 0.013** |

Key: Values are expressed as mean ± standard deviation

Table 2 and 3 show the levels of iodine in commonly consumed grains in Sokoto, Nigeria. Iodine level in rice (25 ± 0.014ppm) was significantly higher ($P < 0.05$) in WZ than (17 ± 0.016 ppm) in EZ. Iodine levels in maize differed significantly ($P < 0.05$) between WZ (28 ± 0.013 ppm) and EZ (20.0 ± 0.013 ppm). Similarly, Significant difference ($P < 0.05$) in iodine level of millet in WZ (18 ± 0.012 ppm**)** was observed to be higher than EZ (11 ± 0.014 ppm). While sorghum, iodine level between WZ (19 ± 0.010 ppm) and EZ (12 ± 0.012 ppm) differed significantly ($P<0.05$).

*TABLE* 4. Showing distribution of goitrogens in selected grains in two Sokoto zones, Nigeria

| | **Central District (CD)** | | | | **Western Zone District (WD)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Sorghum** | **Rice** | **Millet** | **Maize** | **Sorghum** | **Rice** | **Millet** | **Maize** |
| **Cyanogenic glycosides (ppm)** | **7.8 ± 0.11** | **1.2 ± 0.04** | **8.4 ± 0.31** | **5.1 ± 0.39** | **7.5 ± 0.31** | **2.7 ± 0.03** | **8.1 ± 0.54** | **5.2 ± 0.32** |
| **Glucosinolates (ppm)** | **5.2 ± 0.21** | **3.1 ± 0.12** | **5.2 ± 0.68** | **4.2 ± 0.39** | **5.1 ± 0.47** | **2.2 ± 0.04** | **4.9 ± 0.54** | **4.3 ± 0.30** |
| **Thiocyanate (ppm)** | **41 ± 0.44** | **26 ± 0.54** | **45 ± 0.51** | **31 ± 0.28** | **40 ± 0.42** | **25 ± 0.34** | **45 ± 0.44** | **30 ± 0.35** |
| **Total polyphenols (ppm)** | **40 ± 0.61** | **33 ± 0.71** | **45 ± 0.33** | **34 ± 0.55** | **45 ± 0.32** | **30 ± 0.56** | **47 ± 0.53** | **32 ± 0.69** |

Key: Values are expressed as mean± standard deviation

*TABLE 5.* Showing levels of some goitrogens in selected grains in Eastern Sokoto zone, Nigeria

| | **Eastern District (ED)** | | | |
|---|---|---|---|---|
| | **Sorghum** | **Rice** | **Millet** | **Maize** |
| **Cyanogenic glycosides (ppm)** | **7.9 ± 0.28** | **3.8 ± 0.07** | **8.7 ± 0.56** | **5.8 ± 0.24** |
| **Glucosinolates (ppm)** | **5.8 ± 0.16** | **3.3 ± 0.12** | **5.3 ± 0.71** | **4.8 ± 0.40** |
| **Thiocyanate (ppm)** | **42 ± 0.21** | **28 ± 0.07** | **48 ± 0.03** | **32 ± 0.54** |
| **Total polyphenols (ppm)** | **47 ± 0.32** | **34 ± 0.22** | **49 ± 0.21** | **39 ± 0.16** |

Key: Values are expressed as mean± standard deviation

Tables 4 and 5 show the levels of goitrogens in grains collected across the zones of Sokoto state, Nigeria. 1.2 ± 0.04 to 8.7 ± 0.56 ppm, 2.2 ± 0.04 to 5.8 ± 0.16 ppm, 25 ± 0.34 to 48 ± 0.03ppm, and 30 ± 0.56 to 47 ± 0.53 ppm are ranges of cyanogenic glycosides, glucosinolates, thiocyanate, and total polyphenols respectively.

## 4. Discussion

The acidic pH recorded (in Table 1) is a good portend that will facilitate the uptake of iodine by plants, because an alkaline pH reduces the ability of plants to take in iodine content of the soils (Fuge & Johnson, 2015). The uneven availability of iodine in various types of soils across the globe necessitates the need to measure levels of iodine in soils of different areas where plants, animals, and human live. Because, soils that are low in iodine or high in iodine will definitely affect the levels of iodine in crops that are flux into the human food web and affect humans as well (Zimmerman, 2010; Fuge & Johnson, 2015; Duborska et al., 2022).

Iodine remains an essential microelement of emphatic stance in human nutrition serving as an important part of thyroid hormones. Thereof, it was recommended for adults to consume 180-200 microgram and less than 100ug for younger ones for the proper functioning of the human body. However, the levels of iodine been taken by humans are related to the types of foods in their nutrition/ food web. Therefore, in Sokoto it is pertinent to measure levels of iodine in staple foods such as grains (Salau et al., 2011). Tables 2 and 3 show the levels of iodine in different types of grains consumed across different zones of Sokoto. The range of iodine concentration was 11±0.014 ppm (obtained from millet) to 25±0.014ppm (obtained from rice). The values obtained from this study are extremely higher than the concentrations of iodine reported in different vegetables in Kano, Nigeria; and mostly higher than iodine reported in commonly used fruits and vegetables in a southern study (Salau et al., 2011). This might indicate that, the grains are better source of iodine than other food materials such as fruits and vegetables in the country (Fuge & Johnson, 2015); in contrast to some claims that grains are not good source of iodine supplementation because the iodine is poorly mobile to reach the grains/seeds (Zia et al., 2014). Thereof, concentrations of iodine in grains were determined by the levels of iodine in the growing soils and in part by the methods and processes that add iodine to the soil such as irrigation, fertilizers, and livestock feeds (Zimmerman et al., 2008; Zimmerman, 2010).

Nevertheless, iodine is very essential in the production of thyroid hormones that affect several organs and functions (Bouga et al., 2015; Fan et al., 2022). However, recently in many developed populations there exists iodine deficiency presumably due to intake of food materials that contain substances (goitrogens) that interfere with iodine uptake of the body. In this streak, the levels of goitrogens in commonly consumed grains in Sokoto were determined. Therein, Tables 4 and 5 show the concentrations of goitrogens in grains collected across the zones of sokoto state, Nigeria. 1.2±0.04-8.7±0.56 ppm, 2.2 ± 0.04 to 5.8 ± 0.16 ppm, 25 ± 0.34 to 48 ± 0.03 ppm, and 30 ±0.56 to 47 ± 0.53 ppm are ranges of cyanogenic glycosides, glucosinolates, thiocyanate, and total polyphenols respectively. It was reported that, long term intake of food containing goitrogens in people with low habit of iodine intake poses a risky effect on thyroid function (Bouga et al., 2015; Umar et al., 2023); because goitrogens can cause an enlargement of the thyroid gland and in turn changing the regulatory mechanisms of the gland and ultimately the peripheral metabolism. In turn three important hormones, viz T4, T3 and calcitonin are affected (Oladejo et al., 2018; Miya et al., 2023). Noteworthy, the goitrogens (in Tables 4 and 5) determined in this study are extremely higher than the levels recorded in vegetables collected in Kogi state, Nigeria (Oruma et al., 2021). Specifically, thiocyanate act to competitively inhibit the human thyroid sodium/iodide symporter. Therefore, a person who takes low iodine foods is bound to probably be affected by the presence of thiocyanate in his body. Cyanogenic glycosides are plant-based substances that ultimately produce harmful cyanide to the body (Oruma et al., 2021). Thus, common people need to be more aware about iodine deficiency and determinants therein through health education, awareness campaign. Ways for reducing concentrations of goitrogens in common foods should be established and made plain to the public domain.

## 5. Conclusion

Iodine is essential for proper body function as a result of its giant role in thyroid hormones synthesis and have to be taken from food. The common foods in our state are the grains that absorbed iodine from soils. however, grains contain factors (goitrogens0 that affect iodine availability in human body. Therefore, it is pertinent to determine iodine levels in grains commonly consumed in Sokoto and assess the levels of goitrogens in grains as well. In a nutshell, there was significant amount of iodine recorded in soils and grains in the state. However, the significant levels of goitrogens found in the grains could serve as a problem in people that consume low iodine or consume the goitrogens for over a long period of time. Thus, there is need to implore people to take in sufficient concentration of iodine via foods and shun foods that contain much goitrogens. Likewise, it is not better to take in food in raw because the goitrogens may cause effects; therewith, proper treatment of food materials could invariably clear or reduce the goitrogenic factors therein.

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