Nutritional and Anti-nutritional compositions of Jamila and Wita Rice Bran from Kano State, Nigeria

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ABSTRACT

Background: *Rice bran is the outermost layer of brown rice and it is one of the by-products of rice milling process.*

Objective: *This study, investigate quantitatively the nutritional and anti-nutritional factors present in the rice bran of Jamila and Wita cultivated in Kano State, Nigeria.*

Methods: *Rice bran were obtained from Kwanar Dawaki rice processing mills, Dawakin Kudu Local Government Area, Kano State, Nigeria and quantitatively analyzed. Proximate, vitamins, mineral content and anti-nutrients factors of each were determined and the data were statistically analyzed and compared.*

Results: *Both rice bran of Jamila and Wita showed no significant difference ($p > 0.05$) for fat, moisture and vitamins contents but showed significant difference for protein (0.47±0.35 % 0.95±0.02 %), fiber (39.25±0.06 % 47.48±0.04 %), ash (16.63±0.12 % 14.50±0.20 %) and carbohydrate contents (32.67±0.72 % 24.60±0.21 %) ($p < 0.05$) respectively. Mineral analysis showed no significant difference for magnesium, zinc and copper but significant difference ($p < 0.05$) was found for sodium (3.38±0.001 mg/L 1.66±0.000 mg/L), potassium (22.19±1.206 mg/L 4.90±0.781 mg/L) and calcium contents (1.46±0.008 mg/L5.99±0.163 mg/L) respectively. It was also found that Jamila and Wita brans contain anti-nutrients with phytic acid and oxalate having the highest values. The anti-nutrient contents showed no significant difference for phytic acid, oxalate, and hydrogen cyanide respectively, while tannins and saponin showed a significant difference.*

Conclusion: *Jamila and Wita rice bran are excellent sources of dietary fiber, vitamins and some minerals. Therefore, the rice bran can serve as source of nutrients, provided the anti-nutrients are reduced to a level that will not interfere with normal metabolism.*

Keywords: Rice bran, Dietary fiber, Vitamins, Minerals, Anti-nutrients

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INTRODUCTION

Rice, described as the best staple food among cereals is consumed by over 3 billion people, constituting over half of the world's population (1). As the third highest agricultural produce worldwide after sugarcane and maize (2), rice has also emerged as the fastest growing food source in Africa (3). In Nigeria, rice is cultivated across all agro-ecological zones, including Kano, with

different varieties possessing adaptation characters for each ecology (4). *Oryza sativa* and *Oryza glabberima* are the commonly cultivated varieties in Nigeria (5, 6). *Jamila* and *Wita* are two varieties of rice widely grown in Kano, and have shown distinct differences in quality and yield when cooked possibly due to differences in their colloidal structure (7).

Rice bran is the outer covering of rice kernel comprising pericarp, aleurone, sub-aluerone layer, seed coat, nucellus, germ part and small part of starchy endosperm (8, 9). It is light in color, sweet, moderately oily and has nutty flavor (10). Rice bran is a rich source of protein, lipids, dietary fiber, minerals, vitamins and a chief source of choline and inositol (11). It also contains phytochemicals with potential health benefits (12). And its high oil content (12-13%) include highly unsaponifiable components (13). In addition, rice bran contains about 69% of the dietary fiber in brown rice and can contribute significantly to the iron intake if consumed as brown rice (14). In humans, dietary minerals are required to maintain human health, and their deficiencies can lead to undesirable disease conditions (15).

During rice processing, endosperm is the major product while rice husk, bran and germ are obtained as byproducts (16-18). Countries like India and Nigeria produce approximately one million tons of rice bran annually used predominantly for animal feed (19). Recently, utilization of rice bran is gaining importance for the fact that during whole rice processing, huge amounts of the grain's outer layers are removed, raising the concentration of nutrients in the bran and rendering it an important nutrient source for food industries and human consumption (20-25).

Anti-nutritional factors in different cereal bran limits their use as food. Phytic acid, trypsin inhibitors, oxalates, tannins, polyphenols, heamagglutinin and lectins are the undesirable constituents restricting the direct utilization of bran in the diet. Rice bran has higher phytic acid content than wheat bran, corn bran, soybean and oat hulls. Pigmented rice may contain high tannins, which concentrate in the bran during milling (26). Moreover, its utilization is limited due to enzymatic activity after rice dehulling.

Some industries extrude the defatted rice bran for use mainly as animal feed. The rice bran has been introduced into a "multi-mixture" of toasted flour (generally in home-made form) consisting of food industry waste, as part of a Brazilian social program to restore the health of malnourished children (27). Therefore, this study was designed to investigate the nutritional constituents and anti-nutritional factors present in the rice bran of *Jamila* and *Wita* cultivated in Kano state, Nigeria.

MATERIALS AND METHODS

Sample collection and identification

Freshly milled samples of *Jamila and Wita* rice brans were obtained from a rice processing mill at Dawakin Kudu Local Government Area, Kano State, Nigeria. The samples were identified by officials of Kano State Agricultural Rural Development Authority and authenticated at the herbarium of the Department of Plant Science, Bayero University, Kano. Accession numbers BUKHAN 625 and 626 were assigned for *Wita* and *Jamila* rice brans respectively.

Sample preparation

The rice bran samples were air-dried at room temperature for three weeks, and grounded into a fine powder using a mortar and pestle and stored in an air tight container prior to analysis.

Proximate analysis

The rice bran samples were analysed for moisture, protein, fat, fiber, ash and carbohydrate using standard methods (28).

Determination of Moisture content

The moisture content was determined by oven drying method. Three grams of each rice variety sample were oven dried at 115°C overnight, cooled in a desiccator for 30 min and then weighed. The moisture content was calculated as:

(%) Moisture = $(W_1 - W_2/W_1)*100$

W_1 = weight (g) of sample before drying; -W_2 = weight (g) of sample after drying.

Determination of Ash content

Clean empty crucibles for both bran samples were placed in a muffle furnace at 600° C for 1 h, cooled in a desiccator and weighed (ω_1). Five grams of the sample was poured into the crucible, weighed (ω_2) and ashed at 550° C for 4 h. Appearances of greyish white ash indicated complete oxidation of organic matter in the samples. The crucible was cooled and the weighed (ω_3). Percentage ash was calculated as:

(%) Ash = (weight of ash/weight of samples) * 100

Determination of Crude protein

Two grams of dried rice bran samples were digested using concentrated H_2SO_4 and digestion mixture (K_2SO_4 and $CuSO_4$ in 8:1 ratio). The digest was distilled and NH_3 produced was collected as NH_4OH and titrated against 2 M HCl. The percentage protein nitrogen was calculated as:

(%) Nitrogen = ((titre - blank) Ml * 0.014077/weight of samples (g)) * 100

Percentage protein for each sample was calculated from the percentage of nitrogen using the factor 6.25 as follows:

% Protein = % Nitrogen x 6.25

Determination of Crude fat content

Three grams of moisture free sample were extracted with petroleum ether using Soxhlet extractor. After evaporating at 105° C for 2 h, the extracts were cooled in a desiccator. Fat content was determined using the formula:

Fat % = (weight of fat/weight of rice bran samples) * 100

Determination of Crude fiber content

Two grams of defatted sample was boiled with 1.25 M of H_2SO_4 and then with 0.313 M of NaOH. The solution was filtered and the residue dried, weighed (ω_1), and ashed. The ashed sampled was weighed as ω_3. Percentage fiber was calculated as:

(%) Crude fiber = (weight of residues after oven dry/weight of rice bran sample)*100

Determination of Carbohydrate Content

The carbohydrate content was estimated by subtracting the sum of percentage moisture, fat, protein, fibre and ash contents from 100%.

Determination of Vitamin A content

Vitamin A was determined by the method of Rutkowski *et al* (29). One millilitre of the analysed liquid was treated with KOH solution, heated (60° C 20 min), and mixed with xylene after cooling. The tube was centrifuged (1500 rpm, 10 min) and the absorbance A_1 of the supernatant was measured at 335 nm against xylene. The tube was then UV irradiated for 30 min, and its absorbance A_2 measured. Vitamin A (μM) concentration was calculated as:

Vitamin A = $(A_1 - A_2) * 22.23$

Where: 22.23 = the absorption coefficient of 1% solution of vitamin A (retinol form) in xylene at 335 nm in a cuvette of 1 cm thickness.

Determination of Vitamin C content

Vitamin C was determined by the method of Rutkowski *et al* (30). One millilitre of the analysed liquid was mixed with Phosphotungstate reagent, centrifuged (7000 rpm, 10 min). Absorbance of the supernatant (Ax) and standard sample (As) were measured at 700 nm against Phosphotungstate reagent mixture. Vitamin C (μm) concentration was calculated as:

Vitamin C = (Ax/As)*Cs

Where: Cs – concentration of the standard solution.

Determination of Vitamin E content

Vitamin E was determined by the method of Rutkowski *et al* (31). 0.5 mL of the analysed liquid was treated with anhydrous ethanol and xylene, centrifuged (1500 rpm for 10 min) and mixed with batophenanthroline, iron chloride (III) solution and H_3PO_3 solution. The absorbances of test and standard (Trolox prepared using α-tocopherol) were measured at 539 nm. The vitamin E (μM) concentration was calculated as.

Vitamin E = (Ax/As)*Cs

Where: Cs – concentration of the standard solution.

Mineral analysis

Mineral contents were determined using Atomic Absorption Spectrometry (AAS) and Flame Photometry (FP) (28).

Determination of Tannins

0.5 mg of bran samples boiled in distilled water, filtered reacted with Folin-Denis reagent and 17 % (w/v) sodium carbonate solution. These were allowed to stand in water bath at 25 °C for 5 min. The absorbance were taken at 760 nm wavelength using water as reference.

Determination of Phytic acid

Phytic acid content of the rice brans were determined by the protocol of (32). 4.0 g of grounded samples were soaked 2 % HCl for 5 h, filtered, and reacted with 0.3 % ammonium thiocyanate solution. The mixture was titrated with iron (III) chloride solution until a brownish yellow colour persisted for 5 min.

Determination of Oxalate

One gram of each sample was digested with HCL, centrifuged and the supernatant titrated with concentrated ammonium hydroxide solution until salmon pink colour of methyl orange changed to faint yellow. The solutions were heated at 90 °C and the oxalate was precipitated with 5 % calcium chloride ($CaCl_2$) solution. The solution was centrifuged and the residues were titrated against 0.05M $KMnO_4$.

Determination of saponins

Saponins were determined by the method of (32). Five grams of the samples were exhaustively extracted with acetone in the first instance and methanol in the second instance using soxhlet extractor. The extracts and flacks were weighed and the difference in weight represented the weight of saponin extracted.

Determination of Hydrogen Cyanide (HCN)

Ten grams of samples were soaked in a mixture of distilled water and orthophosphoric acid. The mixtures were distilled and the distillates were diluted with distilled water followed by the addition of 6.0 M ammonium hydroxide (NH_4OH) and 5 % (w/v) potassium iodide solutions. The mixtures were then titrated with 0.02 M silver nitrate solution until a faint but permanent turbidity was obtained.

RESULTS

Proximate Parameters of *Jamila* and *Wita* Rice Brans

The results of quantitative compositions of proximate

Table 1: Quantitative compositions of proximate parameters of *Jamila* and *Wita* rice bran

Parameters	Jamila	Wita
Carbohydrate (%)	32.67±0.72[a]	24.60±0.21
Protein (%)	0.47±0.35[b]	0.95±0.02
Ash (%)	16.63±0.12[c]	14.50±0.20
Moisture (%)	6.44±0.05	7.59±0.03
Fat (%)	4.60±0.03	4.88±0.10
Dietary Fiber (%)	39.25±0.06[d]	47.48±0.04

Results were expressed as mean ± standard deviation in triplicates. Values in the same row bearing same superscripts 'a', 'b', 'c' and 'd' signifies significant difference when *Jamila* and *Wita* were compared at $p < 0.05$

Table 2: Quantitative analysis of vitamins present in *Jamila* and *Wita* rice bran.

Vitamins	*Jamila*	*Wita*
Vitamin A (μmol/L)	0.89±0.00	0.74±0.00
Vitamin C (mg/L)	11.07±0.21	10.21±0.22
Vitamin E (mg/L)	9.97±0.01	9.73±0.01

Results were expressed as mean ± standard deviation in triplicates. There were no significant differences in all the vitamins when *Jamila* and *Wita* are compared at $p > 0.05$.

Table 3: Quantitative compositions of some minerals present in *Jamila* and *Wita* rice bran.

Parameters	*Jamila*	Wita
Sodium (mg/L)	3.38±0.001[a]	1.66±0.000
Calcium (mg/L)	1.46±0.008[b]	5.99±0.163
Magnesium (mg/L)	2.15±0.264	2.94±0.136
Zinc (mg/L)	0.10±0.013	0.09±0.001
Potassium (mg/L)	22.19±1.206[c]	4.90±0.781
Copper (mg/L)	0.03±0.004	0.02±0.006

Results were expressed as mean ± standard deviation in triplicates. Values in the same row bearing same superscripts 'a', 'b' and 'c' signifies significant difference when compared at $p < 0.05$.

parameters (Carbohydrate, protein, Ash, moisture, fat and fibre) of *Jamila* and *Wita* rice bran are shown in table 1. Higher levels of carbohydrate (32.67±0.72 %) and ash (16.63±0.12 %) content were found in *Jamila* rice bran while *Wita* bran exhibited higher protein (0.95±0.02 %), moisture (7.59±0.03 %), fat (4.88±0.10 %) and fiber content (47.48±0.04 %).

Statistically significant differences ($p < 0.05$) were observed when the carbohydrate, ash and fiber content of *Jamila* and *Wita* were compared with each other with *Jamila* having higher values for carbohydrate and ash than *Wita*. However, no statistically significant differences ($p > 0.05$) were observed when the moisture and fat of the two rice brans were compared with *Wita* having higher moisture (7.59±0.03 %), and fat (4.88±0.10 %) content.

Vitamin Content of *Jamila* and *Wita* Rice Brans

Table 2 presents the results of quantitative analysis of vitamins present in *Jamila* and *Wita* rice bran. *Jamila* rice bran exhibited higher contents of Vitamins A (0.89±0.00 μmol/L), C (11.07±0.21 mg/L) and E (9.97±0.01 mg/L) while *Wita* had lower vitamins content. However no statistically significant

Table 4: Quantitative compositions of anti-nutrients present in *Jamila* and *Wita* rice bran.

Parameters	*Jamila*	*Wita*
Phytic acid (mg)	23.47±0.03	22.14±0.04
Oxalate (mg)	17.90±0.02	18.79±0.03
Tannin (mg)	8.32±0.09[a]	5.81±0.08
Hydrogen cyanide (mg)	3.91±0.03	3.63±0.03
Saponins (%)	7.80±0.35[b]	5.84±0.05

Results were expressed as mean ± standard deviation in triplicates. Values in the same row bearing the superscripts 'a' and 'b' signifies significant difference when Jamila and Wita is compared at $p < 0.05$.

difference was observed ($p < 0.05$) when the vitamin content of the two brans was compared.

Mineral Composition of *Jamila* and *Wita* Rice Brans

Table 3 presents the quantitative compositions of some minerals present in *Jamila* and *Wita* rice bran. *Jamila* rice bran had higher Sodium (3.38±0.001 mg/L), Zinc (0.10±0.013 mg/L), Potassium (22.19±1.206 mg/L) and Copper content (0.03±0.004 mg/L) while *Wita* had higher Calcium (5.99±0.163 mg/L) and Magnesium content (2.94±0.136 mg/L).

Statistical analysis showed significant difference ($p < 0.05$) between Sodium, Calcium, and Potassium content of *Jamila* and *Wita* rice brans. However, no significant difference ($p > 0.05$) was observed when other mineral element content of the two rice brans was compared.

Anti-nutrient Composition of *Jamila* and *Wita* Rice Brans

Table 4 presents results of some anti-nutrients present in *Jamila* and *Wita* rice bran. Jamila rice bran had higher Phytic acid (23.47±0.03 mg), Tannin (8.32±0.09 mg), Hydrogen Cyanide (3.91±0.03 mg) and Saponins content (7.80±0.35 mg) while *Wita* exhibited higher Oxalate (18.79±0.03 mg). However, only the Tannin and Saponin content of the two rice brans exhibited statistically significant difference when compared while no difference was observed when other anti-nutrient parameters were compared.

DISCUSSION

Two varieties of rice bran, *Jamila* and *Wita* were analyzed for their proximate, minerals, vitamins and anti-nutrient compositions. The dietary fiber content for both rice bran showed the highest percentage, followed by carbohydrates when compared with other proximate parameters, Table 1. Our results disagree with the findings of (33), where carbohydrate content was the highest in all the parameters checked (76.92 – 85.05 %). This could be due to the differences in ecological zones of Nigeria, with different varieties possessing adaptation traits for each ecology. *Wita* had lower carbohydrate content than *Jamila,* probably due to its high moisture content which also affects its milling quality (34), and other environmental factors. Carbohydrates serve the body as source of fuel and energy required for daily activities. The results of the present study agree with the findings of (35), who reported that on average, rice bran has approximately 24.19 % to 40.74 % carbohydrate contents.

Both *Jamila* and *Wita* rice bran are rich in lipids, with no significant difference observed between them which is in accordance with the findings of (36). It was reported that intense lipase activity in the presence of endogenous lipoxygenase leads to rapid deterioration of these lipids by rancidification (37). This susceptibility makes enzymatic inactivation, by applying high temperature for a short time (38), mandatory immediately after bran separation to prevent fatty acid liberation, prolong bran shelf life and allow its commercialization for human consumption (39). The moisture content of both rice bran provides greater activity of water soluble enzymes and coenzymes needed for metabolic activities and help to enhance digestion and peristaltic movement on consumption. Crude protein is responsible for the formation of bones, hairs, teeth and the outer layer of skin. Although protein content of *Wita* rice bran was higher than that of *Jamila* rice bran, there was no statistically significant difference ($p > 0.05$) between them. This corresponds with the findings of (40) and (41). Ash contents, an indicator of mineral contents in biological mass, showed a significant difference ($p < 0.05$) when both brans were compared with each other. The high ash content contributed to their high minerals contents (42).

Rice bran is also a source of vitamins particularly vitamins A, C and E. The vitamins with the highest contents present in both brans were vitamin C, followed by vitamin E and then vitamin A which has the least content, Table 2. When compared between both bran, it was discovered that there was no significant difference ($p > 0.05$) between the three vitamins. The differences in vitamin content indicate

the degree of polishing to get the different fraction of the rice bran (43).

Our results indicate the presence of considerable amounts of minerals in both *Jamila* and *Wita* rice bran (Table 3) which agrees with the findings of (44). Sodium, Calcium and Potassium showed significant difference ($p < 0.05$) whereas, Magnesium, Zinc and Copper showed no significant difference ($p > 0.05$) even though it was seen that *Jamila* rice bran has higher content of Zinc and Copper, while *Wita* rice bran has higher Magnesium content. Potassium content of *Jamila* differed significantly ($p < 0.05$) from that of *Wita* rice bran and this finding is in line with that of (45), who reported the potassium content to be the highest among the minerals in the rice bran investigated. Copper content in the both rice bran was found to be low. Copper is essential to human life but its requirement is in small quantities; as such, the amount found in this study contributes to the daily requirement. Many findings have shown that, variation in mineral contents depends on factors such as availability of soil nutrients, geographical factor, agricultural practices, processing conditions and varietal differences (46).

Anti-nutrients were found in both rice brans analysed, Table 4. Our results obtained for tannins, saponin, phytic acid, oxalate and hydrogen cyanide of *Jamila* and *Wita* brans correlates with the report by (32) who obtained 23.58mg/g, 10.2 mg/g and 17.74 mg/g for phytic acid, tannins and oxalate in rice bran respectively. When present in high amounts, these anti-nutrients interfere with the absorption of nutrients, making their absorption by humans impossible. Among different anti-nutritional factors checked, phytic acid had the highest content, nearly close to a range of 27.69-42.82 mg/g. This range is similar to the report by (47). The content of phytic acid obtained in this study was higher in *Jamila* than that *Wita* but the difference was not statistically significant.

Oxalate form non-absorbable salts with minerals rendering them unavailable (48). High intakes of soluble oxalate may cause calcium oxalate crystallization, forming kidney stones (nephrolithiasis) (49). Oxalate content in this study was the second highest anti-nutrient obtained for both *Jamila* and *Wita* rice bran. Saponins are able to bind to proteins, enhancing protein stability against heat denaturation and susceptibility to proteases. They may also result in gastrointestinal lesions, entering the blood stream and hemolyzing the erythrocytes (50). Tannins complex with proteins causing protein insolubility and inactivating digestive enzymes. They are also significant in lowering blood glucose levels by delaying intestinal glucose absorption, thus delaying the onset of insulin dependent diabetes mellitus (51). As was reported by (32), the saponin and tannin content of full fat rice bran are 3.30 mg/g and 0.70 mg/g respectively. This is lower than saponin (7.80 mg and 5.84 mg) and the tannin content (8.32 mg and 5.81 mg) of *Jamila* and *Wita* in the present study respectively.

To benefit from the health improving biomolecules in rice bran (52), several stabilization techniques have been used to convert the rice bran into food grade for safe consumption (53). It was reported by (36), that the bran can be used as a percentage substitute to enrich different foods including cookies, pasta, bread, pizza, and infant formula to enhance the nutritional value (54). Furthermore, more preference was reported for parboiled rice due to it better nutritional properties when compared to non-parboiled rice (55). This might be due to diffusion of nutrients from the bran to the kernel.

CONCLUSION

This study showed that both *Jamila* and *Wita* rice brans are rich in proximate composition, antioxidant vitamins and mineral constituents especially potassium and sodium. It was also found that both rice bran contain anti-nutrients with phytic acid and oxalate content being the highest. Therefore these brans can serve as excellent sources of dietary fiber, vitamins C and E and minerals, especially if these anti-nutrients are adjusted by food industries to safe levels that cannot cause pathologic conditions.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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