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Nutritional Composition and Heavy Metal Profile of Nigerian Rice Varieties

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Abstract

This study was carried to assess the nutritional composition and heavy metal profile of Nigerian rice varieties. A total of one hundred samples consisting of twenty five samples each of four varieties of white unpolished Nigerian local rice Oryza glaberrima (Ofada rice, Abakaliki rice, Ekpoma rice and Igbimo rice) were purchased from Ofada in Ogun State, Nigeria. Flour samples produced from the rice varieties were evaluated for nutritional (proximate, amino acids and vitamins profile analyses) qualities and heavy metal profile. Results showed ($P \leq 0.05$) that the protein contents in % ranged from 6.72±0.05 – 6.93±0.06 % while the concentration (µg/g) of Ar, Pb and Cd ranged from 1.30±0.05 to 1.45±0.05, 0.89±0.02 to 0.98±0.04 and 1.12±0.01 to 1.30±0.03, respectively. The protein contents were relatively high, although, all the four Nigerian rice varieties were deficient in lysine; arginine and methionine while the non-essential amino acids glycine and glutamic acid, although lysine and methionine were detected in very low quantities. The quantity of heavy metals obtained in the four Nigerian rice varieties flour samples were generally below the maximum acceptable limits and therefore constitute health risk to the consumers.

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Introduction

Rice is a cereal crop that belongs to the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). It has grown in popularity in recent years and is one of the most consumed cereal grain in the world. Rice ranked as the third-highest agricultural commodity with worldwide production as follows when compared with other staple crops.[1]

Rice (*Oryza sativa*) is a staple food in many parts of the world and in many countries of Africa, *Oryza glaberrima* (African rice) as become popular among the people which make rice important staple food for about half of the human race.[2] National Research Council[3] described rice as an important food crop depended upon by over half of the World population for their food need. The growing in importance of the rice has made Food and Agricultural Organization[4] to project about 50% increase in rice production estimate to meet the projected global demand for rice.

Research over the years has shown that rice production and processing technologies have not been able to meet the increasing demand for rice.[4] Nigeria as a nation has experienced a dramatic growth in demanding for rice caused by rising per capita consumption, urbanization and inability of domestic production to meet national demand.[5]

The rice plant is a monocot and it grows to average height of 1–1.8 m (3.3–5.9 ft) tall, which depends on the variety of the crop and soil fertility.[5] It has long, slender leaves 50–100 cm (20–39 in) long and 2–2.5 cm (0.79–0.98 in) broad.[5] Rice has wind-pollinated flowers that are produced in a branched arching to pendulous inflorescence 30–50 cm (12–20 in) long. The rice is a cereal and the seed is a caryopsis which is 5–12 mm long and 2–3 mm thick.[6,7]

There are three varieties of rice and these include long-, medium-, and short-grained rice.[6] The long-grain rice has high in amylose content and the grain tends to remain intact after cooking; medium-grain rice has high in amylopectin content and it becomes stickier on cooking.[6,7]

West African nations had experienced unprecedented importation of rice in the last three decades. Much of these importations of rice to West African sub-region are from South East Asia, where rice has been on large scale. Rice has the potential to improve nutrition, boost food security, foster rural development and support sustainable land use in Africa if its cultivation is boosted and improved upon.[6,7,8]

In Nigeria, rice is important to the people due to several reasons which include being a major contributor to internal and sub-regional trade.[7,8,9] Two types of rice have been mainly cultivated in Nigeria: the African rice (*Oryza glaberrima*) and the Asian rice (*Oryza sativa*).

The production of rice represents 38.89 % of total cereal production in Nigeria.[7,8] Rice production has continued to grow steadily in the last two decades as a result of government intervention and increase in demand for the crop. Presently, global rice production stands at 596.5 million tons from 155 million hectares (ha) in 19997,8,9. Rice produced in Nigeria is marketed throughout the nation and some of the varieties as become delicacy for example the ofada rice. Therefore, rice production and commercialization chain in Nigeria is well developed.[7,8,9] However, Nigerian rice varieties had not been evaluated for nutritional quality and presence of heavy metals especially arsenic which well associated with rice.

The objective of this study therefore was to evaluate the nutritional composition and heavy metals profile of Nigerian rice varieties.

Materials and Methods

Materials

A total of one hundred samples consisting of twenty five samples each of four varieties of white unpolished Nigerian local rice *Oryza glaberrima* (Ofada rice, Abakaliki rice, Ekpoma rice and Igbimo rice) were purchased from Ofada in Ogun State, Nigeria and conveyed to the laboratory.[10] The rice samples were checked visually for stones, dirts and other extraneous objects which were removed manually, sorted, milled and sieved to obtain rice flour. Flour samples produced from rice varieties were placed in cellophane bag until the samples were subjected to analyses within 48 h at ambient temperature.

Preparation of Rice Flour Samples

In this study, four rice varieties were involved: sorted, milled and sieved. The rice flour was prepared by the method reported by.[11] The rice samples were milled with a disc attrition mill (Bawa Equipment, Nigeria) and allowed to pass through 250 µm opening. The flour samples were packaged in Ziploc bag (Zipper seal re-closable bag 10-15/16" X 10-1/2", 1.75 Mil, Clear, PK250) until needed.

Collection of Rice flour Samples for Analysis

In this study, a total of one hundred samples consisting of twenty five samples each of four varieties of white unpolished Nigerian local rice *Oryza glaberrima* (Ofada rice, Abakaliki rice, Ekpoma rice and Igbimo rice) were purchased from Ofada in Ogun State, Nigeria. Flour samples produced from the rice varieties were used for analysis.

Methods

Determination of Nutritional Composition

Proximate Composition

The proximate composition (fat, moisture, protein, ash and crude fibre) of the rice flour samples were determined using standard method.[9] Carbohydrate content was determined by difference.

Amino Acid Profile

Amino acid profile of the rice samples was determined by the method of.[12]

Analysis of Vitamin B_1 (thiamin)

Vitamin B_1 was analyzed in samples using the method described by.[12] Accurately weighed 1.5 g of test sample was introduced into a 200 ml volumetric flask; 100 ml of 0.1N HCL solution was added and the mixture heated in a water bath at 100 °C for 30 min. After cooling, the content of the flask was made up to mark with 0.1M HCL solution and mixed thoroughly. The solution was filtered using Whatman No. 1 filter paper. The first 20 ml of the filtrate was discarded. The remaining filtrate (100 ml) was transferred into centrifuge tube containing 0.5 g frankonite powder (a flocculant which precipitate the particles faster during centrifugation) stirred for 10 min using RAM 2718 stirrer, then centrifuged at 5000 rpm for 5 min to separate layers. The supernatant liquid was discarded while 5 ml of absolute alcohol and 5ml of the potassium ferric-cyanide solution in sodium hydroxide solution were added after it was previously frozen at 0 °C. A pinkish colouration of mixture was observed after 10 min of mixing, and then 10 ml of toluene solution was added, stirred for 10 min and centrifuged for 10 min at 5000 rpm. A very clear pink colour was transferred to the toluene layer. Thiamine standard (0.5 mg) was prepared and 10 ml of the thiamine standard solution was treated same as sample above. The standard and sample solution was read at 530 nm wavelength using the SP 30 UV spectrophotometer (Pye Unican). The amount of thiamine present in each sample was calculated as thus:

Analysis of Vitamin B_2 (riboflavin)

Vitamin B_2 was analyzed in samples using the method described by.[12] Accurately weighed 1.5 g of sample was introduced into 200 ml volumetric flask; 100ml of acetic acid: water mixture (50:50) was added and heated on a boiling water bath at 100 °C for 30 min. The mixture in the flask was cooled to 20°C, then made up to the mark with acetic acid-water solution. The mixture was stirred for 10 min using the stirrer and then filtered in the dark. The first 20 ml of the filtrate was discarded, 0.5 mg of riboflavin standard solution was prepared, and 10 ml of the standard solution was transferred into

Table 1: Proximate composition of Nigerian rice flour samples

Rice varieties	Moisture	Protein	Fat	Crude fibre	Ash	Carbohydrate
Ofada rice	13.19±0.08^{e}	6.81±0.05^{c}	0.50±0.03^{b}	1.40±0.02^{a}	1.53±0.04^{a}	76.57±0.10^{e}
Abakaliki rice	13.04±0.07^{e}	6.93±0.06^{c}	0.54±0.04^{b}	1.48±0.02^{a}	1.77±0.04^{a}	76.24±0.10^{e}
Ekpoma rice	13.97±0.10^{e}	6.72±0.05^{e}	0.47±0.03^{b}	1.40±0.02^{a}	1.69±0.04^{a}	75.75±0.10^{e}
Igbimo rice	13.10±0.08^{e}	6.89±0.05^{e}	0.51±0.03^{b}	1.69±0.02^{a}	1.78±0.04^{a}	76.03±0.010^{a}

Data are means of triplicate samples ± S.D. Data with the same superscripts in the same row are not significantly different at $p \leq 0.05$

200 ml volumetric flask and treated similarly as sample above. The fluorescence of the standard and sample solutions was read using spectrophotometer at 460 nm wavelength. The amount of riboflavin in each sample was calculated as follows

Analysis of Vitamin B_3 (niacin)

Vitamin B_3 was analyzed in samples using the method described by.[12] Sample (1.5 g) was accurately weighed into 200 ml volumetric flask. Hydrochloric acid solution (5 N; 5 ml) was added, and 5.0 ml of dichloromethane and 90 ml of deionized water were added to the mixture, stirred and heated on a boiling water bath at 100°C for 30 min. It was then cooled and the flask content made up to the mark with distilled water, filtered using Whatman No. 1 filter paper discarding the first 20 ml of the filtrate. The niacin standard solution of 0.5 mg was prepared, and 10 ml of the stock solution was taken and treated same as sample above. The absorbance of the standard and sample solutions were taken at 410 nm wavelength using spectrophotometer and calculation followed thus:

Determination of Heavy Metals (Ar, Pb, Hg, Cd and Cr concentrations) in the Samples.

Heavy metals (Ar, Pb, Hg, Cd and Cr concentrations) in the rice flour samples were determined by standard method.[12]

Statistical Analysis

Data were means of triplicates ± standard deviation. Data were analysed using Analysis of Variance (ANOVA) and IBM SPSS Statistics (version 20.0) was employed (IBM Inc., USA). Means were separated by Duncan multiple range test and significances were accepted at 5% confidence level ($p \leq 0.05$).[10]

Table 2: Amino acid profile (g/100g crude protein) of Nigerian rice flour samples

Components	*Ofada rice*	*Abakaliki rice*	*Ekpoma rice*	*Igbimo rice*
Essential amino acids				
Lysine (Lys)	0.59 ±0.03^{b}	0.60 ±0.04^{b}	0.48±0.04^{b}	0.56±0.03^{b}
Histidine (His)	2.27±0.00^{a}	2.34±0.03^{a}	2.31±0.01^{a}	2.28±0.01^{a}
Threonine (Thr)	3.81±0.01^{c}	3.76±0.01^{c}	3.79±0.02^{c}	3.80±0.02^{c}
Valine (Val)	4.94±0.00^{e}	4.97±0.00^{e}	5.02±0.01^{e}	4.89±0.00^{e}
Methionine (Met)	2.29±0.00^{a}	2.31±0.00^{a}	2.36±0.00^{a}	2.28±0.00^{a}
Isoleucine (Ile)	4.10±0.00^{d}	4.09±0.03^{d}	4.06±0.01^{d}	4.01±0.01^{d}
Leucine (Leu)	8.30±0.01^{f}	8.26±0.01^{f}	8.29±0.01^{f}	8.33±0.01^{f}
Phenylalanine (Phe)	9.48.05±0.01^{g}	9.61±0.02^{g}	9.47±0.01^{g}	9.53±0.02^{g}
Total EAA	**7.78**	**37.94**	**37.78**	**37.68**
Non-essential amino acids				
Aspartic acid (Asp)	68±0.03^{g}	4.71±0.03^{g}	4.76±0.01^{g}	4.69±0.03^{g}
Serine (Ser)	4.39±0.00^{f}	4.61±0.01^{f}	4.43±0.01^{f}	4.59±0.01^{f}
Proline (Pro)	1.80±0.00^{d}	1.83±0.00^{d}	1.88±0.01^{d}	1.92±0.00^{d}
Alanine (Ala)	3.46±0.00^{e}	3.51±0.03^{e}	3.48±0.01^{e}	3.43±0.01^{e}
Cystine (Cys)	0.76±0.00^{a}	0.73±0.00^{a}	0.78±0.00^{a}	0.72±0.00^{a}
Tyrosine (Tyr)	2.11±0.01^{c}	2.16±0.01^{c}	2.10±0.01^{c}	2.17±0.01^{c}
Tryptophan (Try)	0.38±0.01^{b}	0.29±0.01^{b}	0.24±0.01^{b}	0.35±0.01^{b}
Total NEAA	**18.58**	**18.84**	**18.67**	**18.87**

Data are means of triplicate samples ± S.D. Data with the same superscripts in the same row are not significantly different at $p \leq 0.05$

Results and Discussions

Proximate Composition

The results of proximate composition of unpolished milled rice flour samples from four Nigeria rice varieties on % dry weight basis are presented in Table 1. There was a significant difference ($p \leq 0.05$) in the proximate compositions of the rice varieties studied. The results showed that the protein contents of the unpolished milled rice flour samples from different varieties ranged from 6.72±0.05 – 6.93±0.06 %. The protein contents of the four varieties of Nigerian rice studied were high. The range of protein contents in the rice flour samples is lower than the value reported by[13] in their study. This could be as a result of prolonged parboiling and some other environmental and edaphic factors. However, this is in agreement with the findings of. [13,14]

The fat contents of the four varieties of Nigerian rice studied were low. The fat contents ranged from 0.47±0.03 – 0.54±0.03 %. The range is in agreement with earlier results reported by[11] who also gave the fat range 0.9 to 1.97% in different milling fractions. However, this is lower than the range obtained by.[11] This could be due to the effect of milling on the flour.[13]

There were no significant differences ($p \leq 0.05$) recorded for crude fibre content among rice varieties. For crude fibre, the values were in the range of 1.40±0.02 to 1.69±0.02 % among the samples analyzed. Igbimo rice was found to have highest value of crude fibre in this study. These were similar to the mean values obtained by.[14,15] Sotelo *et al.,*[15] observed that milling decreased the fibre if rice. The ash contents ranged from 1.53±0.04 – 1.78±0.04 %. The four Nigerian rice varieties contained high percentage of moisture content which ranged from 13.10±0.08 - 13.97±0.10 %. The high percentage of moisture content may be attributed to low drying temperature[15] and prolonged parboiling.

The rice samples contained high quantities of carbohydrates ranging from 75.75±0.10 to 76.57±0.10%. Although these values are higher than the values obtained by,[16] they are within the values (75.37 to 76.37%) reported by.[17]

Table 3: Vitamin Profile (mg/100g) of Nigerian rice flour samples

Components	*Ofada rice*	*Abakaliki rice*	*Ekpoma rice*	*Igbimo rice*
Thiamine	0.10±0.00^{a}	0.08±0.03^{a}	0.11±0.01^{a}	0.10±0.01^{a}
Niacin	2.11±0.01^{d}	2.06±0.01^{d}	2.18±0.01^{d}	2.13±0.01^{d}
Riboflavin	0.04±0.00^{a}	0.05±0.00^{a}	0.04±0.01^{a}	0.04±0.00^{a}
Vitamin A	0.28±0.01^{c}	0.26±0.01^{c}	0.23±0.01^{c}	0.29±0.01^{c}
Vitamin E	0.86±0.00^{b}	0.82±0.00^{b}	0.91±0.01^{b}	0.84±0.00^{b}

Data are means of 3 replicates ± S.D. Data with the same superscripts in the same row are not significantly different at $p \leq 0.05$

Table 4: Heavy metal composition (µg/kg) of Nigerian rice flour samples

Components	*Ofada rice*	*Abakaliki rice*	*Ekpoma rice*	*Igbimo rice*
Arsenic	1.30±0.05^{a}	1.30±0.05^{a}	1.45±0.07^{c}	1.40±0.07^{bq}
Lead	0.98±0.04^{c}	0.90±0.03^{b}	0.92±0.03b^{c}	0.89±0.02^{a}
Cadmium	1.12±0.01^{a}	1.30±0.03^{c}	1.28±0.03b^{c}	1.24±0.02^{b}
Mercury	1.06±0.01^{a}	1.00±0.01^{a}	1.18±0.02^{b}	1.15±0.01^{b}
Chromium	0.91±0.02^{c}	0.86±0.01^{a}	0.89±0.01^{b}	0.93±0.02^{c}

Data are means of triplicate samples ± S.D. Data with the same superscripts in the same row are not significantly different at $p \leq 0.05$

Amino Acids Profile

The amino acid composition of four Nigerian rice varieties flour samples is presented in Table 2. It was observed that among the essential amino acids phenylalanine, leucine and valine were the most abundant in all the four Nigerian rice varieties (Ofada rice, Abakaliki rice, Ekpoma rice and Igbimo rice) flour samples were ranged from 9.48±0.01 - 9.61±0.02, 8.26±0.01 - 8.33±0.01 and 4.89±0.00 - 5.02±0.01 g/100 g crude protein (cp) respectively. These data are important because leucine is a limiting amino acid in cereals. Among the non-essential amino acids, aspartic acid, serine and alanine were the most abundant amino acids in all the four Nigerian rice varieties flour samples and their values ranged between 4.68±0.00 - 4.96±0.01 g/100g crude protein (cp), 4.39±0.00 - 4.61±0.01 g/100g crude protein (cp) and 3.43±0.01 - 3.51±0.03 g/100g crude protein (cp) respectively. Similar results were obtained for different rice varieties flour samples. Several authors had reported similar observations for smoked fish and giant rat.[16-17]

All the four Nigerian rice varieties flour samples were deficient in lysine, arginine and methionine and lysine as well as the nonessential amino acids glycine and glutamic acid, although lysine and methionine were detected in very low quantities. The total EEA for all the four Nigerian rice varieties (Ofada rice, Abakaliki rice, Ekpoma rice and Igbimo rice) flour samples studied ranged from 37.68 g/100 g to 37.94 g/100 g while total ranged from 18.57 g/100 g to 18.87 g/100 g respectively.[18]

Vitamin Profile of the Four Nigerian Rice Varieties Flour Samples

The results of the vitamin profile of the four Nigerian rice varieties flour samples analysed are presented in Table 3. The thiamine, niacin, riboflavin, vitamin A and vitamin E contents for the four Nigerian rice varieties (Ofada rice, Abakaliki rice, Ekpoma rice and Igbimo rice) flour samples were in the range of 0.08±0.03 to 0.11±0.01 mg/100 g, 2.11±0.01 to 2.18±0.01 mg/100 g, 0.04±0.00 to 0.05±0.00 mg/100 g, 0.23±0.01 to 0.29±0.01 mg/100 g and 0.82±0.00 to 0.91±0.01 mg/100 g respectively. The values obtained for these vitamins are high when compared with other cereals. Vitamin E is considered as biological antioxidant[15,16] and played principal role in fertility. The values of vitamins obtained from this study were in agreement with the previous works of.[19, 20]

The presence of riboflavin, niacin, thiamine, ascorbic acid, vitamin A and vitamin E in all the rice flour is a pointer to the nutritional value of rice.[21-24]

Heavy Metal Profile of the four Nigerian Rice Flour Samples

The results of the concentrations of Ar, Pb, Cd, Hg and Cr in the four Nigerian rice flour samples analysed are presented in Table 4. These heavy metals are very important because of their effect on human beings and animals at high concentration.[25-26] Concentration (µg/g) of Ar, Pb and Cd in the four Nigerian rice varieties (Ofada rice, Abakaliki rice, Ekpoma rice and Igbimo rice) flour samples ranged from 1.30±0.05 to 1.45±0.05, 0.89±0.02 to 0.98±0.04 and 1.12±0.01 to 1.30±0.03, respectively. While concentration of Hg and Cr were 1.00±0.01 to 1.18±0.00 and 0.80±0.0 to 0.93±0.02, respectively. The quantity of heavy metals obtained in the four Nigerian rice varieties flour samples were generally below the maximum acceptable limits set by FAO/ World Health Organization[27-32] for Ar (0.3 ppm); Pb (0.3 ppm); Cd (0.2 ppm), Hg (0.2 ppm) and Cr (0.5 ppm) and hence pose no consumption risk.[26-28]

Conclusions

The four Nigerian rice varieties flour samples studied are importance in nutrition and diets of Nigeria. The protein contents were relatively high, although, all the four Nigerian rice varieties were deficient in lysine, arginine and methionine as well as the non-essential amino acids glycine and glutamic acid, although lysine and methionine were detected in very low quantities. This study showed that the four Nigerian rice varieties flour could be used supplement food products because of its moderate protein and fibre and Abakaliki rice had fairly higher protein and fibre contents.

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Conflict of Interest
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