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# Iodine content of soil, white maize (*Zea mays*) and rice (*Oryza sativa*) from rural part of Anambra State, South-east Nigeria

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## ABSTRACT

Iodine is an essential trace element necessary for metabolism and overall health. It is unique because it is the constituent of thyroid hormones. Iodine deficiency leads to health problems known as iodine deficiency disorder (IDD).The entire landscape of Nigeria predisposes the country to iodine deficiency disorders because of its proximity to the equator and the long months of rainfall spreading from April to November. In Nigeria as well as other parts of the world, the consumption of iodized salt to improve iodine intake has been encouraged. However, locally produced salts are still found in local markets especially in our study area. Effort to improve the iodine intake of inhabitants of such areas must begin with a look at data on iodine content of local soil and locally cultivated and consumed staples. Data on iodine content of soil and food samples are relatively scarce. The aim of this study is to determine the iodine content of soil and commonly cultivated and consumed staples (rice and maize) in Ayamelum LGA of Anambra State, Nigeria. Materials and Methods- Soil samples were collected from farm land. Rice and maize samples were bought from farmers that own the farmland where soil samples were collected. The samples were prepared and analysed for iodine using alkaline dry ash method. Descriptive and correlation analysis were carried out using IBM SPSS (version 22). Results and Discussion- The results showed that mean iodine content of soil, rice and maize were 10.992±2.730µg/g, 9.110 ±0.873 µg/g and 9.083±0.857 µg/g, respectively. The iodine content of soil samples in this study was higher than the world- wide mean iodine content of soils which is 3.0µg/g. There was positive correlation between iodine content of soil samples and iodine content of the food samples ($p<0.01$). The sale and consumption of locally made non-iodized salt should be encouraged and enforced.

Keywords: Soil, Iodine, thyroid hormone, maize, rice, iodized salt

## INTRODUCTION

Iodine is an essential trace mineral. Iodine is very important in the synthesis of L-monoiodotyrosine which is a precursor of the thyroid hormones, thyroxine ($T_4$) and triiodothyronine ($T_3$) in the body [1].The thyroxine ($T_4$) and triiodothyronine ($T_3$) are needed for normal growth, physical and mental development in animals and man [2]. Iodine plays a role in the prevention of fibrocystic breast disease, a condition characterized by painful swelling in the breasts. Iodine is involved in controlling the effects of estrogen on breast tissue [3]. According to World Health Organization daily recommendations for iodine, school children require 120microg/day where adolescents and adults need 150microg/ day [4]. During the course of a life time, less than 3g of iodine is needed. The insufficient secretion of thyroid hormone in the body leads to hypothyroidism while hyperthyroidism will occur due to excessive amount of thyroid in the blood [5]. Iodine deficiency disorder (IDD) is a name used to refer to a wide range of health problems associated with iodine deficiency in man. The effect of IDD include goiter, still birth, stunted growth (cretinism), thyroid deficiency and mental defects (impaired neurocognitive development), decreased fertility, infant mortality [6]. The most severe effect is fetal damage which is preventable through adequate iodine exposure to the population [7]. The report by [8] shows that iodine deficiency is the single most common cause of preventable mental retardation and brain damage in the world. Parkinson's diseases, multiple sclerosis and Alzheimer's disease have also been linked with iodine deficiency [9]. Iodine deficiency is distinct from other micronutrient deficiencies in human population in having a high endemic prevalence both in well developed and in developing countries [10]. Globally, iodine deficiency disorders affect 1.9 billion people [2]. IDD results from inadequate intake of iodine or effect of thiocynate in foods such as cassava [6]. Populations suffering from iodine deficiency should be supported with more iodine, especially in the form of iodized salt, iodized oil and iodized flour. Iodine supplements are required for the synthesis of thyroid hormones and for correcting neurological, gastrointestinal and skin abnormalities in human beings [11]. Regular use of iodized salt helps to improve iodine deficiency disorder in short period of time and also restores the lost cognitive functions among school children [12]. Excessive intake of iodine as little as 1000 micrograms of iodine in a day causes irritations like burning of the mouth and throat, nausea, vomiting, stomach ache and even coma [13]. Soil nutrients' status has great implications on human health. According to [14], soil nutrients status and management not only determines crop productivity but also nutrient concentration in plant parts consumed as food and feed. Iodine content of foods varies according to the iodine present in the environment [15] [16]. The same food may contain different levels of iodine depending on the locality where it was produced [14]. The entire landscape of Nigeria predisposes the country to iodine deficiency disorders because of its proximity to the equator and the long months of rainfall spreading from April to November [17].Total goiter rate in Nigeria was put at 20% across the nation [17]. However, it has been observed that in some rural areas, especially Ayamelum communities, locally made salts are still sold in the markets, despite the ban on the sale of such in Nigeria. Any step to promote healthy diet among such farmers must start with data on the iodine content of local soil and commonly cultivated and consumed staples. However, data on iodine contents of soils and staple foods in Nigeria are relatively scarce. This study is aimed at determining the iodine contents of soil, maize (*Zea mays*) and rice (*Oryza sativa*) grown in Ayamelum L.G.A of Anambra State, Nigeria.



## MATERIALS AND METHODS

### Study Area

The study was done in Ayamelum Local Government Area. Ayamelum is a Local Government Area in Anambra State, Nigeria with headquarter located in Anaku. Ayamelum lies between 6o15N Equator and 6o44 East of the Greenwich Meridian. It has 5 communities and population of 158,152 and covers area of 589Km$^2$ (National Population Commission National Bureau of Statistics, 2006). The inhabitants are predominantly farmers. Ayamelum is situated very close to water bodies like Omambala, a tributary of River Niger. The area suffers impact of climate change like flooding and erosion [18].The major staples grown and eaten in the area are maize (*Zea mays*) and rice (*Oryza sativa*).

### Selection of Communities and Farmlands

Three communities were randomly chosen from the 5 communities. One farmland was purposefully chosen from each of the selected communities for the study.

### Sample Collection

Using a steel spade, 50cm x 50cm areas were dug at 3 locations in the 3 chosen farmlands and soil samples collected at depths of 25cm – 50cm using hand trowel. Three maize (30g each) and 3 rice samples (30g each) were bought from farmers of the 3 selected maize and rice farm lands at Omor, Anaku and Umuerum in Ayamelum LGA. Where soil samples were collected.

### Sample Preparation

Soil samples and the grain samples were dried in the oven at 40$^o$ C. The samples were cooled and weighed repeatedly until constant weights were obtained. Each soil and grain sample was then ground separately using vibratory ball Mill and stored in an air tight correctly labeled containers at 4$^o$ C.

### Determination of Iodine in soil and food samples

Iodine concentration in soil and food samples was determined using the alkaline dry ash method as described by [19]. This was carried out as follows: 0.5g of each sample was weighed into nickel crucibles. Then 1ml of a mixture of 0.5M sodium hydroxide and 0.1M potassium nitrate was added to the samples, mixed and allowed to dry. Then the containers were covered with aluminum foil and placed in a muffle furnace for heating. The samples were firstly heated to 250 $^o$ C, allowed to stand for 15minutes. Further heating was done to 480 $^o$ C and again held for 15 minutes. Finally the heating was done up to 580 $^o$ C. The samples were kept at this temperature for 3 hours after which they were allowed to cool to room temperature. The resultant ash extracted with three successive, 2ml portions of a 1.0mM sodium hydroxide solution, made up in double-distilled water. Using polypropylene centrifuge tubes, the solution was centrifuged at 2500g for 20minutes and the supernatant solution collected for iodine determination. Iodine was determined by adding 1 ml of sample solution to a cuvette at 35 ° C and 1 ml of arsenic reagent was added. The initial reaction rate was calculated from the change in absorbance at 420 nm. The Iodine concentrations of the samples were determined from a standard curve.

### Statistical analysis

Data obtained were expressed as means and standard deviations using IBM SPSS (version 22). Pearson correlation analysis was used to establish the relationship among the mean iodine content of the samples and results were presented as tables.



## RESULTS

Table 1 showed that the mean iodine content of soil samples from selected communities in Ayamelum LGA ranged from 8.108 to 13.953µg/g that of rice and maize ranged from 8.106 to 10.119µg/g and 8.106 to 10.082µg/g, respectively.

**Table 1: Iodine content of Soil, rice (*Oryva sativa*) and maize(Zea mays) according to communities(µg/g)**

| Communities (C) | Soil no | Soil iodine ( mean±SD) | Rice no | Rice Iodine (mean±SD) | Maize no | Maize iodine (mean±SD) |
|---|---|---|---|---|---|---|
| C1 | 3 | 8.1080±0.0012 | 3 | 8.1056±0.003 | 3 | 8.1060±0.003 |
| C2 | 3 | 10.9143±1.790 | 3 | 9.1043±0.064 | 3 | 9.0610±0.051 |
| C3 | 3 | 13.9533±0.984 | 3 | 10.1193±0.011 | 3 | 10.0823±0.044 |
| Total | 9 | 10.9919±2.730 | 9 | 9.1098±0.873 | 9 | 9.0831±0.857 |

NB: Values are means of 3 determinations ± SD. C1, C2, C3 represent communities 1, 2 and 3, respectively.

Table 2 showed that the iodine content of soil samples from the selected communities were 8.108µg/g, 10.914µg/g and 13.953µg/g) in Communities 1,2 and 3, respectively.

**Table 2: Comparing the mean Iodine content of soils from the communities**

| Communities | Soil mean iodine content ±SD | F-value | Sig. value | Decision |
|---|---|---|---|---|
| C1 | 8.1080±0.000 | 18.416 | 0.003 | S |
| C2 | 10.9143±1.790 | | | |
| C3 | 13.9533±0.984 | | | |
| Total | 10.9919±2.730 | | | |

P<0.05. C1, C2, C3 represent communities 1, 2 and 3, respectively. S - significant

Table 3 showed that the mean iodine content of rice was 9.110µg/g and that of maize was 9.083µg/g

**Table 3. Iodine content of rice and iodine content of maize compared**

| Sample | Mean ($\bar{x}$) | SD | Sample | Mean ($\bar{x}$) | SD | df | Sig. | Decision |
|---|---|---|---|---|---|---|---|---|
| **Rice 1** | 8.10567 | .002517 | **M 1** | 8.10600 | .003464 | | | |
| **Rice 2** | 9.10433 | .063516 | **M 2** | 9.06100 | .051098 | 8 | 0.065 | NS |
| **Rice 3** | 10.11933 | .011015 | **M 3** | 10.08233 | .044456 | | | |
| **Total** | **9.10978** | **.872549** | | **9.08311** | **.856610** | | | |

**NB:** SD= Standard deviation; df= Degree of freedom; Sig.= P-Value (0.05); NS = Not Significant, M= maize.

Table 4 showed that there is a strong positive correlation between the soil iodine content and iodine content of rice grown in the study area (r = 0.000, p<0.01).

**Table 4. Relationship between soil iodine content and iodine content of rice (*Oryva sativa*) grown on it.**

| Sample | | S.scores | R.Scores |
|---|---|---|---|
| **S.scores** | Pearson Correlation | 1 | .932** |
| | Sig. (2-tailed) | | .000 |
| | N | 9 | 9 |
| **R.Scores** | Pearson Correlation | .932** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 9 | 9 |

**. Correlation is significant at the 0.01 level (2-tailed).S represents soil and R represents rice

Table 5 showed that there is a strong positive correlation between the soil iodine content and iodine content of maize grown in the study area (Pearson correlation coefficient = 0.000, p<0.01)

**Table 5. Relationship between soil iodine content and iodine content of Maize (*Zea mays*) grown on it.**



| Sample | | S.scores | M.scores |
|---|---|---|---|
| **S.scores** | Pearson Correlation | 1 | .920** |
| | Sig. (2-tailed) | | .000 |
| | N | 9 | 9 |
| **M.scores** | Pearson Correlation | .920** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 9 | 9 |

**. Correlation is significant at the 0.01 level (2-tailed). S represents soil and M represents maize

## DISCUSSION

The iodine content of soil samples in this study was higher than the world- wide mean iodine content of soils which is 3.0μg/g as recorded by [20] and global average concentration of iodine in the soil - 2.6mg/Kg [21]. The overall mean soil iodine content obtained in this study (10.992μg/g) is similar to worldwide mean iodine content of soils from coastal zones as reported by [20]. Coastal environments are high in iodine concentration. According to [20], in coastal zones (0-50Km from the sea) there is a large range of iodine content 0.8 - 150μg/g and a geometric mean of 11.6μg/g. In Nigeria, [22] reported soil mean iodine range of 2.1 – 5.8μg/g in Yewa LGA of Ogun State and 7.4μg/g soil iodine value in Lagos State which are all lower than values recorded in this study. The high level of soil iodine recorded in this study may be due to proximity of the study area to River Niger tributaries. The presence of many streams and rivulets make the farm lands water logged for 3-4 months yearly especially during rainy season. High iodine concentration in such coastal and waterlogged area is due to greater input of iodine via deposition through rainfall. Also the mean iodine concentrations in rice (9.110μg/g) and maize (9.083μg/g) samples were higher than that of plant foods (0.002 – 0.7μg/g) as reported by [23]. The iodine content of cereals obtained here was also greater than iodine content of cereals in study by [5]. Also in a study conducted in Southeast Nigeria by [24], a lower iodine concentration in grains was reported. The iodine content of soil samples from the selected communities varied (8.108 – 13.953μg/g) (p<0.05). The variation in iodine content of soils from different localities may explain why same food may contain different levels of iodine depending on the locality where the food was produced [5]. However, the mean iodine content of rice (9.110μg/g) and that of maize (9.083μg/g) in Ayamelum were not different (p<0.05). In other words the iodine contents of the two food samples were similar. In this study, it was observed that there is a strong positive correlation between the soil iodine content and iodine content of rice and maize grown in the study area (Pearson correlation coefficient = 0.000, p<0.01).This is in line with reports by [5] and [14]. When soil iodine increases, it is expected that iodine content of foods grown on it will increase. Therefore, high iodine concentration in food samples recorded in this research may be due to high level of iodine present in the environment.

## CONCLUSION

The mean iodine content of soil, rice and maize in this study were relatively high when compared with values from other studies. However, because most of the land surface is actually iodine deficient so that locally grown crops alone cannot supply the recommended daily allowances of iodine to the local population. There is need for further study in the same area to ascertain the adequacy of iodine intake from these and other staples in order to plan how best to improve iodine status and reduce /eradicate iodine deficiency and its associated disorder in Ayamelum LGA, Anambra State Nigeria..

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