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FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour

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Abstract: FARO 44 rice, brown cowpea and African yam bean seeds were processed into flours and their proximate, functional and pasting properties were assessed. Functional properties—loose bulk density, packed bulk density, water absorption capacity, oil absorption capacity, emulsion capacity, foam capacity, gelation capacity and swelling index ranged from 0.63 to 0.69 g/ml, 0.84 to 1.00 g/ml, 0.63 to 1.32%, 0.46 to 1.48%, 42.50 to 56.78%, 10.40 to 18.17%, 50.93 to 57.90°C and 0.45 to 0.67, respectively. Proximate and amylose composition ranged as follows; Moisture: 8% (75% rice:25% African yam bean) to 14% (100% rice); Protein: 12.86% (100% wheat) to 28.13% (50% rice:50% African yam bean); Fat: 1.64% (100% rice) to 5.79% (100% cowpea); Ash: 1% (100% cowpea, 75% rice:25% African yam bean, 50% rice:50% African yam bean) to 1.97% (25% rice:75% African yam bean); Crude fibre: 0.95% (100% wheat) to 6.27% (100% African yam bean); Carbohydrate: 52.62% (50% rice:50% African yam bean) to 72.58% (100% wheat) and Amylose: 17.13% (100% rice) to 28.07% (100% African yam bean). Pasting properties—peak, trough, breakdown, final, peak time and pasting temperature ranged from 128.50 to 245 RVU, 85.08 to 159.25 RVU, 22.08 to 106.75 RVU, 123.58 to 294.33 RVU, 33.50 to 135.08 RVU, 5.18 to 5.92 min and 79.95 to 84.75°C.

Subjects: Environment & Agriculture; Food Science & Technology; Technology

Keywords: composite flour; pasting properties; functional properties; legumes; proximate; wheat flour

1. Introduction

Wheat is the ideal flour suitable for baking. The high level of its utilization has resulted in an overdependence on wheat flour for baked goods especially in developing countries like Nigeria.

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MO Iwe is a renowned professor in the Department of Food Science and Technology, College of Food Processing and Storage Technology, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State. He majored in processing/extrusion technology and he is a member/fellow in several professional bodies. Iwe has several local and international journal publications to his credit and he is associated in teaching, supervising, training and other related activities in the Department of Food Science and Technology and Michael Okpara University at large.

PUBLIC INTEREST STATEMENT

Most food industries in Nigeria and other countries depend on wheat which cannot be cultivated in humid tropics and therefore must be imported in these areas. However, flour can be produced from locally available resources which are more nutritious, cheap and readily available. This paper explored this by producing composite flour from FARO 44 rice variety, African yam bean and Brown cowpea seeds. The physiochemical property of this composite flour was investigated to determine its suitability for use in food and other industries.

Unfortunately, wheat is a temperate crop that will not do well under tropical conditions due to unfavourable soil and climatic conditions (Abdelghafor, Mustafa, Ibrahim, & Krishnan, 2010; Edema, Sanni, & Sanni, 2005). Hence, wheat-consuming countries located in the tropical regions, which are mostly developing nations, rely on countries located in the temperate regions, mostly developed nations, for wheat importation. Many developing nations spend huge amount of their foreign exchange for the importation of wheat (Ohimain, 2014). It is therefore of economic importance if wheat importation is reduced by substitution with other locally available raw materials (Oyeku et al., 2008) such as cassava, rice, cowpea, maize, potato etc. Seibel (2006) reported that it is well known that no other crop can achieve the baking properties of wheat, hence composite flour has become the subject of numerous studies. Therefore, there has arisen the need to develop a strategy of using less expensive local resources that could still combine optimum nutritive value with good processing attributes to replace wheat flour for use in food industries.

Over the years, there have emerged two definitions of composite flour. Composite flour is a blend or mixture of wheat with other materials to form suitable flour for baking purposes (Dendy, 1992, 1993; Oyeku et al., 2008). Sanni, Christiana, and Silifat (2004) defined composite flour as the name given to wheat that has been diluted with non-wheat materials like cassava, maize and soybean. Of recent, composite flour is now defined as a blend of wholly non-wheat flours for the purpose of baking (Dendy, 1993). Putting both definitions together, Seibel (2006) defined composite flour as a mixture of flours from tubers rich in starch (e.g. cassava, potatoes, yam) and/or protein-rich flours (cowpea, soybean, ground nut) and /or cereals (maize, rice, millet, sorghum) with or without wheat flour.

Some of the documented advantages of composite flour include saving of foreign exchange, promotion of high-yielding native species, a better supply of proteins for human nutrition, enhancement of domestic agriculture, generates rural income and supports rural development (Andrae & Beckman, 1985; Bugusu, Campanella, & Hamaker, 2001; Seibel, 2006). Because of these and other advantages, Nigeria and many developing nations have implemented composite flour policies. Hence, the aim of this study was to achieve protein complementation by blending rice with African yam bean (AYB) and brown cowpea flours in order to improve the utilization of locally grown rice and underutilized legumes.

2. Materials and methods

2.1. Sample collection

Polished FARO 44 rice variety (*Oryza sativa*) was obtained from Ebonyi State Agricultural Development Programme (ADP) Abakiliki, Ebonyi state, Nigeria. AYB seeds (*Sphenostylis stenocarpa*) and brown cowpea (*Vigna unguiculata*) were purchased from Umuahia main market in Abia state, Nigeria.

2.2. Preparation of flours

Rice grains were cleaned, sorted and washed. They were then steeped in water for 12 h, drained and dried in a hot air oven. Milling of the dried rice grains was done using attrition mill and the milled grains were sieved using a 300-μm mesh size sieve to obtain fine flour. AYB seeds were cleaned, sorted, washed and steeped in water for 24 h. They were dehulled manually, dried, milled and sieved using a 300-μm sieve to obtain fine flour (Nwosu, Ahaotu, Ayozie, Udeoozor, & Ahaotu, 2011). Cowpea seeds were cleaned, sorted and steeped in water for 2 h and dehulled manually by rubbing between the palms, dried at 60°C for 3 h in a hot air oven, milled and then sieved using a 300-μm sieve to obtain fine particle size flour.

2.3. Formulation of flour blends

Flour blends of processed rice, AYB and brown cowpea were prepared to fit into the experimental design as shown in Table 1. The flours were thoroughly mixed at predetermined ratios using a Kenwood food mixer run at a speed of 100 rpm for 3 min to obtain a homogenous blend.

Table 1. Proportions of blends of rice, cowpea and AYB flours		
Rice %	**Brown cowpea%**	**AYB %**
100	0	0
0	100	0
0	0	100
75	25	0
25	0	75
50	50	0
50	0	50
25	75	0
75	0	25

2.4. Proximate composition and amylose content of flour blends
Proximate composition of the flour blends was determined using the AOAC (1990) method. Amylose content was determined by the rapid colorimetric method as described by Alexander and Griffiths (1993). Available carbohydrate was calculated by difference.

2.5. Functional properties of flour blends
Bulk density, water absorption, oil absorption, foam and emulsion capacities as well as gelatinization temperature were determined by the methods described by Onwuka (2005). Swelling index was determined using the method described by Ukpabi and Ndimele (1990).

2.6. Pasting properties of flour blends
Pasting properties of the flour blends were determined using a Rapid Visco Analyzer (Newport Scientific, RVA super 3, Switzerland) as described by AACC (2001). Three grams each (on a 100% dry matter basis) of the flour samples was weighed into the canister. The paddle was placed into the canister and the canister was inserted into the instrument. The measurement cycle was initiated by depressing the motor tower of the instrument when the computer commands "Press down the tower". The canister was removed on completion of the test. Flour suspensions (9%w/w dry flour basis, 28 g total weight) were equilibrated at 300°C. All determinations were done in duplicate.

3. Results and discussion
Results of the proximate composition and amylose content of the flour blends are as shown in Table 2.

Results of proximate composition showed that there were significant differences ($p < 0.05$) in the ash, crude fibre, protein, carbohydrate, moisture and fat contents of the flour blends.

Moisture content of the flour blends ranged from 8 to 14% with flour from 75% rice and 25% AYB blend having the lowest, while 100% rice flour had the highest value. There was a significant difference ($p < 0.05$) in the moisture content of the flour blends. The relatively low moisture content is an indication of storage stability and could produce a more shelf stable product. These findings agree with the values reported by Adebayo-Oyetoro et al. (2011) for proximate and functional properties of Ofada rice. The American Association of Cereal Chemists (AACC, 2001) approved methods for determining various properties of flour specify that the higher the moisture content, the lower the amount of dry solids in the flour. Flour specifications usually limit the flour moisture content to 14% or less. Flours with moisture content above 14% are not stable at room temperature and as such organisms present in them will start to grow, thus producing off odours and flavours.

Protein content of the blends increased with every level of legume flour substitution (Table 2). This increase was expected because legume flours contain more protein than rice flour hence the

Table 2. Proximate composition and amylose content of flour blends

Sample blends	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)	Amylose (%)
100% Rice	14.00^{a}	16.00^{i}	1.64^{e}	1.07^{c}	1.59^{f}	65.71^{b}	17.13^{i}
100% Cowpea	10.00^{c}	17.51^{h}	5.79^{a}	1.00^{c}	5.35^{b}	60.35^{cd}	25.10^{b}
100% African yam bean	10.03^{c}	18.63^{f}	5.71^{a}	1.03^{c}	6.27^{a}	58.32^{e}	28.07^{a}
75% Rice:25% Cowpea	12.10^{b}	20.23^{d}	3.61^{c}	1.07^{c}	3.21^{e}	59.78^{d}	17.67^{h}
75% Rice:25% African yam bean	8.00^{d}	23.07^{c}	3.66^{c}	1.00^{c}	3.76^{d}	60.51^{e}	18.37^{g}
50% Rice:50% Cowpea	8.17^{d}	26.23^{b}	3.75^{c}	1.17^{c}	4.52^{c}	56.16^{f}	21.30^{d}
50% Rice:50% African yam bean	10.07^{c}	28.13^{a}	3.56^{cd}	1.00^{c}	4.62^{c}	52.62^{g}	22.03^{c}
25% Rice:75% Cowpea	12.10^{b}	19.37^{e}	4.23^{b}	1.03^{c}	4.42^{c}	58.86^{e}	19.17^{f}
25% Rice:75% African yam bean	10.03^{c}	21.27^{d}	3.39^{d}	1.97^{a}	5.11^{b}	58.23^{e}	19.77^{e}
100% Wheat	10.33^{c}	12.86^{j}	1.71^{e}	1.57^{b}	0.95^{g}	72.58^{a}	18.17^{g}
LSD	0.23	0.22	0.20	0.18	0.22	0.48	0.16

attendant synergistic effects of protein complementation (Yetunde, Ukpong, Olajumoke, & Ime, 2009). This expected increase was the basis for formulating the blends such that the final product will not only have higher protein content but also higher protein quality.

The fat content of the blends was generally low (Table 2) and ranged from 1.64% (100% rice) to 5.79% (100% cowpea). This may be due to the fact that cereals, legumes and tubers store energy in the form of starch rather than lipids. The low fat levels are beneficial as it ensures longer shelf life for the products (Reebe, Gonzalez, & Rengifo, 2000) because all fats and fat containing foods contain some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity. The blends complemented with AYB recorded lower fat values than those of brown cowpea (Table 2).

The ash content of the blends ranged from 1 to 1.97% with the 100% cowpea flour, 50% rice:50% African yam bean, 75% rice:25% African yam bean having the same (lowest) values and the blend 25% rice:75% African yam bean having the highest value. The ash content of a food sample gives an idea of the mineral elements present in the food. It indicates the composition of inorganic constituents after organic materials (fats, proteins and carbohydrates) and moisture have been removed by incineration. It is essentially the mineral content of a food sample. Minerals are a group of essential nutrients which serve a variety of important metabolic functions and are parts of molecules such as haemoglobin, adenosine triphosphate (ATP) and deoxyribonucleic acid (DNA).

The crude fibre of 100% rice flour recorded 1.59% and decreased when compared to other blends. This decrease agrees with the findings of Sotelo, Saisa, Montolvo, Hernandez, and Hernandez (1990). Crude fibre contents of the blends increased slightly as the level of legume flour substitution increased. This may be attributed to the high crude fibre content of legumes which had a greater effect on the rice. Crude fibre slows down the release of glucose into the blood and decreases intercolonic pressure hence reducing the risk of colon cancer (Gibney, 1989). The crude fibre contents of the flour blends ranged between 0.95% and 6.27%. Flour from 100% wheat had the lowest, while 100% AYB flour had the highest value.

The carbohydrate content of the blends ranged from 52.62 to 72.58% with 50% rice: 50% African yam bean flour having the lowest and 100% wheat flour the highest value. There was a significant difference ($p < 0.05$) in the carbohydrate contents of the flours and their blends. The carbohydrate contents of these flour samples is an indicator that the products made from them will be good sources of energy.

The amylose contents of the blends ranged from 17.13 to 28.07% with flour from 100% African yam bean having the highest concentration and 100% rice flour the lowest. Low amylose content has been linked to high swelling power due to low reinforcement of internal work by amylose molecules (Hoover, 2001). A significant difference ($p < 0.05$) was observed in the amylose concentration of the blends. Raja and Ramakrishna (1990) reported that heat treatment caused a reduction in the amylose content of starch-based products. Since the formulated blends will still be heat processed before consumption, the amylose will most likely be reduced further. The amylose content is simply the linear molecular structure of starch. It is an important factor with regard to the end use properties of various products such as noodles and dough (Sievert & Holm, 1993). It has a strong bond and therefore takes a lot of energy to breakdown during digestion due to its tightly packed structure. It is reputed to be an effective prebiotic. Amylose positively influences the functioning of the digestive tract microbial flora, the blood cholesterol level and the glycemic index, and assists in the control of diabetes (Hu, Pan, Malik, & Sun, 2012). Rice is generally known to have a relatively high glycemic index compared to other starchy foods. There is an inverse relationship between glycemic index and amylose content; hence the lower the amylose content, the higher the glycemic index scale and vice versa. Grains are naturally low in amylose as is seen in rice (Hu et al., 2012).

3.1. Functional properties of flour samples

Results of the functional properties of the flour samples are shown in Table 3.

The slight variation in bulk density could be as a result of the variation in starch content. Iwe and Onuh (1992) and Iwe and Onadipe (2001) reported that starch content increased bulk density. This might explain the low bulk density obtained for rice flour in this study. Bulk density is also dependent on factors such as method of measurement, geometry, size, solid density and surface properties of the materials and could be improved when the particles are small, compactible, properly tapped/vibrated and with a suitable packaging material (Machuka, Okeola, Chrispeels, & Jackai, 2000). Bulk density reflects the relative volume of packaging material required. The higher the bulk density, the denser the packaging material required. It indicates the porosity of a product which influences the package design and could be used in determining the type of packaging material required (Iwe & Onadipe, 2001).

The water absorption capacities of the flours were 0.63, 0.70, and 1.32% for brown cowpea, AYB and rice flours, respectively (Table 3). Water absorption capacity is an important functional property required in food formulations especially those involving dough handling (Lorenz & Collins, 1980). The

Table 3. Functional properties of flour samples

	Flour samples			
	Rice	**Cowpea**	**African yam bean**	**LSD**
Loose bulk density (g/ml)	0.69^{a}	0.69^{a}	0.63^{b}	0.02
Packed bulk density (g/ml)	0.84^{a}	1.00^{a}	0.87^{ab}	0.15
Water absorption capacity (%)	1.32^{a}	0.63^{ab}	0.70^{a}	0.65
Oil absorption capacity (%)	0.46^{b}	1.45^{a}	1.48^{a}	0.07
Emulsion capacity (%)	42.50^{b}	56.78^{a}	56.67^{a}	1.06
Foaming capacity (%)	10.40^{b}	18.17^{a}	18.17^{a}	0.75
Gelatinization temperature (°C)	57.90^{a}	50.93^{c}	52.27^{b}	1.22
Swelling index	0.67^{a}	0.45^{c}	0.61^{b}	0.04

Note: Values are means of triplicate determination. Values with the same superscripts in the same row are not significantly different ($p > 0.05$).

observed variation in water absorption capacities between AYB flour and cowpea flour maybe attributed to different protein concentrations, their degree of interaction with water and their conformational characteristics (McWatters, Ouedraogo, Resurreccion, Hung, & Phillips, 2003). This effect could be as a result of the loose association of amylose and amylopectin in the starch granules and weaker associative forces maintaining the granular structure. Water absorption capacity is important in bulking and consistency of products as well as in baking applications (Lorenz & Collins, 1980). Thus, the sample with the highest water absorption capacity is best accepted in baking applications.

Oil absorption capacity is an important functional property that enhances the mouth feel while retaining the flavour of food products (Adebowale & Lawal, 2004). The oil absorption capacities of the flours were 0.46, 1.45 and 1.48 g/ml for rice, cowpea and AYB flours, respectively. From statistical analysis, there was a significant difference ($p < 0.05$) in the oil absorption capacity of the flour samples. Absorption of oil by food products improves mouth feel and flavour retention, and this makes it an important property in such food formulations.

The emulsion capacity values were 42.50, 56.78 and 56.67% for rice, cowpea and AYB flours, respectively. Emulsion capacity did not differ significantly between cowpea and AYB flours. Their higher emulsion capacity could be as a result of higher protein content.

Rice flour had a foaming capacity of 10.40%, cowpea and AYB flours both had 18.17%, respectively. Foaming capacity did not differ significantly between the AYB and cowpea flours. Hence both legumes relate well with each other and any could be used in combination with the rice flour to improve the textural consistency and appearance of foods. Good foam capacity and stability are desirable attributes for flours intended for the production of a variety of baked products such as cookies, angel cakes, muffins, *akara*, etc. and also act as functional agents in other food formulations (El-Adawy, 2001) and so a complementation of either cowpea or AYB flours with rice flour is expected to give a product with improved texture, consistency and appearance.

Gelatinization temperatures were 57.90, 50.93 and 52.27°C for rice, cowpea and AYB flours, respectively. Overall, gelatinization temperature differed significantly ($p < 0.05$) between the three flour samples analysed. Variation in the gelation characteristics of flours could be attributed to the relative ratio of protein, carbohydrates and lipids that make up the flours and the interaction between such components (Sathe, Deshpande, & Salunkhe, 1982). This property of starch granules to form a gel when subjected to heat is important in the formulation of baked goods.

The swelling indices of rice, cowpea and AYB flours were 0.67, 0.45 and 0.61 respectively. The swelling indices of the flour samples differed significantly ($p < 0.05$). This result may be due to the variety of the sample and the processing method adopted. Swelling capacity is regarded as a quality criterion in some good formulations as bakery products. It is an evidence of non-covalent bonding between molecules within starch granules and also a factor of the ratio of α-amylose and amylopectin ratios (Rašper, 1969).

3.2. Pasting properties of flour blends

The pasting properties of the flour blends are as shown in (Table 4). When heat is applied to starch-based foods in the presence of water, a series of changes occur known as gelatinization and pasting. Pasting property is one of the most important properties that influence quality and aesthetic considerations in the food industry since they affect texture and digestibility as well as the end use of starch-based food commodities (Adebowale, Sanni, & Awonarin, 2005; Ajanaku, Ajanaku, Edobor-Osoh, & Nwinyi, 2012; Onweluzo & Nnamuchi, 2009). It is an index for predicting the ability of a food to form a paste when subjected to heat applications.

Peak viscosity is the maximum viscosity developed during or soon after the heating portion. It is an index of the ability of starch-based foods to swell freely before their physical breakdown

(Adebowale, Sanni, & Oladapo, 2008; Sanni, Adebowale, Filani, Oyewole, & Westby, 2006). High peak viscosity is an index of high starch content (Osungbaro, 1990) and this explains why 100% AYB, 100% rice and 25% rice:75% cowpea had a high peak viscosity. High peak viscosity also reflects fragility of the swollen granules which first swell and then breaks down under the continuous mixing of the Rapid Visco Analyzer. The high peak viscosity values noted in this study is of processing advantage and has been reported to be significant in the preparation of stiff dough products like *tuwo shinkafa*, a stiff dough product made from cereal flour and eaten with stew and vegetable (Danbaba et al., 2012).

Trough viscosity is the minimum viscosity value in the constant temperature phase of the Rapid Visco Analyzer pasting profile. In simple terms, trough viscosity is the point at which the viscosity reaches its minimum during either heating or cooling processes. It measures the ability of the paste to withstand breakdown during cooling. The significantly high trough viscosity observed in this study indicates the tendency of the rice flour to breakdown during cooking. The values obtained in this study are similar to the range of 80.3–117.2 RVU of Ofada rice as reported by Danbaba et al. (2012). There was a significant difference ($p < 0.05$) in the trough viscosity of the flour blends (Table 4).

The breakdown viscosity is an index of the stability of the starch and a measure of the ease with which the swollen granules can be disintegrated (Kaur, Shandu, & Singh, 2007). The breakdown viscosity of rice flour is 86.25 RVU. The other flour blends had breakdown viscosities in the range of 22.08–106.75 RVU. The breakdown viscosity values of the flour samples were significantly different ($p < 0.05$). Adebowale et al. (2005) reported that the higher the breakdown viscosity, the lower the ability of the flour to withstand heating and shear stress during cooking. Hence, the flour samples 100% cowpea, 50 rice:50 African yam bean might be able to withstand heating and shear stress compared to the other high-breakdown viscosity blends like AYB and rice flours. For rice, a higher breakdown viscosity is considered to be an indicator of better palatability. Result obtained from comparing the physicochemical properties of rice showed that the cultivar with the highest breakdown viscosity was the most palatable (Tren, Okadome, Murata, Homma, & Ohtsubo, 2001).

Final viscosity is commonly used to define the quality of a particular starch-based flour since it indicates the ability of the flour to form a viscous paste after cooking and cooling. It also gives a measure of the resistance of the paste to shear force during stirring (Adebowale et al., 2005, 2008). The variations in the final viscosity might be due to the simple kinetic effect of cooling on viscosity and the reassociation of starch molecules in the flour samples. There was a significant difference ($p < 0.05$) in the final viscosity of the composite flours. The final viscosity values obtained in this study are similar to the range of 190.3–261 RVU reported for Ofada rice variety (Danbaba et al., 2012). Rice flour had the highest value (Table 4), while 25% rice:75% African yam bean had the lowest value. This may be attributed to the hydrogen bonding during cooling and the high amylose content of the rice flour (Alais & Linden, 1986).

There was a significant difference in the setback viscosity of the composite flour samples. The higher the setback viscosity, the lower the retrogradation of the flour paste during cooling and the lower the staling rate of the products made from the flour (Adeyemi & Idowu, 1990). Setback viscosity has been correlated with the texture of various end products. High setback viscosity is also an indication of the amount of swelling power of the rice samples and is usually related to the amylose content of the sample (Jennifer & Les, 2004). Setback viscosity indicates the tendency of starch granules to retrograde on cooling.

Peak time is a measure of the cooking time and it ranged between 5.18 and 5.92 min with 50% rice: 50% African yam bean flour blend having the highest peak time and 75% rice:25% African yam bean flour blend had the lowest. It indicates the minimum temperature required to cook flour. Peak time values reported in this work are similar to the peak time values of 5.13–5.80 min and 5.01–6.30 min reported for instant yam–breadfruit composite flour and germinated tigernut flour, respectively (Adebowale et al., 2008; Chinma, Ingbian, & Akpapunam, 2007).

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Table 4. Pasting properties of flour blends

Sample blends	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (min)	Pasting temperature (°C)
African yam bean	$225.75^{b} \pm 0.01$	$133.17^{c} \pm 0.00$	$92.58^{b} \pm 0.01$	$194.17^{f} \pm 0.00$	$61.00^{g} \pm 0.00$	$5.33^{f} \pm 0.00$	$83.65^{b} \pm 0.01$
Brown cowpea	$163.17^{d} \pm 0.01$	$135.00^{b} \pm 0.00$	$28.17^{h} \pm 0.01$	$243.58^{c} \pm 0.01$	$108.58^{d} \pm 0.01$	$5.44^{e} \pm 0.01$	$82.58^{c} \pm 0.00$
Rice	$245.50^{d} \pm 0.01$	$159.25^{a} \pm 0.01$	$86.25^{c} \pm 0.00$	$294.33^{a} \pm 0.01$	$135.08^{a} \pm 0.00$	$5.22^{g} \pm 0.00$	$79.95^{h} \pm 0.00$
75 African yam bean:25 Rice	$161.17^{e} \pm 0.01$	$123.25^{d} \pm 0.01$	$37.92^{g} \pm 0.00$	$247.33^{b} \pm 0.01$	$124.08^{b} \pm 0.00$	$5.18^{h} \pm 0.00$	$80.46^{g} \pm 0.01$
50 African yam bean:50 Rice	$128.50^{h} \pm 0.01$	$106.42^{f} \pm 0.00$	$22.08^{i} \pm 0.00$	$229.33^{d} \pm 0.01$	$122.92^{c} \pm 0.01$	$5.92^{a} \pm 0.01$	$83.65^{b} \pm 0.01$
50 Brown cowpea:5 Rice	$128.50^{h} \pm 0.01$	$87.42^{h} \pm 0.00$	$41.08^{f} \pm 0.00$	$186.42^{g} \pm 0.01$	$99.00^{e} \pm 0.01$	$5.33^{d} \pm 0.00$	$81.47^{e} \pm 0.00$
75 Brown cowpea:25 Rice	$157.33^{f} \pm 0.01$	$90.08^{g} \pm 0.00$	$67.25^{d} \pm 0.01$	$123.58^{i} \pm 0.01$	$33.50^{i} \pm 0.01$	$5.49^{d} \pm 0.00$	$82.28^{e} \pm 0.00$
25 Brown cowpea:75Rice	$213.83^{c} \pm 0.01$	$107.08^{e} \pm 0.00$	$106.75^{d} \pm 0.01$	$196.67^{e} \pm 0.01$	$89.58^{f} \pm 0.00$	$5.75^{c} \pm 0.01$	$82.49^{d} \pm 0.01$
25 African yam bean:75 Rice	$133.50^{g} \pm 0.01$	$85.08^{i} \pm 0.01$	$48.42^{e} \pm 0.00$	$145^{h} \pm 0.01$	$60.17^{h} \pm 0.00$	$5.85^{b} \pm 0.01$	$84.75^{a} \pm 0.00$
LSD	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Note: Values are means ± standard deviation of duplicate determinations. Values with the same superscripts in the same column are not significantly different at $p > 0.05$.

The elevated pasting temperature value of the Rice: African yam bean blend could be attributed to the buffering effect of fat on starch which interferes with the gelatinization process (Egouletey & Aworh, 1991). A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starch granules (Adebowale et al., 2008). Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability. It is therefore clear from the results (Table 4), that rice flour will cook faster and less energy will be consumed, thus saving time and cost when compared to other flour blends because of its lower pasting temperature.

4. Conclusion

The study revealed the functional and pasting property variations that exist in samples of composite rice–AYB–brown cowpea flours. Results of water absorption capacities showed the extent to which water can be added during dough preparation using the various flour samples. Knowledge of solubilities, swelling characteristics and pasting properties will assist consumers to know the extent of reconstitution, which will in turn improve texture, consistency and appearance of baked goods prepared from these varying composite flours. The study revealed that complementing rice flour with either of AYB or brown cowpea flours could be an alternative to using 100% wheat flour in order to enhance proximate, pasting and functional properties which are desirable characteristics in the food industries.

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References

AACC. (2001). *Approved methods of the Association of Cereal Chemist* (11th ed., Method 61-02.01. Determination of the pasting properties of rice with the rapid visco analyzer). St. Paul, MN: Author.

Abdelghafor, R. F., Mustafa, A. I., Ibrahim, A. M. H., & Krishnan, P. G. (2010). Quality of bread from composite flour of sorghum and hard white winter wheat. *Advance Journal of Food Science and Technology, 3*, 9–15.

Adebayo-Oyetoro, A. O., Olatidoye, O. P., Ogundipe, O. O., Balogun, O. I., Bamidele, F. A., & Faboya, A. O. (2011). Evaluation of proximate composition and functional properties of Ofada rice (*Oryza sativa*) flour blended with bambara groundnut (*Vigna subterannea* L.). *IOSR Journal of Agriculture and veterinary Science, 3*, 60–66.

Adebowale, A. A., Sanni, L. O., & Awonarin, S. O. (2005). Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. *Food Science and Technology International, 11*, 373–382. http://dx.doi.org/10.1177/1082013205058531

Adebowale, A. R. A., Sanni, S. A., & Oladapo, F. O. (2008). Chemical, functional and sensory properties of instant yam-breadfruit flour. *Nigerian Food Journal, 26*, 2–12.

Adebowale, K. O., & Lawal, O. S. (2004). Comparative study of the functional properties of bambarra groundnut (*Voandzeia subterranean*), jack bean (*Canavalia ensiformis*) and mucuna bean (*Mucuna pruriens*) flours. *Food Research International, 37*, 355–365. http://dx.doi.org/10.1016/j.foodres.2004.01.009

Adeyemi, I. A., & Idowu, M. A. (1990). The evaluation of pregelatinized maize flour in the development of maissa, a baked product. *Nigerian Food Journal, 8*, 63–73.

Ajanaku, K. O., Ajanaku, C. O., & Edobor-Osoh, A., & Nwinyi, O. C. (2012). Nutritive value of sorghum ogi fortified with groundnut seed (*Arachis hypogaea* L.). *American Journal of Food Technology, 7*, 82–88. http://dx.doi.org/10.3923/ajft.2012.82.88

Alais, C., & Linden, G. (1986). Energy and protein intakes of infants and children from the low income group of Ibadan. *Nutrition Research, 26*, 129–137.

Alexander, R. R., & Griffiths, J. M. (1993). *Basic biochemical methods* (2nd ed.). New York, NY: Wiley-Lis.

Andrae, G., & Beckman, B. (1985). *The wheat trap: Bread and underdevelopment in Nigeria* (p. 180, Third World Books). London: Zed Books.

AOAC. (1990). *Association of official and analytical chemists official methods of analysis* (15th ed.). Washington, DC: Author.

Bugusu, B. A., Campanella, O., & Hamaker, B. R. (2001). Improvement of sorghum-wheat composite dough rheological properties and breadmaking quality through Zein addition. *Cereal Chemistry, 78*, 31–35. http://dx.doi.org/10.1094/CCHEM.2001.78.1.31

Chinma, C. E., Ingbian, E. K., & Akpapunam, M. (2007). Processing and acceptability of fried cassava balls (Akara-akpu) supplemented with melon and soybean flours. *Journal of Food Processing and Preservation, 31*, 143–156. http://dx.doi.org/10.1111/jfpp.2007.31.issue-2

Danbaba, N., Anounye, J. C., Gana, A. S., Abo, M. E., Ukwungwu, M. N., & Maji, A. T. (2012). Physical and pasting properties of 'ofada' rice (*Oryza sativa* L.) varieties. *Nigerian Food Journal, 30*, 18–25. http://dx.doi.org/10.1016/S0189-7241(15)30009-6

Dendy, D. A. V. (1992). Composite flour-past, present, and future: A review with special emphasis on the place of composite flour in the semi-arid zones. In M. I. Gomez, L. R. House, L. W. Rooney, & D. A. V. Dendy, (Eds.), *Utilization of sorghum and millets*, (pp. 67–73). Patancheru: International crops institute for the Semi-Arid Tropics.

Dendy, D. A. V. (1993, May). *Review of composite flour technology in the context of Tanzania*. A paper presented at the workshop. Sorghum and millets marketing and utilization (pp. 3–5). Arusha Tazania.

Edema, M., Sanni, L. O., & Sanni, A. I. (2005). Evaluation of maize-soybean flour blends for sour maize bread production in Nigeria. *African Journal of Biotechnology, 4*, 911–918.

Egouletey, M., & Aworh, D. C. (1991). Production and physicochemical properties of Tempeh fortified maize based weaning food. *Nigerian Food Journal, 70*, 92–102.

El-Adawy, T. A. (2001). Characteristics and composition of watermelon, pumpkin, and paprika seed oils and flours. *Journal of Agricultural and Food Chemistry, 49*, 1253–1259. http://dx.doi.org/10.1021/jf001117+

Gibney, M. J. (1989). *Nutrition diet and health* (p. 168). New York, NY, Cambridge University Press.

Hoover, R. (2001). Composition, molecular structure, and physicochemical properties of tuber and root starches: A review. *Carbohydrate Polymers, 45*, 253–267. http://dx.doi.org/10.1016/S0144-8617(00)00260-5

Hu, E. A., Pan, A., Malik, V., & Sun, Q. (2012). White rice consumption and risk of type 2 diabetes: Meta-analysis and systematic review. *British Medical Journal,* 344.

Iwe, M. O., & Onadipe, O. O. (2001). Effect of addition of extruded full fat soy flour into sweet potato flour on the functional properties of the mixture. *Journal of Sustainable Agriculture and the Environment, 3*, 109–117.

Iwe, M. O., & Onuh, J. O. (1992). Functional and sensory properties of soybean and sweet potato flour mixtures. *Lebensmittelwissenschaft und Technologie, 25*, 569–573.

Jennifer, M. D., & Les, C. (2004). Genotype and environmental influences on pasting properties of rice flour. *Journal of Cereal Chemistry, 81*, 486–489.

Kaur, M., Shandu, K. S., & Singh, N. (2007). Comparative study of the functional, thermal and pasting properties of flour from different chickpea cultivars. *Journal of Food Chemistry, 104*, 259–267.

Lorenz, K., & Collins, F. (1980). Quinoa, starch physicochemical properties and functional characteristics of starch/starke *42*, 81–86.

Machuka, J. S., Okeola, O. G., Chrispeels, M. J., & Jackai, L. E. N. (2000). The African yam bean seed lectin affects the development of the cowpea weevil but does not affect the development of larvae of the legume pod borer. *Phytochemistry, 53*, 667–674. http://dx.doi.org/10.1016/S0031-9422(99)00574-9

McWatters, K. H., Ouedraogo, J. B., Resurreccion, A. V. A., Hung, Y., & Phillips, R. D. (2003). Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (*Digitaria exilis*) and cowpea (*Vigna unguiculata*) flours. *International Journal of Food Science and Technology, 38*, 403–410. http://dx.doi.org/10.1046/j.1365-2621.2003.00716.x

Nwosu, J. N., Ahaotu, I., Ayozie, C., Udeoozor, L. O., & Ahaotu, N. N. (2011). The proximate and functional properties of African yam bean (*Sphenostylis stenocarpa*) seeds as affected by processing. *Nigerian Food Journal, 29*, 39–48.

Ohimain, E. I. (2014). The prospects and challenges of composite flour for bread production in Nigeria. *Global Journal of Human-Social Science: H Interdisciplinary, 14*, 42–52.

Onweluzo, J. C., & Nnamuchi, O. M. (2009). Production and evaluation of porridge-type breakfast product from *Treculia Africana* and sorghum bicolor flours. *Pakistan Journal of Nutrition, 8*, 731–736.

Onwuka, G. I. (2005). *Food analysis and instrumentation: Theory and practice* (p. 68). Lagos: Naphthali Prints.

Osungbaro, T. O. (1990). Effect of differences in variety and dry milling of maize on textural characteristics of Ogi (fermented maize porridge) andAgidi (fermented maize meal). *Journal of the Science of Food and Agriculture, 52*, 1–11. http://dx.doi.org/10.1002/(ISSN)1097-0010

Oyeku, O. M., Kupoluyii, C. F., Osibanjo, A. A., Orji, C. N., Ajuebor, F. N., Ajiboshin, I. O., & Asiru, W. B. (2008). An economic assessment of commercial production of 10% cassava-wheat composite flour bread. *Journal of Industrial Research & Technology, 2*, 20–30.
Raja, K. C. M., & Ramakrishna, S. U. (1990). Compositional and pasting characteristics of plain-dried and parboiled cassava (*Manihot esculenta crantz*). *Food Chemistry, 38*, 79–88. http://dx.doi.org/10.1016/0308-8146(90)90154-V
Rašper V. (1969). Investigations on starches from major starch crops grown in Ghana I.—Hot paste viscosity and gel-forming power. *Journal of the Science of Food and Agriculture, 20*, 165–171. http://dx.doi.org/10.1002/(ISSN)1097-0010
Reebe, S., Gonzalez, V. N., & Rengifo, J. (2000). Research on trace elements in common beans. *Food Nutrition Bulletin, 21*, 387–391.
Sanni, L. O., Christiana, A. B., & Silifat, A. S. (2004). Production of instant cassava noodles. *Journal of Food Technology, 2*, 83–89.
Sanni, O. L., Adebowale, T. A., Filani, T. A., Oyewole, O. B., & Westby, A. (2006). Quality of flash and rotary dryer dried fufu flour. *Journal of Food, Agriculture and Environment, 4*, 74–78.
Sathe, S. K., Deshpande, S. S., & Salunkhe, D. K. (1982). Functional properties of lupin seed (*Lupinus mutabilis*) proteins and protein concentrates. *Journal of Food Science, 47*, 491–497. http://dx.doi.org/10.1111/jfds.1982.47.issue-2
Seibel, W. (2006). Composite flours. In L. Popper (Ed.), *Future of flour: A compendium of flour improvement* (pp. 193–198). Verlag AgriMedia.
Sievert, D., & Holm, J. H. (1993). Determination of amylose by differential scanning calorimetry. *Starch - Stärke, 45*, 136–139. http://dx.doi.org/10.1002/(ISSN)1521-379X
Sotelo, A., Saisa, V., Montolvo, I., Hernandez, M., & Hernandez, L. (1990). Chemical composition of different fractions of 12 Mexican varieties of rice obtained during milling. *Cereal Chemistry, 67*, 209–212.
Tren, U. T., Okadome, H., Murata, M., Homma, S., & Ohtsubo, K. (2001). Comparison of Vietnamese and Japanese rice cultivars in terms of physiochemical properties. *Food Science Technology Research, 7*, 328–330.
Ukpabi, U. J., & Ndimele, C. (1990). Evaluation of the quality of garri produced in Imo state. *Nigerian Food Journal, 8*, 105–109.
Yetunde, E. A., Ukpong, S. U., Olajumoke, L., & Ime, F. A. (2009). Nutritional composition and sensory properties of cakes made from wheat and African yam bean flour blends. *Journal of Food Technology, 7*, 115–118.