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Research Paper

Assessment of Five Macro Elements in Some Cereals Obtained from Ajaka Market in Igalamela/Odolu Local Government Area, Kogi State, Nigeria

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Abstract— The concentration of five macro elements; Potassium (K), Calcium (Ca), Magnesium (Mg), Sodium (Na) and Manganese (Mn) in some cereals (red maize, white maize, red guinea corn, white guinea corn and millet) sold in Ajaka market in Igalamela/Odolu Local Government Area of Kogi State, Nigeria, were determined using titration method and UV-Visible spectrophotometer. The concentration of the macro elements (Mn, Na, Mg, Ca and K) ranges from 1.364 mg/Kg to 1.434 mg/Kg, 69.00 mg/Kg to 138 mg/Kg, 108 mg/Kg to 228 mg/Kg, 180 mg/Kg to 380 mg/Kg, 210 mg/Kg to 360 mg/Kg for red maize, white maize, white guinea corn, red guinea corn and millet respectively. The result of the analysis of these cereals are below the standard permissible limits of World Health Organization (WHO)/Food and Agricultural Organization (FAO), indicating mineral deficiencies in the analyzed samples. The low concentration of these elements can have long-term health implications on the consumers of these cereals in the area of study. Therefore, constant monitoring of these macro elements should be carried out regularly on these cereals to ensure nutritious and quality food, since many of these cereals are brought to the market from neighbouring states that are prone to industrial and agricultural toxicants.

Keywords—Cereals; Maize*;* Guinea Corn*;* Millet*;* Macro Elements*;* UV-Visible spectrophotometer; Titration.

1. Introduction

Cereals are edible seeds, small, hard, and dry with or without hulls or fruit layers, and is consumed by human or animals. They are harvested from their plants at maturity phase [**1**]. Cereals are divided into three groups; cool season (maize, millet, rice, wheat, etc), pulses (beans, cowpeas, etc) and oil seeds (linseed, soya beans, sunflower, etc). Because of their size, hardness and dryness, their storage, measurement, and transportation is a lot easier than any other kinds of food crops [**2**]. Finger millet is a nutritious cereal with high calcium, iron and magnesium. Despite all the advantages of growing millet and guinea corn as a grain cereal in times of climate change induced drought, low adoption of sorghum and millet production has been seen in the country [**3**].

The most cultivated cereals in Nigeria are maize, millet, guinea corn, rice and wheat. Many of these species are widely cultivated in the northern states of Nigeria. Cereals have long been regarded as valuable sources of essentials nutrients according to Food and Agricultural Organization FAO, (2007) [**4**]. They provide man and animals with energy, protein, minerals, and vitamins in the diet. Over the years, Global production of cereals grains has been approximately 2000 million tonnes. They are cultivated primarily for human food and livestock feed. They serve as source of materials for starch, biofuel and other industries [**5**]. Cereals are the most widely eaten breakfast foods. They are consumed as breakfast meals in developing countries, particularly sub-Sahara Africa, for both adults and infants who feeds on local staple diet made from cereals, legumes, cassava and potatoes tubers [**6**]. Elements require in large amount in human body for biochemical and physiological functions are known as Macro Elements (MEs). They are dietary elements which the body needs in large amount and are more important than any other mineral elements. Examples of some macro elements are Sodium (Na), Potassium (K), Calcium (Ca) and Magnesium (Mg) which are cations, Chlorine (Cl) and Phosphorus (P) are accompanying anions [**7**].They are require in human and animals' diets, and essential for optimal plant growth and development [**8**]. In carbohydrate and protein metabolism, elements like calcium (Ca) and magnesium (Mg) are essential macro elements required for bone structure development. Calcium and magnesium are also required in fairly large amounts to maintain body electrolytes and tissue homeostasis [**9**]. Electrolytes like Sodium and Phosphorus are needed in the body to maintain acid-base balance and fluid balance (homeostasis) and for normal neurological, myocardial, nerve and muscle function. Activation of neurons and muscles are facilitated by electrolytes activity that takes place between the extracellular (or interstitial fluid) and intracellular fluid [10]. Certain abnormalities such as weak bone and teeth development, mental retardation, child developmental issues, anaemia, insomnia, deceased immune function, and other health related complications in human have been associated to its deficiencies. Hence, the significance of macro elements for human health is well documented [11].

1.1. Titration
The slow addition of one solution of a known concentration (called a titrant) to a known volume of another solution of unknown concentration until the reaction reaches neutralization, which is often indicated by a colour change is called "Titration". To determine the concentration of an identified analyte in the laboratory, titration method is used [12]. The process is usually carried out by gradually adding a standard solution (i.e. a solution of known concentration) of titrating reagent, or titrant, from a burette, essentially a long, graduated measuring tube with a stopcock and a delivery tube at its lower end. The addition is stopped when the equivalence point is reached. Some of the advantages of titrimetric are short time of analysis and low cost of equipment required [13].

1.2. Spectrophotometer
The spectrophotometer is a machine used to measure the concentration of a substance in a solution by passing light of a specified wavelength though it. A photocell at one end receives the transmitted light and analogue meter displays the percent transmittance of light received by the photocell [14]. The extent to which sample absorbs light depends strongly upon the wavelengths. Many substances absorb light and transmit light of wavelengths within the ultraviolet (200-400nm), visible (400-700nm) and near-infrared (700-1000nm) regions of the electromagnetic spectrum [15].

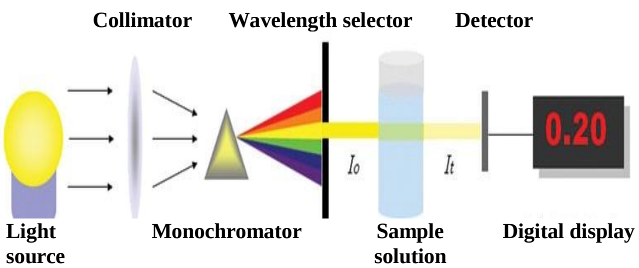

Figure 1: Schematic Diagram of Spectrophotometer (Source: https://microbenotes.com/wpcontent/uploads/2018/10)

1.3. Ultraviolet (UV) Visible Spectroscopy
Spectroscopy is the measurement and interpretation of Electro Magnetic Radiation (EMR) absorbed and emitted when the molecules or atoms or ions of a sample move from one energy to another energy states; in other words the study of electromagnetic radiation and its interaction with chemical compounds is known as spectroscopy [16]. UV-spectroscopy is a physical technique of the optical spectroscopy that uses light in the visible, ultraviolet, and near-infrared ranges and it is based on Beer-lambert law that states that the absorbance of a solution is directly proportional to the concentration of the absorbing species in the solution and path length. Thus, for a fixed path length, it can be used to determine the concentration of the absorber in a solution. It is necessary to know how rapidly the absorbance changes with concentration [17].

1.4. Aim and Objective
The aim of this study is to assess five macro elements in some selected cereals obtained from Ajaka market, and to determine if the cereals brought to the market contain the recommended or standard amount of macro elements in the selected ones.

1.5. Significance of the Study
This study is very necessary for the assessment and monitoring of food supplies, particularly from regions in Nigeria that could be prone to deficiencies or excesses of the nutritionally important elements. This study assess the concentration of the macro elements of the selected cereals as well as identifying the cereals that are rich in macro nutrient.

2. Related Work

Report has shown that guinea corn is an important source of carbohydrate, protein and minerals such as calcium, selenium, manganese and iron in which the bioavailability depends on the level of interactions with various antinutrients [18]. It is rich in B-complex vitamins (thiamine, riboflavin, pantothenic acid, etc.) which play an essential role in metabolism, neural development, hair and skin health [19]. It is also a rich source of magnesium, potassium, phosphorus, and calcium minerals that are important for bone formation, heart health, and over 600 biochemical reactions in the body [20].

Maize kernel is an edible and nutritive part of the plant. Depending on the variety, maize may contain a number of important B vitamins like folic acid, vitamin C, and provitamin A [21]. It also contains iron, calcium, zinc and potassium as a major nutrient present, which has a good significance because an average human diet is deficient in it. Roasted maize kernels are also used as coffee substitute [22]. Millets have higher amount of minerals such as magnesium, manganese, phosphorus, iron, copper, and potassium when compared with corn, sorghum, maize and wheat [23]. The main nutrients in millets are starch, protein, lipid, dietary fibre, vitamins, and minerals. When comparing millet with other cereals, millet contains 65–75% of complex carbohydrates, 5.6–12% protein, fat, 2–5%, 15–20% crude fibre and 2.5–3.5% minerals content than maize, rice, and sorghum [24]. Other potential health benefits of millets are the development and repair of body tissue, the prevention of gallstones, protection against breast cancer and protection against postmenopausal complications and the reduction of chances of childhood cancer [25].

3. Theory/Calculation

Absorbability is the proportion of a mineral that can be absorbed by certain cells from the total content in food. The most effective means of determining the type and concentration of specific minerals in foods is to use atomic absorption spectrophotometer.

Calculating the concentration of macro elements;

$$\text{Conc.} = \frac{\text{Absorbance of sample x Concentration of standard}}{\text{Absorbance of standard x Sample size}}$$

Where; Conc. of Standard = 3 mg/Kg
Absorbance of Standard = 0.475
Sample size = 2 g

4. Experimental Method/Procedure/Design

4.1. Sample Collection and Storage:

Sample of five different kinds of cereals (millet, red maize, white maize, red guinea corn, white guinea corn) were obtained from Ajaka market in Igalamela/Odolu local government area of Kogi State. Sampling was done at random from different retailers and vendors within the market area. All the samples were obtained and stored in polythene bags according to their type and transported to Biochemistry Laboratory of Federal Polytechnic Idah for preparation and treatment.

Figure 2: Millet (Source:https://www.cropscience.bayer.africa/za/html)

Figure 3: Red Maize (Source:https://www.cropscience.bayer.africa/za/html)

Figure 4: White Maize (Source:https://www.cropscience.bayer.africa/za/html)

Figure 5: Red Guinea Corn (Source:https://www.cropscience.bayer.africa/za/html)

Figure 6: White Guinea Corn (Source:https://www.cropscience.bayer.africa/za/html)

4.2 Study Location and Duration:

This research work took place over a period of twelve calendar months at the Federal Polytechnic Idah, Kogi State, in the Department of Science and Laboratory Technology.

4.3. Materials and Reagents:

The materials and reagents used for this project work are as follows; Porcelain crucibles, weighing balance, hot plate, conical flask, distilled water, deionized water, measuring cylinder, test tubes, stop watch, volumetric flask, thermometer, pipette, filter paper, muffle furnace, stirring rod, oven, mortar and pestle, sieve, steam bath, ultraviolet (UV) visible spectroscopy, nitric acid, hydrochloric acid, potassium chromate, silver nitrate, methylene blue, ascorbic & tartaric acid, methanol, citric acid, 0.1 M ethylene diamine tetra acetic acid (EDTA), ammonium chloride (NH_4Cl), ammonium hydroxide (NH_4OH), buffer, Eriochrome Black T (EBT) indicator, dichloroethane.

4.4. Sample Preparation:

All the samples of cereals collected were washed with distilled water followed by deionized water to remove all foreign particles. The different samples of cereals were oven dried at 110^oC for 8 hours. The dried samples were then ground into fine powder by using mortar and pestle. The powdered samples were stored in an air tight glass containers with silica gel for further analysis.

4.5. Sample Digestion:

2 g of each finely ground sample was weighed into different porcelain crucibles using a weighing balance and the samples

were labelled accordingly. The crucibles were then placed into a muffle furnace where they were ignited for 3 hours at a temperature of 500^{o}C. After the samples of cereals has turn to a grey ash residue from the ashing process, it was then transferred from the crucibles into a conical flask and 5 mL of 6 M HCl solution was added to each of the samples. The content of the conical flask were evaporated to dryness using a steam bath. 50 mL of distilled water was then added to each of the conical flask and swirled. It was then filtered into a 100 mL volumetric flask and deionized water was added to the 100 mL mark. The filtrates were stored for element determination as described by AOAC, 2002 [**26**].

4.6. Determination of Elements:

A. **Determination of Calcium (Ca)**

10 mL of each of the ash solution was measured into a 250 mL beaker. 2 mL of buffer solution (NH_4Cl-NH_4OH) was added to the solution in the beaker, a drop of EBT indicator was added to the solution and titrated against 0.1 M EDTA solution until the colour changes from wine red to blue [**27**].

B. Determination of Magnesium (Mg)

10 mL of each of the ash solution was pipetted into a 250 mL beaker. 10 mL pH 10 buffer was added. This was followed by the addition of 25 mL distilled water. 0.1 g EBT indicator was added and the solution swirled to create a wine coloured solution which was titrated against 0.1 M EDTA to a clear blue end point [**27**].

C. Determination of Potassium (K)

10 mL of each of the ash solution was measured into a 250 mL beaker. 2 mL of 5 % potassium chromate was added to the solution and titrated against 0.1 M silver nitrate until a reddish yellow colour was obtained [**27**].

D. Determination of Sodium (Na)

10 mL of each of the ash solution was measured into a 250 mL beaker. 3 mL of 5 % potassium chromate was added to the solutions which create an orange coloured solution. This was titrated against 0.1 M silver nitrate until a red-brown precipitate colour was obtained [**27**].

E. **Determination of Manganese (Mn)**

10 mL of each of the ash solution was pipetted into a test tube. 1 mL of 0.01 % methylene blue was added which changed the colour to blue. 1 mL of 1.2 M HCl was added to the solution followed by 1 mL of saturated ascorbic and tartaric acid mixed together. 1 mL of methanol was also added to the solution followed by 2 mL of dichloroethane which separate the sample into two layers. The organic layer was filtered and then read in the spectrophotometer at 360 nm [**27**]

5. Results and Discussion

Results: The results from the assessment of five macro elements in some selected cereals obtained from Ajaka market is shown in table 1 below:

Table 1: Macro element concentration in the samples of cereals.

	Mn (mg/Kg)	**Na (mg/Kg)**	**Mg (mg/Kg)**	**Ca (mg/Kg)**	**K (mg/Kg)**
RM	1.421	126.50	168	280	210
WM	1.431	138.00	126	210	315
WG	1.434	69.00	180	300	320
RG	1.396	74.75	228	380	360
MI	1.364	132.25	108	180	290

R M = Red maize
W M = White maize
W G = White guinea corn
R G = Red guinea corn
M I = Millet

Table 2: WHO/FAO permissible limits for each of the elements analysed in food.

Elements	**WHO/FOA values (mg/Kg)**
Mn	2
Na	200-250
Mg	375-400
Ca	800-1000
K	470-490

WHO = World Health Organization
FAO = Food and Agriculture Organization

Discussion: The concentration of manganese (Mn) was observed to be 1.421 mg/Kg, 1.431 mg/Kg, 1.434 mg/Kg, 1.396 mg/Kg and 1.364 mg/Kg for red maize, white maize, white guinea corn, red guinea corn and millet respectively. The result showed that the highest concentration of Mn was observed in white guinea corn and was lowest in millet. The permissible limit of Mn in food according to WHO/FAO standard is 2 mg/Kg, therefore, in all samples, the concentration of Mn recorded was below the permissible limits. Since an essentially important mineral element for the normal bone structure, reproduction and normal functioning of the central nervous system [**28**] "manganese" was not found in sufficient amount in the analysed cereals, it is therefore recommended that consumers of these cereals add manganese rich foods to their diet. Foods like dark chocolates, black beans, nuts, avocado, bananas and vegetables are magnesium rich foods.

The study showed that the concentration of sodium in the cereals RM, WM, WG, RG and MI was found to be 126.50mg/Kg, 138.00 mg/Kg, 69 mg/Kg, 74.75 mg/Kg and 132.25 mg/Kg respectively. These values when compared with the WHO/FAO standard permissible limits of 200-250 mg/Kg, showed that all the samples of cereals contain low concentration of sodium and therefore, cannot pose any toxic effect to human health when consumed but it insufficiencies can impair many vital metabolic activities in the body, therefore foods like bread, tomato paste, pizza sandwiches, sardines, baked beans etc., should be included in daily diets [**29**].

The study indicated that the concentration of magnesium (Mg) obtained for each of the cereals was 168 mg/Kg, 126 mg/Kg, 180 mg/Kg, 228 mg/Kg and 108 mg/Kg for RM, WM, WG, RG and MI respectively. The magnesium concentration of all the samples of cereals were found to be below the WHO/FAO standard permissible limits of 375-400 mg/Kg. Since magnesium was not found in sufficient amount in analysed samples, it is therefore very important that consumers of these cereals should add magnesium rich foods to their diet. Foods like nuts, legumes, fruits and vegetables are magnesium rich foods that can be cheaply obtained from market. Lack of Mg is associated with abnormal irritability of muscle and convulsions. Excess Mg however, is associated with depression of the central nervous system [**30**].

The concentration of calcium obtained for each of the cereals in this study was 280 mg/Kg, 210 mg/Kg, 300 mg/Kg, 380 mg/Kg, and 180 mg/Kg for RM, WM, WG, RG, and MI respectively. Comparing the values with the WHO/FAO standard permissible limits of 800-1000 mg/Kg, showed that all the samples of cereals contain low concentration of calcium and therefore would not be a good source of dietary calcium. It is therefore important to supplement Ca intake to enhance bone formation, since calcium is effective in bone formation [**31], [32**].

The concentration of potassium in the samples of cereals was observed to be 210 mg/Kg, 315 mg/Kg, 320 mg/Kg, 360 mg/Kg and 290 mg/Kg for RM, WM, WG, RG and MI respectively. The WHO/FAO standard permissible limits of potassium in food is 470-490 mg/Kg. The potassium concentration in all the cereals were below the standard permissible limits set by WHO/FAO. The low concentration of potassium analyzed might be due to the low level of potassium in soil and other associated environmental factors. According to Soetan *et al.*, (2010) potassium deficiency affects the collecting tubules of the kidney, resulting in the inability to concentrate urine and also causes alterations of gastric secretions and intestinal motility. Potassium deficiencies can be corrected by including the following foods in daily diets, foods like bananas, oranges, pineapples, vegetables, carrots and potatoes.

6. Conclusion and Future Scope

The results obtained were compared with World Health Organization (WHO) standard permissible limits to ascertain whether the cereal types sold in Ajaka Market are within the standard permissible limits or not, which to a greater extend has explained the unusually high prevalence of undernourished children, mothers and students who are major consumers of these cereals sold in Ajaka Market. The study revealed that there was no abnormally high concentration of the five macro elements: Ca, Na, Mg, K, Mn investigated in the cereal samples sold in Ajaka Market, nevertheless, it deficiencies which has impaired many important metabolic activities in the life of it consumers has provided an acceptable explanation that settles the long term debate that existed between sellers and consumers of these cereals in Idah metropolitan regions and its environs.

Considering the importance of cereals in the life of individuals and also macro elements and its various benefits, it is therefore recommended that, agricultural practices in the production of cereals crop should avoid the use of polluted irrigated water, avoid excess application of fertilizer and metal base pesticides, planting cereals close to industrial emission, transportation site etc. and consumers should also store in a safe place before consumption.

Also, further research and investigation should be carried out on other food items brought to the market to ensure the presence and quantities of macro elements in them. More research should be carried out on the soils in the area where these cereals are cultivated.

Data Availability
There is none.

Conflict of Interest
We do not have any conflict of interest.

Funding Source
There was none.

Study Limitations
The limitation faced in the study include inability to ascertain the actual agricultural practices in the production of the sampled cereals, whether or not cereals are planted close to industrial emission areas and if cereals were well stored in a safe place before transporting them to the market, which might significantly affect the current research outcome.

Authors' Contributions
Miss. G.U. Ojattah[1] researched literature, conceived the study, carried out the investigation and gained ethical approval. Mr. **S.O. Oguche[2]** wrote the first draft and the final manuscript, researched more literature and provided concise results interpretation. Both authors reviewed and edited the manuscript and approved the final version of the manuscript.

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G.U. Ojattah pursued National Diploma of Science and Laboratory Technology from Federal Polytechnic Idah, Kogi State in 2016 and Higher National Diploma of Chemistry/Biochemistry from the same institution in 2021. She has completed her National Youth Service Corps in Folk Technical College Ikwo, Ndufu Alike, Ebonyi State. Her research work entitled "Assessment of Five Macro Elements in Some Selected Cereals Obtained from Ajaka Market in Igalamela/Odolu Local Government Area, Kogi State, Nigeria is her first work and made available online.

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