CHEMICAL AND SENSORY PROPERTIES OF ANALOGUE RICE PRODUCED FROM MAIZE GRITS AND HIGH QUALITY CASSAVA FLOUR BLENDS

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Abstract
In order to reduce the large quantity of rice imported into Nigeria on a yearly basis, there is the need to get an alternative food that resembles rice to meet domestic requirement and food diversification. This work was therefore designed to determine the chemical, functional and sensory properties of analogue rice (AR_C) produced from five blends of maize grits and high quality cassava flour (HQCF) using standard methods. The sensory qualities and consumer acceptability of the AR_C were compared with imported rice. Significant differences ($p<0.05$) existed between the chemical and functional properties of the AR_C and reference samples, though most of the values are within the acceptable levels for rice grain and cassava products. The moisture (3.68% to 5.34%); ash (0.50 to 0.68%); fibre (1.57 to 2.47%) and oil absorption capacity (1.75 to 2.00%) values were reducing, while the carbohydrate; (85.18 to 86.12 %); cyanogenic potentials (8.22 to 9.35mgHCN/kg); water (2.50 to 3.10%) and swelling absorption (9.85 to 12.04%) capacities were increasing as the level of HQCF increases. The sensory and consumer acceptability results showed that the AR_C from 75% maize grits and 25% HQCF blend was the most preferred.

Keywords: High Quality Cassava Flour, maize grits, analogue rice

Introduction

Rice (*Oryza sativa L.)* is a cereal foodstuff, which is part of the three major food crops of the world and forms the staple diet of about two third of the world's population providing 20% of the world's dietary energy supply (Choi *et al*. 2010; Siswo *et al*. 2014). It is also one of the staple foods in Nigeria. The United Nation (UN) estimated that the world population will increase from 6.7 billion at present to about 8 billion by 2025; therefore its production must increase from 483.9 million tons at present to over 500 million tons by 2020. The Food Agricultural Organization (FAO) also estimates that by 2050 the world rice requirement will be 524million (FAO 2016). This implies that utilization of rice is predicted by FAO to expand by 1.1% (503.9million tons) in 2017/2018 and taking population growth index by UN into account, global per capita food consumption would pass from 53.7 kilos in 2017/2018 to 53.9 kilos next season.

Over the past decade, the rice consumption rates have risen rapidly as a result of steady increase in human population in Nigeria (Imolehin & Wada 2000). In 2017, the consumption increased to 4.7% (7.9 million tons) almost four times the global consumption and 20% of

Africa's consumption, while domestic production was 5.8million tons. A significant gap of 26.6% between production and demand was therefore recorded (Goronyo, 2017). The nation though is the largest producer of rice in West Africa, is the third largest importer of rice in the world due to this gap. The domestic rice production is grossly inadequate, thus the balance is imported from major rice producing countries mainly from Thailand (Imolehin & Wada 2000; Adebowale *et al*. 2011; Dogara & Jumare 2014;)**.**

According to Ajala & Gana (2015), the production and processing of rice in Nigeria is faced with many challenges such as unfavorable government policy. Several other factors facing rice value chain include soil fertility, pests and diseases, irrigation system, mechanization, harvesting method, postharvest handling, processing, and marketing. In addition to these, low agricultural inputs and fragmented rice value chain have also brought about set back in the production and marketing of rice because production is basically driven by small farm holders who produce only for self-consumption (Akande 2001). All these challenges have made local rice to be poorly produced, processed and expensive, though as a way out, the government has come up with different policies; recently the President put a ban on rice importation which is still not enough to motivate or help rice farmers, support to small-scale farmers through training, improved access to credit and other processing inputs. This was aimed at boosting domestic production as well as overall performance of rice sector and improving self-sufficiency of the commodity. However, this is yet to yield self-sufficiency in rice production and processing in Nigeria. The proposed ban on importation of rice by the end of 2018 (Buhari, 2018) may be another bottleneck to availability of rice in Nigeria. There is therefore the need for an alternative food that resembles rice to meet the requirement of domestic rice and for food diversification. The production of analogue using abundantly available and cheap crops was therefore conceived as a way out.

Maize and cassava are most important staple food crops grown in tropical Africa (Karim *et al*. 2009). Nigeria is currently the largest producer of cassava, while maize is a cheap cereal in the country. They play major role in efforts to alleviate the African food crisis because of their efficient production of food energy, year-round availability, tolerance to extreme stress conditions, and suitability to present farming and food systems in Africa (Karim *et al*. 2009). According to Siswo *et al*. (2014), the production of analogue rice from composite flour of cassava, green bean and hanjeli flour (*Coix lacryma*-jobi L.) is one possibility of food diversification and a way to reduce over-reliance on rice. It is expected that any developed analogue should have similar characteristics with whole rice for consumer acceptability. The use of maize and cassava to produce maize grits and High Quality Cassava Flour (HQCF) respectively for the production of analogue rice (AR_C) was the target of the study. The combination of maize and cassava for food production has been previously reported (Moore *et al*. 2005). This research was therefore developed to evaluate the chemical, functional and sensory properties of analogue rice produced from high quality cassava flour and maize grits blends

Materials and Methods

White variety dry maize and freshly harvested cassava root (TMS30572) were obtained from the Teaching and Research farm of the Faculty of Agriculture, University of Ilorin and Ipata market, Ilorin, Nigeria respectively.

Production of maize grits

Maize grits was prepared as previously reported by IITA, (2010) with slight modifications. Briefly, white dry maize were sorted to select the good ones, the grains were then winnowed to remove the chaff, adulterants and other form of contaminants. Thereafter, the dried winnowed maize was milled using fabricated attrition milling. The resulting milled samples were then sieved using motorized flour sifter fitted with a 250µm screen after which the maize grits was ready for use.

Production of High Quality Cassava Flour (HQCF)

HQCF was produced according to the method described by Toah *et al*. (2015) except that drying was done in a cabinet oven (Gallen Kamp) at 50^0C for 6-7 hours till a dry mass was obtained. The dried cassava mash was milled into flour using attrition mill. After proper milling, the flour was sieved by means of a motorized flour sifter fitted with a 250 µm screen in order to obtain smooth flour with a uniform particle size. The flour was packaged in polypropylene bags to avoid moisture uptake before further processing.

Production of Analogue Rice

Analogue rice (**AR_C**) was formulated using blends of HQCF and maize grits (Table 1) obtained at 5% level of differences using the method of Siswo *et al.* (2014). A preliminary study was used to establish the range of difference and five treatments adopted for the study.

Table 1: Research Design for Production of Analogue Rice

Treatment	Maize grits (%)	HQCF (%)
$M_{95}C_5$	95	5
$M_{90}C_{10}$	90	10
$M_{85}C_{15}$	85	15
$M_{80}C_{20}$	80	20
$M_{75}C_{25}$	75	25

Analyses

Proximate composition

Moisture, fat and ash contents were determined using AOAC (2000) methods. Protein content was determined by the Kjeldahl method (6.25×N) and crude fibre content was determined by standard laboratory procedure and total carbohydrate was calculated by difference.

Starch and Sugar Content

The starch and sugar contents were determined using the AOAC (2005) method. The sample was weighed into centrifuge tubes, wetted with ethanol and 2 mL of distilled water, followed by 10 mL hot ethanol. The mixture was vortexed and centrifuged using a Sorvall centrifuge (model GLC-1; Ivan Sorvall Inc., Newtown, CT) at 2000 rpm for 10 min. The supernatant was collected and used for free sugar analysis, while the residue was used for starch analysis.

Amylose Content and Cyanogenic Potentials

Amylose contents of the starches was determined by iodine binding method (Williams *et al.* 1970). Cyanogenic potential was determined using the automated enzymic method developed by (Rao & Hahn 1984).

Colour

The CIE tristimulus L, a, and b parameters of the analogue rice was measured using a Minolta portable chroma-meter as previously reported (Siswo *et al.* 2014). The colorimeter operates on the CIE L, a and b color schemes, L (lightness) axis – 0 is black, 100 is white, a (red-green) axis- positive values are red; negative values are green and 0 is neutral, b (yellow-blue) axis- positive values are yellow; negative values are blue and 0 is neutral. The instrument was standardized and the samples were placed in the sample holder. Color measurement was determined in triplicates.

Functional properties

Determination of Water Absorption Capacity (WAC)

This was determined using the method described by Awolu *et al.* (2017). One gram of the sample was dispensed into a weighed centrifuge tube with 10ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hour before being centrifuged at 3500rpm for 30 minutes at room temperature. The supernatant was decanted and the tube inverted over an adsorbent paper to drain dry. The weight of water absorbed was determined by difference. The Water Absorption Capacity (WAC) was calculated as:

$$WAC\ (\%) = \frac{\text{Volume of water used} - \text{Volume of free water}}{\text{Weight of sample used}} \times 100$$

Determination of Swelling Capacity

The method described by Riley *et al.* (2006) was used. Ten grams of the sample was measured into a 300ml measuring cylinder. Then 150ml of distilled water was added to the sample and allowed to stand for four hours. The final volume after swelling was recorded. The percentage swelling was calculated as;

$$\%\ \text{Swelling Capacity} = \frac{\text{Final volume} - \text{Initial Volume}}{\text{Initial Volume}} \times 100$$

Determination of Oil Absorption Capacity (OAC)

The method outlined by Riley *et al.* (2006) was used. One gram of the sample was weighed on an analytical balance and poured in a centrifuge tube, 10ml of oil was poured into the centrifuge tube containing the sample, the samples was

placed in the centrifuge tube and then spin using (Kenwood blender) at 3500rpm for 30 sec at room temperature. The mixture was allowed to stand for 30 min. The supernatant was decanted and weight of oil absorbed was calculated and expressed. The centrifuge tube was removed and the oil was from sample into a measuring cylinder and the volume recorded

Sensory evaluation

The sensory quality and consumer acceptability of boiled AR_C samples and one imported rice (Rice E4334 - Source: (Oko *et al.* 2012) were evaluated using 50 panelists that were familiar with boiled rice. A five point ranking test as described by Iwe (2003) was adopted. The scale ranged from the best (5) to least (1). Each of the samples was ranked for appearance, aroma, taste, texture, mouth feel and overall acceptability

Statistical analysis

One-way Analysis of Variance (ANOVA) was carried out on all the data using statistical package for social sciences at 5% (SPSS version 20.00). The means were separated using Duncan's multiple range tests.

Results and Discussion

Proximate composition

A significant difference ($p<0.05$) was obtained between the proximate compositions of the AR_C samples and the imported whole rice grain as the reference (Table 2). The $M_{75}C_{25}$ and $M_{95}C_5$ blends had the highest (5.34%) and lowest (3.68%) moisture content respectively. The variation of the moisture content is connected to the varied level of maize grit and HQCF. The moisture contents do not have any particular trend and are within the range of values (3.67 to 9.67%) reported for rice samples (Oko *et al.* 2012). They are also below the acceptable level (14%) for rice storage that would prevent the growth of mold that often exist in cereal/ grains. High moisture content also affects the milling and cooking characteristics of rice (Kibar *et al.* 2010; Oko & Onyekwere 2010).

The ash content of the AR_C samples varied significantly between 0.50 and 0.68%. The ash content in food also gives an idea of the mineral elements present in the food. There was a significant difference ($p<0.05$) in the crude fibre contents of the AR_C samples. Fibre is an essential component of food, as it absorbs water and provides roughage for the bowels, assisting intestinal transit. The fibre contents in this study are similar to the findings of Oko *et al.* (2012) on twenty varieties of local and newly introduced rice varieties of 1.0 to 2.0% fibre content. This establishes the similarity in the chemical composition of the AR_C and whole rice grain.

The fat content of the AR_C samples is in the range of 1.04 to 1.59%. The fat content of the samples decreased with increase in HQCF, which could be attributed to low fat content of cassava compared to maize. The result of the study are in agreement with earlier results (0.5 to 3.5%) on different rice varieties reported by (Oko & Onyekwere 2010; Oko *et al.* 2012). The protein (5.29 to 6.54%) contents of the AR_C also decreased with increase in the level of HQCF, suggesting the low levels of protein in cassava. Previous studies similarly reported that cassava is low in protein (Akingbala *et al.* 2005). Protein content in rice affects absorption of water. Rice with high protein needs more water and time for cooking as starch granule is veiled with protein layer and it prevents water to enter the starch granules. The absorption of water early during cooking determines the hydration of the protein and the starch and texture of the cooked rice (Martin & Fitzgerald 2002). Carbohydrates were the major components (approx. 86%) of the rice samples and agrees with values (76.92-86.03%) previously reported (Oko *et al.* 2012).

Table 2: Proximate Composition of Uncooked Analogue Rice Produced from Cassava and Maize

Samples	**Moisture (%)**	**Ash (%)**	**Fibre (%)**	**Fat (%)**	**Protein (%)**	**Carbohydrate (%)**
$M_{95}C_5$	$3.68^{c}\pm0.56$	$0.50^{e}\pm0.01$	$1.57^{f}\pm0.00$	$1.59^{a}\pm0.13$	$6.54^{a}\pm0.18$	$86.12^{bc}\pm0.00$
$M_{90}C_{10}$	$4.59^{b}\pm0.39$	$0.58^{d}\pm0.02$	$1.60^{e}\pm0.00$	$1.35^{b}\pm0.12$	$6.21^{a}\pm0.22$	$85.67^{b}\pm0.14$
$M_{85}C_{15}$	$4.67^{ab}\pm0.06$	$0.61^{cd}\pm0.01$	$1.95^{d}\pm0.00$	$1.19^{c}\pm0.08$	$5.79^{b}\pm0.13$	$85.79^{c}\pm0.09$
$M_{80}C_{20}$	$4.71^{ab}\pm0.02$	$0.64^{bc}\pm0.02$	$2.19^{c}\pm0.00$	$1.15^{bc}\pm0.09$	$5.58^{ab}\pm0.16$	$85.73^{a}\pm0.65$
$M_{75}C_{25}$	$5.34^{a}\pm0.05$	$0.68^{b}\pm0.02$	$2.47^{b}\pm0.00$	$1.04^{c}\pm0.08$	$5.29^{c}\pm0.05$	$85.18^{a}\pm0.42$
Rice (E4334) Source: Oko *et al.*, 2012)	5.30^{d}	1.0^{f}	1.0^{a}	1.5^{de}	5.60^{cd}	85.57^{d}

Value with the same superscripts along the column were not significantly different ($p<0.05$)

$M_{95}C_5$= 95% maize grits, 5% HQCF $M_{90}C_{10}$= 90% maize grits, 5% HQCF $M_{85}C_{15}$= 85% maize grits, 15% HQCF
$M_{80}C_{20}$= 80% maize grits, 20% HQCF $M_{75}C_{25}$= 75% maize grits, 25% HQCF (Rice E4334 -

Starch and sugar contents

There was a significant difference ($p<0.05$) between the starch content of the AR_C samples ranging from 57.76 to 67.48%. According, to Riley *et al.* (2006)) high starch content normally suggests the relatively high digestibility of cassava starch. The low starch contents observed in some samples may be due to the high dry matter displayed by these samples and, hence, low digestibility and creation of side products during hydrolysis such as isomaltose and maltose (van der Veen *et al.* 2004). Starch content affects other \

starch properties such as the swelling power (Tester & Morrison 1992).

The sugar contents of the AR_C samples increased with increasing levels of HQCF (Table 3). According to Charles *et al.* (2005) cassava has relatively high sugar content compared to other roots and tubers.

Table 3: Starch and Sugar Contents of Analogue Rice Produced from Cassava and Maize

Samples	Starch (%)	Sugar (%)
$M_{95}C_5$	$57.76^d \pm 0.35$	$1.93^e \pm 0.57$
$M_{90}C_{10}$	$58.95^{cd} \pm 1.51$	$3.22^d \pm 0.06$
$M_{85}C_{15}$	$61.23^c \pm 0.14$	$3.64^{cd} \pm 0.42$
$M_{80}C_{20}$	$65.29^b \pm 1.66$	$3.89^{bc} \pm 0.64$
$M_{75}C_{25}$	$67.48^b \pm 0.27$	$4.32^b \pm 0.18$

Amylose content and cyanogenic potential

The amylose fractions in the starch of the AR_C ranged between 23.56 to 30.48% (Fig.1). Amylose content is one of the components of starch that determines the physical properties of rice, for example, low levels of amylose produces a fluffier rice and vice versa. Great variations in the amylose and amylopectin ratio in rice grains of different varieties that allow their classification as waxy (1-2% amylose), very low amylose (2-12%), low amylose content (12-20%), intermediate amylose content (20-25%) and high amylose content (25-33%) has been observed by some authors (Lawal *et al.* 2011). Therefore, the AR_C can be classified as high amylose rice. Rice with high amylose content provides dry and fluffy textures while low amylose rice gives moist, chewy and clingy textures after cooking. According to Mir *et al.* (2013), the physicochemical and metabolic properties of rice are influenced by numerous factors such as amylose content which is often used to predict rate of starch digestion, blood glucose and body response (insulin) to rice.

Cyanide contents (8.22-9.35 mg HCN/kg) of the ARc samples are within the acceptable cyanide content (10mg/kg) for cassava food products (FAO/WHO 1991).

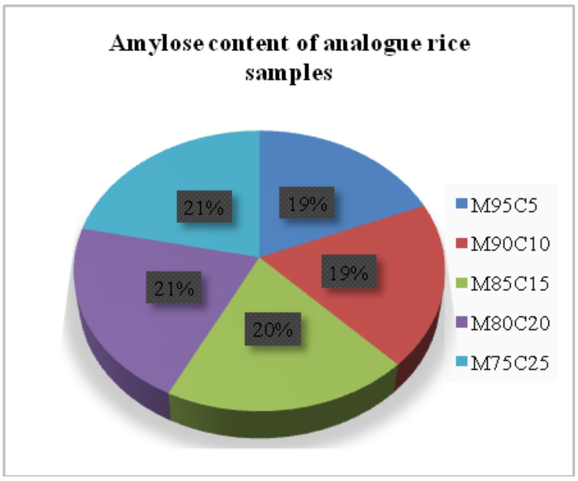

Figure 1: Amylose content of analogue rice produced from cassava and maize

Table 4: Cyanogenic potential (CNP) of Analogue Rice Produced from Cassava and Maize

Sample	CNP (mgHCN/kg)
$M_{95}C_5$	$8.22^e \pm 0.05$
$M_{90}C_{10}$	$8.49^d \pm 0.00$
$M_{85}C_{15}$	$8.54^d \pm 0.03$
$M_{80}C_{20}$	$9.29^c \pm 0.01$
$M_{75}C_{25}$	$9.35^b \pm 0.00$

Functional properties

The Water Absorption Capacity (WAC) varied significantly ($p<0.05$) among the samples. The AR_C produced from $M_{95}C_5$ samples produced the highest WAC (3.10 ml H_2O/g) which was significantly different ($p<0.05$) from other samples. The high WAC is attributed to lose association of starch polymers in the native granule and ability of the food material to absorb water and swell for improved consistency. The differences observed in WAC of the samples may be due to the differences in moisture contents of the respective flour samples used as well as the variation in the degree of the associative forces within the starch granules. WAC is an important characteristic for cooking and acceptability of rice.

Oil Absorption Capacity (OAC) (1.75 to 2.0%) of the rice samples similarly showed significant differences ($p<0.05$) and could be due to the presence of more non-polar amino acids. The presence of several non-polar side chains may bind the hydrocarbon chains of fats, thereby resulting in higher OAC. El Nasri & El Tinay (2007) reported that surface area and hydrophobicity improve and also high protein content shows high OAC. OAC ranging from 1.0 to 2.5g/g (100 to 250%) has been confirmed as a vital food product development property because of its ability to impact flavour and mouthfeel to foods (Awolu *et al.* 2017).

The AR_C samples produced from $M_{95}C_5$ had the highest swelling capacity (12.04%). There was a gradual decline in swelling capacity as the level of HQCF increases. This probably indicates the level at which the swelling tendency of HQCF overpowers that of maize starch. A similar trend was reported for cassava starch with durum wheat semolina flour (Oladunmoye *et al.* 2014). Swelling indicates the degree of exposure of the internal structures of the starch granules to action of water and may be affected by the presence of reducing sugars in starch which leads to unavailability of total starch for water absorption (Moore *et al*. 2005). Thus, the decreased swelling capacity may be attributed to the increase in sugar contents of the rice samples (Table 5).

Table 5: Functional Properties of Analogue Rice Produced from Cassava and Maize

Samples	**Water absorption Capacity (ml H_2O)**	**Oil absorption capacity (%)**	**Swelling capacity (%)**
$M_{95}C_5$	$3.10^{c}\pm0.00$	$1.75^{d}\pm0.71$	$12.04^{a}\pm0.77$
$M_{90}C_{10}$	$3.10^{b}\pm0.14$	$1.80^{cd}\pm0.00$	$11.67^{a}\pm0.29$
$M_{85}C_{15}$	$2.70^{c}\pm0.14$	$1.85^{cd}\pm0.71$	$11.36^{a}\pm1.04$
$M_{80}C_{20}$	$2.60^{c}\pm0.14$	$1.90^{c}\pm0.00$	$10.79^{a}\pm0.25$
$M_{75}C_{25}$	$2.50^{c}\pm0.14$	$2.00^{b}\pm0.00$	$9.85^{a}\pm1.99$

Colour Profile

The lightness of the AR_C was measured using Minolta portable chroma-meter. Colour profile of AR_C (Table 6) showed increasing brightness (L*) with slight significant difference ($p<0.05$), reducing redness (a*) with no significant difference, and increasing yellowness (b*) with significant difference as the incorporation of HQCF reduces and maize grit increases. The addition of cassava flour decreased the lightness and increased brightness of AR_C. This agrees with the report of Siswo *et al*., (2014) that as cassava is increased brightness is increased. This may be attributed to the quality of the cassava starch against maize (ATSDR, 2006, Maziya *et al.*, 2007).

Table 6: Colour Profile of Analogue Rice Produced from Cassava and Maize

Samples	**L***	**a***	**b***
$M_{95}C_5$	$84.41^{a}\pm0.01$	$-0.02^{a}\pm0.35$	$1.79^{ab}\pm0.00$
$M_{90}C_{10}$	$84.58^{a}\pm0.01$	$-0.03^{a}\pm0.35$	$1.79^{b}\pm0.00$
$M_{85}C_{15}$	$84.49^{a}\pm0.20$	$-0.01^{a}\pm0.31$	$1.69^{c}\pm0.02$
$M_{80}C_{20}$	$84.57^{a}\pm0.00$	$-0.34^{a}\pm0.00$	$1.82^{b}\pm0.00$
$M_{75}C_{25}$	$83.79^{c}\pm0.01$	$-0.01^{a}\pm0.03$	$1.80^{ab}\pm0.00$

Sensory properties and acceptability

Sensory attributes was carried out using ranking test as described by Iwe, (2003). The ranking ranged from 1-7 (1 as the most preferred and 7 as the least preferred). Mean sensory scores revealed that the reference (imported) rice was ranked the best among the samples (Table 7). This may be due to the fact that the panellists were familiar with the rice quality. The AR_C from $M_{75}C_{25}$ was ranked next (3.65) which was not significantly different ($p<0.05$) from other AR_C samples. The same trend was obtained for the texture quality. Generally, consumers tend to prefer hard rice that is not sticky. Hardness is an important textural characteristic that influences palatability of cooked rice (Odenigbo *et al.* 2014). This might be the reason why the consumers preferred the imported rice to AR_C samples. Furthermore, differences in the rice components such as moisture, protein, starch and fat contents may also have accounted for the variation in the taste and general characteristics of the rice. For instance, high moisture content of rough rice contributes to improved colour and palatability attributes, while lower protein contents seems to be more desirable for taste (Zheng *et al.* 2011).The AR_C from $M_{75}C_{25}$ recorded the lowest protein and fat content. This may be responsible for the ranking result of the taste quality. The report of Siswo *et al.* (2014) showed that the taste quality determines the viscosity of cooked rice and is a property that the consumer considered in acceptability of rice. In overall, AR_C sample produced from $M_{75}C_{25}$ was the most preferred among the samples and ranked next to the imported rice.

Table 7: Sensory and Acceptability of Cooked
Analogue Rice Produced from Cassava and Maize

Samples	Appearance	Aroma	Texture	Taste	Acceptability
$M_{95}C_5$	4.65[b]	3.20[c]	3.70[c]	3.60[cd]	3.55[b]
$M_{90}C_{10}$	4.10[b]	4.15[abc]	4.50[ab]	4.85[b]	4.25[b]
$M_{85}C_{15}$	5.20[a]	4.30[ab]	4.45[ab]	4.80[b]	5.20[a]
$M_{80}C_{20}$	3.85[b]	3.25[bc]	4.30[ab]	4.40[bc]	4.35[b]
$M_{75}C_{25}$	3.65[b]	3.65[abc]	3.55[b]	3.05[d]	3.55[b]
Rice E4334	1.05[a]	1.57[d]	1.25[c]	1.45[e]	1.10[c]

Source: Oko *et al.*, 2012

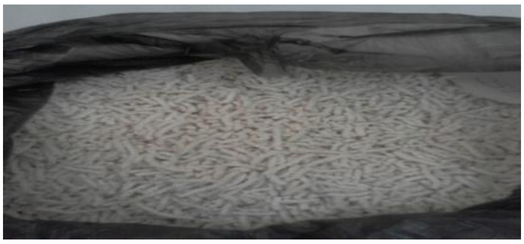

Plate 1: Analogue rice produced from maize grits and HQCF

Conclusion

The production of analogue rice from maize grits and HQCF is possible. Analogue rice was produced using five treatments. Though panelists complained of sogginess, the chemical, functional and sensory qualities varied significantly with the ratio of raw materials. The most accepted sample by the consumer was the analogue rice produced from $M_{75}C_{25}$. The pasting property and possible ways of improving the texture property of the analogue rice are recommended for further study.

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References

Adebowale A.A, Sanni L.O, Owo H.O &, Karim O.R (2011) Effect of variety and moisture content on some engineering properties of paddy rice. *Journal of Food Science and Technology* 48:551-559

Ajala A & Gana A (2015) Analysis of Challenges Facing Rice Processing in Nigeria. *Journal of Food Processing* 2015:1-6

Akande T (2001) An overview of the Nigerian rice economy. Monography published by the *Nigerian Institute of Social and Economic Research (NISER) Ibadan*

Akingbala J. O, Oyewole O.B, Uzo-Peters P.I, Karim R.O & Baccus-Taylor G.S (2005) Evaluating stored cassava quality in gari production. *Journal of Food, Agriculture and sEnvironment* 3:75-80

Asscoaition of official Analytical Chemists, (AOAC) (2000) Offcial methods of analysis. 17th edition. *Asscoaition of official Analytical Chemists, Rockville,*

AOAC (2005) Official Methods of Analysis. 18th Edition, *Association of Official Analytical Chemists. Washington D.C, USA*

Awolu O,O, Ojewumi M,E, Isa J, Ojo D.O, Olofin H.I & Jegede S.O (2017) Comparative analyses of functional, pasting and morphological characteristics of native and modified tigernut starches with their blends. *Cogent Food Agriculture* 3:1306934

Buhari M (2018) 2018 Presidential New Year Speech. January, 01, 9:44am Nigeria.

Charles AL, Sriroth K, Huang T-c (2005) Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. *Journal of Food Chemistry* 92:615-620

Choi HJ, Chang JL, Cho EJ, Choi SJ. MoonTW (2010). Preparation, digestibility, and glucose response in mice of rice coated with resistant starch type 4 using locust bean gum and agar. *International Journal of Food Science and Technology*, 45(12), 2612–2621.

Dogara AM, Jumare AI (2014) Origin, distribution and heading date in cultivated rice. *International Journal of Plant Biology Reserve* 2:2-6

El Nasri NA, El Tinay A (2007) Functional properties of fenugreek (Trigonella foenum graecum) protein concentrate. *Journal of Food Chemistry* 103:582-589

FAO (2016) WFP (2015), The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. *Food and Agriculture Organization Publications*, *Rome*

FAO (2018) Rice Market Monitor (RMM) *Food and Agriculture Organization Publications, Rome*

FAO/WHO (1991) Joint FAO/WHO Food Standards Programme, *Codex Alimentarius Commission XII. FAO/WHO, Rome, Ital*y

Imolehin E, Wada A (2000) Meeting the rice production and consumption demands of Nigeria with improved technologies. *International Rice Commission Newsletter* 49:33-41

IITA (2010). Post Harvest Technology. Annual Report. 62-80

Iwe M (2003) *The science and Technology of Soybean Rejoint communiction Services Limited, Enugu, Nigeria*, ISBN 978-32124-8-6

Karim O, Fasasi O, Oyeyinka S (2009) Gari yield and chemical composition of cassava roots stored using traditional methods. *Pakistan Journal of Nutrition* 8:1830-1833

Kibar H, Öztürk T, Esen E (2010) The effect of moisture content on physical and mechanical. *Spanish Journal of Agricultural Resources* 8:741-749

Lawal OS, Lapasin R, Bellich B, Olayiwola TO, Cesàro A, Yoshimura M, Nishinari K (2011)

Rheology and functional properties of starches isolated from five improved rice varieties from West Africa. *Journal of Food Hydrocolloid* 25:1785-1792

Martin M, Fitzgerald M (2002) Proteins in rice grains influence cooking properties! *Journal of Cereal Science*. 36:285-294

Mir J, Srikaeo K, García J (2013) Effects of amylose and resistant starch on starch digestibility of rice flours and starches. *International Food Resources Journa*l 20:1329-1335

Moore GRP, Canto LRd, Amante ER, Soldi V (2005) Cassava and corn starch in maltodextrin production. *Química nova* 28:596-600

Odenigbo AM, Ngadi M, Ejebe C, Woin N, Ndindeng SA (2014) Physicochemical, cooking characteristics and textural properties of TOX 3145 milled rice. *Journal of Food Resources* 3:82-90

Oko A, Onyekwere S (2010) Studies on the proximate chemical composition and mineral element contents of five new lowland rice varieties in Ebonyi State. *International Journal of Biotechnoly Biochemestry*. 6:949-955

Oko A, Ubi B, Efisue A, Dambaba N (2012) Comparative analysis of the chemical nutrient composition of selected local and newly introduced rice varieties grown in Ebonyi State of Nigeria. *International Journal of Agriculture and Forestry* 2:16-23

Oladunmoye O.O, Aworh OC, Maziya-Dixon B, Erukainure OL, Elemo GN (2014) Chemical and functional properties of cassava starch, durum wheat semolina flour, and their blends. *Food Science Nutrition Journal*. 2:132-138

Rao P.V & Hahn S (1984) An automated enzymic assay for determining the cyanide content of cassava (Manihot esculenta Crantz) and cassava products. *Journal of Science, Food and Agriculture* 35:426-436

Riley C, Wheatley A, Asemota H (2006) Isolation and characterization of starches from eight Dioscorea alata cultivars grown in Jamaica. *African Journal of Biotechnology* 5:1528-1536

Siswo S, Pudjihastuti S, Poerwoprajitno A, Selvi M (2014) Physicochemical Properties of Analoge Rice from Composite Flour: Cassava, Green Bean and Hanjeli. *World Application Science Journal*. 32 (6): 1140-1146:1140-1111

Tester R, Morrison W (1992) Swelling and gelatinization of cereal starches. III. Some properties of waxy and normal nonwaxy barley starches. *Cereal Chemistry Journal* 69:654-658

Toah AP, Tay DN, Hayford O (2015) Degradation of cyanogenic glycosides during the processing of high quality cassava flour (HQCF). *Annals Food Science and Technology* 16:471-478

van der Veen ME, Van Iersel DG, van der Goot A.J & Boom RM (2004) Shear- Induced Inactivation of α- Amylase in a Plain Shear Field. *Biotechnology Programme* 20:1140-1145

Williams P, Kuzina F, & Hlynka I (1970) Rapid colorimetric procedure for estimating the amylose content of starches and flours. *Cereal Chemistry journal* 47:411-420

Zheng X-Z, Liu C-H, Chen Z-Y, Ding N-Y, & Jin C-J (2011) Effect of drying conditions on the texture and taste characteristics of rough rice. *Dry Technology* 29:1297-1305