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Evaluation of the chemical composition and sensory quality of parboiled local and imported milled rice varieties marketed in south-east zone of Nigeria

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Rice imported into Nigeria is generally *perceived* to be of higher quality nutritionally than local rice which has caused low patronage and low market share for local rice. It is therefore essential to compare the nutritional composition and sensory quality of these local and imported rice varieties to verify the perceived claims. Eighteen local and 3 imported rice varieties coded Ip1, Ip2 and Ip3, were evaluated for proximate, mineral and sensory properties using standard methods. All the local rice varieties had significant ($p<0.05$) higher protein content (7.72-12.32%) than the imported rice varieties (6.36-7.30%) except Taraba rice (4.71). Omor-Mas had the highest ash content (2.73%). Ip2 had the highest fibre content (3.70%) though it was not significantly ($p>0.05$) different from Omor-Mas (3.50 %). The imported rice varieties had higher carbohydrate content (72.20-76.21%) though all the rice varieties had high carbohydrate content (67.72-76.21%). Local parboiled rice were extremely rich in phosphorus (235.02-421.01 mg/L), magnesium (106.32-296.12 mg/L), potassium (109.01-238.02 mg/L) and sodium (124.01-169.01 mg/L) though Ip1 and Ip3 had the highest phosphorus (550.01 mg/L) and potassium content (260.01 mg/L) respectively. Eighty-eight percent (88.89%) of the local rice varieties were not significantly ($p >0.05$) different from the imported rice varieties in their sensory overall acceptability. Different percentages of the local rice varieties were better than the imported rice varieties in protein, ash, magnesium, iron, zinc, calcium, manganese and sodium. This knowledge is expedient to educate, increase patronage of local rice and enhance value addition.

Keywords: *Oryza sativa* L, proximate composition, mineral composition, imported rice, local rice.

INTRODUCTION

Rice is the staple food for billions of people especially in developing countries (Oko and Ugwu, 2011; Juliano, 1993; Abiona, 2011; Imolehin and Wada, 2009; Anonymous, 2009). It is the predominant staple food in at

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least 33 developing countries (Kennedy et al., 2002) including Nigeria. There has been great increase in rice consumption in Nigeria since the 1960s, when rice was served essentially at banquets and celebrations. It has become one of the basic foods in Nigerians' diet. Urban growth has caused a continual rise in annual rice consumption, which went from 8 kg per person in 1960 to 27 kg per person in 2007 (Diagne et al., 2011). Local rice sold in Nigeria markets are parboiled along with those imported into Nigeria. Parboiling increases the nutrient composition of the rice grains as the minerals, protein and vitamins present in the hull and bran of paddy, migrate to the starchy endosperm during parboiling thereby increasing the protein and mineral composition of the grain and among also other benefits (Nkama et al., 2011). Most people in developing countries suffer from protein-energy malnutrition and micronutrient malnutrition. The severe forms of these diseases are usually associated with high level of mortality (Ubesie and Ibeziakor, 2012). Protein-energy malnutrition and micronutrient malnutrition has recorded death of which hundreds of millions of pregnant women and young children are particularly affected. Apart from marasmus and kwashiorkor, deficiencies in iron, iodine, vitamin A and zinc are the main manifestations of malnutrition in developing countries. In these communities, a high prevalence of poor diet and infectious disease regularly unites into a vicious circle (Müller and Krawinkel, 2005). Therefore parboiling of rice before consumption is encouraged to increase the protein and micronutrient intake of rice consumers and contribute in no little significant way to curb malnutrition.

Parboiled local rice is perceived to be less nutritional than parboiled imported rice which has led to poor market share for local rice while increasing the patronage of imported rice especially among urban dwellers with high income. Dependence of the urban dwellers on imported rice has caused an influx of imported rice in the market whereas local rice is neglected and reserved for the rural and urban poor because they are cheap. A survey conducted on the food rice consumption pattern in the capital and commercial cities of Nigeria, Abuja and Lagos state respectively showed a high disparity in the local rice and imported rice consumption pattern. The survey showed the value of imported rice consumption in these places as 88.3% and only 2.6% for local rice consumption. A value of 9.1% was recorded for the consumption pattern of both local and imported rice varieties (Adeyeye, 2013). Nigeria is a country with a population estimated at over 177 million (177,155,754) people as at September, 2014 (Nigeria Demographics Profile, 2014). The population of people residing in these commercial places is approximately 7% of the population data. The cost of these rice imports represents a significant amount of lost earnings for the country in terms of GDP, jobs and income (Diagne et al., 2011) especially at a time when majority of Nigerian youths are unemployed.

Importation of rice has caused depletion of Nigeria's foreign reserve as former Minister of Agriculture and Rural Development, Dr. Akinwumi Adesina in December 2013 revealed that the country spends over N356 billion on yearly importation of rice, out of which about 1 billion is used per day (Akinwumi, 2013). In order to conserve Nigeria's foreign revenue and increase the market share of local rice, it is first essential to evaluate the nutritional composition of the local and imported rice varieties and verify the perceived claims whereby further research will focus on fortifying the local rice varieties where deficiency exist. Proximate and mineral composition of rice in Ebonyi state Nigeria have been studied by different researchers (Oko and Ugwu 2011; Oko et al., 2012., Alaka et al., 2011) but limited studies have been conducted on comparing the chemical composition and sensory properties of local and imported rice varieties marketed in South-East zone of Nigeria. The objective of this work was to evaluate the proximate, mineral composition and sensory properties of parboiled milled local rice varieties sold in South-East Nigeria, and compare them to the imported varieties, in order to educate, enhance value addition, increase patronage of local rice and suggest fortification where deficiency exist.

MATERIALS AND METHODS

Eighteen varieties of parboiled milled local rice samples were obtained from different markets and rice processing units in Enugu State (FARO 44, Fadama, Fortin 16 and Fortin 16 old variety), Anambra State (Omor-Mas, R-Bus, FARO 40, Igboukwu rice, Aguleri rice, Taraba rice and B-G) and Ebonyi State (Akpujie, kpurukpuru, Afikpo-Mas, Abakiliki Mas, R-8, 306 and Geshua). Three imported rice varieties (coded Ip1, Ip2, and Ip3 serving as controls) were purchased from Ogige market in Nsukka Local Government Area of Enugu State, Nigeria. The imported rice varieties were procured based on cost (Ip1), commonly consumed rice variety (Ip2) and difference in length size (Ip3). The samples collected were cleaned manually using plastic trays to remove husk, shriveled kernels (defectives), stones and seeds according to the method by Moongngarm et al. (2014). The rice samples were stored at 25 ± 2°C in moisture free environment until needed. All reagents used in this study were of analytical grades.

Proximate analysis

The moisture, crude protein, crude fat, crude fibre and ash contents of the rice grain samples were determined using AOAC methods (2010). Carbohydrate was calculated by difference. Duplicate determinations were made in each evaluation.

Mineral analysis

The mineral content of the rice samples was determined using the methods of the AOAC as described by ASEAN manual of food analysis (2011). Calcium, Magnesium, Sodium and Potassium, iron, zinc, manganese and lead were determined by Atomic Absorption Spectrometry (Hitachi model 170-10) at 422.7, 285.2, 589.0, 766.5, 248.3, 213.9, 279.5 and 217 nm respectively. Phosphorus was

determined by Molybdate gravimetric method as described by ASEAN manual of food analysis.

Sensory analysis

Sensory evaluation of cooked grain samples was conducted according to the method as described by Ihekoronye and Ngoddy (1985). A ten man semi-trained panellist was used for the analysis. The samples were evaluated for colour, texture, mouth feel, taste, aroma, and overall acceptability. A 9-point hedonic scale was used to determine the overall acceptability of the samples where 9 represented like extremely and 1 represented dislike extremely. Potable water was provided for the panelists for rinsing their mouth intermittently during the analysis.

Statistical analysis

The study adopted a completely randomized design (CRD). The data generated were subjected to statistical analysis of variance (ANOVA) using SPSS version 20.0 to determine significance among treatment at 5% level of probability. Means were separated using the Duncan's Multiple Range Test (DMRT) (Akande et al., 2017).

RESULTS AND DISCUSSION

Proximate composition of parboiled milled local rice varieties

Table 1 shows the proximate composition of parboiled milled local rice varieties sold in South-East Nigeria. All the local rice varieties had higher protein content (7.72-12.32%) than the imported rice varieties (6.36-7.30%) except for Taraba rice (4.67%). The local rice varieties had higher protein content than the USDA standard value (7.00%) for white raw rice. The local rice varieties were also far better than the value of 2.83% reported by Pachuau et al. (2017) for crude protein content of glutinous Mizoram rice from India but some were within the range 7.88-9.48% reported by Alaka et al. (2011) on chemical properties of some selected rice varieties (9 milled rice varieties) in Ebonyi state. The protein content of the local rice varieties were also higher than the value (1.58-7.94%) reported by Oko et al. (2012) on chemical composition of selected local and newly introduced rice varieties (15 cultivars) grown in Ebonyi state. Afikpo-Mas and Kpurukpuru had protein content of 9.20 and 8.22% respectively which did not differ widely from the result reported by Alaka et al. (2011) of 7.86 and 9.48% respectively.

Ip1 had the highest fat content (3.94%) among all the other rice varieties and was significantly ($p<0.05$) different from all the other rice varieties (2.19-3.47%). The composition of fat present in a cultivar is dependent on the degree of milling, bran and germ removal and also on cultivar. The higher the degree of milling, bran and germ removal, the less the fat content of the cultivar because most of the oil content is present in the germ. The high fat content of Ip3 may be as a result of cultivar as most of the imported rice varieties are milled to high degree compared to local rice resulting in large removal of bran and germ. Some (38.89%) of the local rice varieties had higher fat content (3.06 -3.47%) than Ip3 (3.05%) while 66.67% of the local rice varieties had higher fat content than Ip2 (2.73%). The fat content of rice is healthy as it is rich in monounsaturated and polyunsaturated fat (Anonymous, 2017c). Fat gives satiety when eaten. Rice varieties from Ebonyi State had fat content of 2.47-3.17%. which were higher than the value reported by Alaka et al. (2011) who reported a fat content of 2.02-2.23% but within the range of value reported by Oko et al. (2012) of 0.5-3.0%.

Omor-Mas had the highest ash content (2.73%) among all the rice varieties followed by R-8 (2.55%) and then Geshua (2.54). The values of the ash content of local rice varieties (1.80- 2.73%) were within the values reported by Oko et al. (2012) of (0.5-2.0%) and Alaka et al. (2011) of (0.8- 2.40%) for ash content. The ash content of the rice varieties is an indication of the mineral content of the rice varieties. The higher the milling degree (removal of germ and bran), the lower the mineral composition of the rice varieties because most of the minerals are contained in the bran and germ. Ip2 had the highest fibre content (3.70%) among all the rice varieties though there were no significant ($p>0.05$) differences between it and Omor – Mas of value 3.50%. A significant percentage (50%) of the local rice varieties had fibre content higher than Ip1 while a large percentage (77.78%) of the local rice varieties had fibre content higher than Ip3. Omor-Mas had the highest fibre content (3.50%) among the local rice varieties followed by FARO 44 (3.31) and then Abakiliki-mas (3.28). The fibre content of the local varieties (1.81-3.50%) were within the range reported by Oko et al. (2012) (1.0-2.5%) though higher than USDA report of 1.3%. The higher the milling degree (removal of germ and bran), the lower the fibre composition of the rice varieties because most of the fibre is contained in the bran. Fibre adds bulk to food and aids in bowel movement.

A large percentage (72.22%) of the local rice varieties had moisture content of 9.60-11.97% which is within the limit for safe long term storage (12%) and therefore will have longer shelf-life (more than a year) without spoilage. Rice varieties with high moisture content will sell at a higher price than those with low moisture content as moisture is weight and has to be paid for. Moisture content values were higher than the values (3.67-8.0%) reported by Oko et al. (2012) but within the range of value 7.6-12.2% reported by Alaka et al. (2011) The difference in moisture content may be as a result of humidity of different environment during storage as rice is hygroscopic in nature. Significant ($p < 0.05$) differences existed in the carbohydrate content of the imported rice varieties. It was observed that the lower the protein content of the rice varieties the higher the carbohydrate

Table 1. Proximate Composition (%) of Milled Domestic Rice Varieties Sold in South-East Nigeria.

Rice variety	Moisture	Protein	Fat	Ash	Fibre	carbohydrate
Imported rice varieties						
Ip1	13.55^{a}±0.04	7.30^{fgh}±0.14	3.94^{a}±0.08	1.79^{f}±0.02	2.80^{ef}±0.14	72.20^{i}±0.09
Ip2	11.86^{f}±0.05	6.51^{ghi}±0.28	2.73^{ef}±0.10	2.31^{cd}±0.13	3.70^{a}±0.14	75.29^{cd}±0.13
Ip3	11.56^{gh}±0.19	6.36^{hi}±0.20	3.05^{d}±0.07	2.25^{de}±0.08	2.35^{h}±0.07	76.21^{a}±0.14
Enugu state						
FARO 44	12.82^{cd}±0.01	12.32^{ab}±0.12	2.19^{i}±0.02	2.25^{de}±0.08	3.31^{bc}±0.13	69.10^{k}±0.12
Fadama	10.29^{jk}±0.11	10.21^{bcd}±0.01	3.37^{bc}±0.05	2.33^{cd}±0.11	2.60^{fg}±0.14	73.29^{g}±0.08
Fortin 16	11.79^{fg}±0.11	13.89^{a}±0.02	3.42^{b}±0.11	1.85^{f}±0.08	2.96^{de}±0.06	67.72^{L}±0.01
Fortin 16 (old variety)	12.56^{de}±0.06	11.16^{bc}±0.01	2.76^{ef}±0.06	2.27^{de}±0.14	2.96^{de}±0.06	70.33^{j}±0.15
Anambra state						
Omor-Mas	11.97^{f}±0.08	11.06^{bc}±0.08	2.78^{e}±0.28	2.73^{a}±0.08	3.50^{ab}±0.14	70.45^{j}±0.17
R-Bus	10.33^{jk}±0.18	11.21^{bc}±0.13	2.53^{fgh}±0.11	2.28^{cd}±0.05	2.84^{ef}±0.09	72.74^{h}±0.01
FARO 40	10.83^{i}±0.19	8.62^{defg}±0.13	3.16^{c}±0.06	1.44^{g}±0.03	2.31^{h}±0.12	74.63^{e} ±0.14
Igboukwu rice	9.60^{L}±0.14	9.11^{cdef}±0.01	2.79^{e}±0.02	1.70^{f}±0.06	2.66^{fg}±0.06	75.61^{b}±1.13
Aguleri rice	9.63^{L}±0.14	10.08^{cd}±0.05	2.31^{hi}±0.13	2.07^{e}±0.06	1.81^{i}±0.13	75.78^{b}±0.22
Taraba rice	11.4^{h}±0.21	4.67^{i}±4.26	3.06^{d}±0.06	2.29^{cd}±0.04	2.06^{i}±0.08	75.52^{bc} ±0.16
B-G	10.82^{i}±0.08	7.72^{efgh}±0.01	3.47^{b}±0.18	2.48^{bc}±0.05	2.51^{gh}±0.13	75.17^{d} ±0.06
Ebonyi state						
Akpujie	10.48^{jk}±0.21	8.34^{defgh}±0.14	2.62^{efg}±0.11	1.80 ^{f}±0.04	2.98^{de}±0.03	75.23^{d} ±0.01
Kpurukpuru	12.50^{e}±0.24	8.22^{defgh}±0.14	3.17^{c}±0.42	1.73^{f}±0.05	2.71^{fg}±0.13	72.85^{h}±0.08
Afikpo Mas	10.40^{jk}±0.14	9.20^{cdef}±0.04	3.05^{d}±0.07	2.17 ^{de}±0.13	2.31^{h}±0.13	74.78^{e}±0.07
Abakiliki Mas	10.20^{k}±0.01	9.58^{cde}±0.06	3.15^{c}±0.08	2.22 ^{de}±0.14	3.28^{bc}±0.04	73.73^{f} ±0.07
R-8	13.18^{b}±0.09	10.38^{bcd}±0.08	2.73^{ef}±0.25	2.55^{ab}±0.08	2.96^{de}±0.06	70.32^{j}±0.15
306	10.56^{ij}±0.18	10.17^{bcd}±0.06	2.77^{e}±0.09	2.19 ^{de}±0.05	2.51^{gh}±0.13	73.80^{f}±0.12
Geshua	12.91^{bc}±0.04	11.07^{bc}±0.06	2.47^{gh}±0.09	2.54 ^{ab}±0.16	3.17^{cd}±0.04	70.38^{j}±0.11
Mean	11.24	9.83	2.88	2.16	2.75	72.86
SE	0.06	0.65	0.05	0.05	0.04	0.05
$LSD_{0.05}$	0.16	1.92	0.16	0.16	0.12	0.15
CV (%)	0.7	9.8	2.6	3.6	2.0	0.1

* Values are means± standard deviation of duplicate determination. Means in the same column carrying similar superscript are not significantly ($p > 0.05$) different.

content. All the rice varieties had high carbohydrate content (67.72 -76.21%) which supports the fact that rice is a starchy food. Ip3 (76.21%) had the highest carbohydrate content but lower than the USDA report of 80% for white raw rice (USDA, 2018). The local rice varieties from Enugu State had a low carbohydrate content compared to the rice varieties from Anambra State which may be as a result of soil composition. The carbohydrate content of the local rice varieties (67.72 - 75.78%) were within the range of value 51.33-86.82% as reported by Oko et al. (2012) but however, slightly less than the value of 83.48% earlier reported by Pachuau et al. (2017) for glutinous rice starch of Mizoram rice, India.

Mineral composition of the local and imported rice varieties

Table 2 shows the mineral composition of the rice varieties. All the rice varieties were extremely low on lead (0.02 -0.15 mg/L) which is good as lead is poisonous to human. They were also low on manganese (0.00 -0.04 mg/L) and zinc (0.02 -1.21 mg/L) when compared to cereals like Oat which is rich in manganese 7.7 mg (Ravi, 2018a) and zinc 6.2 mg (Ravi, 2018b). A significant ($p<0.05$) percentage (33.33%) of the local rice varieties had higher magnesium content (296.12- 162.01 mg/L) than the imported rice varieties. The zinc content of the rice varieties were low compared to the report of Alaka et al. (2011) of 6.54-9.81 mg. A significant percentage (50%) of the local rice varieties had iron content (1.13 - 2.52 mg/L) higher than the 0.8 mg reported by USDA for long white raw rice (USDA, 2018), also it was higher than the imported rice varieties (0.25-1.12 mg/L) and higher than 0.96-1.21 reported by Alaka et al. (2011). The phosphorus content of the local rice varieties (235.02-421.01 mg/L) were within the range reported by nutrition data 333 mg (Self-Nutrition Data, 2018) but 33.33% of the rice varieties were higher than the reported value though Ip1 had a higher phosphorus content (550.01 mg/L). The magnesium (106.32 -296.12 mg/L), potassium (127.02-260.01 mg/L) and sodium (124.01 - 169.01 mg/L) content of the local rice varieties were higher than the values reported by USDA of 25 mg for magnesium; 115 mg for potassium and 5 mg for sodium in rice. Ip3 had higher potassium content (260.01 mg/L) but the local rice varieties had higher sodium and magnesium content. The rice varieties were moderately low on calcium (28.01 -41.02 mg/L) but higher than the value reported by USDA of 28 .00 mg and also higher than the value 1.0- 1.75 mg reported by Alaka et al., (2011).

Phosphorus, magnesium, potassium and sodium support hundreds of chemical reactions in the body. Magnesium acts as a co factor or helper molecule in the biochemical reactions continuously performed by enzymes (Anonymous, 2017a). Phosphorus helps in healthy bone formation along with calcium. Phosphorus also helps in improved digestion, hormonal balance, improved energy extraction, optimized chemical reactions and proper nutrient utilization (Anonymous, 2017b). Fifty percent (50%) of local rice varieties had higher iron content (2.52- 1.13 mg/L) than the imported rice varieties (1.12 mg/L). A significant percentage (55.56%) of the local rice varieties had higher sodium (169.01-132.02 mg/L) and zinc (1.21-1.02 mg/L) than the imported rice varieties. A significant percentage (22.22%) of the local rice had higher phosphorus content than Ip2 and Ip3. A high percentage (94.4%) of the local rice varieties had higher potassium content than Ip1 and Ip2.

Sensory evaluation

Table 3 shows the sensory quality of local and imported rice varieties sold in South-East Nigeria. Significant ($p < 0.05$) differences existed in the colour quality of the imported rice varieties and some of the local rice varieties. The colour acceptability level of the imported rice varieties ranged from 4.40-8.70 while that of the local rice varieties ranged from 3.20- 8.20. Ip3 was mostly preferred (8.70) followed by Ip2 and then Ip1. Ip3 had a white colour while Ip1 had a slight brown colour and then Ip2 had a creamy colour. Abakiliki-Mas (8.20) and Omor-Mas (8.20) were also liked very much with white colour. This showed that consumers preferred rice with pure white colour than rice with other colours and some of the local rice were also white in colour along with the imported rice. Geshua had brown colour with red streak and was disliked moderately (3.20)

The texture acceptability level of the imported rice varieties ranged from 5.10-6.90 while that of the local rice varieties ranged from 5.80- 7.80. There was no significant ($p > 0.05$) difference in texture among Ip1, Ip2 and 94.44% of the local rice varieties. The texture of a large percentage (94.44%) of the local rice varieties along with Ip1 and Ip2 tends to be clumpy and slightly less tender when cooled. Ip3 was neither liked nor disliked because it was clumpy (packed together) while Geshua was neither liked nor disliked because it was non-clumpy and dry. This shows that Nigerian rice consumers do not like rice which are clumpy or dry in texture and most of the local rice along with Ip1 and 1p2 were not associated with this property.

There was no significant ($p > 0.05$) difference in the mouthfeel of the imported rice varieties and a large percentage (88.89%) of the local rice varieties. The mouthfeel of most of the rice samples was moist and tender and were liked from moderately (7.00) to slightly (6.00). FARO 44 was liked moderately in mouthfeel (7.80) than all the other rice varieties. Geshua was disliked slightly (4.60) by consumers. Geshua is dry in the mouth which may be the reason why it was disliked. Rice consumers do not like rice that is dry in the mouth. They

Table 2. Mineral composition (mg/100g) of local rice varieties obtained from South-East zone of Nigeria.

Rice variety	Mg	Fe	Ca	Na	P	K	Zn	Mn	Pb
Imported rice variety									
Ip1	148.02^{j}±0.03	1.12^{g}±0.01	40.02^{b}±0.02	124.02^{m}±0.03	550.01^{a}±0.01	108.01^{t}±0.01	0.25^{d}±0.01	0.01^{b}±0.01	0.02^{f}±0.01
Ip2	168.01^{g}±0.01	0.25^{k}±0.03	33.02^{d}±0.02	126.01^{l}±0.01	310.02^{k}±0.03	116.01^{r}±0.01	0.24^{de}±0.01	0.01^{b}±0.01	0.11^{c}±0.00
Ip3	159.01^{i}±0.01	0.48^{i}±0.01	38.01^{d}±0.01	132.01^{h}±0.01	345.01^{f}±0.01	260.01^{a}±0.01	0.23^{e}±0.01	0.01^{b}±0.01	0.12^{c}±0.00
Enugu state									
FARO 44	115.01^{r}±0.01	1.19^{e}±0.01	29.01^{l}±0.01	138.01^{e}±0.01	415.02^{c}±0.02	237.02^{c}±0.02	1.13^{b}±0.01	0.01^{b}±0.01	0.12^{c}±0.00
Fadama	125.12^{n}±0.03	0.20^{l}±0.01	22.02^{n}±0.02	169.01^{a}±0.01	364.01^{e}±0.01	128.01^{p}±0.01	0.14^{f}±0.01	0.01^{b}±0.01	0.11^{d}±0.00
Fortin 16	129.02^{m}±0.02	2.24^{b}±0.02	30.01^{k}±0.01	145.02^{b}±0.02	273.02^{p}±0.02	134.01^{m}±0.01	0.13^{f}±0.00	0.01^{b}±0.01	0.12^{c}±0.00
Fortin 16 (old variety)	202.42^{d}±0.02	1.42^{d}±0.01	34.01^{h}±0.01	130.02^{i}±0.02	304.01^{l}±0.01	129.01^{o}±0.01	1.12^{b}±0.01	0.00^{b}±0.00	0.13^{b}±0.00
Anambra state									
Omor-Mas	162.01^{h}±0.01	0.13^{m}±0.01	41.02^{a}±0.03	137.01^{f}±0.01	294.00^{n}±0.00	142.02^{k}±0.02	1.03^{c}±0.01	0.01^{b}±0.01	0.02^{f}±0.00
R-Bus	121.01^{p}±0.01	0.22^{kl}±0.01	36.02^{f}±0.02	135.02^{g}±0.02	281.01^{o}±0.01	238.02^{b}±0.03	0.02^{g}±0.01	0.01^{b}±0.01	0.01^{g}±0.00
FARO 40	296.12^{a}±0.02	0.31^{j}±0.01	28.01^{m}±0.01	138.02^{e}±0.03	327.02^{i}±0.03	234.02^{d}±0.01	0.03^{g}±0.01	0.01^{b}±0.01	0.01^{g}±0.00
Igboukwu rice	290.02^{b}±0.03	1.13^{fg}±0.02	31.01^{j}±0.01	124.01^{m}±0.01	342.01^{g}±0.01	143.02^{j}±0.03	1.03^{c}±0.01	0.00^{b}±0.00	0.02^{f}±0.00
Aguleri rice	142.01^{k}±0.01	0.25^{k}±0.01	38.02^{d}±0.02	127.01^{k}±0.01	421.01^{b}±0.01	145.01^{h}±0.01	1.14^{b}±0.01	0.00^{b}±0.00	0.02^{f}±0.00
Taraba rice	141.32^{l}±0.02	0.22^{kl}±0.01	40.02^{b}±0.03	130.01^{i}±0.01	403.01^{d}±0.01	138.01^{l}±0.01	0.12^{f}±0.01	0.00^{b}±0.00	0.02^{f}±0.00
B-G	198.22^{e}±0.03	2.27^{b}±0.01	35.01^{g}±0.01	132.02^{h}±0.02	328.01^{h}±0.01	146.02^{g}±0.02	1.12^{b}±0.01	0.01^{b}±0.00	0.02^{f}±0.00
Ebonyi state									
Akpujie	113.01^{s}±0.01	1.16^{ef}±0.02	38.00^{d}±0.00	129.01^{j}±0.01	342.01^{g}±0.01	149.01^{f}±0.01	0.03^{g}±0.01	0.00^{b}±0.00	0.02^{f}±0.01
kpurukpuru	112.12^{t}±0.02	0.22^{kl}±0.01	40.02^{b}±0.03	140.02^{c}±0.03	235.02^{t}±0.02	151.02^{e}±0.03	1.02^{c}±0.01	0.00^{b}±0.00	0.12^{c}±0.00
Afikpo-Mas	192.32^{f}±0.03	0.16^{m}±0.01	37.02^{e}±0.02	139.02^{d}±0.02	302.01^{m}±0.01	142.02^{k}±0.02	0.04^{g}±0.01	0.00^{b}±0.00	0.12^{c} ±0.00
Abakiliki Mas	123.41^{o}±0.01	1.43^{d}±0.02	39.01^{c}±0.01	130.01^{i}±0.01	321.00^{j}±0.00	109.01^{s}±0.01	1.03^{c}±0.01	0.04^{a}±0.00	0.01^{g}±0.00
R-8	116.22^{q}±0.02	1.72^{c}±0.01	41.01^{a}±0.01	132.01^{h}±0.01	265.02^{q}±0.02	127.02^{q}±0.02	1.12^{b}±0.02	0.01^{b}±0.00	0.13^{b}±0.00
306	106.32^{u}±0.03	0.52^{h}±0.01	36.02^{f}±0.03	135.02^{g}±0.02	249.02^{r}±0.03	132.02^{n}±0.03	0.22^{e}±0.02	0.00^{b}±0.00	0.10^{e}±0.00
Geshua	211.01^{c}±0.01	2.52^{a}±0.02	35.02^{g}±0.02	129.01^{j}±0.01	237.02^{s}±0.02	144.02^{i}±0.02	1.21^{a}±0.01	0.00^{b}±0.00	0.15^{a}±0.00
Mean	160.56±53.91	0.91±0.77	35.30±4.91	134.34±9.55	328.96±72.66	154.87±44.73	0.59±0.49	0.01±0.01	0.07±0.05

* Values are means± standard deviation of triplicate determination. Means in the same column carrying similar superscript are not significantly ($p > 0.05$) different.

prefer rice that is moist and tender as seen in most of the rice cultivars. There were no significant ($p > 0.05$) differences in taste between the imported rice varieties and the local rice varieties. The taste of the rice varieties ranged from sour to sweet taste and bland. Igboukwu rice had a bland taste. The taste of Igboukwu rice was liked moderately (7.70) than all the other rice varieties. This showed that the taste of rice is insignificant to its acceptability by consumers. There were no significant ($p > 0.05$) differences in aroma of the imported rice varieties and a large

Table 3. Sensory evaluation of cooked domestic rice varieties sold in South-East Nigeria.

Rice varieties	Colour	Texture	Mouthfeel	Taste	Aroma	Overall acceptability
Imported rice varieties						
Ip1	4.40^{ab}±2.37	6.90^{bcd}±1.52	5.80^{ab}±1.69	6.40^{abc}±1.58	6.40^{ab}±1.96	6.30^{bcd}±2.87
Ip2	7.00^{efghi}±1.25	7.20^{bcd}±1.69	6.70^{bc}±2.06	7.50^{bc}±1.43	7.00^{ab}±1.63	7.50^{cd}±1.08
Ip3	8.70^{j}±0.67	5.10^{a}±2.72	6.50^{bc}±2.80	6.90^{abc}±2.38	7.30^{b}±1.42	6.80^{bcd}±2.94
Enugu State						
FARO 44	8.0^{hij}±1.05	7.80^{cd}±0.92	7.80^{c}±1.32	7.40^{bc}±1.65	7.40^{b}±1.51	7.90^{d}±1.29
Fadama	6.70^{defgh}±0.48	7.20^{bcd}±0.79	7.30^{bc}±1.25	7.00^{abc}±1.76	7.00^{ab}±1.33	6.80^{bcd}±1.40
Fortin 16	5.30^{bcd}±2.00	6.90^{bcd}±1.44	6.00^{ab}±2.21	6.90^{abc}±1.66	7.50^{b}±1.43	6.20^{bc}±1.87
Fortin 16 (old variety)	6.40^{cdef}±0.70	6.60^{bcd}±0.70	6.40^{bc}±1.26	6.80^{abc}±1.23	7.00^{ab}±0.67	6.90^{bcd}±1.37
Anambra State						
Omor-Mas	8.20^{ij}±0.92	7.50^{cd}±1.1.27	7.50^{bc}±1.90	7.10^{abc}±1.29	7.50^{b}±1.27	7.90^{d}±0.88
R-Bus	6.20^{cdef}±1.87	7.30^{bcd}±1.49	6.60^{bc}±1.35	6.20^{abc}±1.40	7.30^{b}±1.57	7.10^{bcd}±1.20
FARO 40	5.20^{bc}±2.04	6.90^{bcd}±1.20	5.90^{ab}±2.08	6.00^{ab}±1.76	6.80^{ab}±1.69	5.70^{ab}±1.83
Igboukwu rice	5.30^{bcd}±2.11	6.80^{bcd}±1.23	7.30^{bc}±1.25	7.70^{c}±0.67	7.40^{b}±0.97	7.00^{bc}±1.25
Aguleri rice	6.50^{cdefg}±0.53	6.40^{abcd}±1.07	6.50^{bc}±0.71	6.90^{abc}±1.20	7.00^{ab}±0.82	6.90^{bcd}±0.74
Taraba rice	7.00^{efghi}±1.15	6.20^{abc}±1.48	6.50^{bc}±1.18	6.90^{abc}±1.37	6.60^{ab}±1.26	6.90^{bcd}±0.99
B-G	6.40^{cdef}±1.65	6.70^{bcd}±1.49	6.90^{bc}±0.88	7.10^{abc}±1.37	5.50^{a}±2.59	6.70^{bcd}±0.67
Ebonyi State						
Akpujie	7.20^{efghi}±0.79	7.70^{cd}±1.06	7.00^{bc}±0.67	6.90^{abc}±0.94	7.50^{b}±0.85	7.60^{cd}±0.97
kpurukpuru	7.90^{ghij}±0.88	7.30^{bcd}±0.82	7.20^{bc}±0.63	7.20^{abc}±1.13	7.40^{b}±0.52	7.70^{cd}±0.82
Afikpo-Mas	7.40^{fghij}±0.97	7.40^{cd}±0.70	7.10^{bc}±0.99	7.60^{bc}±0.70	7.20^{b}±1.14	7.20^{bcd}±1.23
Abakiliki-Mas	8.20^{ij}±0.92	7.80^{cd}±1.57	6.70^{bc}±2.00	5.20^{abc}±1.90	6.60^{ab}±2.27	7.40^{cd}±1.17
R-8	5.80^{cde}±2.10	6.40^{abcd}±1.96	6.00^{ab}±2.05	6.30^{abc}±1.83	6.60^{ab}±0.97	6.60^{bcd}±1.71
306	7.90^{ghij}±0.57	7.50^{cd}±0.97	7.30^{bc}±0.82	6.90^{abc}±1.52	7.50^{b}±0.71	7.80^{cd}±0.92
Geshua	3.20^{a}±1.87	5.80^{ab}±1.62	4.60^{a}±1.84	5.70^{a}±1.77	6.10^{ab}±1.37	4.40^{a}±2.07
Mean	6.61±1.92	6.92±1.50	6.65±1.67	6.79±1.62	6.98±1.45	6.92±1.65
SE	0.44	0.45	0.51	0.47	0.45	0.48
$LSD_{0.05}$	1.22	1.24	1.42	1.32	1.24	1.35
CV (%)	40.8	45.7	48.1	47.8	46.7	49.8

* Values are means± standard deviation of replicate determination. Means in the same column carrying similar superscript are not significantly ($p > 0.05$) different.
9=like extremely, 8= like very much, 7= like moderately, 6= like slightly, 5= neither like nor dislike, 4=dislike slightly, 3= dislike moderately. 2= dislike very much, 1= dislike extremely.

percentage (94.44%) of the local rice varieties. Significant differences existed between Ip3 and B-G. B-G had an unpleasant aroma while Ip3 had a sweet aroma. B-G (5.50) was neither liked nor disliked. The aroma of all other local rice varieties were liked from moderately to slightly. Geshua (6.10), R-8 (6.60), Abakiliki-Mas (6.60), Taraba rice (6.60) and FARO 40 (6.80) were liked slightly. For local rice varieties which were aromatic, their aroma was less pronounced. The overall acceptability level of the imported rice varieties ranged from 6.30- 7.50 while that of the local rice varieties ranged from 4.40-7.90. Geshua (4.40) was disliked slightly while FARO 40 (5.70) was neither liked nor disliked. FARO 40 was neither liked nor disliked which may be as a result of its slight brown colour. There was no significant ($p > 0.05$) difference in the overall acceptability of the imported rice varieties and a large percentage (88.89%) of the local rice varieties. The sensory quality showed that there were no significant ($p > 0.05$) differences in the eating quality of the imported rice cultivars to a large percentage (88.9%) of the local rice cultivars. The local rice varieties were liked moderately than the imported rice varieties in overall acceptability though there was no significant ($p<0.05$) difference between them, so fair share of the market and consumption of local rice is encouraged among Nigerian rice consumers.

Conclusion

Ninety-four (94.44%) of Nigerian local rice varieties had higher protein (12.32%); 27.78% higher ash (2.73%); 33.33% higher magnesium (296.12 mg/L); 50% higher iron (2.52 mg/L); 11.11% higher calcium (41.02 mg/L); 61.11% higher sodium (169.01 mg/L); 50% higher zinc (1.21 mg/l) and Abakiliki-Mas higher manganese (0.04 mg/L) than the imported rice varieties. Selection and consumption of local rice varieties with higher protein, ash and mineral content is highly encouraged to increase the protein and mineral intake of Nigeria rice consumers no matter how minute it may be since protein and micronutrient deficiency still exists in many parts of Nigeria and 88.89% of the local rice varieties were not significantly ($p >0.05$) different from imported rice varieties in their eating overall acceptability. Rice breeders are encouraged to produce rice varieties with higher mineral content compared to what is available. As staple foods, these local rice varieties are good food vehicle for fortification without dietary diversification to improve the protein, zinc and iron intake of consumers since its protein, zinc and iron content is generally low when compared to protein, zinc and iron rich foods.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abiona OE (2011). Impact of nerica rice project on small scale rice farmer food accessibility. A case study ofon Obafemi Owode Local government Area, Ogun State, Nigeria. M.Sc. Dissertation, Larenstein University Netherlands.

Adeyeye VA (2013). Strategies for enhancing consumption of locally produced rice in Nigeria. igerian Institute of Social and Economic Research (NISER), Ibadan, Nigeria.

Akande SA, Onyegbula AF, Salawu RA, Oladipo AK, Adetunji CO (2017). Effects of post-harvest handling on hydrogen cyanide content of cassava products obtained from Ilorin-West urban markets, Nigeria. African Journal of Food Science 11(11):362-368.

Akinwumi A (2013). Rice consumption and importation in Nigeria, no solution in sight Vanguard news. Available at: http://www.vanguardngr.com/2013/12/rice-consumption-importation-nigeria-solution-sight/

Alaka IC, Ituma JOS, Ekwu FC (2011). Physical and chemical properties of some selected rice varieties in Ebonyi State. Nigerian Journal of Biotechnology 22:40-46.

Anonymous (2009). The origin of rice. basmati.ru. http://basmati.ru/en/origin-of-rice. Available at: http://www. basmati.ru

Anonymous (2017a). Health benefits of phosphorus. Available at: https://www.google.com.ng/amp/s/www.organicfacts.net/health-benefits/minerals/health-benefits-of-phosphorus.html%3fisamp=1#ampshare=https://www.organicfacts.net/health-benefits/minerals/health-benefits-of-phosphorus.html

Anonymous (2017b). Ten proven magnesium health benefits. Available at: https://authoritynutrition.com/10-proven-magnesium-benefits/

Anonymous (2017c). 10 health benefits of bran oil. Available at: https://food.ndtv.com/food-drinks/why-rice-bran-oil-is-one-of-the-healthiest-improves-heart-health-745433

Association of Official Analytical Chemists (AOAC) (2010). Official method of analysis. Association of Official Analytical Chemists, 13th Edition. Washington D. C., USA.

ASEAN Manual of Food Analysis (2011). (Puwastien P, Siong TE, Kantasubrata J, Craven G, Feliciano RR, Judprasong K (eds). Regional Centre of ASEAN Network of Food Data System Institute of Nutrition, Mahidol University Thailand.

Diagne A, Bamba I, Manful J (2011). Historic opportunities for rice growers in Nigeria. Inter-réseaux développement rural. Available at: http://www.inter-reseaux.org/revue-grain-de-sel/51-special-issue-nigeria/article/historic-oppotunities-for-rice?lang=fr

Ihekoronye AI, Ngoddy PO (1985). Integrated Food Science and Technology for the Tropics. Macmillan Publishing Press Ltd, London, pp. 270- 291.

Imolehin ED, Wada AC (2009). Meeting the rice production and consumption demands of Nigeria with improved technologies. International Rice Commission Newsletter. Available at: http://www.fao.org/docrep/ x7164t/x7164t04.htm

Juliano BO (1993). Rice in human nutrition. Food and Agriculture Organisations of the United Nations, Rome.

Kennedy G, Burlingame B, Nguyen VN (2002). Nutritional contribution of rice and impact of biotechnology and biodiversity in rice-consuming countries. Proceedings of the 20th session of the international rice commission Bangkok, Thailand. Available at: http://www.fao.org/docrep/006/y4751e/y4751e05.htm

Moongngarm A, Moontree T, Deedpinrum P, Padtong K (2014). Functional Properties of Brown Rice Flour as Affected by Germination. APCBEE Procedia 8:41-46.

Müller O, Krawinkel M (2005). Malnutrition and health in developing countries. CMAJ 173(3):79-286.

Nigeria Demographics Profile (2014). Available at: http://www.indexmundi.com/nigeria/demographicsprofile.html

Nkama I, Kassum AL, Jato AAK (2011). Rice processing in Nigeria. Publication of the Intellectual Property and Technology Transfer office, University of Maiduguri, Maiduguri, Nigeria.

Oko AO, Ugwu SI (2011). The proximate and mineral composition of five major rice varieties in Abakiliki South-Eastern Nigeria. International Journal of Plant Physiology and Biochemistry 3(2):25-27

Oko AO, Ubi BE, Danbaba 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.

Pachuau L, Dutta RS, KumarRoy P, Kalita P, Lalhlenmawia H (2017). Physicochemical and disintegrant properties of glutinous rice starch of Mizoram, India. International Journal of Biological Macromolecules 95:1298-1304.

Ravi TT (2018a). Top 25 foods rich in manganese. Available at: https://www.stylecraze.com/articles/foods-high-in-manganese/#WhatAreTheFoodsRich In Manganese?

Ravi TT (2018b). Top 25 Foods High in Zinc You Should Include In Your Diet. Available at: https://www.stylecraze.com/articles/foods-that-are-rich-in-zinc/#gref

Ubesie AC, Ibeziakor NS (2012). High burden of protein-energy malnutrition in Nigeria beyond the health care setting. Annnals of Medical and Health Sciences Research 2(1):66-69.

US Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory (USDA) (2018). National Nutrient Database for Standard Reference. Available at: http:/nea/bhnrc/ndl.