DETERMINATION OF THE MINERAL COMPOSITION OF AFRICAN NUTMEG (*Monodora myristica*)

BY

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DEPARTMENT OF CROP SCIENCE
FACULTY OF AGRICULTURE,
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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF CROP SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF AGRICULTURE DEGREE B. AGRIC (CROP SCIENCE)

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CERTIFICATION

This is to certify that this project work was conducted by **Eki Stephanie OKOEKA** of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin city, Edo State, Nigeria.

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DEDICATION

This project is dedicated to my loving father, **Mr. P.S OKOEKA** and my ever caring mother, **Mrs. R.N OKOEKA,** thank you for your immense support and sacrifices towards my education and life, may God continue to keep you in good health. Amen

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support in one way or the other, may we continue to scale new heights as we move to a new phase.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

ABSTRACT

Monodora myristica is a perennial, edible plant used in West Africa and other parts of the world for its medicinal and culinary value. There is paucity of data on the nutritional contents of *M. myristica seeds* in the four regions of Nigeria where the seeds are easily available. This study was undertaken to determine the mineral contents of *M. myristica (*African nutmeg) seeds from Abuja, Awka, Benin City and Ondo Towns.

Seeds of *M. myristica used* were deshelled, oven-dried and ground into fine powder. The powdered sample was subjected to mineral analysis using atomic absorption spectrometry.

The mineral analysis showed that there were highly significant differences in the mineral contents of African nutmeg samples sourced from the various locations in calcium, chromium, potassium and zinc. But the iron, magnesium, manganese, and sodium contents were not significantly different from one location to the other. The results showed that the *Monodora myristica* seeds are rich in minerals and that the content levels vary in some minerals as a result of the location. This may be as a result of the different soil types and the nutritive state of the soil where the plants were grown. It should also be noted that no particular location exhibited better mineral element composition across all the minerals studied. More mineral elements both beneficial and harmful should be studied in African nutmeg from more locations.

CHAPTER ONE

1.0 INTRODUCTION

Monodora myristica is a perennial edible plant of the *Annonaceae* family that grows wild in the evergreen forest of West Africa and is widely distributed from Africa to the Caribbean Islands and even some parts of Asia. *Monodora myristica* has the common names of African nutmeg and Calabash nutmeg, and in Nigeria, it is called "Ehuru" by Igbo-speaking tribes, "Abolakoshe" by native Yoruba speakers, and "Ebenoyoba" in Benin (Ameh *et al.,* 2016).

Dating as far back as the pre-colonial era, African traditional medicine integrated the use of the bark, seeds, and leaves of the *Monodora myristica* plant into its practices (Erukainure *et al.,* 2011). It was believed that these plant parts possessed the ability to cure a variety of illnesses (Ameh *et al.,* 2016).

African Nutmeg continues to play a significant role in traditional medicine, and this role is backed up by numerous claims that the plant parts possess various therapeutic properties such as antifungal, antibacterial, and anti-inflammatory effects. To begin with, hemorrhoids, stomach aches, fever pains, and eye conditions can all be treated using *M. myristica* stem bark (Onimawo *et al*., 2017). In addition to this, the pungent flavor of *Monodora myristica* is used to treat bronchitis and increase appetite (Ugwuona, 2014). Notwithstanding the importance of the stem, bark, and leaves of *Monodora myristica*, the plant's most valuable component are the seeds that are concealed within the subspherical fruit's white, fragrant pulp (Ameh *et al.,* 2016).

In some cultures, the seeds of the *M. myristica* plant are roasted and ground into a paste, which is then applied to the skin to treat certain skin ailments (Irvine, 1961), indicating that they may have germicidal or antiseptic properties. Away from its medicinal properties, the kernel that is extracted from the seeds of the *M. myristica* plant has a fragrant flavor that makes it excellent for use as a flavoring agent in food and beverages. In West Africa, these flavorful seeds are used in making native stews, soups, cakes, and desserts (Weiss, 2002).

In recent years, several studies have been conducted to determine the mineral composition of *M. myristica.* In Kanu and Onuegbu (2020) study, the mineral composition of raw *Monodora myristica* seed noted calcium: 4.62%, magnesium: 2.01%, sodium: 0.45%, potassium :1.20%, phosphorus :0.61%, nitrogen:2.52%, copper: 23.24(mg), zinc: 98.20(mg), iron : 15.82(mg), and lead : 0.30(mg) while the toasted seeds contained calcium: 5.22%, magnesium: 2.01%, sodium : 0.33%, potassium: 1.38%, phosphorus: 0.78%, nitrogen: 4.06%, copper: 19.15(mg), zinc: 25.26(mg), iron: 14.51(mg) and lead: 0.26(mg).

Calcium, one of the minerals found in the seed, is vital for maintaining bone health, muscle function, and nerve transmission (Weaver *et` al.*, 2009). On the other hand, Magnesium is an important mineral that is involved in over 300 enzymatic reactions in the body, including energy production, protein synthesis, and DNA repair (Ford, 2012).

1.1 Justification of the Study

The study of the mineral composition of *M. myristica* is important for understanding its nutritional and medicinal properties. From already existing research, it can be inferred that African Nutmeg's mineral and bioactive chemical composition play an active role in its outstanding health-enhancing properties. However, there is limited research on the mineral composition of this plant species, particularly one that cuts across the major geographic regions in Nigeria. This study aims to address this knowledge gap by analyzing the mineral contents of *M. myristica* seeds sourced from four different regions of Nigeria, namely the North, West, East, and South.

African Nutmeg is grown in various parts of the country, and factors such as soil type, climate, and agricultural practices can influence its mineral content. (Nkwocha *et al,* 2019)**.** Thus, it is important to analyze the mineral composition of *M. myristica* seeds obtained from different geographic regions to gain a comprehensive understanding of their nutrient profile. The mineral content of *M. myristica* may also be influenced by factors such as processing and storage. For instance, drying, roasting, or grinding nutmeg can affect its mineral content (Mandal and Mandal, 2015).

Similarly, storage conditions such as temperature, humidity, and light exposure in different regions can also impact the nutrient content of nutmeg (Mohamed *et al.,* 2020)**.** Thus, it is important to examine the mineral composition of *M. myristica* to ensure accurate and reliable data.

Africa nutmeg is known to have pharmacological properties such as antioxidant, antifungal, antibacterial, and antidiabetic effects. However, the relationship between its mineral content and these health benefits is not well established. By analyzing the mineral composition of *M. myristica*, this study can provide valuable insights into the potential health benefits of nutmeg (Lobo *et al,* 2010)

Taking into consideration its multipurpose uses, it is easy to deduce that understanding the mineral composition of *M. myristica seeds* is essential for culinary, medicinal, and even cosmetic purposes (Nkwocha *et al,* 2019).

Furthermore, this study will provide valuable information on the influence of geographical climate on the nutrient content of *M. myristica*. This will, in turn, help to ensure the accurate labeling of food products containing African nutmeg and inform consumers on the best region to obtain nutmeg in order to preserve its nutritional value (Ford, 2012).

In addition to that, the study of the mineral composition of *M. myristica* will also play a vital part in understanding and encouraging the proper utilization of the nutritional and medicinal properties of the plant.

1.2 Aims and Objectives of the Study

The broad objective of this study was to determine the mineral composition of *M. myristica* obtained from the Northern, Eastern, Western, and Southern parts of Nigeria.

The specific objectives are to:

i. evaluate the mineral composition of *M. myristica* obtained from Northern, Eastern, Western, and Southern Nigeria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.1 Botany of Africa Nutmeg (*Monodora myristica)*

Morphologically, *Monodora myristica is* a perennial plant of the *Annonaceae* or custard apple family of flowering plants (Ojiako *et al*., 2010). The tree grows naturally in the evergreen forests of the sub-Saharan African regions in West Africa: from Liberia to Nigeria, Cameroon and Ghana, as well as in Angola, Uganda and West Kenya (Ojiako *et al*., 2010). Globally, the plant is widely distributed from Africa to Asia, Central and South America and Australia (Ekeanyanwu and Etienajirhevwe, 2012). The tree can reach a height of 35 m and 2 m in diameter. Fruiting occurs from August-November. The fruit of *M. myristica* is a berry of 20 cm in diameter, smooth, green and spherical and becomes woody at maturity. It is attached to a long stalk, which can be up to 60 cm long. Inside the fruit are the numerous oblongs, pale brown seeds which are usually 1.5 cm long and are embedded in a white sweet-smelling pulp (Ekeanyanwu and Etienajirhevwe, 2012). It has been observed that an average of 119-122 seeds can be found in one fruit. *Monodora myristica* is listed presently under Kew's difficult seeds due to its inability to grow easily outside its natural habitat. The plant is largely harvested from the wild and greatly affected by wildfires, urbanization, reckless and uncontrolled felling of trees for timber and firewood without replanting (Uyoh *et al.,* 2014). It is variously known as "Ehuru" in Igbo speaking cultures “Abolakoshe" by native Yoruba speakers, and “Ebenoyoba" in Benin (Ameh *et al.,* 2016).

Study of Onyenibe *et al*. (2015) has shown that almost every part of the tree was important economically and a number of medicinal properties have been ascribed to various parts of this highly esteemed plant (Uyoh *et al.,* 2014). The timber is hard, easy to work with and is used for carpentry, house fittings and joinery while the seeds are also made into necklaces (Enabulele *et al*. 2014). The most economically important parts are the seeds. After harvesting, various unit operations, such as fermentation, washing, drying and cracking are performed before consumption or storage. The presence of bioactive compounds in the plant makes it possible for the seeds to be used in traditional medicines as well as a spice in local foods. The aromatic seeds are antiemetic, aperient, stimulant, stomachic, tonic and they are added to medicines impart stimulating properties (Akpojotor and Kagbo, 2016).

2.1.2 Uses of African Nutmeg

Myristicin, the active ingredient in African nutmeg, has several pharmacological and therapeutic benefits including the prevention of oxidative damage through its antioxidant activity (Ansory *et al*., 2019). It has antimicrobial properties and is used in many food industries as a preservative and flavoring agent (Enabulele et al., 2014). Myristicin, although very beneficial, can have toxic effects when used in higher amounts, leading to mental confusion and degeneration of the liver, and damages to the central nervous system (Jaiswal *et al.*, 2009).

Plate 1: Picture of African Nutmeg
Source: Ameh *et al* (2016).

2.2 Minerals

Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life. Minerals are chemical constituents used by the body in many ways. Although they yield no energy, they have important roles to play in many activities in the body (Soetan *et a*l., 2010). Every form of living matter requires these inorganic elements or minerals for their normal life processes. Minerals may be broadly classified as macro (major) or micro (trace) elements. The third category is the ultra-trace elements. The macro-minerals include calcium, phosphorus, sodium and chloride, while the micro-elements include iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium and sulfur *(*Soetan *al*., 2010). The macro-minerals are required in amounts greater than 100 mg/dl and the micro-minerals are required in amounts less than 100 mg/dl (Murray *et al*., 2010). The ultra trace elements include boron, silicon, arsenic and nickel which have been found in animals and are believed to be essential for these animals. Evidence for requirements and importance of others like cadmium, lead, tin, lithium and vanadium is weak. The mineral elements are separate entities from the other essential nutrients like proteins, fats, carbohydrates, and vitamins. Animal husbandry had demonstrated the need for minerals in the diet. Micronutrient deficiencies are a major public health problem in many developing countries, with infants and pregnant women especially at risk (Nath and Dutta, 2016). Infants deserve extra concern because they need adequate micronutrients to maintain normal growth and development (Chua and Adnan, 2014). The micronutrient deficiencies which are of greatest public health significance are iron deficiency, causing varying degrees of impairment in cognitive performance, lowered work capacity, lowered immunity to infections, pregnancy complications e.g. babies with low birth weight, poor learning capacity and reduced psychomotor skills. There have been suggestions that more than anything else, lack of adequate information about the composition of varied feed resources in some regions have been the major drawback to their utilization, rather than real shortage (Oche *et al.,* 2017). Data on mineral contents of human foods and animal feeds are essential for formulation of feeding regimes and food processing techniques.

2.3 Importance of Mineral Elements

The importance of mineral elements in human and animal nutrition has been well recognized (Soetan *et al*., 2010). Deficiencies or disturbances in the nutrition of an animal cause a variety of diseases and can arise in several ways (Oche *et al.,* 2017). When a trace element is deficient, a characteristic syndrome is produced which reflects the specific functions of the nutrient in the metabolism of the animal. The trace elements are essential components of enzyme systems. Simple or conditioned deficiencies of mineral elements therefore have profound effects on metabolism and tissue structure. To assess the dietary intake and adequacy of minerals, information needs to be collected on mineral element content of diets (Idris *et al*., 2011). The significance of the mineral elements in humans, animals and plants nutrition cannot be overemphasized. The presence of mineral elements in animal feed is vital for the animal's metabolic processes. Grazing livestock from tropical countries often do not receive mineral supplementation except for common salt and must depend almost exclusively upon forage for their mineral requirements (Soetan *et al*., 2010). Mineral deficiencies or imbalances in forages account partly for low animal production and reproductive problems. Mineral elements play important roles in health and disease states of humans and domestic animals. For example, iron deficiency causes anemia while goiter is due to iodine deficiency, both are reported to be problems of public health importance in some communities (Tiwari *et al.,* 2011). Trace elements of significance to people with Human Immunodeficiency Virus (HIV) are zinc and selenium. Selenium is an antioxidant that increases immune function. Zinc, usually taken to stimulate the immune system, has been reported to weaken immune system function and lower calcium levels in HIV – positive men. Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of prothrombin to thrombin and also takes part in milk clotting. It plays a vital role in enzyme activation. Calcium activates a large number of enzymes such as adenosine triphosphatase (ATPase), succinic dehydrogenase, lipase etc. It is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability (Nath and Dutta, 2016).

Phosphorus is located in every cell of the body and is vitally concerned with many metabolic processes, including those involving the buffers in body fluids. It functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids. It serves buffering action, that is, phosphate buffers, functions in the formation of high energy compounds, that is, adenosine triphosphate (ATP) and is involved in the synthesis of phospholipids and phosphoproteins. Practically, every form of energy exchange inside living cells involves the forming or breaking of high-energy bonds that link oxides of phosphorus to carbon or to carbon-nitrogen com-pounds (Murray *et al.*, 2010). Vitamin D is probably involved in the control of phosphorus absorption and serum levels are regulated by kidney reabsorption.

Sodium regulates plasma volume and acid-base balance, involved in the maintenance of osmotic pressure of the body fluids, preserves normal irritability of muscles and cell permeability, activates nerve and muscle function and involved in Na + /K + -ATPase, maintenance of membrane potentials, transmission of nerve impulses and the absorptive processes of monosaccharides, amino acids, pyrimidines, and bile salts. The changes in osmotic pressure are largely dependent on sodium concentration (Murray *et al.*, 2010). Its metabolism is regulated by aldosterone. Commonly used vegetable foodstuffs do not contain sufficient quantities of sodium to meet the animal's dietary need. This inadequacy is compensated for by including sodium chloride, common salt, in their diet or by allowing them to consume salt ad libitum. Sodium is readily absorbed as the sodium ion and circulates throughout the body. Excretion occurs mainly through the kidney as sodium chloride or phosphate (Idris *et al*., 2011).

2.4 Mineral Composition of *Monodora myristica*

The seeds possess magnesium, calcium, potassium, phosphorus, manganese, iron, sodium, copper, aluminum and zinc (Eze-Steven *et al.*, 2013). Minerals are known to play important metabolic and physiological functions in living cells (Vaclavic and Christian, 2008). The calcium/phosphorus ratio is greater than 1, indicating that it would serve as good source of mineral for bone formation. The ratio of sodium to potassium in the body is of great concern for prevention of high blood pressure. Sodium/potassium ratio of less than 1 is recommended (Feyisayo and Oluokun, 2014). This is an indication that the inclusion of African nutmeg in the diet would probably reduce high blood pressure diseases since its sodium/potassium ratio is less than 1 (Feyisayo and Oluokun, 2014). Nkwocha *et al,* (2019) undertook a study to determine the mineral and vitamin contents of *M. myristica* (African nutmeg) seeds from Nsukka, Enugu State, Nigeria. Seeds of *M.*

myristica used were deshelled, oven-dried and ground into fine powder. The powdered sample was subjected to mineral analysis using atomic absorption spectrometry and the vitamin content was determined using spectrophotometry. Nkwocha *et al*, (2019) mineral analyses showed that the seed had the highest calcium content (333.33±1.4 mg/100 g). Other minerals found were magnesium (182.99±0.03 mg/100 g), manganese (10.35±0.13 mg/100 g), sodium (5.47±0.31 mg/100 g), lead (0.00 mg/100 g), nickel (1.43 ±0.25mg/100 g), iron (90.0±0.01 mg/100 g), zinc (3.73±0.2 mg/100 g) and chromium (9.26±0.55 mg/100 g). Vitamin C had the highest vitamin concentration at 9.88±1.72 mg/100 g; the other concentrations were as follows: vitamin B12 (0.17±0.03 mg/100 g), vitamin B3 (0.68±0.14 mg/100 g), vitamin B9 (0.22±0.04 mg/100 g), vitamin B6 (0.54±0.07 mg/100 g), vitamin B1 (5.63±0.92 mg/100 g), vitamin B2 (0.82±0.65 mg/100 g), vitamin A (0.92±0.07 mg/100 g) and vitamin E (5.50±1.41 mg/100 g). Nkwocha *et al*, (2019) results showed that the seed is rich in minerals and vitamins and the levels vary compared to those found in the literature, which could be attributed to the different soil types and the nutritive state of the soil where the plant is cultivated.

According to Akpabio and Akpakpan, (2012), nutritive composition of the *Monodora myristica*(African nutmeg) showed that the seeds contained a moisture of 4.32 %, ash 2.60%, crude fat 43.80%, crude fibre 1.70%, crude protein 7.70%, carbohydrate 44.20%, and have caloric value of 601.80 kcal. Magnesium, potassium, calcium, manganese, copper, sodium, zinc, iron and phosphorous were also found to be present at the levels of 54.86 mg/100g, 68.00 mg/100g, 3.57 mg/100g, 0.80 mg/100g, 3.10 mg/100g, 3.20 mg/100g, 8.72 mg/100g, 8.76 mg/100g, and 0.04 mg/100g respectively.

Proximate and mineral compositions of three selected traditional spices (*Zingiber officinale, Allium sativum, and Monodora myristica*) were evaluated by Onimawo *et al,* (2019). The results showed that, moisture, ash, crude protein, fat, fiber and carbohydrate content of ginger were 72.20, 0.81, 8.91, 11.71, 1.38, and 2.01% respectively; Garlic were 59.90, 0.94, 12.41, 6.13, 1.95, 18.53% respectively while African nutmeg had 8.14, 1.39, 13.57, 46.48, 27.39, and 3.06% respectively. More so, sodium, zinc, iron, and calcium were 7.32, 4.99, 9.68, and 182.67mg/100g respectively in ginger, 9.41, 1.89, 8.47, 1016mg/100g in garlic. In African nutmeg, it was found to be 110.20, 135.91, 147.28, and 166.10mg/100g respectively. Consequently, ginger, garlic, and African nutmeg possessed varying proportions of the proximate components as well as mineral elements. However, African nutmeg possessed better moisture, ash, crude protein, crude fat, and crude fibre with a higher sodium, zinc, and iron mineral contents compared to others (Onimawo *et al*, (2019).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Location

Mineral analysis was carried out in the Central Laboratory, Faculty of Agriculture, University of Benin, Benin City Edo State. The study was carried out to determine mineral composition (quantitative) analysis of pulverized seed of *Monodora myristica*. The seeds were obtained from different locations namely, Awka, Anambra State (East), Benin City, Edo State (South), Ondo Town, Ondo State (West), and Abuja, Federal Capital Territory (North).

3.2 Preparation of *Monodora myristica*

The *Monodora myristica* seeds obtained were inspected to ensure they were evenly dried and not rotten. The seeds were then air dried for one week after which, they were milled to fine powder and stored in air tight containers for mineral analysis.

3.3 Experimental Design.

The experiment had 4 treatments of *Monodora myristica* seeds which were obtained from different locations in (Awka East), Ondo (west), Edo (south) and

Abuja (north) and replicated 3 times. Experimental design was completely randomized design (CRD) with four treatments replicated three times.

3.4 Equipment Used

The following are the equipment used in the determination of minerals of African Nutmeg which includes Flame Photometer, Volumetric Flask, Digestion Block, Oven, Mortar, pestle, AAS Solar 968 Unicorn series and Foil paper.

3.5 Determination of Minerals

The determination of mineral contents was carried out using Atomic Absorption Spectrophotometer (AAS model: SOLAAR 968 Unicam Series) for Ca, Fe, Mg and Zn; Flame Photometer for Na, K and Spectrophotometer (model: Spectronic 20D+) for P followed methods described by AOAC (2003).

3.5.1 Wet Digestion of Samples

1.0 g of the powdered sample was weighed in a digestion flask. Twelve mils of concentrated HNO_3 was added and kept overnight at room temperature. Four mils of $HCLO_4$ was added to the mixture and heated in digestion block, starting at 50°C and gradually increased to 250°C. The appearance of fumes at 70 – 80 min signaled completion of digestion. The mixture was allowed to cool before transferring into a 100 ml volumetric flask and thereafter made to mark with distilled water. The wet digested solution was stored in a plastic reagent bottle for use in determination of minerals following the principles and procedures expounded by Gul and Safdar (2009).

3.5.2 Determination of Phosphorus (P)) by Spectrometer

Colorimetric determination is based on the principle that certain elements or compounds on reaction with suitable reagents develop colour. The intensity of the colour is measured with a calorimeter or spectrometer. The organic phosphorus reacts with ammonium molybdate. Ammonium phosphomolybdate reacts with ammonium Molybdate. Ammonium Phosphomolybdate is formed which on reaction produce Molybdenum blue. The blue colour of the solution was measured and the amount of phosphorus was determined.

3.5.2.1 Procedure

Sample from final blue Solution was taken in a cuvette and introduced to spectrophotometer. The readings of the phosphorus were recorded in Ppm. The calculation for the total mineral intake involves the same procedure as given in AAS.

3.6 Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using GENSTAT statistical software version 12.1. Means were separated using students' Newman-Keuls test at 5% level probability.

CHAPTER FOUR

4.0 RESULTS

4.1 Variations due to location in mineral contents of African nutmeg seeds (*Monodora myristica*)

Variation due to location in the mineral contents of African Nutmeg seeds are presented as mean squares in Table 4.1. Significant variance (mean square values) were ($P < 0.05$) observed due to the effect of location in calcium, Chromium, Potassium and Zinc contents.

However, Iron, Magnesium, Manganese and Sodium contents were not significantly different ($p > 0.05$) from one location to the other.

4.2 Mean value of mineral elements in African nutmeg (*Monodora myristica*) seeds from different locations in Nigeria.

The mean values of the mineral elements contents in African nutmeg (*Monodora myristica*) seeds from different locations in Nigeria are presented in Table 2.

4.2.1 Calcium

The African Nutmeg seeds sourced from Abuja had the highest value (522.10 mg/kg) which was significantly ($p < 0.05$) different from the sample from Ondo (461.80 mg/kg). The sample from Ondo was significantly different from the samples from Awka (425.50 mg/kg) and Benin City (436.80 mg/kg), however the samples from Awka and Benin City were not significantly ($p > 0.05$) different from each other. The coefficient (CV) of the procedure was 1.8 %.

Table 1: Variation due to location in mineral contents of African nutmeg seeds

	df	Ca	Cr	Fe	K	Mg	Mn	Na	Zn
Location	3	5575.06*	2.81*	13.58^{ns}	40.66*	0.61^{ns}	2.06^{ns}	20.13^{ns}	0.94*
Residual	8	65.97	0.31	38.24	4.23	0.36	0.93	34.24	0.17

Table 2: Mineral Composition of *Monodora myristica*

Location	Ca mg/kg	Cr mg/kg	Fe mg/kg	K mg/kg	Mg mg/kg	Mn mg/kg	Na mg/kg	Zn mg/kg
Awka	425.50^{c}	7.56^{b}	98.90^{aa}	81.95^{a}	11.02^{a}	11.00^{a}	4.35^{a}	3.01^{ab}
Abuja	522.10^{a}	8.77^{a}	99.80^{a}	73.96^{b}	11.12^{a}	11.11^{a}	3.74^{a}	2.91^{ab}
Benin	436.80^{c}	6.93^{b}	103.60^{a}	76.55^{b}	11.93^{a}	10.32^{a}	9.32^{a}	2.08^{b}
Ondo	461.81^{b}	8.93^{a}	99.40^{a}	74.34^{b}	10.99^{a}	9.31^{a}	4.44^{a}	3.42^{a}
CV	1.8%	6.9%	6.2%	2.7%	5.3%	10.71%	14.5%	14.5%
SED	6.63	0.45	5.05	1.68	0.491	0.79	4.78	0.34

Means with the same alphabets on the same rows are not significantly different ($p>0.05$)

4.2.2 Chromium

The seeds sourced from Ondo Town had the highest Chromium content value (8.93 mg/kg) which was not significantly ($p > 0.05$) different from the Abuja (8.77 mg/kg). The values from Ondo and Abuja were however significantly ($p < 0.05$) different from Benin City (6.93 mg/kg) and Awka (7.56 mg/kg). The values from Benin City and Awka were not significantly different from each other. The coefficient (CV) of the procedure was 6.9 %.

4.2.3 Iron

The iron content values showed that Benin City recorded the highest iron value of 103.60 mg/kg, followed by Abuja (99.80 mg/kg) and Ondo (99.40 mg/kg). The least iron content (98.90 mg/kg) was recorded in the Awka seeds. The result showed that there was no significant difference in iron content across the four locations. The coefficient (CV) of the procedure was 6.2 %.

4.2.4 Potassium

The highest potassium content was found in the seeds from Awka (81.95 mg/lg) which was significantly different from all the other three locations. There was no significant difference in the potassium content of the samples from Benin City (76.55 mg/kg), Ondo Town (74.34 mg/kg) and Abuja (73.96 mg/kg). The coefficient (CV) of the procedure was 2.7 %.

4.2.5 Magnesium

The result showed that the Benin had the highest concentration of magnesium, with a value of 11.93 mg/kg, followed by the Abuja and Awka, with mean values of 11.12 mg/kg and 11.02 mg/kg respectively. Ondo region had the lowest magnesium content, with a mean value of 10.99 mg/kg. The result indicated there was no significant ($p > 0.05$) difference in magnesium content for the four locations studied. The coefficient (CV) of the procedure was 5.3 %.

4.2.6 Manganese

The result indicated that the manganese content ranged from 9.31 mg/kg to 11.11 mg/kg. The highest (11.11 mg/kg) manganese content was recorded in Abuja region while the least (9.31 mg/kg) manganese content was recorded in Ondo Town. The amount of manganese showed that all the locations studied had similar manganese content, with no significant ($p > 0.05$) differences observed. The coefficient (CV) of the procedure was 10.71 %.

4.2.7 Sodium

The sodium content ranged from 3.74 mg/kg to 9.32 mg/kg. The result indicated that the highest (9.32 mg/kg) sodium content was recorded in Benin City while the least (3.74 mg/kg) sodium content was recorded in Abuja. The amount of sodium showed that all the regions had similar sodium content, with no significant ($p > 0.05$) differences observed. The coefficient (CV) of the procedure was 107.1 %.

4.2.8 Zinc

The zinc content ranged from 2.08 mg/kg to 3.42 mg/kg. The result indicated that the highest (3.42 mg/kg) zinc content was recorded in Ondo sample while the least (2.08 mg/kg) zinc content was recorded in Benin City sample. The zinc content in Ondo seed was not significantly different from that of Awka (3.01 mg/kg) and Abuja (2.91 mg/kg). It was however significantly different from the zinc content of the Benin seeds (.2.08 mg/kg). There was no significant difference in the zinc content of the samples from Benin City, Abuja and Awka. The coefficient (CV) of the procedure was 14.5 %.

CHAPTER FIVE

5.0 DISCUSSION

This study was on the mineral composition of *Monodora myristica* seeds. Some of the mineral parameters observed varied significantly ($p < 0.05$) different across the locations. These differences could be as a result of climatic condition, agronomy practice and soil nutrient composition (Feyisayo and Oluokun, 2014). Calcium is a mineral that is essential for the development and maintenance of healthy bones and teeth. It plays a crucial role in muscle function, nerve transmission, and blood clotting. The calcium content in this study ranged from 425.50 mg/kg to 522.10 mg/kg across the region. The calcium content was lowest in the seeds sourced from Awka and this may be as a result of the nature of the soil. A study by Okenmuo *et al.*, (2020) showed that southeastern soils have low calcium content. The mineral content values for chromium showed that there was significant ($p < 0.05$) difference due to location in the samples studied. Chromium is a trace element important for glucose metabolism, and it helps regulate blood sugar level which is often associated with potential health benefits related to diabetes. The variation observed in Chromium content in this study could be as a result of differences in soil nutrient, climatic factor and crop cultivar (Onimawo *et al.,* 2019).

There was no significant ($p > 0.05$) difference in the iron content levels. The lack of variation means that African nutmeg seeds can supply a consistent amount of iron regardless of the location from which it is sourced. The amount of potassium showed that there was significant ($p>0.05$) difference between the sample sourced from Awka and the ones from other locations. Potassium is an electrolyte important for maintaining proper muscle and nerve function which helps regulate blood pressure and fluid balance in the body. The potassium content in this study ranged from 73.96 mg/kg to 81.95 mg/kg. This is higher than the potassium content in Akpabio and Akpakpan, (2012) report which was recorded at 68.00 mg/100g.

There was no significant ($p > 0.05$) difference in magnesium content across the locations. This showed that soil nutrient, climatic factors, agronomic practices and edaphic factor were favorable across the regions (Onimawo *et al.,*2019). Magnesium is crucial for muscle and nerve function, bone health, and energy production. It plays a role in over 300 biochemical reactions in the body.

Zinc content was significantly different across the locations. The zinc content in this study ranged from 2.08 to 3.42 mg/kg which is in line with reports on ginger (4.99 mg/100 g) obtained from a study by Okwu, (2004), *Xylopia Aethiopica*(3.8 mg/100 g) and *Mondia Whitei* (3.7 mg/100 g). This finding shows that the zinc contained in most spices is relatively small in quantity; hence, it can be deduced that the body contains only a small quantity of a biologically active pool of zinc. Therefore, a dietary supply of zinc is continually needed. And as such, the inclusion of African Nutmeg seeds in the human diet will play a significant role in supplying the body's zinc needs. (Nkwocha *et al*., 2019).

The amount of manganese and sodium content showed that all the regions had similar manganese and sodium content, with no significant ($p > 0.05$) differences observed. This showed that soil nutrient, climatic factors, agronomic practices and edaphic factor were favorable across the regions (Nkwocha *et al.,*2019). The mineral composition in this study was higher than the report of Akpabio and Akpakpan, (2012) Magnesium, potassium, calcium, manganese, copper, sodium, zinc, iron and phosphorous were also found to be present at the levels of 54.86 mg/100g, 68.00 mg/100g, 3.57 mg/100g, 0.80 mg/100g, 3.10 mg/100g, 3.20 mg/100g, 8.72 mg/100g, 8.76 mg/100g, and 0.04 mg/100g respectively. The results in this study are also higher than Onimawo *et al.* 2019) results which reported that African nutmeg sodium, iron, and calcium were found to be 110.20 mg/kg, 147.28 mg/kg and 166.10mg/100g respectively.

In essence, the findings of the experiment showed that inclusion of African Nutmeg into the human diet either as a spice or a component of traditional medicine is an effective way of supplying some of the body's mineral needs.

5.1 Conclusion

The analysis of the mineral composition of *Monodora myristica* seeds across different locations in Nigeria has provided valuable insights into the variation in nutrient content of the same seed on the basis of location. The study revealed distinct regional differences in the levels of calcium, chromium, potassium, and zinc.

Interestingly, no significant differences were observed in the manganese, sodium, and magnesium content across the various regions, indicating a degree of uniformity in these particular mineral concentrations. These findings highlight the importance of considering regional variations when studying the nutritional composition of plant species, as they can have implications for dietary recommendations and agricultural practices. Further research in this area could also help optimize the cultivation and utilization of *Monodora myristica* seeds for its potential health benefits and economic value in different parts of Nigeria.

5.2 Recommendation

Based on the mineral composition findings, it is recommended to consider the regional variations when utilizing *Monodora myristica* seeds for nutritional or industrial purposes. Regions with higher levels of minerals, such as calcium and potassium, may be valuable sources for consumption.

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