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Comparative study of mineral and amino acid composition of some selected Nigerian rice varieties cultivated in Ebonyi State, Nigeria

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ABSTRACT

Physical appearance of rice grains does not provide an indication of its nutritional composition but poses a problem in choice making even among the most common varieties. The mineral and amino acid composition of 14 rice varieties were studied using standard analytical methods. There was significant variation in the composition of rice varieties. *CP* showed the highest amount of phosphorus (126.72±1.48mg/100g). *Ton2* showed the highest composition of iron (2.67±0.03mg/100g) and the highest amounts of six essential amino acids: lysine (5.47±0.04mg), methionine(2.54±0.04mg), leucine (8.29±0.08mg), isoleucine (4.51±0.01mg), valine (4.77±0.00mg) and phenylalanine (4.71±0.07mg) per 100g. Iron showed negative correlation with all the minerals analyzed except phosphorus. To ensure nitrogen balance while relying on rice, one should have *Ton2* as the variety of choice among the ones studied in this work. These findings will serve as a useful guide to healthy consumption in addition to ensuring satisfaction of rice consumers.

Keywords: Minerals, amino acid and rice

INTRODUCTION

Rice has been domesticated and cultivated by man as food crop for several centuries. It is a very important cereal for consumption by humans [1]. Rice is a cereal that forms large part of human diet, feeding about fifty percent of the world's human population [2]. In many parts of the world, rice contributes between 40 - 80% of energy intake by humans. Rice is normally cooked and eaten as whole grains. [3], noted that the preference of consumers varies based on the type of rice and their origin. [4], suggested that variation in composition and other qualities of rice depend on genetic constitution and the rice growing environmental conditions. The quality of rice grains is influenced by many physico-chemical properties which are responsible for the cooking properties and the texture of cooked rice grains [2]. Properties such as amylose content, amylopectin composition, alkali spreading property and the consistency of the gels of various varieties influence both the cooking and eating qualities of rice, which vary among the varieties [5]. Rice is normally harvested when the moisture content of the grains is about 25%. This is followed by threshing which is generally done manually in Nigeria although mechanical threshers are available. For successful milling to be achieved, the paddy should be dried to reduce the moisture content [6]. Drying is also done to avoid formation of moulds which occur due to high moisture content. The seeds of rice are milled to remove the husk. The product obtained from this process is the brown rice. However, further milling may be carried out to remove the bran and produce white rice which lacks some important nutrients [6]. Frequent consumption of white rice may increase the incidence of beriberi.

Nutrients may be added to white rice to replace those lost during milling by adding powdered nutrients. Parboiling causes nutrients from the outer husk to move into the grain especially vitamin B1, thiamine. Thus,

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parboiled rice is nutritionally superior to unparboiled rice. Also, parboiled rice does not stick to pot during cooking like the unparboiled. This is because the grains of parboiled rice are gelatinized while inside the husk before milling. Rice is generally rich in carbohydrate but low in other nutrients. Rice does not contain all the essential amino acids in sufficient amounts that are required for good health [7]. Nutrient composition of rice varies based on a number of factors which include the strain of rice (white, brown, red, black and purple varieties), nutrient composition of the soil where rice was grown, method of polishing, processing method and the method by which rice was prepared for consumption. Colour of rice may be indicative of presence of some special components. Purple rice derives its colour from anthocyanins and tocols [8]. These colour pigments have antioxidant properties and are important to our health. Jang and Xu (2009) reported a greater quality of hydrophilic antioxidants in purple rice bran than lipophilic antioxidants. They also reported that the hydrophilic antioxidants have higher free radical scavenging activity than lipophilic antioxidants. These researchers reported anthocyanins and γ-tocopherols to be largely present in the inner portion of purple rice bran. Rice has about 80g of carbohydrate, 0.12g of free sugar, 7.13g of protein and 0.66g of fat per 100g [9].

Rice is an economically important food crop with nutritional diversification. It is ranked as the world's number one human food crop. But even in the midst of food, there is still hidden hunger associated with inadequacy of micronutrients required by our bodies [10]. Rice that has more than 10 percent crude protein is regarded as a high protein type [11]. Waxy type rice has more protein than varieties with high amylose content. This gives the belief that the endosperm of waxy rice is more favourable for the accumulation of protein than the endosperm of high amylose variety. Finding out rice varieties with high content of minerals is one thrust area in rice research since rice is generally low in minerals. Nutrient deficiency diseases such as anaemia can be avoided if rice varieties with high content of iron are available considering rice as a staple food. The demand for more nutrients in rice informed people's preference for unpolished rice. Starch is the highest component of rice followed by protein. The relevance of plant protein lies in the presence and amount of essential amino acids in it. Quantifying the amino acids present in the different rice varieties are therefore one of the core targets of this research. This research is aimed at comparing the nutritional composition of some Nigerian rice varieties grown in Ebonyi State. Therefore, this study was undertaken to (1) determine and compare the minerals (Na, K, Ca, Mg, P and Fe) composition of the different rice varieties, and (2) determine and compare the essential amino acid composition of the different rice varieties.

Materials and Methods

Plant materials

Fourteen rice varieties sourced from different parts of Nigeria: *Aiwa8*, *Awafum*, *B12*, *Canada*, *Cp*, *Dangot*, *Eleco20*, FARO52, *Maruwa*, *Mass*, NERICA7, *Short Caro*, *Ton2* and *306* were grown under the same normal agronomic practices in the Faculty of Sciences, Ebonyi State University, Abakaliki. All analyses were carried out at the National Cereal Research Institute, Badeggi, Niger State, Nigeria.

Sample preparation

The rice grains were harvested at maturity and threshed. The grains were parboiled and sun-dried. The paddy were dehusked using laboratory Dehusker, THU 35B (Satake Engineering Company Ltd, Tokyo) and then prepared for analyses.

Mineral Analysis

The percentage composition of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P) and iron (Fe) were determined in each of the varieties as shown below.

Determination of Alkali and Alkaline Earth Metals Using Flame Photometer

The flame photometer was switched on, and the air and fuel pressure were set on lighting the flame to non-luminous flame. Different filters were selected for each of the minerals, K-766nm, Na-589nm, Ca-623nm. The instrument was zeroed with distilled water while the 100 was set with standard solution of the element to be measured after connecting to the atomizer. The dilute sample in the beaker was connected to the atomizer. Result was taken when the reading was stable and concentrations were read from calibration chart [12].

Determination of Phosphorus Content

This was determined using the HCl extract of ash by phosphotungstic acid method. Aliquots of standard solution: 1, 2, 3, 4, 5 ml were pipetted and transferred into different boiling tubes. The sample extract: 5, 4,3,2,1 ml were added to the tubes respectively. The content was mixed and absorbance of the yellow colour formed was read at 420nm. The concentration of each extract was read from the standard curve [13].

Determination of Iron Content

Standard solution of iron was prepared and diluted to 100ppm. 10ml of the stock solution of each variety was diluted to 100ml. Absorbance of standard solution as well as sample solution was read by Spectronic 301

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spectrophotometer at 508nm. Concentration of iron in samples was read from the graph of concentrations in X-axis against absorbance in Y-axis [13].

Determination of Amino Acid Profile

The amino acid profile of each variety was determined following the method described by [14]. The flour of each rice variety was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-sample Amino Acid Analyzer (TSM). Each sample was defatted using chloroform/methanol mixture of ratio 2:1. 4g of rice flour was put in the extraction thimble of the soxhlet extraction apparatus and extracted following the outlined procedure of [13]. The defatted samples were then hydrolyzed with acid in the following steps. Equal weights of the defatted samples were weighed into glass ampoule. Approximately 7ml of 6M HCl was added and oxygen was expelled by passing nitrogen into the ampoule as this will avoid possible oxidation of some amino acids during hydrolysis (methionine and cystine). The glass ampoule was then sealed with flame of Bunsen burner. The sealed glass ampoule was put in an oven at 105^{o}C for 22hours. The ampoules were allowed to cool before being broken at the tip and the contents were filtered. The filterate was then evaporated to dryness at 40^{o}C under vacuum in a rotary evaporator. The residue of each sample was dissolved in 5ml acetate buffer and stored in plastic specimen bottles which were freezed. The hydrolysate (5 microlitre) was loaded into the TSM analyzer. The hydrolysate was dispensed into the cartridge of TSM. The analyzer is designed to separate and analyze free acidic, neutral and basic amino acids. Amino acid values were calculated from the chromatogram peaks by an integrator attached to the analyzer. The integrator calculates the peak area proportional to the concentration of each of the amino acids. The net height of each peak produced by the chart recorder of the TSM in which each one represents an amino acid is also measured. The half-height of the peak on the chart was measured and the width of the peak on the half height was measured and recorded. The approximate area of each peak was calculated as a product of height and width at half-height.

Statistical Analysis

All data were expressed as mean ± standard deviation. Analyses were done by analysis of variance (ANOVA) using SAS software version 9.1 (SAS institute, 1998). Differences were declared statistically significant at $P \leq 0.05$. Where significant differences were obtained, the means were separated by least significant difference (LSD) at 5% probability level. Inter-relationships among trait values were estimated using Pearson correlation coefficient.

Results

Mineral composition

Table 1 show that *CP* has the highest amount of phosphorus (126.72±1.4mg/100g of sample) followed by NERICA7 (118.58±0.03mg/100g) but the least value was found in *Aiwa 8* (51.78±0.24mg/100g). FARO52 and *B12* have highest value of potassium (0.33±0.01%) while least amount was found in *Maruwa* with 0.10±0.01%. Rice type *Aiwa8* has the highest amount of sodium (0.26±0.01%) while the least amount was found in *Maruwa* (0.06±0.01%). The table also shows the distribution of calcium across the 14 rice varieties. *Short Caro* has the highest composition (1.52±0.01%) and *Ton2* showed the least composition (0.52±0.16%) of calcium. *B12* is richest in magnesium (2.94±0.00mg) while *Aiwa8* had least content (0.10±0.02mg/100g). The highest amount of iron (2.67±0.03mg/100g) was found in *Ton2* with least amount (1.50±0.03mg/100g) in *Awafum.* Magnesium showed positive correlation with all other minerals while iron showed positive correlation with phosphorus only (table 3).

Amino Acid composition

The variety *Ton2* is the richest in the essential amino acids: Lysine (5.47±0.04mg), methionine (2.54±0.04mg), leucine (8.29±0.08mg), isoleucine (4.51±0.01mg), valine (4.77±0.00mg) and phenylalanine (4.71±0.07mg), while FARO52 is richest in threonine (3.46±0.65mg), histidine (2.67±0.01mg) and arginine (5.84±0.06mg) as presented in Table 2. Aspartic acid ranged from 10.03 - 15.36mg. Serine ranged from 2.28 - 3.34mg. Glutamic acid was found to be in the range 9.60 - 13.28mg. Proline ranged from 2.10 - 3.20mg while glycine ranged from 4.25 - 3.22mg. Alanine ranged from 3.12 - 3.60mg. Cystine was found to range from 0.99 - 1.48mg while tyrosine ranged from 1.97 - 3.16mg.

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Table 1. Mean Values of Mineral Composition of Rice Grains

VARIETES	P(mg|/100g)	K(%)	Na(%)	Ca(%)	Mg(mg/100g)	Fe(mg/100g)
MARUWA	52.70 ±0.37^{l}	0.10±0.01^{e}	0.06±0.01^{f}	0.68±0.04^{e}	0.51±0.03^{gh}	1.67±0.03^{f}
AIWA8	51.78±0.24^{m}	0.18±0.01^{e}	0.26±0.01^{a}	1.38±0.02^{ab}	0.10±0.02^{h}	2.20±0.03^{b}
AWAFUM	87.58±0.3^{i}	0.26±0.02^{b}	0.19±0.03^{bc}	1.04±0.14^{c}	0.54±0.02^{h}	1.50±0.03^{h}
CANADA	62.70±0.16^{k}	0.21±0.01^{cd}	0.23±0.01^{b}	1.43±0.03^{a}	0.55±0.02^{g}	1.60±0.02^{g}
MASS	94.32±0.02^{g}	0.20±0.01^{cd}	0.20±0.01^{bc}	1.21±0.02^{b}	0.77±0.03^{f}	2.04±0.03^{a}
TON2	99.42±0.39^{e}	0.16±0.01^{d}	0.12±0.02^{b}	0.52±0.16^{f}	1.55±0.02^{c}	2.67±0.03^{a}
306	71.53±0.06^{j}	0.24±0.03^{c}	0.22±0.02^{b}	1.32±0.02^{ab}	0.81±0.02^{d}	1.70±0.02^{f}
Cp	126.72±1.48^{a}	0.18±0.01^{d}	0.19±0.01^{bc}	0.91±0.02^{d}	0.75±0.01^{f}	1.90±0.02^{d}
FARO52	105.07±0.08^{a}	0.33±0.01^{a}	0.18±0.02^{bc}	1.24±0.01^{b}	0.81±0.01^{e}	1.68±0.03^{f}
DANGOT	92.97±0.02^{h}	0.18±0.01^{d}	O.18±0.02^{b}	1.40±0.01^{ab}	2.14±0.02^{b}	1.89±0.03^{d}
NERICA7	118.58±0.03^{e}	0.16±0.01^{d}	0.10±0.01^{e}	0.74±0.02^{e}	0.73±0.02^{fg}	1.63±0.02^{g}
SHORT CARO	101.09±0.02^{d}	0.22±0.02^{c}	0.15±0.01^{a}	1.52±0.01^{a}	0.72±0.02^{fg}	1.91±0.01^{d}
ELECO20	97.06±0.02^{f}	0.22±0.01^{cd}	0.18±0.01^{c}	0.71±0.03^{e}	0.52±0.03^{g}	1.85±0.03^{e}
B12	87.23±22.0^{j}	O.33±0.02^{a}	0.22±0.01^{b}	1.36±0.01^{ab}	2.94±0.02^{a}	1.51±0.01^{h}
GRAND Average	89.23± 0.22	0.21±0.06	0.19±0.06	1.10±0.33	0.96±0.73	1.84±0.31

*Values are mean ± standard deviation
* Means with the same letters down the column are not significantly different at p≤ 0.05.

Table 2: Mean values of Amino Acid Composition of Rice Grains (mg/100g)

VARITIES	LYSINE	HISTIDINE	ARGININE	ASPARTIC ACID	THREONINE	SERINE	GLUTAMIC ACID	PROLINE	GLYCINE
ELECO20	4.17±0.01^{d}	2.08±0.01^{e}	4.64±0.17^{d}	10.55±0.62^{g}	2.16±0.07^{b}	2.59±0.08^{cd}	10.08±0.01^{h}	2.10±0.014^{fg}	3.22±o.08^{c}
B12	5.01±0.01^{b}	2.22±0.00^{d}	5.74±0.17^{d}	13.03±0.06^{c}	2.89±0.07^{ab}	2.64±0.08^{c}	12.52±0.014^{d}	2.65±0.14^{d}	3.75±o.08^{b}
SHORTCARO	5.28±0.00a^{b}	2.3±0.01^{c}	5.62±0.00^{ab}	14.52±0.00^{b}	3.345±0.01^{a}	3.24±o.08^{b}	12.74±0.08^{b}	3.02±0.00^{b}	4.10±0.00^{a}
CANADA	4.85±0.06^{ab}	2.17±0.01^{de}	5.48±0.05^{ab}	12.80±0.01^{cd}	2.62±0.01^{b}	2.95±0.08^{b}	11.86±0.08^{f}	2.27±0.08^{d}	3.37±0.016^{bc}
AIWA8	4.85±0.06^{b}	1.83±0.01^{f}	4.54±0.08^{de}	10.03±0.02^{h}	2.19±0.12^{b}	2.28±0.07^{d}	9.60±0.08^{fg}	2.15±0.08^{fg}	3.33±0.16^{c}
TON2	5.47±0.04^{a}	2,34±0.01^{e}	5.73±0.08^{a}	15.36±0.02^{a}	3.07±0.64^{a}	3.42±0.08^{a}	13.28±0.08^{a}	3.20±0.08^{fg}	4.25±0.00^{a}
FARO52	5.19±0.01^{ab}	2,67±0.01^{f}	5.84±0.06^{a}	13.19±0.01^{c}	3.46±0.65^{a}	3.23±0.08^{a}	11.32±0.08^{e}	2.83±0.08^{c}	3.54±0.15^{b}
MARUWA	4.63±0.14^{c}	2.08±0.02^{e}	5.15±0.07^{b}	12.13±0.01^{d}	2.32±0.00^{b}	3.17±0.01^{ab}	10.72±0.08^{f}	2.20±0.00^{f}	3.4±0.15^{bc}
CP	4.61±0.14^{c}	2.18±0.02^{de}	4.94±0.01^{c}	11.55±o.00^{e}	2.22±0.08^{b}	2.76±0.08^{c}	10.47±0.07^{g}	2.20±0.00^{f}	3.25±0.05^{c}
DANGOT	4.82±0.03b^{c}	2.17±0.01^{de}	5.62±0.00^{ab}	13.12±0.07^{c}	2.84±0.00^{ab}	2.53±0.08^{cd}	12.52±0.01^{c}	2.55±0.01^{e}	3.51±0.04^{bc}
306	4.19±0.011^{d}	2.09±0.02^{d}	4.73±0.05^{d}	10.93±0.07^{c}	2.21±0.00^{b}	2.65±0.01^{c}	10.08±0.01^{h}	2.26±0.08^{f}	3.69±0.00^{b}
MASS	4.90±0.14^{b}	2.21±0.02^{d}	5.62±0.00^{ab}	13.12±0.07^{c}	2.84±0.00^{cd}	2.53±0.08^{cd}	12.52±0.01^{b}	2.55±0.01^{e}	3.69±0.000^{b}
NERICA7	5.38±0.13^{a}	2.31±0.02^{c}	5.67±0.06^{a}	14.47±0.07^{b}	3.30±0.08^{a}	3.34±0.07^{a}	12.74±0.08^{b}	3.03±0.01^{b}	4.08±0.04^{a}
AWAFUM	4.88±0.01^{b}	2.16±0.00^{de}	5.44±0.00^{ab}	12.86±0.07^{c}	2.67±0.08^{ab}	2.95±0.07^{d}	11.85±0.07^{d}	2.32±0.00^{f}	3.51±0.04^{bc}
GRAND AVERAGE	4.88±0.45	2.20±0.18	5.31±0.44	12.63±1.51	2.70±0.47	2.91±0.034	11.51±1.15	2.50±0.37	3.62±0.34

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Table 2 (continued): Amino Acid Composition of Rice Grains (mg/100g)

VAERITIES	ALANINE	CYSTINE	VALINE	METHIONINE	ISOLEUCINE	LEUCINE	TYROSINE	PHENYLANINE
ELECO20	3.12±0.16^{b}	1.11±0.01^{bc}	3.36±0.08^{bc}	1.01±0.01^{c}	3.01±0.01^{cc}	6.12±0.14^{e}	2.10±0.08^{e}	3.50±0.14^{c}
B12	3.50±0.02^{ab}	1.25±0.01^{b}	3.66±0.08^{b}	1.46±0.01^{b}	1.95±0.01^{h}	7.10±0.00^{c}	2.87±0.08^{b}	4.34±0.14^{ab}
SHORTCARO	3.60±0.08^{a}	1.24±0.00^{b}	2.92±0.00^{d}	1.19±0.01^{b}	3.26±0.00^{b}	7.10±0.00^{c}	2.93±0.08^{b}	4.38±0.00^{ab}
CANADA	3.46±0.08^{ab}	1.22±0.03^{b}	3.23±0.07^{c}	1.28±0.01^{b}	2.92±0.01^{d}	7.81±0.08^{bc}	2.71±0.08^{b}	4.25±0.08^{ab}
AIWA8	3.13±0.04^{b}	0.099±0.03^{c}	2.6±0.07^{e}	0.86±0.00^{bc}	2.16±0.01^{g}	6.29±0.08^{e}	1.97±0.03^{cd}	3.47±0.08^{cd}
TON2	3.84±0.04^{a}	1.48±0.05^{a}	4.77±0.00^{a}	2.54±0.040^{a}	4.51±0.01^{a}	8.29±0.08^{a}	3.16±0.0.0^{a}	4.71±0.07^{a}
FARO52	3.26±0.00^{b}	1.30±0.08^{b}	3.49±0.06^{bc}	0.83±0.73^{bc}	3.21±0.01^{bc}	6.93±0.08^{cd}	2.81±0.01^{b}	4.32±0.01^{ab}
MARUWA	3.31±0.OO^{ab}	1.16±0.06^{bc}	3.22±0.00^{c}	1.19±0.01^{b}	2.35±0.00^{f}	6.57±0.15^{d}	2.33±0.01^{c}	3.60±0.14^{c}
CP	3.16±0.22^{b}	1.06±0.07^{bc}	3.34±0.08^{c}	1.17±0.01^{b}	2.13±0.04^{g}	6.22±0.08^{e}	2.14±0.01^{cd}	3.62±0.14^{c}
DANGOT	3.39±0.22^{ab}	1.12±0.01^{bc}	3.16±0.00^{cd}	1.27±0.03^{b}	2.44±0.04^{b}	6.62±0.02^{d}	2.50±0.02^{c}	3.73±0.16^{c}
306	3.13±0.14^{b}	1.16±0.06^{bc}	3.46±0.07^{bc}	1.03±0.01^{bc}	3.01±0.02^{c}	6.24±0.02^{e}	2.13±0.04^{cd}	3.71±0.16^{c}
MASS	3.58±0.14^{a}	1.14±0.04^{bc}	3.55±0.07^{b}	1.45±0.00^{b}	1.95±0.02^{h}	6.82±0.08^{cd}	2.84±0.04^{b}	4.12±0.03^{b}
NERICA 7	3.550.14^{ab}	1.23±0.01^{b}	2.87±0.08^{d}	1.19±0.01^{b}	3.24±0.03^{b}	7.12±0.08^{c}	2.83±0.12^{b}	4.60±0.03^{a}
AWAFUM	3.50±0.14^{ab}	1.24±0.01^{b}	3.34±0.08^{c}	1.28±0.2^{b}	2.95±0.03^{d}	6.75±0.00^{cd}	2.80±0.21^{b}	4.06±0.0^{b}
Grand Average	3.39±0.23	1.19±0.12	3.35±0.49	1.27±0.43	2.79±0.68	6.85±0.61	2.58±0.38	4.03±0.42

*Values are mean ± standard deviation. *Means with the same letter in the same column are not significantly different at $p \leq 0.05$

Table 3: Correlation between Minerals

	P	K	Na	Ca	Mg	Fe
P	1					
K	0.161	1				
Na	-0.204	0.486**	1			
Ca	-0.261	0.490**	0.715**	1		
Mg	0.206	0.351*	0.138	0.148	1	
Fe	0.077	-0.409**	-0.070	-0.287	-0.027	1

* Correlation is significant at the 0.05 level (2-tailed)
** CORRELATION IS SIGNIFICANT AT THE 0.01 LEVEL (2-TAILED)

DISCUSSION

Rice types such as *CP* with the highest amount of phosphorus and *B12* will boost more biological processes since minerals are most important factors in maintaining all physiological processes. They are constituents of the teeth, bones, blood, muscle, and nerve cells and act as catalysts for many biological reactions within the human body [15]. It has been shown that potassium and calcium have a negative correlation while magnesium has a positive correlation to the overall palatability of cooked rice grains [16] and *B12* with the highest amount of magnesium will be most palatable. High Mg/K ratio was found by [17] to correspond to a better eating quality of rice. This result showed that *Dangot* has highest Mg/k ratio with a value of 11.6 and thus might have the best eating quality. *Maruwa*, a choice variety for water logged areas, is lower in most of the minerals which will negatively affect transmission of messages through the nervous system, digestion and/or utilization of all nutrients in foods. Calcium is needed for vitamin C utilization and *Short Caro* has the highest amount of calcium while *Ton2* is comparatively low in calcium (Table 1). Magnesium is required in utilization of B complex and *B12* will support this better than other varieties of rice considering its highest composition of magnesium while *Aiwa8* has the least composition of magnesium. The electrical potential gradient created by sodium–potassium pump, helps generate muscle contraction and regulates the heartbeat [15], and will be best supported by *B12* followed by FARO52 that has higher amounts of potassium unlike *Maruwa*, *Ton2* and NERICA7 with lower amounts of sodium. Highest amount of iron was found in *Ton2*. This means that *Ton2* will boost erythrocyte formation more than the other 13 varieties. Consequently, there will be less incidence of anaemia in consumption of *Ton2* than the other varieties while consumption of *Awafum* will comparatively increase incidence of anaemia. The rice varieties, *CP*, followed by NERICA7 is the richest in Phosphorus which is an important element required in many metabolic processes for which phosphorylase enzymes are involved. Consumption of *Maruwa*, *Aiwa8* and *Canada* will not favour cell division and formation of adenosine triphosphate (ATP) compared with the other varieties. *CP* is the richest

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variety in phosphorus and will as a result support the above phosphate utilizing processes more than other rice varieties. *B12* which is richer in magnesium and relatively rich in calcium will apart from other nutritional functions support tooth and bone formation. Consumption of *B12* will hence reduce incidence of osteoporosis in consumers. Adenosine triphosphate (ATP), the main source of energy in cells, must be bound to a magnesium ion (Mg^{2+}) in order to be biologically active. Thus, *B12* has higher amount of magnesium and will play a better role in the stability of all polyphosphate compounds in the cell, including those associated with deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Phosphorus showed no significant correlation with the other minerals. Iron showed significant negative correlation with potassium only. Magnesium and potassium are positively correlated at $p \leq 0.05$ (table 3). There was significant difference ($P<0.05$) in the amino acid composition of the varieties (Table 2). The rice variety, *Ton2* had the highest amount of 14 amino acids with FAR052 having the highest amount of the remaining three (Histidine, Threonine and Arginine). The rice variety *Aiwa8* had the least amount of 10 amino acids (3 essential and 7 non-essentials). No detectable value was obtained for Tryptophan and this agrees with the report of [16] that also recorded zero value for tryptophan. This is because Tryptophan is hydrolyzed by acid during sample preparation. High concentration of aspartic acid was recorded in all the varieties, ranging from 10.03 - 15.36mg per 100g of sample. Cysteine had the least concentration in all the varieties (0.099±0.03 – 1.48±0.05mg/100g). It should be noted that the most (aspartic acid) and least (cysteine) abundant amino acids in this analysis are both nutritionally non-essential. It can be inferred from the result that *Ton2* has the highest amount of the essential amino acids which our bodies do not synthesize and is therefore the best in composition of nutritionally essential amino acids. All the 20 amino acids present in proteins are essential for health. Over consumption of these varieties which are poor sources of nutritionally -essential amino acids, even though *Ton2* and FARO52 have relatively high amounts, will result in deficiency disease like kwashiorkor [15]. There will be higher incidence of Kwashiorkor when children are weaned on rice diet such as *Eleco20* and *Aiwa8* which is poor in essential amino acids compared with *Ton2* and FARO52. Varieties like *306* and *Aiwa8* that are low in arginine will affect children's growth negatively. This is because arginine is nutritionally semi-essential and is therefore needed in children's diet. To ensure nitrogen balance while relying on rice, one should have *Ton2* as the variety of choice among the ones studied in this work.

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CONCLUSION

Farmers and consumers alike are mostly interested in the physical properties of rice varieties with less attention to the nutritional properties of the rice varieties. The result of this study showed significant variations in the cooking and nutritional qualities of the varieties of rice studied. This research has revealed the nutritional properties of these varieties of rice that are common in Nigeria. We have shown that some varieties such as *Ton2* and FARO52 are richer in essential amino acids than the others. It is obvious that choice of a particular variety should be made depending on the intended satisfaction of the consumer. However, the health status, age and occupation of individuals need special consideration in making such choice.

Conflict of Interests

The authors declare that there is no conflict of interest

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