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Comparative Assessment of Proximate, Mineral and Anti-Nutritional Component of Indigenous and Foreign Rice in Ado-Odo Ota Local Government Area of Ogun State, Nigeria

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ABSTRACT

Rice (Oryza sativa) is a popular staple food in Nigeria. A comparative analysis of one foreign and four indigenous rice consume in Ado-Odo Ota Local Government, Southwest Nigeria were investigated. The proximate compositions (moisture, total ash, crude protein, crude fat, crude fibre and carbohydrate) were estimated using AOAC method. The phytate and oxalate were determined by titrimetry while trypsin inhibitor was determined with Spectrophotometer. The mineral element contents (Ca, Fe, K, Mg, Na, Cu, Mn, Zn, Cd and Cr) were determined using the inductively Coupled Plasma- Optical Emission Spectrophotometer (ICP-OES) after the samples were digested. The highest protein content was observed in the foreign rice with 8.59%, carbohydrate content was highest in the Ofada rice (80.64%). Crude fat, crude fibre and ash values ranges from 0.30-1.07%; 1.17-1.79%; 0.37-1.18% respectively. Mineral contents were significantly higher in the indigenous rice than the foreign rice variety while Cd and Cr were not detected in all the rice samples. Phytate, Oxalate and Trypsin inhibitor were higher in the foreign rice samples than the indigenous rice samples. These results provide the information needed for improving the consumption of the indigenous rice among Nigerian citizens.

Keywords: *Rice, Proximate composition, Minerals, Anti-Nutrition.*

INTRODUCTION

One of the many growing global concerns is food security. Data on food composition is necessary when estimating a population's nutrients intake and dietary exposure to toxins and diet quality [1]. All over the world, rice occupies one of the staple foods crops that feeds nearly over half of the world population [2] and its preference has continued to increase against other roots and tubers products. The Asian countries are the largest rice producer, while countries in Africa, Latin America and the Middle East have shown considerable increase in rice consumption and demand. In West Africa, Nigeria is the highest producer of rice [3] and is grown in virtually all the agro ecological zone in Nigeria. Over the years, the demand for rice has soar greatly; this is partly due to the increase in human population [4]. Rice consumption has been anticipated to grow around 36 million tons by the end of 2026 different from the 27-28 million tons of rice consumed presently. The United States Drug Agency (USDA) also expects that the importation of rice will continue to grow from 12.3 million tons in 2017 to 15,4 million tons by 2026. The implication of this is that Sub Sahara Africa is projected to be the largest rice importer in the world due to increase in demand and limited production growth in addition to the preference of consumer for imported rice over the indigenous rice [5].

Rice is considered as the queen among cereal due to its nutritional quality and higher digestibility [6]. Rice, a rich source of carbohydrate, contains moderate amount of protein and fat. In addition to these, it is also a good source of riboflavin, niacin and thiamin. Rice grain is composed of 12% water, 75%-80% starch and only 7% protein along with a full complement of amino acids [7]. Before rice are sold, it goes through milling which produces four fractions: brown rice, hull, white rice and bran. These fractions vary in chemical composition depending on the variety and type of milling. A significant amount of nutrients and dietary fibres are contained in unmilled rice when compared to milled or polished rice. Despite the valuable content of brown rice, most rice is consumed as white rice. Complete milling and polishing convert brown rice into white rice which destroys 67% of the vitamins B3, 80% of the vitamin B1, half of the manganese, half of the phosphorus, 60% of the iron, and all of the dietary fibre and essential fatty acids [8].

Relying on the importation of food on global markets simulates domestic inflation and also hurts Nigerian farmers, displacing indigenous production and fueling increase in unemployment. There have been several governmental programmes intended to increase domestic rice production to bridge the demand-supply gap, making Nigeria to be more self-sufficient in rice production [9].

Although most consumers combine imported and indigenous rice in their diets, the urban households prefer imported rice. Cleanliness, higher quality, swelling capacity, taste, grain shape, non-broken and free from stone are some of the characteristics that endeared many consumers to imported rice. This paper examines the elemental content, proximate and anti-nutritional components of rice available in the market of Ado-Odo Ota Local Government Area of Ogun State, Nigeria.

Materials and Methods

Sample Collection and Preparation

A total of five (5) indigenous rice and one (1) imported rice samples were purchased from a local market in Sango-ota Ogun state, Southwest Nigeria. Based on the information on package label, the indigenous rice was grown in Abakaliki, Ogun, Ebonyi, Jigawaand Nassarawa while the imported was grown in Thailand and is labelled Aroso. The samples were transported to the laboratory in the Department of Science Laboratory Technology, The Federal Polytechnic, Ilaro, Ogun State. The samples were washed with deionized water and allowed to air-dry under shed for 7days.

Proximate Analysis

The official standard method outlined by the AOAC [10] was adopted for the proximate analysis (moisture content, total ash, crude fat, crude protein, and crude fiber). The difference, as reported by Onyeike [11] was used to calculate the overall percentage of carbohydrate content in the rice sample. All analysis were carried out in triplicates

Anti-nutritional Composition

Oxalate

This was determined by titrimetric method as follows. 1g of sample was weighed into a 250 mL clean conical flask. 150 mL of 3 M H_2SO_4 was added and left for 30min. This was filtered using filter paper. 50 mL of filtrate was measured into another flask and 2 drops of methyl red indicator added. The filtrate containing the indicator was then heated on a hot plate to boil. The boiled solution was titrated immediately against 0.05 M; $KMnO_4$ solution until a faint pink colour appears and persists for at least 30 sec. The oxalate content was calculated by taking 1 mL of 0.05 M; $KMnO_4$ as equivalent to 2.2 mg/kg Oxalate [12].The result was expressed on a dry basis.

Phytate

The phytate content was determined by the method described by Russel [13]. A 2 g rice sample was weighed into a 250 mL conical flask then 100 mL; of 2% concentrated HCl was added and allowed to soak for 3 hours. This solution was filtered using a filter paper and 50 mL of the filtrate was placed in a 250 mL beaker with 0.3% ammonium thiocyanate (10mL) added as indicator then,107 mL of distilled water was then added to the mixture to give it proper acidity. The resulting solution was titrated with standard Fe (III) chloride solution ($FeCl_3$), which contains 0.0020 g; of iron per cm^3, until a brownish yellow color appeared which persists for 5mins.

$$\text{Phytic acid}\ \frac{g}{kg} = \frac{0.00195 \text{ x volume of } FeCl_3 \text{ consumed}}{\text{weight of sample}} \quad Eqn\ 1$$

Trypsin Inhibitor

1.00 g of well blended sample was weighed into a clean conical flask with 50 mL of NaCl added, the solution shaken properly and left to stand for about 30 mins. The mixture was then centrifuged at 1500 rpm for exactly 5 mins. 10 mL of the supernatant was transferred into another flask with 2 mL of known concentration of standard trypsin inhibitor added to spike the trypsin in the sample. The absorbance of the solution was read at 410nm using SpectrumLab 23A Spectrophotometer and the concentration was obtained by comparing with a standard trypsin standard graph [14].

Mineral Analysis

The mineral contents which include Ca, Fe, Na, Mg, Cu, Mn, Zn, K and toxic Cd and Cr were determined by using the Agilent 720-ES Inductively Coupled Plasma - Optical Emission Spectrophotometer (ICP-OES) with megapixel CCD detector. Analysis of digest was done in triplicates using Agilent Expert II Software. Prior to analysis, Samples for analysis were digested according to the method describe by AOAC [10]. 2 g of the rice samples was placed in a conical flask followed by the addition of 10 mL HNO_3 and 5 mL $HClO_4$. The solution was mixed and placed in a digestion tube at 100 °C for 10 minutes to obtain a clear digest. The aliquot digest was made up to the 100 mL mark with distilled water. A blank digestion for each rice sample under same condition was also carried out.

Health Risk Assessment

The health risk assessments of metals (Fe, Zn, Cu, Mn) were calculated for Average Daily Dose (ADD)and non-cancer hazard index (HI) using the formulas prescribed by USEPA [15, 16, 17].

$$ADD = \frac{C\ x\ (IR\ x\ EF\ x\ ED)}{BW\ x\ AT}\ x\ CF \quad Eqn\ 2$$

$$HI = \frac{ADD}{RfD} \qquad Eqn\ 3$$

Where;

ADD = Average Daily Dose (mg/kg/day)

C = Concentration of metals (mg kg-1),

IR = Ingestion rate (200mg day-1 for children and 100 mg day-1 for adults) [18].

ED = Exposure duration (years) = 6 years for children and 24years for adults [18],

EF = Exposure frequency (day/year) = 350 days year-1[19],

BW = Body weight (Kg) = 15 kg for children and 70 kg for adults [20].

AT = Averaging time or life expectancy = ED×365 days (6 x 365days for children and 70 x 365days for adults) [21],

CF = Conversion factor =E-6

RfD =Reference Dose for Fe, Zn, Cu and Mn were 0.7, 0.3, 0.04 and 0.14 respectively [18].

Data Analysis

Triplicates of all the samples were analysed and all data were reported for at least duplicates analysis of the same extract. All statistical analyses were carried out using SPSS 20.0 for the analysis of variance (ANOVA) and the Pearson correlation coefficients. Significance of the differences was ascribed at the $P < 0.001$.

Results and Discussion

Proximate Composition

The proximate compositions of the foreign (Aroso) and indigenous (Abakaliki, Ebonyi, Ofada, Nassarawa and Jigawa) rice varieties are shown in Table 1, this tables shows the mean and SD data of the proximate analysis. The analysis of variance shows that there was significant difference ($p<0.001$) in the proximate compositions of the rice varieties studied. There was significant difference ($p<0.001$) in protein, phytate, Trypsin inhibitor, oxalate and crude fibre while no significant difference ($p>0.001$) exists in moisture, ash and carbohydrate contents of the rice varieties studied.

Aroso, Abakaliki and Ofada rice varieties have low moisture contents while Ebonyi and Nassarawa rice varieties had high moisture contents which could be attributed to the drying temperature used [22]. A relatively high moisture content may also have effect on its storage and shelf life. It has also been shown that high moisture content aids in stabilizing the protoplasmic contents of the cells and as such maintains the homeostasis of the cells [23]. The foreign rice (Aroso) and two of the indigenous rice varieties (Abakaliki and Ebonyi) however recorded lower moisture content which may be attributed to the perboiling process and may have the potential to store relatively longer [22].The percentage differences observed in the moisture content of the rice varieties may be attributed to temperature and duration of drying as well as difference in storage conditions at source [24]. The crude protein observed in this study ranged from 8.12-8.59% with the Aroso rice variety being the highest percentage. The findings in this study are similar to the results obtained by Edeogu et al. (2007) (8.00-8.68 %) while the Jigawa rice variety has the lowest value (8.13 %). Crude fat values obtained ranged between 0.30-1.07 % with ofada rice being the highest (1.07 %). The results of this study are in agreement with earlier results reported by Juliano [25] who also gave the fat range 0.3 to 1.97% in different milling fractions. Thus, the observed difference may be attributed to the degree of milling in both the indigenous and imported brands. Report has shown that milling and polishing of rice removes the outer layer of the grain where most of the fats are concentrated [26].Crude fibre values ranged from 1.17-1.79%. Generally, the milling of rice decreases the fibre contents of rice hence the decrease in fibre in the foreign rice as compared to the indigenous ones. Dietary fibre functions help in maintaining bowel movement and can prevent diverticulosis by aiding the absorption of trace elements in the guts [27].Ash values ranged from 0.37- 1.18%, which is similar to values obtained by Ebuehi and Oyewole [28] who reported ash values of 0.53% and 0.80% for raw 'ofada' and 'aroso' rice varieties respectively in Nigeria. The lower ash content in the indigenous rice varieties may be due to the difference in genetic architecture of the rice varieties [7]. Carbohydrate content in the varieties ranged between 74.98 - 80.64 %, these values correspond closely with the values obtained by Ebuehi and Oyewole [28] who reported carbohydrate values of 78.3% and 81.1% for raw 'aroso' and 'ofada' rice varieties respectively in Nigeria. These values obtained are relatively higher than those obtained by Oko et al., [30] 76.92 to 86.03 %.

Table1. *Percentage (%) mean concentration of proximate compositions of the various rice samples analysed*

Rice varieties	Phytate	Oxalate	Trypsin Inhibitor
Aroso (foreign)	4.07 ±0.02^{e}	6.50 ±0.11^{c}	2.09 ± 0.5^{c}
Jigawa(indigenous)	3.89 ±0.02^{e}	6.42 ±0.21^{d}	2.06 ± 0.03^{b}
Ofada (indigenous)	3.71 ±0.02^{e}	6.34 ±0.06^{g}	1.43 ± 0.04^{a}
Ebonyi(indigenous)	3.22 ±0.02^{e}	5.09 ± 0.09^{c}	1.95 ± 0.01^{f}
Abakaliki(indigenous)	3.51 ±0.08^{h}	5.08 ±0.05^{a}	1.80 ± 0.04^{a}
Nasarawa(indigenous)	3.69 ±0.00^{f}	2.82 ± 0.05^{a}	1.89 ± 0.05^{a}

Values with different superscripts on the same row are significantly different (p<0.001)

Anti-Nutritional Compositions

These are chemical substances produced by plants that have the potential of affecting the availability of nutrients by interfering with metabolic processes [27]. The result of the anti-nutrient in the present study is shown in Table 2.Trypsin Inhibitor and phytic acid were higher in the imported processed rice varieties than the indigenous one. Trypsin inhibitors, being low molecular weight proteins, was minimum in the Ofada rice (1.43 mg/g) and maximum in the Aroso rice (2.09 mg/g), these results correspond slightly to values obtained by Aminu et al [31]. Phytate values ranged from 3.22-3.89 mg/g, phytate has been considered as an antinutrient because of its ability to interact with minerals, proteins, and starch, resulting in insoluble complexes that modify the functionality, digestion, and absorption of these food components [32]. The oxalate content in the rice varieties range from 2.85-6.58 mg/g with the imported rice having the highest value of 6.58 mg/g, as it can form non-absorbable salts with sodium, calcium, and ammonium ions, rendering these minerals unavailable [33]. High intakes of soluble oxalate may cause calcium oxalate crystallization and the formation of kidney stones (nephrolithiasis) in the urinary tract [34]. It has also been reported that phytate and oxalates have the ability to form chelates with di-and trivalent metallic ions such as Cd, Mg, Zn and Fe to form poorly soluble compounds that are not readily absorbed from the gastrointestinal tract thus decreasing their bioavailability [27].

Table2. *Percentage mean concentration of Anti-Nutritional compositions of rice samples (mg/100g)*

Rice varieties	Phytate	Oxalate	Trypsin inhibitor
Aroso (imported)	4.07±0.02^{e}	6.50±0.11^{c}	2.09±0.15^{c}
Jigawa (indigenous)	3.89±0.02^{e}	6.42±0.21^{d}	2.06±0.03^{b}
Ofada (indigenous)	3.71±0.02^{e}	6.34±0.06^{g}	1.43±0.04^{a}
Ebonyi (indigenous)	3.22±0.02^{e}	5.09±0.09^{c}	1.95±0.01^{f}
Abakaliki (indigenous)	3.51±0.08^{h}	5.08±0.04^{a}	1.80±0.04^{a}
Nassarawa (indigenous)	3.69±0.00^{f}	2.82±0.05^{a}	1.89±0.05^{a}

values with different superscripts on the same row are significantly different ($p<0.001$)

Mineral Compositions

The results of the mineral (Fe, Zn, Mg, Mn, Ca, K, Na, Cu, Cr and Cd) analysis are shown in Table 3.Minerals are known as important nutrients and play a crucial part in the efficient operation of the human body [35]. There are generally macro and micro minerals. The macro minerals are essential for the body's healthy functioning and metabolism, but as the human body is unable to create them, they must be taken from food sources. Calcium, chloride, magnesium, potassium, phosphorus, and other elements are examples of these minerals.

The macro minerals, commonly referred to as trace metals, are necessary in minute levels [36]. In general, the mean concentrations of macro-minerals follow the sequence K>Ca>Mg>Na for all samples and micro-minerals follow the sequence Fe>Zn>Cu>Mg for all samples. Potassium was found to be very dominant in all five rice samples than other mineral elements which corresponds to results obtained by Vunain et al., [37]. Calcium and iron were highest in The Abakaliki rice samples with values of 8.95 mg/Kg and 0.68 mg/Kg respectively. The potassium levels range from (9.62-23.95 mg/Kg), the highest value was recorded in the Ebonyi sample (23.95 mg/Kg), Abakaliki (22.81 mg/Kg), Ofada (19.29 mg/Kg), Aroso (15.81 mg/Kg) and Nassarawa (9.62 mg/Kg) and this could be attributed to the difference in soil conditions various milling and polishing process of the rice samples. [38]. Table 4 shows the FAO/WHO recommendation of some minerals in different age groups. According to FAO [39], the required level of sodium in rice is 5.3 mg/Kg, however the low sodium content of indigenous rice makes it suitable for consumption by all. It was however observed that there is high sodium content in the Ebonyi rice variety. The recommended level of calcium (8.1 mg/Kg) in rice, is low in most of the rice varieties (indigenous and foreign). This implies that consumption of rice should be accompanied by calcium rich source, such as vegetables and fruits [40]. However, it was observed that the Abakaliki rice variety is within the recommended level.Other trace elements such as cadmium and chromium, in all the three samples were below the detection limit. Potentially toxic metals to humans have proven to be a major threat with severe health risks associated with it [41]; hence, their absence in the white rice varieties is desirable

Table3. *Percentage mineral compositions of the various rice samples analysed*

Minerals (mg/Kg)	Foreign			Indigenous		
	Aroso	**Ofada**	**Nassarawa**	**Abakaliki**	**Ebonyi**	**Jigawa**
Ca	3.27	2.54	4.29	8.95	3.46	4.05
Fe	0.32	0.55	0.43	0.68	0.54	0.46
K	15.81	19.29	9.62	22.81	23.95	14.66
Mg	2.76	4.54	1.91	4.26	3.47	3.59
Na	1.42	4.79	2.05	3.25	40.04	1.71
Cu	0.03	0.03	0.01	0.06	0.7	0.03
Mn	0.03	0.03	0.01	0.13	0.06	0.04
Zn	0.29	0.42	0.16	1.25	0.39	0.24
Cd	ND	ND	ND	ND	ND	ND
Cr	ND	ND	ND	ND	ND	ND

Each value represents the average from three replicates ND- Not detected

Table4. *FAO/WHO recommendation of some minerals (mg/day)*

Metal	Infants	Pregnant Women	Lactating Women	Elderly (> 65)
Zn	2.8-4.1	5.5-10.0	7.2-9.5	4.9-7.0
Fe	8-9	1040	15	11-14
Mg	26-36	220	270	190-230
Mn	0.003-0.6	2.0	2.6	1.8-2.3
Cu	0.2-0.3	1.0	1.3	0.9

Health Risk Assessment

The average daily dose(ADD) and the hazard index (HI) values of Fe^{2+}, Zn^{2+}, Cu^{2+}, Mn^{2+} in the various rice samples are presented in Table 5 and 6 respectively. The ADD values of metals in food samples were generally lower than the permissible limits of the FAO/WHO. There is no appreciable danger of non-carcinogenic consequences if the HI is less than 1.0. On the other hand, HI values above 1.0 imply a higher risk of non-carcinogenic effects, with the likelihood of these events tending to rise with HI values [42]. The average daily dose of Fe^{2+} for both adult and children ranges between 0.02-8.69x10^{-6} with the highest value for adults being 0.04x10^{-6} while for children it is 8.69x10^{-6} both in the Abalaliki rice variety. Zn^{2+}, Cu^{2+}, Mn^{2+} as lower values as compared with Fe^{2+} for both adult and children. However, all the values are lower than 1 which means they don't pose any appreciable danger of non-carcinogenic consequences [42].

Table5. *Average Daily Dose of some metals in the Rice samples analysed (mg/ kg/day)*

	RICE SAMPLES											
	Aroso		Ofada		Nassarawa		Abakaliki		Ebonyi		Jigawa	
Minerals	Ch	Ad	Ch	Ad	Ch	Ad	Ch	Ad	Ch	Ad	Ch	Ad
Fe^{2+}	4.09E-6	0.02E-6	7.03E-6	0.03E-6	5.49E-6	0.02E-6	8.69E-6	0.04E-6	6.90E-6	0.03E-6	5.88E-6	0.03E-6
Zn^{2+}	3.71E-6	0.02E-6	5.37E-6	0.02E-6	2.05E-6	0.09E-7	1.59E-5	0.07E-6	4.99E-6	0.02E-6	3.07E-6	0.01E-6
Cu^{2+}	0.38E-6	0.17E-8	0.38E-6	0.17E-8	0.13E-6	0.57E-9	0.77E-6	0.34E-8	0.89E-6	0.39E-8	0.38E-6	0.17E-8
Mn^{2+}	0.38E-6	0.17E-8	2.05E-6	0.09E-7	0.13E-6	0.57E-9	1.66E-6	0.74E-8	0.77E-6	0.34E-8	0.05E-6	0.23E-8

Ch= children; Ad= Adult

Table6. *Hazard Index of some metals in the rice samples analysed (mg/ kg/day)*

	RICE SAMPLES											
	Aroso		Ofada		Nassarawa		Abakaliki		Ebonyi		Jigawa	
Minerals	Ch	Ad	Ch	Ad	Ch	Ad	Ch	Ad	Ch	Ad	Ch	Ad
Fe^{2+}	5.84E-6	0.03E-6	10.04E-6	0.04E-6	7.84E-6	0.03E-6	12.41E-6	0.06E-6	9.86E-6	0.04E-6	8.40E-6	0.04E-6
Zn^{2+}	12.37E-6	0.07E-6	17.90E-6	0.07E-6	6.83E-6	0.30E-7	5.30E-5	0.23 E-6	16.63E-6	0.07E-6	10.23E-6	0.03E-6
Cu^{2+}	9.5E-6	4.25E-8	9.5E-6	4.25E-8	3.25E-6	14.25E-9	19.25E-6	8.5 E-8	22.25E-6	9.75E-8	9.5E-6	4.25E-8
Mn^{2+}	2.71E-6	1.2 E-8	14.64E-6	0.82E-7	0.93E-6	4.07E-9	11.86E-6	5.29 E-8	5.29E-6	2.43E-8	0.36E-6	1.64E-8

Ch= children; Ad= Adult

CONCLUSION

The results of this study evaluate proximate, anti-nutritional and elemental contents of rice varieties available for consumption in Nigeria. The indigenous rice compared well with imported rice in terms of carbohydrate (74.98-80.64 %), however, the indigenously sourced rice variety are higher in protein, fibre and fat values. Phytate, Oxalate and Trypsin inhibitor with 4.07, 6.50 and 2.09 mg/g respectively which are higher in the foreign rice sample as compared to the indigenous rice samples the results show that indigenous rice is a nutritious staple crop, containing most of the essential nutrients needed for optimal growth and development of human beings. Efforts to improve indigenous rice consumption in Nigeria should be encouraged to make indigenous rice attractive to consumers.

Education and advertisement of nutritional characteristics of indigenous rice are important steps to improve the patronage of indigenous rice sales in Nigeria.

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