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Assessment of Proximate Composition, Functional and Pasting Properties of Blends of Wheat, Local Rice, and Water Yam Flours

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ABSTRACT

The proximate, functional and pasting properties of Wheat, local rice, and wateryam flours were determined using standard method. The proximate and amylose contents of 100% of each of the flour (wheat, rice, and water yam) was analyzed and significant ($P<0.05$) differences were observed in the moisture content (8.58 – 12.1%), crude protein (5.58-12.4%), fat (1.27-1.58%), ash (1.04-2.23%), fibre (1.38-1.75%), and amylose content (16.92 - 27.75 %). Functional properties which include loose bulk density, tapped bulk density, Carr index, water absorption capacity, oil absorption capacity, dispersibility, and gelatinization temperature ranged from 0.57 – 0.70g/ml, 0.77 – 0.93g/ml, 15 – 26%, 1.80 – 2.15ml/g, 1.37 – 2.99, 69.50 – 75.00%, and 52.50 – 65.5^{0}C respectively. The pasting properties ranged from the peak viscosity (98.34 – 247.75), breakdown viscosity (37.70 – 88.12), final viscosity (242.47 – 292.16), setback viscosity (127.50 – 193.92), pasting time (5.78 – 6.71min), and pasting time (80.47 – 95.28^{0}C). The local rice flour had the highest bulk density, gelatinization temperature, and breakdown viscosity, but had the least amylose content. These results showed that mixing the components of wheat, local rice, and water yam flour could be used to enhance the proximate and pasting properties to suit their application in food and other industrial products.

KEYWORDS: *Composite flours, wheat flour, faro 44, amylose content*

INTRODUCTION

Composite flour is a mixture of different flours from roots and tubers, legumes, cereals or other raw materials that is created to satisfy specific functional characteristics and nutrient composition. Use of composite flour in food processing has the advantage of reducing the huge foreign exchange spent on wheat flour importation, coupled with the prospects of the utilisation of underutilised crops. Wheat has exceptional baking properties due to its high gluten content which contributes greatly to dough sponginess and elasticity. However, the increasing demands for wheat, as a result of increasing populations, urbanisation and changing food habits especially in the developing countries, has led to increased importation (Ajatta *et al*., 2016). FAO (1990) reported that the substitution of wheat flour with 20 percent non-wheat flour for the manufacture of bakery products would result in an estimated savings in foreign exchange of twenty million US dollars for developing countries of the world. Rice flour has been used partially or fully to substitute wheat in noodles production in many Asian countries (Makdoud and Rosentrater, 2017; Ahmed *et al*., 2016; Ahmed *et al*., 2015; Jeong-Ju and Suyong, 2014; Reungmaneepaitoon *et al*., 2008). Some other advantages of composite flour include improvement in the supply of proteins for human nutrition, and generation of income and support for rural development.

As rice output continues to increase in Nigeria, one of the ways to increase rice utilization and reduce dependency on wheat importation is to convert rice into flour, which will eventually be used to substitute wheat in making wheat based products like bread, noodles and others.

Water yam (*Dioscorea alata*) is a staple starchy food that is highly economical and desirable for the diabetic due to its low sugar content (Adeola *et al*., 2017). Besides being an energy rich tuber, water yam provides protein three times more superior than the one of cassava and sweet potato (Ezeocha and Ojimelukwe, 2012). Water yam is also known to contain bioactive compounds such as dioscorine, diosgenin and water soluble polysaccharide, and these protein and polysaccharides are essential in controlling and management of hypertension, cholesterol metabolism, obesity, and anti- tumor activity (Egbedike *et al*., 2016). But water yam, though very nutritive, belongs to the neglected crops and many constraints limit its production. Conversion of water yam into yam flour and apply include in composite flours will improve the shelf life of water yam, increase its utilization and encourage its farmers to produce more. Functionality of foods is the characteristics of food ingredient other than nutritional quality, which has a great influence on its utilization. Whereas the pasting properties are useful in predicting the pasting behavior and ability of the flour samples. Therefore, this research proposes to study the proximate, functional and pasting properties of blends of wheat-local rice-water yam flours.

MATERIALS AND METHODS

Raw material sources

Polished rice of FARO 44 variety used for this study was obtained from Abakaliki rice mill in Ebonyi State, Nigeria. The hard white wheat flour used for the production of instant noodles samples was obtained from the Noodles manufacturing industry located in Abia State, Nigeria. The tubers of water yam (*Dioscorea alata)* was obtained from the farm of National Root Crop Research Institute (NRCRI). The soy beans were purchased in New Market in Aba, Abia State.

Raw Sample Preparation

Preparation of rice flour used: Rice grains were cleaned, sorted and washed. They were then steeped in water for 12 h, drained and dried at 60^0C in a hot air oven. Milling of the dried rice grains was done using attrition mill make and the milled grains sieved using a 300-µm mesh size sieve to obtain fine flour, according to the method described by Omeire *et al*. (2014).

Preparation of water yam flour
Water yam tubers were washed with clean water to remove adhering soil and other undesirable materials. The tubers were thereafter hand-peeled, using kitchen knives and sliced into sizes of 2 to 3cm thickness. The yam slices were dried at 60^0C in an oven. The dried yam slices was milled with a Fritsch hammer mill (Glen Creston Ltd, Stanmore, Middx HA7, serial No. 950401) to pass through a 250 µm sieve (Endecotts Ltd, England) and packed in a high density polythene bag, stored at room temperature in a wood shelve in the Food Processing Laboratory, Food Technology department, Abia State Polytechnic Aba, until needed for analysis.

The component proportions by volume of wheat, rice, and wateryam flours were measured in a measuring cylinder and introduced into the blender and the alkali mixture ingredients added in a blender, and thoroughly mixed.

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.

Functional Analysis

The loose bulk density, bulk density, carr index, water absorption capacity, oil absorption capacity, dispersibility, and gelatinization temperature were determined according to the method described by Onwuka (2018).

Pasting property.
The pasting properties of the flour samples were determined using the rapid visco analyzer (RVA) according to (Newport scientific, Narrabeen Australia) as described by Imoisi *et al*. (2020); Baek and Lee (2014). In a typical experiment, 3.50 g of the flour was mixed with 25.0 ml of distilled water with continuous paddling to form a paste. The samples were then inserted in the rapid visco analyzer. The analysis was carried out at a programmed heating and cooling circle where the samples were held at 50^0C for 1 minute, heated at 95^0C for 3.8 minutes and held at 50^0C for 1.4 minutes. The pasting performance of the flour samples was automatically recorded on the graduated sheet of the instrument. Parameters that was determined are final viscosity, setback viscosity, pasting time and pasting temperature.

RESULTS AND DISCUSSION

Proximate and Amylose Composition of local Rice, Water Yam, and Wheat Flours.

The proximate composition and amylose content of the flour samples were presented in Table 1. These analyses were performed on the flour samples to establish the characteristics of the raw materials flour samples used in this study. The moisture contents ranged from 5.58 to 12.10 %, and were significantly different ($p<0.05$) (Table 1). The local rice flour had the highest moisture content (12.10 %) while the industrially produced wheat flour used for noodle production had the least moisture content of 8.58 %. However, the moisture content of rice and water yam flours were not significantly different ($p>0.05$). The relative high moisture contents of rice and water yam flours might be due to soaking before drying of the raw samples of rice. Low moisture content favours long shelf life, while higher moisture content shortens the shelf life of a product through encouraging microbial growth which causes spoilage of the product.

The crude protein contents of the flours made from rice, water yam and wheat were significantly different ($p<0.05$). From Table 1, the wheat flour had the highest protein content of 12.40 %, followed by the protein content of rice flour (10.08 %), while the water yam flour had the least protein content (5.58 %). The protein content of rice flour falls within the range expected for the variety (faro 44) (Odenigbo *et al*., 2014).

Table 1. Proximate Composition and Amylose contents of Flour Samples

Samples	M.C (%)	Crude Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)	Amylose
RICE	$12.10^{a}\pm0.42$	$10.08^{b}\pm0.32$	$1.58^{a}\pm0.06$	$1.04^{b}\pm0.08$	$1.38^{b}\pm0.04$	$72.63^{b}\pm1.05$	$16.92^{c}\pm0.54$
WYAM	$11.57^{a}\pm0.19$	$5.82^{c}\pm0.25$	$1.49^{ab}\pm0.11$	$2.23^{a}\pm0.11$	$1.75^{a}\pm0.07$	$78.03^{a}\pm0.62$	$22.03^{b}\pm0.33$
WHEAT	$8.58^{b}\pm0.11$	$11.40^{a}\pm0.28$	$1.27^{b}\pm0.04$	$1.23^{b}\pm0.01$	$0.52^{c}\pm0.01$	$76.71^{a}\pm1.13$	$27.75^{a}\pm0.35$
LSD	2.99	1.72	0.31	1.00	0.38	5.40	5.11

The protein content of water yam flour is in agreement with the protein content of the water yam variety (*D alata Hingurala*) reported by Senanayake *et al*. (2012), while the protein content (12.40 %) of wheat falls within the range expected of wheat grains used for preparation of noodles (Gulia *et al*., 2014). The relative high protein in wheat is due to the presence of gluten which is the protein responsible for the visco-elastic characteristics of dough made from wheat.

The crude fat content of the flours ranged from 1.27 to 1.58%, and were significantly different ($p<0.05$) as indicated in Table 1. The rice flour had the highest level of fat content (1.58 %), followed by the fat content (1.47 %) of water yam, but their fat contents are not significantly different ($p>0.05$). Wheat flour had the least fat content of 1.27 % which is significantly lower ($p<0.05$) than the fat content of rice flour.

The water yam flour had the highest ash content (2.23 %) that was significantly higher than that of rice (1.04 %) and that of wheat (1.23 %). However, the ash contents of both rice and wheat flour were not significantly different.

The fibre contents of the flours are significantly different ($p<0.05$). Water yam flour had the highest (1.75 %), followed by that of rice (1.38 %), while the wheat flour had the least fibre content of 0.52.

The carbohydrate contents of water yam and wheat flours were 78.08 % and 78.71 % respectively with no significant difference (p>0.05). Rice flour had the least carbohydrate content of 72.63 %.

Wheat flour had the highest amylose content of 27.75 %, followed by water yam flour with amylose content of 22.03 %, while the rice flour had the least amylose content of 16.92. An amylose content can be classified as waxy (0-2%), low (10-20%), intermediate (20-25%) and high (>25) amylose content (Chatterjee and Das, 2018). Thus, based on this classification, the rice used for this study can be classified as low. High amylose content (>25 g/100 g) in rice plays a critical role in creating a gel network or structure in products such as noodle (Fari *et al*., 2011). The amount of amylose present in the starch granule has significant effects on the starch physicochemical and functional properties. Amylose has been reported to play a role in the initial resistance of granules to swelling and solubility, as swelling proceeds rapidly after leaching of amylose molecules. Also the capacity of amylose molecules to form lipid complexes prevents their leaching and consequently the swelling capacity (Alcázar-Alay and Meireles, 2015).

Functional Properties of Blended Flours

Tables 2 below depicts some functional properties of the rice flour (faro 44 rice), water yam flour, and wheat flour samples. Functional properties can be defined as the characteristics which govern the behavior of nutrients in food during processing, storage, and preparation as they affect food quality and acceptability (Onwuka, 2018).

The loose bulk densities (LBDs) ranged from 0.57 to 0.70 g/ml. However, the LBDs of the flour samples were not statistically different (p>0.05). The 100 % rice flour had the highest LBD of 0.70 g/ml and was consistent with the levels reported by Iwe *et al*. (2016).

The tapped bulk density (TBD) of the flour samples were significantly different (p<0.05). Among the pure samples (not blended), the 100 % rice flour had the highest bulk density of 0.82 g/ml and was consistent with the values of bulk density on local rice flour reported by Iwe (2015). Sample 100 % wheat (W) had the second highest bulk density (0.78 g/ml), while the 100 % water yam (Y) flour had the least bulk density of 0.77 g/ml. The bulk densities of wheat and water yam flours were not significantly different (p>0.05). Blending of flours did not significantly affect the bulk densities of the flour samples as indicated in Table 2 Sample RY (rice:water yam 50:50) had the highest tapped bulk density of 0.93 g/ml, but not significantly different from samples 100 % R, WR (50:50), WRY(66.6:16.7:16.7), and RWY(66.7:16.7:16.7). Low bulk density is desirable in infant feeding (Omeire *et al*. 2014), which also reduces storage and transportation cost. The carr index of the blended flour samples ranged from 15 to 28 % and were statistically different (p<0.05). Flour sample 100 % W had the highest carr index of 28 %, while the flour with the least carr index (15 %) is sample (100 % R). The carr index is used to measure the compressibility of powder, and is often applied in pharmaceutics as an indication of flowability of powder. Flour that has carr index greater than 25 is rated 'poor flowability', while the one below 15 is rated 'good flowability' (Onwuka, 2018). Thus sample 100 % W used for this study has poor flowability, while the 100 % rice flour has fairly good flowability. Blending of flours did not significantly (p>0.05) affect the flowability of the flour samples as indicated in Table 2.

Table 2. Functional Properties of blended Flour Samples

Samples	LBD (g/ml)	TBD (g/ml)	Carr index (%)	WAC (ml/g)	OAC (ml/g)	Dispersibility (%)	G.T. (^{0}C)
100% W	0.57±0.06	0.78^b±0.03	28^a±0.02	2.15±0.50	1.85^b±0.15	75.00^a±6.50	52.5^e±2.12
100% R	0.70±0.03	0.82^{ab}±0.03	15^b±0.02	1.90±0.20	2.99^a±0.10	59.00^c±4.50	60.0^{bcd}±1.41
100%Y	0.60±0.02	0.77^b±0.07	22^{ab}±0.00	2.10±0.40	1.76^b±0.20	70.50^{ab}±3.50	65.5^{ab}±2.12
W:R (50:50)	0.63±0.00	0.85^{ab}±0.00	20^{ab}±0.01	2.10±0.45	1.93^b±0.04	71.00^{ab}±4.50	54.0^{de}±2.82
R:Y (50:50)	0.69±0.01	0.93^a±0.02	26^a±0.00	1.95±0.20	1.85^b±0.10	69.50^{ab}±4.00	69.0^a±2.4
W:Y (50:50)	0.58±0.06	0.79^b±0.03	26^a±0.01	2.12±0.50	1.78^b±0.20	71.50^{ab}±4.00	62.0^{abc}±2.3
WRY(66.6:16.7:16.7)	0.70±0.08	0.87^{ab}±0.07	21^{ab}±0.02	1.90±0.30	1.37^c±0.10	73.50^a±2.5	55.0^{cde}±1.2
RWY(66.7:16.7:16.7)	0.70±0.07	0.89^{ab}±0.01	21^{ab}±0.01	1.80±0.20	1.94^b±0.25	65.00^b±5.0	61.5^{bc}±2.12
LSD:	NS	0.15	0.11	NS	0.08	5.5	7.5

W = Wheat flour, R = Rice flour, Y = Water yam flour. NS = Not significant at 5% significant level. Means in the same column with different superscripts are significantly different. G.T. = gelatinization temperature

Water absorption capacity is the ability of a product to associate with water under a water limiting condition. The water absorption capacities (WACs) ranged from 1.80 to 2.15 ml/g. However, the differences in WACs capacities of the flour samples are not statistically different ($p>0.05$). Flours with high WAC are susceptible to enzyme degradation and low shelf life (Sanni and Akakaye 2007).

The oil absorption capacities (OACs) of the flour samples were significantly different ($p<0.05$). Sample 100 % R had the highest OAC of 2.99 ml/g and is significantly different from OACS of samples 100 % W and 100 % Y. However, the OACs of 100 % W (1.85 ml/g) and that of 100 % Y (1.76 ml/g) were not significantly different ($p>0.05$) (Table 2.). Sample WRY (67.7:16.7:16.7) had the least OAC of 1.30 ml/g. Flours ability to absorb and retain oil may help to improve binding of the structure, enhance flavour retention, and improve the mouthfeel (Aboshora *et al*., 2014).

The percentage dispersibility ranged from 59 to 75 %, and were significantly different ($p<0.05$). The 100 % wheat flour had the highest dispersibility, while 100 % local rice flour had the least dispersibily of 59 %, and then the 100 % water yam flour had 70.50 % dispersibility. Blending of wheat flour with either rice and/or water yam flour as seen in the flour sample mixture RWY

(66.7:16.7:16.7) reduced the dispersiblity significantly ($p<0.05$). Dispersibility is used to indicate the reconstitutability of flours or blends in water (Sanni and Ajakaye, 2007). Thus, the 100 % wheat flour which had the highest dispersibility will reconstitute better in water than the rice and water yam flours.

Gelatinization temperatures (GTs) for wheat, local rice, and water yam flours were 52.50, 60.00, and 65.5^{0}C respectively, and were significantly different ($p<0.05$) from each other. Variations in GTs has been reported to be as a result of relative ratio of protein, carbohydrates and lipids that make up the flours and the interaction between such components (Iwe *et al*., 2016). GT is also associated with cooking time of starchy products. Rice cultivar with low gelatinization temperature coupled with high amylose content is suitable for making rice noodles (Cham and Suwannaporn, 2010).

Pasting Properties of Flour Samples

Table 3 depicts the pasting characteristics of wheat, local rice, and water yam flour samples and blends. During heating of starch-based foods in the presence of water, series of changes known as gelatinization and pasting occur.

The peak viscosities of the flour samples produced ranged from 98.34 - 247.35 RVU and are significantly different ($p<0.05$). The wheat flour had the least peak viscosity (98.34 RVU) while the highest peak viscosity (247 RVU) was from the rice flour. The peak viscosity of the flour mixture component (75W:25R) was 108.54 RVU but not significantly different ($p>0.05$) from that of 100 % wheat. This implies that substituting 25 % of wheat with rice flour did not significantly ($p>0.05$) affect the peak viscosity.

Peak viscosity (PV) indicates the water-holding capacity of the starch or mixture. It is an index of the ability of starch-based foods to swell freely before their physical breakdown. The higher the peak viscosity the higher the swelling index, while low peak viscosity is indicative of higher solubility as a result of starch degradation or dextrinization (Imoisi *et al*., 2020). According to Sanni and Ajakaye (2007), higher peak viscosity indicates higher granular disruption, and the granules swell enormously leading to weakening of associated forces which in turn makes them susceptible to breakdown. This indicates that rice flour has higher susceptibility to granular disruption and breakdown than water yam and wheat flours. High peak viscosity values has been reported to be of processing advantage in the preparation of stiff tuwo shinkafa, a stiff dough product made from cereal flour (Iwe *et al*., 2016). The differences observed in the cooking time of starchy foods could be attributed to differences in their gelatinization temperature (Ahmed *et al*., 2015). The values of breakdown viscosity varied significantly ($p<0.05$) from 31.70 – 88.12 RVU with wheat having the least breakdown viscosity (31.7 0RVU) while the rice flour sample had the highest breakdown viscosity (88.12 RVU). The samples (75:25 and 66.6:16.7:16.7) had a breakdown viscosity of 38.70 and 39.12 RVU respectively but not significantly different ($p>0.05$) from that (31.7 RVU) of 100 % wheat. 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, and the higher the breakdown viscosity, the lower the ability of the flour to withstand heating and shear stress during cooking. The low breakdown viscosity in wheat flour is an advantage in noodles textural quality as the structure of noodles is not sheared during cooking. High breakdown viscosity as observed in rice may be a disadvantage in rice noodles textural quality, as the rice noodles may disintegrate in water during water.

Table 3. Pasting Characteristics of Wheat, Local Rice, Water Yam Flour Blends

W:R:Y	Peak Viscosity	Breakdown Viscosity	Final Viscosity	Setback	P.Time (min)	Pasting Temp (^{0}C)
100 W	98.34^c±2,34	317^b±1.02	253.54^b±2.05	193.92^a±1.52	6.71^a±0.12	95.28^a±1.01
100 R	247.75^a±2.10	88.12^a±2.65	292.16^a±3.06	132.54^b±3.54	6.47^a±0.07	80.47^b±0.74
100 Y	164.53^b±3.20	39.83^b±1.06	242.95^b±4.75	127.50^b±29	5.78^b±0.30	85.56^b±1.39
75:25:0	108.54^c±7.75	38.70^b±1.20	242.47^b±3.50	183.49^a±5.41	6.52^a±0.92	85.33^b±0.05
66.6:16.7:16.7	140.93^b±2.05	39.12^b±2.65	244.63^b±4.65	156.45^b±4.67	5.80^b±0.70	81.32^b±0.42
50:50:0	240.86^a±5.30	79.37^a±6.36	281.51^a±5.12	138.04^b±6.20	6.69^a±0.80	814^b±1.50
LSD	31.19	38.29	27.62	27.38	0.61	9.7

W=Wheat, R=Rice, Y=water yam.

The final viscosities of the flours which ranged from 242.95 to 292.16 RVU varied significantly with water yam flour having the least (242.95 RVU) while the rice flour had the highest final viscosity (292.16 RVU). The values of the final viscosities of flour samples with mixture components of 100 Y, 75W:25R, and 66.6W:16.7R:16.7Y were not significantly different from that found in 100 % W (Table 3). This implies that substituting wheat with 25% rice flour did not significantly ($p>0.05$) affect the peak viscosity of the composite flour. Final viscosity is used to indicate the ability of starch to form a viscous paste on cooling. It is thus reported as the most commonly used parameter to determine a particular starch-based sample quality.

The values of Setback viscosities of the flour components ranged from 127.50 (100 Y) – 193.92 (100 W) RVU. The setback viscosity of 100 W (193.92 RVU) did not differ significantly ($p>0.05$) from the setback viscosity (183.49 RVU) observed in 75W:25R (Table). Setback viscosity has been reported as a measure of the stability of the paste after cooking (Sanni and Ajakaye, 2007). It is the phase pasting curve after cooling of the starch and this phase involves re-association, retrogradation or re-ordering of starch molecules. Low set back of indicates that the flour will exhibit a low tendency to undergo retrogradation during freeze/thaw cycles (Maziya-Dixon *et al*., 2005). Whereas, high setback viscosity in rice samples is also an indication of the amount of swelling power and is usually related to the amylose content of the rice samples.

Peak time is a measure of the cooking time and it ranged from 5.78 to 6.71 min in the component flour samples as shown in Table 3. The 100 % water yam flour had the least peak time (5.78 min), followed by the peak time (5.80 min) observed from flour sample 66.6W:16.7R:16.7Y, while the wheat flour had the highest peak time (6.71 min). This implies that the incorporation of water yam flour in wheat flour used for manufacturing noodles may impact shorter cooking time.

CONCLUSION

The study showed that blending of different proportions of wheat, local rice and water yam significantly ($p<0.05$) affected the functional and pasting characteristics of the flour mixture. Substitution wheat flour with 25% rice flour did not significantly ($P>0.05$) the pasting properties – peak viscosity, breakdown viscosity, and final viscosity. The same thing applies in the composite flour when wheat was substituted with 32.34% (16.17 % rice and 16.17% wateryam flours) of both rice and water. This implies that composite flours from wheat-rice-wateryam could be used to reduce wheat importation and in the achievement of desired food security. In this way it will advance the promotion, processing and improve the suitability for their application in food and other industrial products.

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