Nutritional Composition and Heavy Metal Profile of Nigerian Rice Varieties

ADEYEE, SAMUEL AYOFEI OLALEKAN*1,2, BOLAJI, OLUSHOLA TIMOTHY3, ABEGUNDE, TITILOPE ADEBUSAYO3, IDOWU-ABEBAYO, FOLAKE4,5, TIAMIYU, HUSSAINA KEHINDE6 and ADEBAYO-OYETORO, ABIODUN OMOWONUOLA7

1Department for Management of Science and Technology Development, Ton Duc Thang University, Ho Chi Minh City, Vietnam.
2Faculty of Environment and Labour Safety, Ton Duc Thang University, Ho Chi Minh City, Vietnam.
3Department of Food Technology, Lagos State Polytechnic, Ikorodu, Nigeria.
4Department of Food Science & Technology, Federal University, Oye-Ekiti, Nigeria.
5Food Quality and Design Group, Wageningen University and Research, the Netherlands.
7Department of Food Technology, Yaba College of Technology, Lagos, Nigeria.

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≤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.
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 Council3 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 Organization4 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, dirt 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. 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. Carbohydrate content was determined by difference.

Amino Acid Profile
Amino acid profile of the rice samples was determined by the method of.

Analysis of Vitamin B₁ (thiamin)
Vitamin B₁ was analyzed in samples using the method described by. Accurately weighed 1.5 g of test sample was introduced into a 200 ml volumetric flask; 100 ml 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 prepared, and 10 ml of the standard solution was transferred into

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

Data are means of triplicate samples ± S.D. Data with the same superscripts in the same row are not significantly different at p≤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 B₃ (niacin)**

Vitamin B₃ 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≤0.05).¹⁰

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

<table>
<thead>
<tr>
<th>Components</th>
<th>Ofada rice</th>
<th>Abakaliki rice</th>
<th>Ekpoma rice</th>
<th>Igbimo rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential amino acids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lysine (Lys)</td>
<td>0.59±0.03ᵃ</td>
<td>0.60±0.04ᵇ</td>
<td>0.48±0.04ᵇ</td>
<td>0.56±0.03ᵇ</td>
</tr>
<tr>
<td>Histidine (His)</td>
<td>2.27±0.00ᵃ</td>
<td>2.34±0.03ᵃ</td>
<td>2.31±0.01ᵃ</td>
<td>2.28±0.01ᵃ</td>
</tr>
<tr>
<td>Threonine (Thr)</td>
<td>3.81±0.01ᶜ</td>
<td>3.76±0.01ᶜ</td>
<td>3.79±0.02ᶜ</td>
<td>3.80±0.02ᶜ</td>
</tr>
<tr>
<td>Valine (Val)</td>
<td>4.94±0.00ᵃ</td>
<td>4.97±0.00ᵃ</td>
<td>5.02±0.01ᵃ</td>
<td>4.89±0.00ᵃ</td>
</tr>
<tr>
<td>Methionine (Met)</td>
<td>2.29±0.00ᵃ</td>
<td>2.31±0.00ᵃ</td>
<td>2.36±0.00ᵃ</td>
<td>2.28±0.00ᵃ</td>
</tr>
<tr>
<td>Isoleucine (Ile)</td>
<td>4.10±0.00ᵈ</td>
<td>4.09±0.03ᵈ</td>
<td>4.06±0.01ᵈ</td>
<td>4.01±0.01ᵈ</td>
</tr>
<tr>
<td>Leucine (Leu)</td>
<td>8.30±0.01ᵉ</td>
<td>8.26±0.01¹</td>
<td>8.29±0.01¹</td>
<td>8.33±0.01¹</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>9.48±0.01ᵍ</td>
<td>9.61±0.02ᵍ</td>
<td>9.47±0.01ᵍ</td>
<td>9.53±0.02ᵍ</td>
</tr>
<tr>
<td>(Phe)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total EAA</td>
<td>7.78</td>
<td>37.94</td>
<td>37.78</td>
<td>37.68</td>
</tr>
<tr>
<td>Non-essential amino acids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspartic acid (Asp)</td>
<td>68±0.03ᵍ</td>
<td>4.71±0.03ᵍ</td>
<td>4.76±0.01ᵍ</td>
<td>4.69±0.03ᵍ</td>
</tr>
<tr>
<td>Serine (Ser)</td>
<td>4.39±0.00ᵉ</td>
<td>4.61±0.01¹</td>
<td>4.43±0.01¹</td>
<td>4.59±0.01¹</td>
</tr>
<tr>
<td>Proline (Pro)</td>
<td>1.80±0.00ᵈ</td>
<td>1.83±0.00ᵈ</td>
<td>1.88±0.01ᵈ</td>
<td>1.92±0.00ᵈ</td>
</tr>
<tr>
<td>Alanine (Ala)</td>
<td>3.46±0.00ᵃ</td>
<td>3.51±0.03ᵃ</td>
<td>3.48±0.01ᵃ</td>
<td>3.43±0.01ᵃ</td>
</tr>
<tr>
<td>Cystine (Cys)</td>
<td>0.76±0.00ᵃ</td>
<td>0.73±0.00ᵃ</td>
<td>0.78±0.00ᵃ</td>
<td>0.72±0.00ᵃ</td>
</tr>
<tr>
<td>Tyrosine (Tyr)</td>
<td>2.11±0.01ᶜ</td>
<td>2.16±0.01ᶜ</td>
<td>2.10±0.01ᶜ</td>
<td>2.17±0.01ᶜ</td>
</tr>
<tr>
<td>Tryptophan (Try)</td>
<td>0.38±0.01ᵇ</td>
<td>0.29±0.01ᵇ</td>
<td>0.24±0.01ᵇ</td>
<td>0.35±0.01ᵇ</td>
</tr>
<tr>
<td>Total NEAA</td>
<td>18.58</td>
<td>18.84</td>
<td>18.67</td>
<td>18.87</td>
</tr>
</tbody>
</table>

Data are means of triplicate samples ± S.D. Data with the same superscripts in the same row are not significantly different at p≤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**

<table>
<thead>
<tr>
<th>Components</th>
<th>Ofada rice</th>
<th>Abakaliki rice</th>
<th>Ekpoma rice</th>
<th>Igbimo rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamine</td>
<td>0.10±0.00(^a)</td>
<td>0.08±0.03(^a)</td>
<td>0.11±0.01(^a)</td>
<td>0.10±0.01(^a)</td>
</tr>
<tr>
<td>Niacin</td>
<td>2.11±0.01(^c)</td>
<td>2.06±0.01(^d)</td>
<td>2.18±0.01(^d)</td>
<td>2.13±0.01(^e)</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.04±0.00(^a)</td>
<td>0.05±0.00(^a)</td>
<td>0.04±0.01(^a)</td>
<td>0.04±0.00(^a)</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0.28±0.01(^c)</td>
<td>0.26±0.01(^c)</td>
<td>0.23±0.01(^c)</td>
<td>0.29±0.01(^d)</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>0.86±0.00(^b)</td>
<td>0.82±0.00(^b)</td>
<td>0.91±0.01(^b)</td>
<td>0.84±0.00(^b)</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Components</th>
<th>Ofada rice</th>
<th>Abakaliki rice</th>
<th>Ekpoma rice</th>
<th>Igbimo rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>1.30±0.05(^a)</td>
<td>1.30±0.05(^a)</td>
<td>1.45±0.07(^c)</td>
<td>1.40±0.07(^d)</td>
</tr>
<tr>
<td>Lead</td>
<td>0.98±0.04(^c)</td>
<td>0.90±0.03(^b)</td>
<td>0.92±0.03(^b)</td>
<td>0.89±0.02(^a)</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1.12±0.01(^a)</td>
<td>1.30±0.03(^a)</td>
<td>1.28±0.03(^b)</td>
<td>1.24±0.02(^b)</td>
</tr>
<tr>
<td>Mercury</td>
<td>1.06±0.01(^a)</td>
<td>1.00±0.01(^a)</td>
<td>1.18±0.02(^a)</td>
<td>1.15±0.01(^b)</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.91±0.02(^c)</td>
<td>0.86±0.01(^a)</td>
<td>0.89±0.01(^b)</td>
<td>0.93±0.02(^c)</td>
</tr>
</tbody>
</table>

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 Igboro 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

Vitamin Profile of the Four Nigerian Rice Varieties Flour Samples
The results of the vitamin profile of the four Nigerian rice varieties flour samples 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 Igboro 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 antioxidant15,16 and played principal role in fertility. The values of vitamins obtained from this study were in agreement with the previous works of.19, 20

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 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 Igboro 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 Organization27-32 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 are important 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.

Acknowledgement
The author appreciates the Technical staffs of Multidisciplinary Central Research Laboratory of University of Ibadan for their technical support.
Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest
The author(s) do not have any conflict of interest.

References


