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ASSESSMENT OF NUTRIENT AND ANTI-NUTRIENT CONTENTS OF DIFFERENT LOCAL RICE CULTIVATED IN DANDUME LOCAL GOVERNMENT, KATSINA STATE NIGERIA

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ABSTRACT

Rice is considered a wholesome cereal grain that is ideal for the many nutritional needs owing to its significance in human nutrition by providing bulk of calories and few micronutrients requirement for more than half of the world's population. The aim of this study was to evaluate the nutritional composition and anti-nutritional contents of different local rice varieties cultivated in Dandume Local Government Area, Katsina State. Nutritional and anti-nutritional contents of the rice samples were determined. The percentage moisture contents of 'Yar yarima and Farar cikin ja were significantly high ($p<0.05$) than the other rice varieties recorded 12.05-13.55%. But the percentage fat contents of the rice varieties were not significantly different ($p>0.05$) ranged from 0.89-1.25%. The percentage crude protein contents of the rice varieties were not significantly different ($p>0.05$) recorded 8.31-9.31%. However, the carbohydrate content was not significantly different ($p>0.05$) among the rice varieties ranges from 75.36% - 81.18%. There were significant differences ($p<0.05$) in calcium, magnesium, potassium, sodium and iron contents among the rice varieties recorded 158.29 - 219.69 (mg/100g), 33.34 - 44.26 (mg/100g), 75.47 - 92.25 (mg/100g), 23.71 - 29.22 mg/100g and 62.70 – 96.89 (mg/100g) respectively. The total phytate contents of the rice samples recorded 0.91 – 1.59% which were below the reference range (≤3.6), while the total oxalate contents ranged from 22.75 - 44.62% and these were above the reference range (<1.25). This study confirmed varietal influence of the nutritional and anti-nutritional compositions of different local rice varieties which may contribute to the daily requirement.

Keywords: Calcium, Carbohydrate, Oxalate, Phytate, Rice

INTRODUCTION

Food consumption data is essential for estimating a population's nutrient intake, dietary exposure to toxins, and overall diet quality because food security is one of the world's most pressing issues, encompassing both the quality and supply of food (Mohammed and Ahmad, 2014). About 90% of cereal grains produced worldwide are cereal grains, which are mostly composed of rice (*Oryza sativa*), maize (*Zea mays*), and other staple foods (Otitujo *et al.*, 2014). Moreover, rice (*Oryza spp*.) is a staple food of half of the world's population and also the second most popular cereal after wheat (Abbas *et al*., 2011). Due to growing urbanisation, high population growth, and changes in eating patterns, its consumption is rising more quickly than that of any other staple food on the continent (Oko *et al*., 2012).

A significant cereal plant that is a member of the *Poaceae* family of grasses is rice (*Oryza sativa*) (Vaughan *et al*., 2003). One of the two cultivable species in the genus, it is native to Asia and comes from China, India, and Thailand; *Oryza glaberrima*, sometimes known as African native rice, is mostly farmed in West African nations (Linares, 2002). Nigeria is the highest producer of rice in West Africa (Singh *et al*., 1997). Nigeria produces two types of rice: *O. glaberrima*, 'Ofada, which is grown in the town of Ofada in the country's southwest, and novel rice (NERICA), which is a cross between *O. sativa* and *O. glaberrima* (WARDA, 2008). These species are found in Nigeria's "fadama," or highland, lowland, and marshy regions. Specifically, in the regions of Abakalaki, Bida, Abeokuta, Makurdi, Mokwa, Sokoto, Nasarawa, and Benue, it is primarily grown for human consumption (Adebowale *et al*., 2010). Asian rice, on the other hand, originated in Southeast Asia and is currently grown all over the world. Similarly, *O. globbemasteud*, the native rice, was forced to the periphery with the arrival of *O. sativa* from Asia. Majority of rice is farmed in the eastern (Enugu, Cross River, and Ebonyi states) and middle belt (Benue, Kaduna, Niger, and Taraba states) regions of the nation, which spans from the northern to the southern zones (Daramola, 2005). It is estimated that annual rice production should be increased from 586 million metric tons in 2001 to meet the project global demand of about 756 million metric tons by 2030 (FAO, 2011).

In terms of nutrition, rice is regarded as a nutritious cereal grain that is suitable for a range of dietary requirements. Its protein level is similar to that of wheat, corn, and sorghum, while its carbohydrate content is primarily high (URF, 2002). Due to its better nutritional qualities compared to other cereal grains, rice has been regarded as the best staple meal with trace amounts of iron, zinc, copper, manganese, and potassium, the minerals magnesium, calcium, and phosphorus are found (URF, 2002).

Anti-nutritional compositions are chemical substances produced by plants that have the potential of affecting the availability of nutrients by interfering with metabolic processes (Ebuehi and Oyewole, 2007). Phytate has been considered as an anti-nutrient 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 (Savage *et al*., 2000). High intakes of soluble oxalate may cause calcium oxalate crystallization and the formation of kidney stones (nephrolithiasis) in the urinary tract (Wang *et al*., 2011). 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 (Ebuehi and Oyewole, 2007). Additionally, 90–95% of Nigerians consume rice, which can to improve nutrition, provide food security, promote rural development, and support sustainable landrace. According to Sri Lankan folklore and ethnomedicine, several types of local rice were said to have therapeutic qualities (Dharmasena, 2010; Abeysekera and Premakumara, 2016). These health claims, which include some nutritional and antioxidant properties, were scientifically proven in recent studies (Abeysekera *et al*., 2015; Abeysekera and Premakumara, 2016). These circumstances highlighted the urgent need for additional research on the specific nutrient profiles and compositions of rice grown domestically in order to create a sizable market for a crop that can be grown throughout the nation, where increased domestic production can improve food security and lower the need for foreign exchange for imports.

MATERIALS AND METHODS

Materials

Rice, mortar, pestle, testtubes, hydrochloric acid, concentrated sulfuric acid, nitric acid, boric acid, kjeldah catalyst ($CuSO_4$ + Na_2SO_4), sodium hydroxide, methyl red, petroleum ether, distilled water, aqueous ammonia, iron (iii) chloride solution, orthophosphoric acid, calcium chloride, silver nitrate, alkaline picrate solution, Potassium iodide, ammonium thiocyanate and potassium tetreoxomanganate (vii).

Methods

Sample collection and preparation

Rice (*Oyza sativa*) samples were collected from three different areas of Dandume local government, Katisna state. The clean rice samples were sorted and ground with a mortar and pestle into fine powdered form and stored in labeled containers at a temperature of 45ºC prior to use of analysis.

Proximate Analysis

The proximate composition of the rice samples for moisture, ash, fat, crude fibre, total carbohydrate contents were determined based on the methods described by AOAC (2000).

Determination of Moisture Content

The method is based on loss on drying at an oven temperature of 105 ºC, cooled in a desiccator and weighed (W_1). Two grams (2.0 g) of finely ground samples were accurately weighted into previously labeled crucible and reweighed (W_2). The petri dish containing the sample was dried in an oven at 105 ºC to a constant weight and weighed (W_3). The percentage of moisture content was calculated as:

$$\%\, Moisture = 100 \text{ x } \frac{W_2 - W_3}{W_2 - W_1} \qquad (1)$$

Where W_1= weight of empty petri-dish, W_2= weight of petri-dish + sample before moisture

W_3= Weight of sample after moisture

Determination of Ash Content

Two grams (2 g) of rice samples were weighed and transferred into a clean, dry and pre-weighted crucible. Then the crucible was kept into muffle furnace at 55 ºC for 6 hours. The crucible containing the ash was then removed cooled in the desiccators and weighed. The percentage of ash content was calculated as:

$$\%\, Ash = 100 \text{ x } \frac{W_2 - W_3}{W_2 - W_1} \ldots \qquad (2)$$

Where W_1= weight of empty crucible, W_2= weight of crucible + sample before ashing, W_3= Weight of sample after ashing

Determination of Crude Fibre Content

Defatted sample (2 g) were boiled with 200 cm^3 of sulphuric acid for 30 minutes on a hot plate and was filtered through a muslin bag and washed with boiling water to remove the acidity. The residue was boiled with 200 cm^3 sodium hydroxide solution for 30 minutes. The residue was filtered with filter paper dried in oven for 2 hours at 130 ºC and was transferred for dry-ashing and the crude fibre was calculated as:

$$\%\, Crude\ fibre = 100 \text{ x } \frac{Weight_{after\ drying}}{Weight_{before\ drying}} \ldots \qquad (3)$$

Determination of crude protein

The sample (1.5 g) was weighed into a kjeldahl digestion flask, 0.8 g of catalyst were added into the flask to facilitate digestion. 2 ml of concentrated sulphuric acid was added. The mixture in digestion burner at an incline position until clear solution was obtained. After cooling the solution was made alkaline with 15 mol of 40% sodium hydroxide sodium and the digest was then transfer to the teamed-out apparatus using minimum volume of water. The ammonia steamed distilled into 15m 4% boric solution with 5 drops of methyl red indicator. Distillation continued until the pink colour turns green. The distilled ammonia was titrated with 0.002 M hydrochloric acid until the end point was indicated by a change from green to pink.

$$\%\, Nitrogen = (V_1 - V_2) \text{x } N \text{ x } F \text{ x } 0.014 \text{ x } \frac{100}{V} \text{ x } \frac{100}{S} \qquad (4)$$

Where V_1 = Titre for the sample (ml), V_2 = Titre for back (ml), N = Normality of standard HCl solution (0.002), F = Factor of standard HCl solution, V = volume of diluted digest taken for distillation (10ml), S = Weight of sample taken (g)

$$\%\, Protein = Nitrogen \text{ x } 6.25 \ldots \qquad (5)$$

Determination of Crude Lipid content

Exactly three (3.0 g) of the samples were wrapped in clean defatted filter paper and recorded as (W_1), placed inside an extractor. 300 cm^{3}petroleum ether was measured into extraction flask and was connected to the condenser and heated for about 3 hours. The heat vaporized the solvent which pass up the arm and was condensed unto sample. The condensed solvent falls drop by drop to extract the fat content when it reaches the level of siphon height, the condenser containing the wash fat flows down into the extraction flask, it was then re-evaporated leaving the extracted fat behind and this process was repeated until six siphoning were taken. The flask was then removed and the solvent was then evaporated. The samples were heated to dryness and transferred in desiccators to cool and new weight is recorded as (W_2), the percentage was then calculated as:

$$\%\, Lipid = \frac{W_i - W_{ii}}{W_{iii}} \times 100 \qquad (6)$$

W_i = weight before extraction, W_{ii} = weight after extraction, W_{iii} = weight of the sample

Determination of Carbohydrate Content

The total carbohydrate content of the samples was calculated by subtracting the value of moisture, ash, crude lipid, crude protein and crude fibre from 100 (FAO, 2004) as follows:

$$\%\, Carbohydrate = 100 - (\%\, M + \%\, A + \%\, \%\, Ft + \%\, P + \%\, F) \ldots \qquad (7)$$

% M = % moisture, % A = % ash, % F = % fibre, % P = % protein, % Ft = % fat

Determination of Mineral Elements

The mineral content of the samples was determined according to the method described by (Johann *et al*., 2012).

Determination of Calcium, Magnesium and Iron by Atomic Absorption Spectrophotometer (AAS)

Sample Digestion: One gram of each sample was weighed and digested with 20 ml mixture of 60 ml nitric acid, 80 ml par chloric acid and 20ml sulphuric acid and heated at 100 °C for 5 hours.

Measuring Absorbance: - The absorbance of individual mineral was measured using atomic absorption spectrophotometer (AAS) as follows: calcium at 430nm; magnesium at 285 nm, iron at 248 nm and the level of each mineral was extrapolated from a standard curve (AOAC, 2000).

Determination of Sodium and Potassium by Flame Photometry

Two grams (2.0 g) of each sample were digested in 20ml mixture of 60 ml nitric acid, 80 ml per chloric acid 20 ml sulphuric acid at 100 °C for 5 hours.

Measuring absorbance: the digest was measured in a flame photometer sodium was measured at 767 nm while potassium was at 589 nm (AOAC, 2000).

Anti-nutritional Analysis

Anti-nutritional analysis was carried out on each of the rice varieties to test for the phytate and oxalate contents.

Determination of Phytate

Four gram (4 g) of finely ground samples were soaked in 100 cm^3 of 2% HCI for 3 hours and then filtered. 25 cm^3 of the filtrate was placed in a 100 cm^3 conical flask and 5 cm^3 of 0.03% Ammonium thiocyanide (NIL_4SCN) solution was then added as indicator. 50 cm3 of distilled water was then added to give it the proper acidity. This was titrated with ferric chloride solution which contained about 0.005 mg of mg of Fe per cm3 of $FeCl_3$ used, the equivalent was obtained and from this, the phytate content in mg/100 g was calculated (Edwige, 2012)

Iron equivalent = Titre value x 1.95

$$Phytic\ acid = Titre\ value \times 1.95 \times 1.19 \times \frac{3.55\ \text{mg}}{phyti\ acid} \ldots \quad (8)$$

Therefore

$$\%\ Phytic\ acid = \alpha \times \frac{8.24}{100} \times \frac{100}{Weight\ of\ sample} \quad (9)$$

Where α = titre value

Determination of Oxalate

One gram (1 g) of the samples was weighed into 100 ml conical flask. 75ml of 1.5N H_2SO_4 was added and the solution was carefully stirred intermittently with a magnetic stirrer for about 1hr and then filtered using filter paper. 25 ml of sample filtrate (extract) was collected and titrated hot (80 ~ 90 °C) against 0.1N $KmnO_4$ solution to the point when a faint pink colour appeared that persisted for at least 30 seconds. (Adebayo *et al.*, 2013)

The oxalate content was then calculated as follows:

$$\%\ Oxalate = \frac{(Titre\ value \times Vme \times DF)}{ME \times MF} \quad (10)$$

Vme = Volume of acid (titrants), DF = Dilution factor, ME = Molarity of acid, MF = Mass sample.

Statistical Analysis

Results were expressed as mean ± standard deviation using SPSS software and were analysed by ANOVA using the GraphPad instant software. Probability value was set at (P<0.05).

RESULTS AND DISCUSSION

Proximate Composition

The result of the proximate composition of the local rice varieties is presented in table 1. The moisture content of the rice samples varied from 7.23% to 13.55%. The protein contents of the rice samples range from 8.31% to 8.97%. While crude fibre values of the rice samples range from 0.62% to 0.67%. The percentage of fat contents of the rice samples ranges from 0.57% to 1.72%. The ash content of the rice samples ranges from 0.72% to 0.94%. The carbohydrate values of the rice range from 75.37% to 81.18%.

Table 1: Proximate composition of rice varieties

Rice Varieties	Moisture (%)	Protein (%)	Fibre (%)	Fat (%)	Ash (%)	Carbohydrate (%)
Yar laima	$12.05{\pm}0.05^a$	$8.31{\pm}0.02^a$	$0.63{\pm}0.01^a$	$0.89{\pm}0.01^a$	$0.86{\pm}0.02^a$	$77.18{\pm}0.07^a$
Yar yarima	$7.23{\pm}0.6^b$	$9.31{\pm}0.01^a$	$0.67{\pm}0.02^a$	$0.94{\pm}0.01^a$	$0.77{\pm}0.02^a$	$81.18{\pm}0.17^b$
Doguwar Ruwa	$10.27{\pm}0.06^b$	$8.97{\pm}0.02^a$	$0.67{\pm}0.02^a$	$0.57{\pm}0.01^a$	$0.94{\pm}0.02^a$	$78.60{\pm}0.01^c$
Farar cikin Jaa	$13.55{\pm}0.09^a$	$8.70{\pm}0.06^a$	$0.62{\pm}0.02^a$	$1.25{\pm}0.01^a$	$0.72{\pm}0.02^a$	$75.36{\pm}0.04^d$

Values are expressed as mean ± standard deviation and mean sharing similar superscript along the same column are significantly at (p<0.05), n=3

Mineral Composition

The values of the element including calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and iron (Fe) in the four samples were determined. The result of each mineral element contents was presented below.

There was variation in mineral composition among the rice varieties (table 2). The contents of magnesium, potassium and iron showed values between 33.34-54.59 (mg/100g), 75.47-92.25 (mg/100g) and 62.70-96.89 (mg/100g) respectively. While sodium content was having the values between 23.71 - 29.22 (mg/100g). And the calcium content was recorded 158.29-219.69 (mg/100g).

Table 2: Determination of mineral element composition

Rice Varieties	Magnesium (mg/100g)	Potassium (mg/100g)	Sodium (mg/100g)	Iron (mg/100g)	Calcium (mg/100g)
'Yar laima	$44.26{\pm}0.09^a$	$83.54{\pm}0.03^a$	$28.66.{\pm}0.04^a$	$96.89{\pm}0.02^a$	219.69±2.40a
'Yar yarima	$50.75{\pm}0.04^b$	$92.25{\pm}0.07^b$	$23.71{\pm}0.22^b$	$62.70{\pm}0.06^b$	$164.08{\pm}3.60^b$
Doguwar Ruwa	$33.34{\pm}2.50^c$	$75.47{\pm}1.00^c$	$27.82{\pm}1.50^c$	$93.50{\pm}0.07^c$	$158.29{\pm}3.33^c$
Farar cikin Ja	$54.59{\pm}1.80^d$	$89.61{\pm}0.88^d$	$29.22{\pm}1.00^d$	$73.81{\pm}0.90^d$	$176.12{\pm}4.55^d$

Values are expressed as mean ± standard deviation and mean sharing similar superscript along the same column are significantly at (p<0.05) and n=3.

Anti-Nutritional Content

The anti-nutrient contents of the rice varieties are presented in table 3. The phytate content of the rice samples range from 0.91% to 1.59% (mg/100 g), while the percentage of oxalate content in the rice samples range from 22.75% to 44.62% (mg/100 g).

Table 3: Percentage anti-nutrient contents of the rice varieties

Rice varieties	Phytate (%)	Oxalate (%)
'Yar Laima	1.16	44.62
'Yar Yarima	1.47	23.74
Doguwar Ruwa	0.91	22.75
Farar Cikin Ja	1.59	42.81

Anti-nutrient contents are expressed in percentages among the rice varieties

Discussion

The moisture contents of 'Yar yarima and Farar cikin ja were significantly higher ($p<0.05$) than the other rice varieties ranges (12.05-13.55%). Moisture content of the rice grain has important quality parameters such as keeping quality (shelf life), milling quality, cooking and processing qualities of rice. The grains can be stored only two to three weeks if moisture content is high (14-18%) as it leads to growth of moulds, rapid loss of viability and a reduction on eating quality (Juliano, 1985). The results of this study are in agreement with standard range value of moisture content (7-11%) provided by FAO. Similarly, Ebuchi and Oyewole (2007) reported that the moisture content of rice also affects its storage capacity. The percentage of ash contents of all rice varieties studied were significantly similar ($p>0.05$) ranges (0.86-0.94). The ash content of a food samples usually gives an idea of the mineral contents present in the food sample (Teresa *et al.,* 2010). The percentage fat contents of the rice varieties were significantly the same ($p>0.05$) ranges (0.89-1.25), and it is in line with previous study on five major rice varieties (improve and local varieties) in south eastern Nigeria ranges of 0.5-3.5% by (Oko and Ugwu, 2011); and also, the standard FAO reference fat content of rice range from 0.5%-2.23%. The fat content in the rice is a good source of essential fatty acids and rice does not contain cholesterol (Eggum *et al*., 1983).

The percentage crude protein contents of the rice varieties were significantly similar ($p>0.05$) ranges (8.31-9.31). This is in line with the finding of Kennedy and Burlingame, (2003) where over 300 varieties of African rice have (5.7% - 12.7%) protein content. The percentage fibre contents of the four rice varieties were not significantly different ($p>0.05$) ranges (0.62% - 0.67%). Although this range was a bit lower than the (1.50% - 2.00%) reported by Oko and Ogwu, (2011).

Carbohydrate is the major component of the rice grain and it is important in obtaining significant amount of dietary energy. It was observed that the carbohydrate contents were not significantly different ($p>0.05$) among the rice varieties ranges from 75.36% - 81.18%.

Although one of these values is higher than the 75.76 – 76.57% values reported by Ayofemi and Olushola, (2019). The level of minerals composition revealed that the rice varieties have significant difference ($p<0.05$) in their mineral content among all the rice samples. The calcium content of the rice varieties ranges from 158.29 - 219.69 (mg/100g). There was significant difference ($p<0.05$) in calcium concentration among the rice varieties. Calcium is stored mostly in the bones and the teeth. It is also essential for muscle contraction, nervous system function, blood vessel expansion and contraction, secretion of hormone and enzymes (McDowell, 1992). Adequate intake of calcium for adult is 1000 – 1300 (mg/day), depending on age and gender (IOM, 1997). The magnesium content of the rice varieties ranged from 33.34 - 44.26 (mg/100g). There was significant difference ($p<0.05$) in magnesium concentration in varieties of rice samples studied. Symptoms of magnesium deficiency ranges from growth retardation, nausea, muscle weakness and this deficiency may affect cardiac functions (McDowell, 1992). The recommended daily intake in male adult is 420mg/day and that of female adult is 320mg/day (IOM, 1997).

Significant difference ($p<0.05$) observed in potassium concentration among the rice varieties. The potassium content of the rice varieties ranges from 75.47 - 92.25 (mg/100g). Potassium is the third most abundant mineral in human body and is essential to human life. The recommended dietary allowance for potassium in adult is 3500mg/day (Coma, 1991).

The sodium content of the rice samples studied ranges from 23.71 - 29.22 mg/100g. Significant difference ($p<0.05$) occurred in sodium concentration among the four varieties of rice. Sodium is essential in humans and used for regulating blood pressure and blood volume, and is critical for muscle and nerve functions. The recommended daily intake of sodium is 1200mg/day for children between ages of 4 – 8 while, 1500 mg/day for adults between the ages of 18 – 50 years (FNB, 2013). The iron content of the rice samples ranged from 62.70 – 96.89 (mg/100g). There was significant difference ($p<0.05$) in iron content of the rice varieties.

Most of the iron in the body is found in heme protein such haemoglobin and myoglobin, both involved in oxygen transport. Iron is found as a constituent of heme enzymes such as cytochromes, catalase and peroxidase and other non-heme compounds. The recommended dietary allowance for iron in adult female between the ages of 19 – 50 years is 8mg/day; those above 50 years is 18mg/day. In adult males, the recommended dietary allowance is 8mg/day (FNB, 2013). The values for mineral composition in this present study are comparable with data reported on Nigerian milled rice 'ofada' (Ebuchi and Oyewole, 2007).

The anti-nutritional contents of the rice samples have different values due to the difference in the amount of anti-nutrient in the individual samples. Phytate is a storage form of phosphorous and is particularly abundant in cereals and legumes (Reddy *et al*., 1989). This chelated divalent cations such as Ca, Mg, Zn and Fe, thereby reducing their bioavailabilities (Sandberg, 2002). In this study the total phytate content in the rice samples were ranges of 0.91 – 1.59%. The phytate content of all the rice varieties were in agreement with the standard phytate values provided by FAO (≤ 3.6).

Staple food rich in oxalate have adverse effects when eaten because oxalate binds calcium and other minerals thereby causing calcium deficiency. The oxalate content of the rice varieties was ranged of 22.75 - 44.62%. This indicated that the oxalate content of the rice varieties was not in line with standard range values provided FAO (<1.25). This high oxalate content might be as a result of industrial effluent around the farm land.

CONCLUSION

Yar yarima was observed to have high percentage of carbohydrate, fibre, protein and potassium contents among other rice varieties. And the phytate content of the rice varieties were within the reference range as provided by FAO. But, oxalate contents of the rice varieties were higher than the reference level as provided by FAO.

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