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In-Depth Assessment of Proximate, Vitamin, and Mineral Composition Analysis of Locally Cultivated Rice Varieties in South-Eastern Nigeria

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Abstract
In this research, the aim was to assess the proximate analysis, as well as the vitamin and mineral composition analysis of locally cultivated rice varieties in rice south-eastern Nigeria with a focus on the location-based effect and grain-length-based effect on proximate analysis, mineral, and vitamin contents of FARO 44 rice species farmed in Southeast Nigeria. The study area includes several locations in southeast Nigeria: Omasi (Latitude: 6° 42' 14" N, Longitude: 6°58' 46" E), Omar (Latitude: 6° 30' 37" N, Longitude: 6° 57' 32" E), Ikwo (Latitude: 6.0659° N, longitude: 8.0953° E), Izzi (Latitude: 6.5792° N, Longitude: 8.0475° E), Adani (Latitude: 6.7340° N, longitude: 7.0095° E), and Eha-Amufu (Latitude: 6.6590° N, Longitude: 7.7607°E). Standard methods were followed during sampling and laboratory analysis. The study found that the main effect of locations on the proximate analysis of FARO 44 rice species was not significant, except for protein, moisture, and carbohydrate (CHO) content. The highest protein content was observed in the Ikwo location, while moisture content was similar among several locations except for Eha-Amufu, which had the lowest moisture content. Regarding vitamin content, the location had a significant influence, with variations observed in different locations for vitamin E, B1, B2, vitamin C, and B-Carotene. Furthermore, both location and grain length had a significant effect on mineral content, particularly copper, zinc, and potassium, with variations observed among different locations and grain lengths.
Keywords: mineral composition, proximate analysis, vitamin, rice, south-east Nigeria
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Introduction

The progress towards achieving universal access to safe and nutritious food, as well as eradicating malnutrition, has been slow globally due to various factors such as conflicts, climate change, extreme weather events, and economic downturns. The COVID-19 pandemic has worsened these challenges, leading to an increase in hunger. In 2020, the number of people experiencing hunger ranged from 720 to 811 million, with an estimated midpoint of 768 million. This represents an increase of 118 million compared to 2019, and in the worst-case scenario, the increase could be as high as 161 million individuals (FAO, 2021).

Food insecurity is particularly severe in Africa, where one in five people (20.2 percent) faced hunger in 2021, compared to lower rates in other regions. Globally, an estimated 2.3 billion people (29.3 percent of the population) experienced moderate or severe food insecurity in 2021, with 923.7 million people facing severe food insecurity (FAO, 2022). Projections indicate that by 2030, nearly 670 million people will still be undernourished, which is 78 million more than in a scenario without the pandemic. Additionally, the ongoing war in Ukraine is expected to have further implications for global agricultural markets, trade, production, and prices, potentially impacting food security and nutrition for many countries (FAO, 2022).

Cereals and grains are significant contributors to essential nutrients globally. In Nigeria, rice holds a prominent position as a staple food in numerous households. Despite being more expensive, locally grown rice often takes a backseat to imported rice in terms of consumer preference. Therefore, there is a need to increase awareness about the nutrient content of locally-grown rice, this can encourage its acceptance and consumption among the Nigerian population (Thomas et al., 2016). Understanding the nutritional value and health advantages of rice plays a crucial role in promoting the inclusion of rice in our daily diet. It is imperative to raise awareness about these aspects to encourage greater rice consumption among individuals (Verma & Srivastav, 2017).

There is an obvious dearth of literature on the location-based effect and grain-length-based effect on proximate analysis, mineral, and vitamin contents of FARO 44 rice species farmed in Southeast Nigeria. The present study was designed to in-depth assessment of food energy, mineral composition, and proximate analysis of locally cultivated rice varieties in the south-Eastern Nigeria

Materials and methods

Study Area

The study area includes several locations in southeast Nigeria: Omasi (Latitude: 6° 42' 14" N, Longitude: 6° 58' 46" E), Omar (Latitude: 6° 30' 37" N, Longitude: 6° 57' 32" E), Ikwo (Latitude: 6.0659° N, Longitude: 8.0953° E), Izzi (Latitude: 6.5792° N, Longitude: 8.0475° E), Adani (Latitude: 6.7340° N, Longitude: 7.0095° E), and Eha-Amufu (Latitude: 6.6590° N, Longitude: 7.7607° E). These areas have a tropical humid climate with distinct wet and dry seasons, experiencing annual rainfall ranging from 1300-3000mm. They are characterized by high temperatures, rainfall, and humidity. Ikwo LGA covers an area of 500 square kilometers and has an average temperature of 27 degrees Celsius. It has a semi-tropical climate with an average humidity level of 68% and annual rainfall between 1613.8 mm to 2136.27 mm. Izzi LGA covers an area of 2,264 square kilometers and has an average temperature of 27 degrees Celsius. It is dominated by guinea savannah vegetation and has an estimated elevation of 140 meters above sea level. The average humidity level in Izzi is 70%. Uzo-Uwani LGA has a tropical wet-and-dry (savanna) climate with varying annual rainfall, ranging from approximately 1,650mm on the northeast plateau to 147mm in the western lowland. It covers an area of 855 square kilometers and has an average temperature of 28 degrees Celsius. Eha-Amufu, situated at an elevation of 109 meters above sea level, has an average temperature of 27.0 degrees Celsius and an average precipitation of 1669 mm.

Field Sampling, Experimental Design, and Sample Preparation

Samples were collected from three states in southeast Nigeria known for rice farming: Anambra, Ebonyi, and Enugu. Two farm settlements were selected in each state based on their productivity. In Anambra state, the selected settlements were Omasi and Omar in Ayamelum LGA. In Ebonyi state, the selected settlements were Ikwo and Izzi in their respective LGAs. In Enugu state, the selected settlements were Adani and Eha-Amufu in Uzo-Uwani and Isi-Uzo LGAs. The study focused on the most commonly cultivated rice species in Nigeria, which is FARO 44 (both short and long grains). A total of 18 samples of each variety of FARO 44 were collected from the six selected locations, resulting in a total of 36 samples of FARO 44 (long and short grains). The samples were transported to the laboratories within 48 hours. Upon arrival, the samples were shade dried, ground into powder using a grinder, sieved with a 2 mm mesh size, and sealed in airtight plastic containers. They were then stored in sacks for laboratory analysis. The Soil Science Laboratory at the University of Nigeria, Nsukka, Enugu state, evaluated proximate constituents, mineral contents, and vitamin contents of the samples.

Determination of Proximate Compositions

The proximate compositions of the samples were determined using the methods described by the Association of Official Agricultural Chemists (AOAC) in 2016.

Determination of Mineral Contents

The mineral contents of the samples were determined using a microwave digestion system (Ethos easy). Each sample (200 milligrams) was weighed and transferred into Teflon vessels. Then, 7 mg of HNO3, 2 ml of H2O2, and 1 ml of HClO4 were added to each vessel. The vessels with the digestion rotor were placed into the microwave digestion system, and digestion was conducted according to the specified program for plant tissue. After digestion, the digest was filtered using Whatman filter paper and diluted to a volume of 50 ml. A 2 ml solution from each sample was used for mineral determination using Micro-Plasma Atomic Emission Spectroscopy (MP-AES).

Determination of Vitamin E, B1, B2, C, and β-Carotene Contents

The selected vitamin contents of the sample were determined following the method of Umar et al. 2013.

Statistical Analysis

The collected data were analyzed using analysis of variance (ANOVA) with GENSTAT Release 7.22 DE (2012). Significant differences between treatment means were determined using the least significant difference at a 5% probability level.

Results

The main effect of locations on the proximate analysis of FARO 44 rice species was not significant ($P<0.05$) in most of the traits measured except in protein, moisture, and CHO (Table 1). Ikwo had the highest protein contents (11.62) but the value of other locations was statistically similar. The moisture contents of Adani (11.90), Omasi (11.83), Omar (11.25), and Izzi (11.57) were statistically similar while Eha-Amufu had the lowest moisture contents (7.92) from other locations. Adani and Omar produced the highest CHO contents while other locations were statistically similar. The result of the main effect of grain length on proximate analysis does not show any significant effect (Table 2). The values of proximate composition were statistically similar across the grain length.

Table 1: Main effect of locations on proximate contents of FARO 44 rice species

Locations	Protein (%)	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	CHO (%)	Dry matter (%)
Eha-Amufu	6.25	7.92	3.75	3.79	3.50	79.66	92.92
Adani	5.91	11.90	4.08	3.50	3.54	81.81	92.93
Omasi	7.07	11.83	2.12	4.08	4.00	79.62	92.92
Omor	6.62	11.25	3.67	4.25	3.50	81.21	93.67
Izzi	8.76	11.57	4.58	4.00	3.16	77.48	93.20
Ikwo	11.62	9.25	3.67	3.5	3.67	76.06	93.08
LSD (0.05)	2.66	2.92	n.s	n.s	n.s	2.99	n.s

n.s= non-significant, CHO=Carbohydrate

Table 2: Main effect of grain length on proximate contents of FARO 44 rice species

Grain length	Protein (%)	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	CHO (%)	Dry matter (%)
Short	7.94	11.11	3.89	4.01	3.42	79.49	92.96
Long	7.47	10.13	3.40	3.69	3.70	79.13	93.28
LSD(0.05)	n.s	n.s	n.s	n.s	n.s	n.s	n.s

n.s= non-significant, CHO=Carbohydrate

The main effect of locations on vitamin content was all significantly (P<0.05) influenced (Table 3). The Ikwo location had the highest value of vitamin E while Eha-Amufu had the lowest value (2.30). The values of vitamin B1 and B2 were statistically similar at Eha-Amufu, Omasi, Izzi, and Ikwo while Adani and Omor gave the lowest values. The Izzi location recorded the best result on vitamin C (42.17) while the Omor location had the lowest value (8.67). The Ikwo location recorded the highest value of B-Carotene (283.41) and followed Izzi (185.83) and Omor (180.91) while Eha-Amufu had the lowest value of B-Carotene (64.17). The result showed the grain length of FARO 44 had a significant effect on vitamin C (Table 4). The long grain had a higher value of vitamin C (27.17) than the short (23.83) grain of FARO 44. The values of other vitamins were statistically similar across the grain lengths.

Table 3: Main effect of locations on some selected vitamin contents of FARO 44 rice species

Locations	VIT E (mg/100g)	VIT B1 (mg/100g)	VIT B2 (mg/100g)	VIT C (mg/100g)	B-CAROTENE (μ)
Eha-Amufu	2.30	2.92	4.20	36.17	64.17
Adani	3.70	0.65	0.80	14.67	83.33
Omasi	4.68	2.17	3.37	24.17	131.67
Omor	4.68	0.45	0.57	8.67	180.91
Izzi	5.85	3.72	4.41	42.17	185.83
Ikwo	7.65	2.92	3.37	27.17	283.41
LSD(0.05)	2.83	2.05	2.40	3.00	2.90

LSD=Least Significant Difference

Table 4: Main effect of grain length on some selected vitamin contents of FARO 44 rice species

Grain length	VIT E (mg/100g)	VIT B1 (mg/100g)	VIT B2 (mg/100g)	VIT C (mg/100g)	B-CAROTENE (μ)
Short	4.87	2.02	2.73	23.83	155.58
Long	4.75	2.20	2.96	27.17	154.19
LSD(0.05)	n.s	n.s	n.s	1.73	n.s

LSD=Least significant difference, n.s= non-significant

The main effect of location on mineral contents of FARO 44 rice species had a significant (P<0.05) effect on copper, zinc, and potassium content (Table 5). The Izzi location contains higher copper content (48.96) while Omasi had a lower value (14.12). The Omasi location contains the best result on zinc content (702.67) whereas Adani and Omor were the same value of zinc content (602.67). The Izzi location had a higher value of potassium content (11.44) followed by Ikwo (10.74) while other locations were statistically similar. The result of grain length on the mineral content of FARO 44 rice species had a significant (P<0.05) effect on copper and zinc content (Table 6). The long grain length had higher copper content (41.19) than the short grain length. The short-grain length contains more zinc content (469.33) than the long-grain length.

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Table 5: Main effect of locations on mineral contents of FARO 44 rice species

Locations	Ca (mg/100g)	Cu (mg/100g)	Fe (mg/100g)	Mg (mg/100g)	Mn (mg/100g)	Na (ppm)	P (mg/100g)	Zn (mg/100g)	K (ppm)
Eha-Amufu	3.47	48.96	3.33	2.62	3.11	3.62	4.58	302.67	5.72
Adani	3.59	37.26	3.19	2.63	3.15	3.46	4.75	602.67	6.53
Omasi	3.47	14.12	3.33	2.62	3.10	3.62	4.87	702.67	6.45
Omor	4.67	43.16	3.19	2.76	3.15	3.62	3.04	602.67	6.66
Izzi	4.21	48.96	3.13	2.71	3.11	4.17	4.05	202.67	11.44
Ikwo	4.21	37.34	3.05	2.71	3.15	3.36	4.75	302.50	10.74
LSD(0.05)	n.s	2.98	n.s	n.s	n.s	n.s	n.s	3.00	2.89

An LSD-Least significant difference, n.s-non-significant, Ca-Calcium, Cu-Copper, Fe-Iron, Mg-Magnesium, Mn-Magnese, Na-Sodium, P-Phosphorus, Zn-Zinc, K-Potassium.

Table 6: Main effect of grain length on mineral contents of FARO 44 rice species

Grain length	Ca (mg/100g)	Cu (mg/100g)	Fe (mg/100g)	Mg (mg/100g)	Mn (mg/100g)	Na (ppm)	P (mg/100g)	Zn (mg/100g)	K (ppm)
Short	3.75	35.41	3.10	2.65	3.14	3.46	4.03	469.33	7.19
Long	4.12	41.19	3.31	2.70	3.12	3.82	4.65	435.94	8.66
LSD(0.05)	n.s	1.72	n.s	n.s	n.s	n.s	n.s	1.73	n.s

An LSD-Least significant difference, n.s-non-significant, Ca-Calcium, Cu-Copper, Fe-Iron, Mg-Magnesium, Mn-Magnese, Na-Sodium, P-Phosphorus, Zn-Zinc, K-Potassium.

Discussion

Globally, rice is recognized as a staple food, especially in developing nations. In 2018, World Health Organization made a publication on Guideline: fortification of Rice with Vitamins and Minerals as a public health strategy. A study on Bangladeshi children and their caregivers showed that rice was the main source of zinc intake, providing 49% of dietary zinc to children and 69% to women (Arsenault *et al*., 2010). It is documented that rice provides the bulk of daily calories for many companion animals and humans (Ryan, 2011). In 2004, Anderson (2004) reported that the pigment of certain rice can inhibit the formation of atherosclerotic plaque because it has anti-oxidative or anti-inflammatory effects.

A comprehensive analysis of the proximate, mineral composition, and vitamin content of locally cultivated rice varieties in South-Eastern Nigeria. Our findings reveal significant variations in the nutritional profiles of these rice varieties, highlighting the potential for dietary diversification and improved food security in the region. In the course of this study, we critically observed that there is an obvious knowledge gap on the location-based effect and grain-length-based effect on proximate analysis, mineral, and vitamin contents of different rice species.

The main effect of locations and grain length on the proximate analysis of FARO 44 rice species was not significant ($P<0.05$) in most of the traits measured except in protein, moisture, and CHO. The proximate analysis gives information on the basic nutrients present (Akiode et al., 2018). Content values obtained in this study were significantly higher than that of Oko & Ugwu (2017) except for carbohydrates whose values were statistically similar. Similarly, our findings were at variance with Vunain et al., 2020 except for values obtained in carbohydrates and moisture. However, we carefully observed that their samples were not from the same rice species we used.

The main effect of locations on vitamin content was all significantly ($P<0.05$) influenced. The result also revealed that the grain length of FARO 44 had a significant effect on vitamin C. Our findings were at variance with Adekola (2022).

The main effect of location on the mineral contents of FARO 44 rice species had a significant ($P<0.05$) effect on copper, zinc, and potassium content while the result of grain length on the mineral content of FARO 44 rice species had a significant ($P<0.05$) effect on copper and zinc content. Content values obtained in this study were significantly higher than that of Oko & Ugwu (2017) except for carbohydrates whose values were statistically similar. Similarly, our findings were at variance with Vunain et al., 2020 except for values obtained in carbohydrates and moisture. However, we carefully observed that their samples were not from the same rice species we used.

Conclusion

The study found that the main effect of locations on the proximate analysis of FARO 44 rice species was not significant, except for protein, moisture, and carbohydrate (CHO) content. The highest protein content was observed in the Ikwo location, while moisture content was similar among several locations except for Eha-

Amufu, which had the lowest moisture content. Regarding vitamin content, the location had a significant influence, with variations observed in different locations for vitamin E, B1, B2, vitamin C, and B-Carotene. Furthermore, both location and grain length had a significant effect on mineral content, particularly copper, zinc, and potassium, with variations observed among different locations and grain lengths.

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Conflict of interest: The authors declare that they have no conflict of interest.

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