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Major nutritional differences among selected local, foreign and diabetic rice varieties consumed in South East Nigeria

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ABSTRACT

Price differences among different categories of rice consumed in Nigerian have necessitated the need to investigate some useful parameters that could prove their nutritional worth. Three each of Nigerian local varieties (Abaomege Kpurukpuru, Izzi 306 and Ikwo Adaigbo), foreign processed types (Sarina, Super Eagle and Mama Africa) and very expensive special imported types (assumed as diabetic rice) (Golden Penny, Brown Basmati and White Basmati) were analyzed for some important constituents including protein, amylose and vitamin A using standard methods. Brown Basmati, Izzi 306, Ikwo Adaigbo and Mama Africa had comparatively high protein contents with the mean values of 9.13 ± 0.014, 8.80 ± 0.008, 8.62 ± 0.049 and 8.49 ± 0.007, respectively. Incidentally, the three assumed diabetic rice types showed extraordinarily high percentage amylose contents (28.7 ±0.141 to 31.7± 9.141) relative to others. On the other hand, only Ikwo Adaigbo showed a presence of vitamin A with mean value 0.015 ± 0.000 (µg/g). In the same vein, significant variations (p <0.05) were also observed between the varieties in other important components. The inexplicably high amylose contents in the assumed diabetic rice varieties and the presence of Vitamin A in Ikwo Adaigbo were the major distinguishing factors between the rice types.

Key words: *Rice, amylose content, Vitamin A, proximate compositions, minerals*

Rice (*Oryza sativa* L.) grain plays a very important dietary role in the nutrition of human beings amongst the cereal crops. It ranks 2nd after wheat and maize (Akintola 1998) and constitutes the most important staple food for about half of the world's population (Thakur and Gupta 2006; Osaretin and Abosede 2007). Rice plays a very important role in the diets of many people in developing countries where it provides 27% of the dietary energy supply and 20% of dietary protein intake. Rice is an excellent source of complex carbohydrates, protein and minerals (Yadav and Jundal 2007). In addition to varietal differences, protein content of rice is affected by environmental conditions, such as soil and nitrogenous fertilizer application. Protein is mainly distributed in the bran and periphery of endosperm. The central part of rice grain contains only a small proportion of rice's protein. Rice is unique in the richness of alkali-soluble proteins or glutellin (about 70 %), whereas other cereals are rich in alcohol- soluble proteins, include 4-9 % water soluble proteins or albumin and 10 % salt soluble protein or globulins (Sanni *et al*. 2005). According to USA Rice Federation (2002), rice contains 7.1 - 8.3 % protein for brown rice, 6.3-7.1 % for milled rice, 11.3-14.9 % for rice bran, 14.1-20.6 % for rice embryo.

More than 90% of the energy in rice comes from carbohydrate. Rice contains both simple and complex carbohydrates. Simple carbohydrates in rice are starch and fiber. About 85 % of the rice grain weight is starch. Amylose is the linear fraction of the rice starch, and is negatively correlated with the cohesiveness, tenderness, colour and the gloss of the cooked rice.

Acceding to the USDA nutrient database, rice contains about 70 g carbohydrates/100 g. Also a report on USA Rice Federation (2002) revealed that rice contains 67.9 -75.5 % for brown rice and 76.7-78.4 % for milled rice. Eggum *et al*. (1982) as supported by Ibukun, (2008) stated that milled rice contains 0.7-25% fat. Rice is considered as a health food because it contains linoleic acid but not cholesterol. The moisture content of rice is not constant, but varies as ambient changes. Rice under storage condition with high moisture content in dry condition creates the problem of losing weight due to loss of moisture. Other proximate contents such as crude fiber, already stated in the literature as component of carbohydrate though indigestible made up of 0.6-10 % in brown rice, 0.2-0.5 % in milled rice, 7.0-11.4 % in rice bran and 2.3-3.2 % in polished rice. For ash content, brown rice contains 1.0-1.5 %, milled rice contains 0.3-0.5% while in polished rice is 5.2-7.3 % (USA Rice Federation 2002).

Rice contains several types of vitamins in trace amounts including vitamin E that protects vitamin A and essential fatty acid from oxidation. Recently, scientist in Switzerland and Germany developed "Golden Rice" through genetic engineering and substantially increased vitamin A content in rice due to its importance. In terms of mineral compositions, potassium (K) is the most abundant mineral found in rice (brown, parboiled brown, milled and parboiled milled rice) followed by magnesium (Mg) and calcium (Ca). Among microelements, the presence of copper (Cu), iron (Fe), molybdenum (Mo), manganese (Mn), sodium (Na) and Zinc (Zn) in rice is outstanding. Rice mainly consists of starch made up of two ingredients, amylose which is a linear combination of glucose by means of -1, 4 linkage and amylopectin that has a cluster (fan-shaped) of -1, 6 linkage branching out from the linear chain of -1, 4 linkage. Rice is divided into non-glutinous and glutinous rice based upon its starch characteristics. Glutinous rice consists solely of amylopectin, while non-glutinous rice comprises both amylose and amylopectin. In general, rice with high amylose content is not sticky when cooked, while rice with low amylose content becomes soft and sticky when cooked.

There is a structural increase in rice consumption in the world and this increase would continue in the nearest future. Rice bran is a valuable commodity in Asia and is used for many daily needs. It is a moist, oily outer layer which produces oil upon heating (Dutta *et al*. 1998). Raw rice may be ground into flour for many uses, including making many kinds of beverages, such as amazake, harchata, rice milk and rice wine. Rice may also be made into various types of noodles. Raw, wild or brown rice may also be consumed by raw-foodists or fruitarians if soaked and sprouted (usually a week to 30 days- gaba rice) (Wasserman and Calderwood 1972). Processed rice seeds may be boiled or steamed before eating. Boiled rice may be further fried in cooking oil or butter (known as fried rice) or beaten in a tub to make mochi.

Rice is grown in all the ecological zones of Nigeria with different varieties, processing and adaptation traits for each ecology (Sanni *et al*. 2005). Ebonyi State is a major rice producer in Nigeria and rice production in the state has witnessed a spectacular increase in the recent time. The ideal vegetation for rice production in Ebonyi State has given rise to different varieties that have adapted to specific local environment, and these varieties bear names reflecting the towns in which they are grown (Alaka and Okaka 2011). Rice is an economic crop which is important in household food security, ceremonies, nutritional diversification, income generation and employment (Perez *et al*. 1987). It is utilized mostly at the household level where it is consumed as boiled, fried or ground rice with stew or soup (Osaretin and Abosede 2007).

Consumer demand for good quality rice is high resulting in high patronage for imported rice types. Since rice production is the major occupation of most farmers in Ebonyi State and to ensure that locally processed rice varieties remain vital and relevant to rural economy and agricultural production, there is need to evaluate their quality so as to compare them with their imported counterparts, hence the decision to compare the proximate, mineral compositions, amylose and vitamin A contents of some selected local, foreign and diabetic rice varieties consumed in South Eastern Nigeria.

MATERIALS AND METHODS

Sample collection

A total of nine rice samples; three each of local varieties (Abaomege Kpurukpuru Izzi 306 and Ikwo Adaigbo), foreign varieties (Sarina, Super Eagle and Mama

Africa) and diabetic rice varieties (Golden Penny, brown Basmati and White Basmati) were bought from Ebonyi State, Enugu State and their environs (all in South Eastern Nigeria).

Analytical method

The biochemical analysis was carried out at the Global Technology Institute (GTI) in Akwa Ibom State of Nigeria and the Biochemistry laboratory of the National Rice Research Institute (NRRI), Cuttack, India. The rice varieties were ground with a plate mill, and dried in a hot air oven at 400C for 12 hours to reduce the moisture content up to 14%. The ground samples were used for biochemical analysis.

Estimation of crude protein, fat and ash

The crude protein (N x 5.95), fat and Ash for all rice varieties were determined using approved methods 46-11A, 30-10 and 08-01 (AACC, 2000).

Minerals composition measurement

The minerals composition were determined using AAS model 305B (Osaretin and Abosede 2007). The base line of the instrument was set to zero with the Boerhinger commercial control as per manufacturer's instruction. Rice grain (50g) was taken with moisture content 12-13% and dehulled and milled (10%). From milled sample, 2g flour was taken in 100 ml volumetric flask and 15ml of conc. HNO_3 was added. The mixture was kept overnight. Next day, 2ml of $HClO_4$ was added and heated at 60ºC till brown fumes of HNO_3 stops. Then sample was allowed to digest at 90ºC till white fumes come out. The mixture was cooled down and made volume up to 50ml using double distilled water. Then filtrate was obtained through Whatman No. 41 filter paper into 125ml bottles for taking readings in AAS.

Estimation of vitamin A

The estimation of beta carotene was followed as described by Santra *et al*. (2006) with some modifications. Ten gram flour was taken in 250 ml volumetric flask and volume made up to 100 ml with water saturated n-butanol (WSB). For complete extraction of β-carotene, the contents of the flasks were mixed vigorously for 5 min. and kept overnight (16-18 hrs) at room temperature under dark condition. Next day, the contents were shaken again for 10 min. and filtered completely through the Whatman No.1 filter paper into a 100 ml volumetric flask. The absorbance was measured at 440 nm and the calibration curve was established. Pure WSB was used as blank during measurement. The β-carotene content was calculated from calibration curve from known amount of β-carotene as discussed below and expressed as parts per million (µg/g). For making standard solution of β-carotene (Sigma), WSB was used to make the concentration of 5 **µ**g/ml (WSB was prepared by mixing n-butanol with distilled water at ratio 8:2). With the proper dilution of the standard solution in 10 ml volumetric flasks the calibration curve was prepared. The absorbance of each dilution was measured and the calibration curve was established. Content of β-carotene of unknown samples was calculated from standard curve expressed as µg/g of sample flour.

Amylose measurement methods

Amylose and amylopectin contents were estimated by using amylose/amylopectin assay kit Megazyme kit (Megazyme Ireland International, Ltd., Bray Ireland) followed according to the manufacturer's recommendation. Exactly 20 mg rice flour sample was taken into a 10 ml falcon tube and dispersed by heating with 1 ml dimethyl sulphoxide (DMSO) and lipids were removed by precipitating the starch in ethanol (6 ml). Precipitated starch of the sample was dissolved in an acetate/salt solution where amylopectin is precipitated by the addition of concanavalin A (4 ml) followed by centrifugation. The amylose in the supernatant was then enzymetically hydrolysed to D-glucose and analyzed using glucose oxidase/peroxidase reagent. The total starch was also measured in a separate aliquot of the acetate/salt solution using same treatment. The concentration of amylose in the starch sample was estimated as the ratio of GOPOD absorbance at 510 nm of the supernatant of the concanavalin A precipitated sample to that of the total starch sample.

Statistical Analysis

Data were analyzed using analysis of variance (ANOVA) according to (Snedecor and Cochran 1969) to detect any difference in mean values from triplicate runs of each treatment.

RESULTS AND DISCUSSION

Carbohydrate was the highest % proximate component as usual among selected rice varieties (Table 1). White

Table 1. Proximate composition of the nine rice samples (%)

Samples	Moisture	Crude protein	Crude fiber	Ash	Fat	Carbohydrate
Abaomege Kpurukpuru	13.30 ± 0.141^{b}	7.95 ± 0.042^{g}	1.32 ± 0.014^{c}	0.81 ± 0.014^{i}	2.21 ± 0.021^{b}	74.41 ± 0.092^{e}
Izzi 306	13.15 ± 0.071^{b}	8.80 ± 0.008^{f}	1.50 ± 0.021^{f}	1.04 ± 0.056^{h}	2.10 ± 0.028^{cd}	73.41 ± 0.021^{e}
Ikwo Adaigbo	14.10 ± 0.141^{a}	8.62 ± 0.049^{b}	1.62 ± 0.007^{b}	1.38 ± 0.007^{c}	2.48 ± 0.014^{a}	71.80 ± 0.177^{f}
Sarina	13.20 ± 0.282^{c}	8.14 ± 0.056^{e}	1.61 ± 0.006^{d}	1.42 ± 0.021^{f}	$2.08+0.008^{d}$	73.55 ± 0.346^{d}
Super Eagle	13.45 ± 0.071^{e}	8.25 ± 0.014^{d}	1.60 ± 0.008^{e}	1.22 ± 0.007^{g}	2.13 ± 0.014^{c}	73.35 ± 0.049^{a}
Mama Africa	13.60 ± 0.006^{d}	8.49 ± 0.007^{c}	1.63 ± 0.014^{c}	1.58 ± 0.007^{e}	2.03 ± 0.014^{e}	72.67 ± 0.014^{d}
Golden penny	13.65 ± 0.071^{e}	8.24 ± 0.008^{d}	1.68 ± 0.006^{b}	1.07 ± 0.014^{d}	2.11 ± 0.014^{cd}	73.25 ± 0.099^{c}
Brown Basmati	13.20 ± 0.007^{f}	9.13 ± 0.014^{a}	1.56 ± 0.007^{a}	1.80 ± 0.008^{a}	2.42 ± 0.028^{e}	71.89 ± 0.042^{e}
White Basmati	12.60 ± 0.005^{g}	8.24 ± 0.028^{c}	1.01 ± 0.014^{d}	0.72 ± 0.014^{b}	2.02 ± 0.006^{e}	75.41 ± 0.014^{b}

Means with different superscripts are statistically significant difference ($p < 0.05$)

basmati had the highest % of carbohydrate followed by Abaomege Kpurukpuru, Sarina, Izzi 306 and Super Eagle with mean values of 75.41 ± 0.014, 74.41 ± 0.092, 73.55 ± 0.346, 73.41 ± 0.021 and 73.35 ± 0.049, respectively. Ikwo Adaigbo had the least carbohydrate content with mean values of 71.80 ± 0.177. Brown Basmati had the highest ash content with a mean value of 1.8 ± 0.008. Ash content is taken to be the measure for mineral composition of a sample. Abaomege Kpurupuru had the least protein content with a mean value of 7.95 ± 0.042 while Brown Basmati, Izzi 306 and Ikwo Adaigbo had the highest protein contents with mean values 9.13 ± 0.014, 8.80 ± 0.008 and 8.62 ± 0.049, respectively.

The results of the mean amylose content showed that Abaomege Kpurukpuru had the least amylose content (%) and the highest amylopectin content (%) with mean value of 18.4 ± 0.283 and 81.60 ± 0.283, respectively (Table 2). Brown Basmati and Golden Penny had the highest mean amylose content with values of 31.70 ± 9.141 and 30.2 ± 0.636, respectively. The results of the mineral composition (Table 3) shows that Golden Penny had the highest potassium content (mg/kg) while Mama Africa had the highest magnesium content with mean values of 486.32

Table 2. Percentage amylose and amylopectin contents of the nine rice samples (%)

Sample	**Amylose**	**Amylopectin**
Abaomege Kpurukpuru	18.40 ± 0.283^{g}	81.60 ± 0.283^{a}
Izzi 306	25.60 ± 1.131^{d}	74.40 ± 1.31^{d}
Ikwo Adaigbo	20.65 ± 0.071^{f}	79.35 ± 0.071^{b}
Sarina	20.15 ± 0.071^{f}	79.85 ± 0.71^{b}
Super Eagle	24.50 ± 9.141^{e}	75.50 ± 0.141^{c}
Mama Africa	27.70 ± 0.141^{c}	72.30 ± 0.141^{e}
Golden Penny	30.20 ± 0.636^{b}	69.80 ± 0.636^{f}
Brown Basmati	31.70 ± 9.141^{a}	68.30 ± 0.141^{g}
White Basmati	28.70 ± 0.141^{a}	71.30 ± 0.141^{g}

Means with different superscripts are statistically significant difference ($p < 0.05$)

± 0.000 and 170.14 ± 0.000, respectively. Brown Basmati had the highest iron content (mg/kg) with the mean value of 18.60 ± 0.007 followed by Golden Penny with the mean value of 16.44 ± 0.000. Among the rice varieties, Brown Basmati had the highest zinc content (mg/kg) with the mean value of 36.3 ± 0.141. Ikwo Adigbo was the only variety that showed a quantifiable value for vitamin A with mean value of 0.015±000a (Table 4).

The results for the nine rice varieties characterized for their proximate composition, amylose content, mineral and vitamin A contents show some marked differences in the inter groups as well as similarities in the intra groups varieties. For moisture content, all the values generated for each of the varieties are almost similar and below 14% optimal values for bag storage of grains (Juliano and Villareal 1993), except Ikwo Adigbo that had a value of 14.1%. Low moisture content is known to enhance keeping quality of rice under storage.

The fat contents (%) did not vary significantly ($p<0.05$) with the different varieties except Ikwo Adigbo that had a high value of 2.48 ±0.014. The results were much higher than the values of 1.10-1.50% for some milled rice varieties earlier reported by (Juliano and Villareal 1993). Since fat is more on the bran layer, the more this layer is removed during milling, the less the fat content of the milled rice (Okaka 2005). This could be the reason for the high fat content of Ikwo Adigbo. Higher fat content exposes the grains to spoilage during storage due to oxidation. For the nine rice varieties studied, Brown Basmati had the highest percentage protein content followed by Izzi 306, Ikwo Adaigbo and Mama Africa. All the varieties studied contained sufficient amount of protein which are above the reported values of 7% (Dipti *et al*. 2002; Dutta *et al*.

Table 3. Mineral composition of the nine rice samples (mg/kg)

Sample	Potassium	Magnesium	Sodium	Calcium	Iron	Zinc
Abaomege Kpurukpuru	278.16±0.014[c]	156.55±0.007[cd]	56.13±0.00[b]	73.5±0.007[g]	8.98±0.000[g]	21.98±0.007
Izzi 306	276.21±0.000[c]	154.125±0.007[d]	56.12±0.000[b]	78±0.000[f]	7.955±0.007[h]	24.2±0.000[b]
Ikwo Adaigbo	374.20±0.000[cd]	162.15±0.007[c]	58.14±0.000[b]	66±0.028[e]	12.18±0.000[f]	24.2±0.000[b]
Sarina	368.19±0.028[e]	158.14±0.000[cd]	55.13±0.000[b]	75.5±0.007[b]	13.24±0.000[e]	26.3±0.000[ab]
Super Eagle	382.95±0.000[b]	160.165±0.007[cd]	56.12±0.000[b]	67.09±0.014[d]	13.24±0.000[e]	24.2±0.000[b]
Mama Africa	367.90±0.007[d]	170.14±0.000[c]	60.14±0.028[b]	72.43±0.028[bc]	14.27±0.014[d]	20.5±0.141[a]
Golden Penny	486.32±0.000[a]	166.17±0.085[a]	55.13±0.014[b]	71.5±0.007[c]	16.44±0.000	20.5±0.141[a]
Brown Basmati	476.32±0.000[a]	164.12±0.000[a]	55.13±0.014[b]	91.05±0.014[a]	18.605±0.007[a]	36.3±0.141[ab]
White Basmati	428.34±0.000[a]	112.05±0.014[b]	63.17±0.014[a]	75.32±0.014[bc]	7.58±0.000[b]	28.5±0.141[a]

Means with different superscripts are statistically significant difference ($p < 0.05$)

1998). Protein helps in body growth; repairing and maintaining of body tissues. Prolonged parboiling and other environment/edaphic factors lower the protein content of rice. Brown Basmati had the highest value for protein. Crude fiber reduces the risk of bowel disorders and fights constipation. All the studied varieties showed high ash content which did not differ significantly ($P<0.05$) from each other and were within the acceptable ash value of 0.50-2.50 (%) reported by Edeogu *et al*. (2007). Ash residual generally taken to be a measure of the mineral content in milled rice is an indication of a good quantity of mineral content in the rice sample (Dipti *et al*. 2003).

Amylose content of rice is considered to be one of the most important factors influencing the cooking and processing characteristics of rice (Delwiche *et al*. 1995). The percentage amylose content of the assumed three diabetic rice; Brown Basmati, white Basmati and Golden Penny were high for natural rice (Oko *et al*. 2012; Panlasigui *et al*. 1991) and could be suspected to have been artificially constructed/reconstituted to meet this standard. Although Pete Vegas (Sage V Foods) in an online article claimed that Basmati rice (from India and Pakistan) has high amylose content and a firm dry texture when properly cooked, he failed to give the range of the percentage amylose to serve as a guide. Takeda *et al*. (1987) had calculated true amylose content of rice to be in the range of 15-19% for non-waxy rice. Rice varieties with a greater proportion of starch in the form of amylose tend to have a lower glycemic index. Amylose content of milled rice are said to correlate positively with hardness values of cooked rice and negatively with stickiness values (Perez and Juliano 1987). Low amylose levels are associated with cohesive, tender, and glossy cooked rice. On the other hand, high levels of amylose cause rice to absorb more water and consequently expand more during cooking, and the grains tend to cook dry, fluffy, and separate (Juliano 1971). Rice starch with high amylose starch show higher degree of retrogradation and lower increase in consistency index, shear stress and plastic viscosities than rice starch of lower amylose content (Tukomane and Varavinit 2008). Denardin *et al*. (2012) reported that high amylose feeds results in longer satiation, gain in body weight and apparent increases in digestibility, fecal water content and nitrogen excretion, reduced fecal pH, lower postprandial blood glucose response, serum total cholesterol, triglycerides levels, pancreas weight, and higher fasting serum glucose concentration as well as increased liver weight. Panlasigui *et al*. (1991) reported that digestibilities and glycemic responses are significantly different among rice varieties with similar amylose concentrations, arguing that amylose and amylopectin ratio is not the sole determining factor in rate of starch digestion and postprandial glycemic responses. However, the report of Fitzgerald *et al*. (2011) which stated that amylose was the only grain constituent that affected glycemic index, might be the basis on which the rice with high amylose contents in our report are used as diabetic specialty foods.

Table 4. Vitamin A (β -carotene) composition of the nine rice samples (μg)

Sample	Vitamin A (β -carotene)
Abaomege Kpurukpuru	0±- [b]
Izzi 306	0±-[b]
Ikwo Adaigbo	0.015±000[a]
Sarina	0± - [b]
Super Eagle	0± - [b]
Mama Africa	0± - [b]
Golden Penny	0± - [b]
Brown Basmati	0± - [b]
White Basmati	0±- [b]

Means with different superscripts are statistically significant difference ($p < 0.05$)

Micronutrient deficiencies in the rice are caused mainly due to low dietary intake of iron, vitamin A and zinc. Among vitamins, vitamin A deficiency (VAD) is prevalent among the people whose diets are based mainly on rice. Rice does not contain any β-carotene (apart from the golden rice), which the human body could convert into vitamin A. Major rice consuming population in the world therefore, having threat of VAD which affecting small children and pregnant women. Vitamin A can be obtained from food, either as preformed vitamin A in animal products or as provitamin A carotenoids, mainly β-carotene in plant products (*e.g*., dark-green leafy vegetables and fruit). The intake of vitamin A provides humans with an important nutrient for vision, growth, reproduction, cellular differentiation and proliferation, and integrity of the immune system. Therefore, the presence of β-carotene (vitamin A) in Ikwo Adaigbo is a very desirable trait which could be improved for better rice nutrition in the area.

The mineral contents of the varieties were within range expected (Shabbir *et al*. 2008). The zinc content of all the tested varieties were found satisfactory, as it was within the range reported by Kennedy *et al*. (1975). The calcium content was high when compared to the range reported by Kennedy *et al*. (1975). Presence of calcium in rice is a clear indication that when taken, will aid normal development and maintenance of bones and teeth, clotting of the blood and nerve irritability in the blood.

In conclusion, the values for percentage amylose recorded for the three so-called diabetic rice types does not present them as natural rice types as no literature supports such value of amylose for any cereal crop. On the other, the presence of vitamin A (β-carotene) in Ikwo Adaigbo is a desirable trait that could be exploited by both breeders and plant biotechnologists to develop an alternative to the called Golden rice.

REFERENCES

AACC 2000. Approved methods of analysis. American Association of Cereal Chemists. St. Paul, Minnesota, USA

Akintola AA 1998. Industrial Utilization and Processing of Rice: Implication for Sustainable Production and Industrial Policy Formulation-Workshop, IITA, Ibadan October, 19-24th

Alaka IC and Okaka JC 2011. Physicochemical and milling characteristics of some selected locally processed rice in South Eastern Nigeria. Journal of Science and Technology 17(1): 20-32

Delwiche SR, Bean MM, Miller RE, Webb BB and Williams PC 1995. Amylose content of rice is considered to be one of the most important factors influencing the cooking and processing characteristics of rice. Analytical techniques and instrumentation; Apparent amylose content of milled rice by near-infrared reflectance spectrophotometry. Cereal Chem. 72(2): 182-187

Denardin CC, Boufleur N, Reckziegel P, Leila Picolli da Silva and Walter M 2012. Amylose content in rice (*Oryza sativa* L.) affects performance, glycemic and lipidic metabolism in rats. Ciência Rural, Santa Maria. 42(2): 381-387

Dipti SS, Bari MN and Kabir KA 2003. Grain Quality Characteristics of some Beruin Rice Varieties of Bangladesh. Pakistan Journal of Nutrition 1(4): 242-245

Dipti SS, Hossain ST, Bari MN and Kabir KA 2002. Physiochemical and Cooking Properties of some fine rice varieties. Pakistan Journal of Nutrition 1(4): 188-190

Dutta RK, Lihiri BP and Basetmia MA 1998. Characterization of some aromatic and fine rice cultivars in relation to their physicochemical quality of grain. Ind. J. Plant Physiol. 3: 61-64

Edeogu CO, Ezeonu FC, Okaka ANC, Eku CE and Elom SO 2007. Proximate composition of staple food crops in Ebonyi State, South Eastern Niger. International Journal of Biotechnology and Biochemistry 3(1): 1-8

Eggum BO, Juliano BO and Magningat CC 1982. Protein and energy utilization of rice milling fractions. Journal of Human Nutrition 31: 371-376

Fitzgerald MA, Rahman S and Resurreccion AP 2011. Identification of a major genetic determinant of glycaemic index in rice. Rice 4(2): 66-74

Ibukun EO 2008. Effect of prolonged parboiling duration on proximate composition of rice. Journal of Scientific Research and Essay 3(7): 323-325

Juliano BO and Villarreal CP 1993. Grain quality evaluation of world rice. P. 148. International Rice Research Institute, Philippines

Juliano BO 1971. A simplified assay for milled-rice amylose. Cereal Sci. Today 16: 334-340 & 360

Kennedy BM, Schelstraete M and Tamai K 1975. Chemical, physical and nutritional properties of high-protein flours and residual kernel from the over milling of uncooked milled rice VI. Thiamine, Ribiflavin, Niasin and Pyridoxine. Cereal Chemistry 52: 181-188

Okaka JC 2005. Handling, storage and processing of plant foods. OCJ Publishers Enugu. pp. 3-5

Oko AO, Ubi BE and Dambaba N 2012. Rice cooking quality and physico-chemical characteristics:A comparative analysis of selected local and newly introduced rice varieties in Ebonyi State, Nigeria. Food and Public health 2(1): 43-49

Osaretin ATE and Abosede CO 2007. Effect of cooking and soaking on physical characteristics and sensory evaluation of indigenous and foreign rice varieties in Nigeria. African Journal of Biotechnology 6(8): 1016-1020

Panlasigui LN, Thompson LU, Juliano BO, Perez CM, Yiu SH and Greenberg GR 1991. Rice varieties with similar amylose content differ in starch digestibility and glycemic response in humans. Am. J. Clin. Nutr. 54: 871-877

Perez CM, Juliano BO, Pascal CG and Novenario VG 1987. Extracted lipids and carbohydrate during washing and boiling of milled rice starch. 36: 386-390

Shabbir MA, Anjum FM, Zahoor T and Nawaz H 2008. Mineral and pasting characterization of *Indica* rice varieties with different milling fractions. Int. J. Agri. Biol. 10: 556-60

Sanni SA, Okeleye KA, Soyode AF and Taiwo OC 2005. Physiochemical properties of early and medium maturing and Nigerian rice varieties. Nigerian Food Journal 23: 148-152

Snedecor GW and Cochran G 1969. Statistical method 6th Edition. The Iowa State University Press meshan. USA pp. 59-234

Takeda Y, Hizukud S and Juliano BO 1987. Structures of rice amylopectins with low and high affinities for iodine. Carbohydr. Res.168(1): 79-88

Thakur A and Gupta AK 2006. Water absorption characteristics of paddy; brown rice and husk uring soaking. Journal of Food Engineering 75: 252-257

Tukomane T and Varavinit S 2008. Classification of rice starch amylose content from rheological changes of starch paste after cold recrystallization. Starch/ Stärke. 60: 292-297

USA Rice Federation 2002. The natural history of rice, Food and Cultural Encyclopedia pp. 1-4

Wasserman T and Calderwood DL 1972. Rough Rice Drying. In D.F.Houston ed. Rice Chemistry and Technology. Am. Association Cereal Chemistry in crop. St. Paul. Mn. USA. pp. 166-187

Yadav BK and Jindal VK 2007. Modeling varietal effect on the water uptake behaviour of milled rice (*Oryza sativa* L) during soaking. Journal of Food Process Engineering 30: 670- 684