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Physicochemical properties and akara making potentials of water yam and cowpea composite flour.

P. A. Okorie*, O. J. Ikegwu, V. N. Nwobasi, M. O. Odo and C. N. Egbedike

Department of Food Science and Technology, Ebonyi State University, P.M.B. 053, Abakaliki, Nigeria.

ABSTRACT

Akara (deep-fat fried balls) prepared from cowpea (*Vigna unguiculata*) paste is widely consumed in West Africa as a cheap source of protein. The akara making potentials of cowpea-water yam composite flour blends in different proportions of 90:10, 80:20, 70:30, 60:40 and 50:50 were used in the production of akara. The flour blends were reconstituted into a thick paste, and deep fried in hot vegetable oil at 193 ^oC for minutes. The proximate, functional and pasting properties of the flour blends were studied. The result showed that there was significant different ($p<0.05$) in the proximate composition in all the flour blends. The protein ranged from 1.85-18.56%, fat content, 0.42-0.63%, while ash content was between 2.04-4.01%, which increased with increase in level of cowpea addition. The fibre, moisture and carbohydrate contents decreased with values ranging from 2.56-3.88%, 9.64-10.44% and 64.15-81.37%, respectively. The functional properties result showed that bulk density, water absorption, oil absorption and foam capacity with the exception of foam stability significantly increased with increase in cowpea flour addition with their values ranging from 0.57-0.63g/cm^3, 190.02-202.07%, 152.08-196.07% and 58.9-69.2% respectively. The pasting characteristics of the water yam-cowpea blends gave a peak viscosity ranging from 195.8-280.9RVU. There was no significant difference ($p>0.05$) in the pasting time and temperature of the flour blends. The swelling and solubility index of all the composite flours improved as the pH increased. Sensory attributes of the akara were significantly different ($p<0.05$) from each other with the akara made from 10 to 30% water yam cowpea composite flours having better overall acceptability ratings for all the attributes measured.

Keywords: Akara, cowpea, water yam, proximate, functional, pasting

Corresponding author

INTRODUCTION

Cowpea (*Vigna unguiculata*) is the most common legume consumed in African countries especially Nigeria and it is an important source of plant protein and a nutritious component in the human diet (Enwere, 1998). It can be used to prepare such fast foods as moin-moin a steamed cooked paste and akara a deep fat product (Ngoddy et al., 1986). Akara is a deep fat fried ball products which is made from whipped cowpea paste flavourd with salt, fresh onion, and fresh hot pepper, by street and market vendors as well as in the home. The batter is dropped by spoonful portions into hot oil and forms spongy balls during frying. It is consumed as a breakfast or snack food by both children and adults (Falola et al., 2008). Blending and whipping are important steps in processing of cowpea into akara. Blending clearly aids in reducing the particle size of paste to a more acceptable level and thus aiding in better distribution of moisture. Whipping incorporates air into paste, thus making it foam and giving it good dispensing properties and frying qualities (Mbofung et al., 2002).

Studies on various aspects of production of akara from cowpea paste have been made (Olapade et al., 2004; Falola et al., 2008; Prinyawiwatkul et al., 1994). Traditionally, cowpea paste is prepared by the combined processes of soaking, dehulling and wet-milling of cowpea seeds and these processes are tedious, time-consuming and labour intensive. Efforts have been directed towards the production of functional flour which could be used to produce akara that was as acceptable from a sensory point of view as traditionally prepared samples. Edema et al. (2005), reported the need for strategic development and use of inexpensive local resources in the production of popular foods has led to the initiation of the composite flour program, the objective of which was to seek ways of substituting flours, starches and protein concentrates from indigenous crops such as cassava, maize, yam, sorghum and millet, for as much wheat as possible in baked products.

The yam tuber (*Genus Dioscorea*) is a stable food for millions of people in the tropical world. In Nigeria, *Dioscorea alata* also known as ji abana in Igbo, is one of the lesser- known yams and are underutilized. Yams are consumed in form of chunks, flour, chips, fufu and slices. The raw yam flour has found increasing use in bakery as dough conditioner in bread making, stabilizer in ice-cream and thickener in soups (Iwuoha, 2004), and in baby foods. Yams, especially water yam (*D. alata*) can be grated, mixed with salt, pepper and other spices and fried in hot palm oil to produce akara. This is popular with some Igbos' of south eastern Nigeria. There is a need to exploit the industrial potentials of native water yam for akara making in Nigeria. However, this requires prior information and understanding of desirable functional properties and the behavior of the material in systems during processing, manufacturing, storage, preparation as well as consumption.

Literature also abounds on the use cowpea paste and flour for akara and other food preparation (Fasasi and Karim, 2011; Osho and Karim, 2007), however, there is no information on the use of native water yam flour in the production of "akara". The lack of information on many basic aspects of underutilized crops such as the native water yam hinders their development and sustainable utilization. There is a need to get more information and understand the characteristics of this crop for its optimal use and application in areas where it is newly introduced. Therefore, the aim of this study was to determine the nutrient composition and functional properties of cowpea water yam composite flour as well as the "akara" making potentials of composite flour produced from cowpea and native water yam.

MATERIALS AND METHODS

Source of samples

The native water yam samples used for this study were obtained from a local market in Abakaliki, and the cowpea seed was obtained from Abakpa main market in Abakaliki, Ebonyi State Nigeria.

Sample preparation

Water yam (native) flour processing

The method of Ekwu et al. (2005) was adopted for the production of water yam flour.

Cowpea flour processing

Cowpea seeds were manually sorted to remove impurities; it was soaked in water at room temperature (28±2ºC) for 10 min to soften the testa, which was manually removed and washed off. The cleaned cotyledons were oven dried at 60ºC for 24 h and milled into four using disc attrition mill, followed by sieving (300-µm aperture). All flour samples were kept in high density polythene until analysis.

Production of “akara”

Composite flour of cowpea and water yam was prepared using the formulation in Table 1, while akara was prepared using methods described by McWatters, (1983). The composite flour was mixed with measured volume of water. This was allowed to form batter. The batter was whipped severally to incorporate air for about 2 min. Other ingredient like pepper, onion, salts, spices were then added. This was then scooped to make ball into already heated Grand vegetable oil. The scooped balls were turned frequently until deep fried (193ºC) and golden brown colour is obtained.

Table 1. Formulation of flour blends for the production of akara

Cowpea flour (%)	Water yam flour (%)
100	0
90	10
80	20
70	30
60	40
50	50
0	100

Determination of Proximate Composition of cowpea-water yam composite flour

The proximate composition of the water yam-cowpea composite flours was determined by standard methods (AOAC, 2000). Moisture content was determined using the electric oven method at 105˚C for 12 hours; crude protein content was determined by the Kjeldahl method; crude fat was determined using the Soxhlet extraction method and total ash by dry ashing in an electric furnace at 550˚C for 8 hours. Crude fiber was determined by the gravimetric method, while the total carbohydrate was determined by difference.

Functional Properties

Bulk Density was determined using method described by Butt and Batool (2010), water absorption capacity (WAC) and oil absorption capacity (OAC) by Appiah et al. (2010) method, swelling capacity by Falade and Olugbuyi, (2010) method, least gelation concentration by Mugendi et al. (2010) method, foam capacity and foam stability were determined according to the method of Butt and Batool (2010).

Pasting Properties

The pasting properties of cowpea-water yam composite flours were analyzed with a Series 4 Rapid Visco Analyzer (RVA) (Newport Scientific from Australia) with Thermocline for Windows software. The analysis was done using standard one profile. The flour suspensions (6.72 g in 25.28 ml H_2O) corrected to 14% moisture content were exposed to the following time/temperature sequence: 50˚C for 1 minute, heating from 50˚C to 95˚C at 12.16˚C /minute, maintained at 95˚C for 2.5 minutes, and cooled from 95˚C to 50˚C at 11.84˚C/minutes rate. The apparent viscosity was expressed in RVU (Newport Scientific, 1998).

Sensory Evaluation

Coded samples were presented to twenty members of panels which are familiar with “akara” for sensory evaluation. The panelists rated the taste, flavor, aroma, texture, colour and overall acceptance using a nine point hedonic scale, where 9 indicated ‘like extremely’ and 1 ‘dislike extremely’ (Iwe, 2002).

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Statistical Analysis

All experimental analyses in this study were done in triplicates. All the data analysis was done using SPSS version 16.0 Software. Analysis of variance (ANOVA) was performed to generate treatment means and Duncan's multiple range test ($P < 0.05$) was used to separate the means.

RESULTS AND DISCUSSION

Proximate composition of water yam cowpea composite flour

The proximate composition of the composite flours from cowpea and water yam flour is presented in Table 2.

Table 2. Chemical composition of water yam-cowpea composite flour

Wateryam-cowpea (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Moisture content (%)	Sugar (%)	Starch (%)
0 : 100	18.56±0.04^{a}	0.63±0.01^{a}	4.01±0.03^{a}	3.01±0.03^{a}	9.64±0.03^{a}	4.58±0.03^{a}	59.57±0.03^{g}
10 : 90	17.44±0.09^{b}	0.60±0.03^{ab}	3.94±0.03^{a}	2.56±0.03^{b}	9.65±0.06^{a}	4.33±0.03^{a}	61.48±0.06^{f}
20 : 80	16.77±0.03^{c}	0.57±0.02^{ab}	3.76±0.03^{b}	2.62±0.02^{b}	9.77±0.04^{b}	3.64±0.04^{b}	62.87±0.09^{e}
30 : 70	13.67±0.03^{d}	0.53±0.03^{bc}	3.55±0.04^{c}	2.96±0.03^{a}	9.85±0.03^{b}	3.52±0.03^{bd}	65.92±0.04^{d}
40 : 60	11.08±0.05^{e}	0.49±0.02^{cd}	2.72±0.03^{d}	3.28±0.04^{c}	10.05±0.03^{c}	3.95±0.03^{c}	68.43±0.09^{c}
50 : 50	4.95±0.03^{f}	0.45±0.03^{d}	2.49±0.03^{e}	3.46±0.03^{d}	9.43±0.04^{d}	3.22±0.01^{d}	76.00±0.03^{b}
100: 0	1.85±0.02^{g}	0.42±0.03^{d}	2.04±0.02^{f}	3.88±0.02^{e}	10.44±0.03^{e}	3.06±0.04^{e}	78.31±0.04^{a}

Values are mean of triplicate determination. Values with different superscript within a column are significantly different ($p>0.05$).

The result showed that the inclusion of cowpea flour to water yam flour affected the proximate composition significantly. The moisture content of 100% water yam flour was the highest (10.44%) while composite flour from water yam with 50% cowpea flour had the lowest moisture content (9.43%). The addition of water yam to cowpea flour decreased the moisture content of the composite flours.

The protein content of the 100% cowpea flour was the highest (18.56%), while 100% water yam flour was the lowest (1.85%). All the water yam composite flours had higher protein values than 100% water yam flour. Generally, the protein content of the composite flours increased with increasing ratio of cowpea flour.

The fat, ash, crude fibre and carbohydrate content of the composite flours ranged from 0.42-0.63%, 2.04-4.01%, 2.56-3.88% and 64.15-81.37% respectively. It was observed that the addition of cowpea flour at different ratio affected the carbohydrate content significantly. Generally, the composite flours had relatively higher values of carbohydrate than 100% cowpea flour.

Functional properties of the water yam- cowpea composite flour

The result of the functional properties of water yam-cowpea composite flour is presented in Table 3.

Table 3. Functional properties of water yam-cowpea composite flour

Water yam-cowpea (%)	Bulk density (g/cm³)	WAC (%)	OAC (%)	Foaming capacity (%)	Foam stability (%)
0 : 100	0.63±0.00^{a}	202.07±0.02^{a}	196.07±0.02^{a}	69.2±0.02^{a}	7.86±0.03^{a}
10 : 90	0.62±0.00^{a}	200.01±0.02^{b}	191.12±0.02^{b}	66.6±0.03^{b}	8.46±0.01^{b}
20 : 80	0.61±0.00^{a}	195.15±0.01^{c}	185.07±0.01^{c}	65.8±0.03^{b}	8.52±0.01^{b}
30 : 70	0.60±0.00^{a}	193.18±0.03^{d}	174.21±0.01^{d}	65.5±0.02^{b}	8.76±0.01^{c}
40 : 60	0.60±0.00^{a}	192.45±0.02^{e}	168.11±0.01^{e}	63.8±0.03^{c}	8.98±0.02^{d}
50 : 50	0.60±0.00^{a}	192.02±0.01^{f}	165.17±0.02^{e}	62.2±0.03^{d}	9.04±0.02^{de}
100 : 0	0.57±0.00^{a}	190.02±0.01^{g}	152.08±0.02^{f}	58.9±0.02^{e}	9.15±0.02^{e}

Values are mean of triplicate determination. Values with different superscript within a column are significantly different (p>0.05).

Bulk density depicts the behaviour of the material in dry mixes and is an important parameter that can determine packaging requirements of the product (Mohamed et al., 2009). The bulk densities of the composite flours (Table 3) showed that the packed bulk density (PBD) ranged from 0.57 to 0.63 gcm^{-3}. The bulk density result for the water yam-cowpea composite flour from this study were slightly higher compared to 0.55 - 0.62 gcm^{-3} reported for tigernut (C*yoperus esculentus*) seed flour (Oladele. and Aina, 2007), 0.53 gcm^{-3} for defatted chick pea (Valim and Batistuti, 1998) and similar with 0.63 gcm^{-3} for soybean protein meal (Amadou et al., 2010). Amadou et al. (2010) reported that the bulk density of the flour would vary with the particle size or fineness of the flour. The higher bulk densities indicated greater compactness of the particles because particle size is inversely proportional to bulk densities (Falade and Olugbuyi, 2010).

Interactions of water and oil with proteins are very important in food systems because of their effects on the flavour and texture of foods (Amadou et al., 2010). Water and oil absorption capacities (WAC, OAC) are useful indices of the ability of the protein in the material to prevent fluid loss from a product during food storage or processing (Kiosseoglou and Paraskevopoulou, 2011). The intrinsic factors that affect water binding properties of food flours with relatively high protein content relate to amino acid composition, protein conformation and surface polarity (Fekria et al., 2012). The results of WAC and OAC for the cowpea water yam composite flours are presented in Table 3. The water absorption capacity of the flour samples ranged between 190.02 and 202.07%, with flour from 100% cowpea having the highest (202.07%) WAC, while flour from 100% water yam had the least (190.02%) water absorption capacity. There were significant differences among the composite flours. The WAC for water yam-cowpea composite flour in this study was lower than that reported by Hussain et al. (2008) for defatted flax seed protein concentrate (2.2 g/g). The variation in WAC of the flour samples may be attributed to the difference in protein structure and the presence of different hydrophilic carbohydrates. Flours with high WAC tend to have more hydrophilic polysaccharide and protein constituents (Fekria et al., 2012). The oil absorption capacity ranged between 152 and 196 %. OAC has been reported to be important for the development of new food products and have influence on their storage stability, particularly for flavour binding and on the development of rancidity (Falade and Kolawole, 2012). High protein contents in flours and the nature of the proteins also contribute significantly to the oil retaining properties of food materials (Ravi and Sushelamma, 2005). Therefore, the high OAC of the flours could be attributed to the high protein contents in the composite flours used. Fekria et al. (2012) reported that the ability of the flour to absorb and retain water and oil may help to improve the binding capacity and enhance flavor retention, improve mouthfeel and reduce moisture and fat losses of extended meat products. The high water absorption capacity of the water yam-cowpea composite flours makes it desirable for use in meats, sausage, bread, mayonnaise, akara and cakes.

The foaming capacity (FC) of a protein refers to the amount of interfacial area that can be created by the protein while foam stability refers to the ability of protein to stabilize against gravitational and mechanical stresses. Foam formation and stability are a function of the type of protein, pH, processing methods, viscosity and surface tension (Fekria et al., 2012). The FC ranged from 58.9 to 69.2%, with flour from 100% water yam having the highest FC value, while flour from 100% cowpea had the least FC value. The values for foaming capacity recorded in this study (Table 3) were higher than those reported for defatted ground nut flour (4% - 4.2%) (Fekria et al., 2012), but comparable to those reported for defatted Baru nut flour (69%) (Guimarães et al., 2012). On the other hand the values for Foam stability of water yam-cowpea flour were lower than those reported for defatted ground nut flour (97% - 97.50%) (Fekria et al., 2012) but higher than those of defatted Baru nut flour (35%) (Guimarães et al., 2012). Egg white powder which is widely used for its excellent foaming characteristics has been reported to have higher FC values of 97.5% and FS values of 78.3 % (Ndife et al., 2010). Result from this study indicate that the water yam-cowpea flour has potential for application in food systems that require high percentage of porosity such as ice cream, akara and cakes as well as in non food products as a foaming agent.

Protein solubility is probably the most critical functional property since it affects other properties such as emulsification, foaming and gelation. It is influenced by many factors such as origin of the protein, processing conditions, pH, ionic strength as well as presence of other ingredients (Fekria et al., 2012). Effect of pH on swelling capacity and solubility of water yam-cowpea composite flours are presented in Figures 1 and 2, respectively.

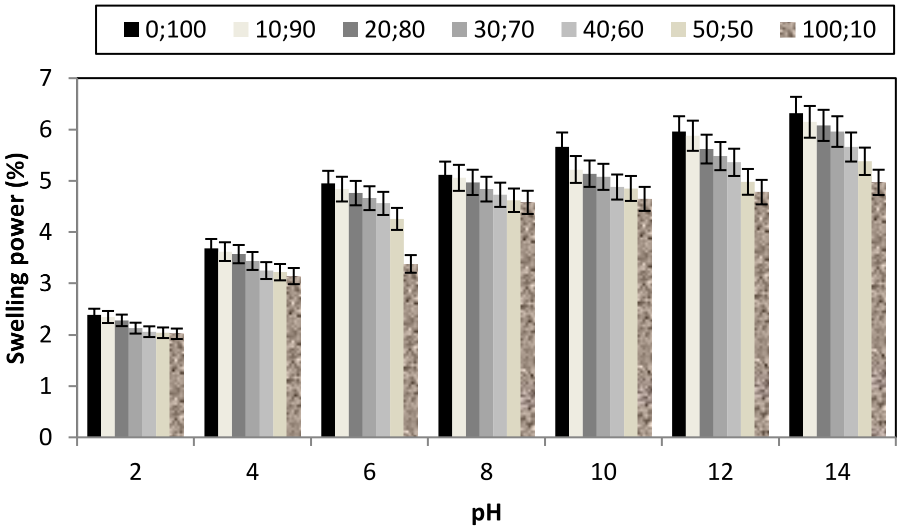

Figure 1. Effect of pH on swelling power of water yam cowpea composite flours, Error bars: Standard deviations.

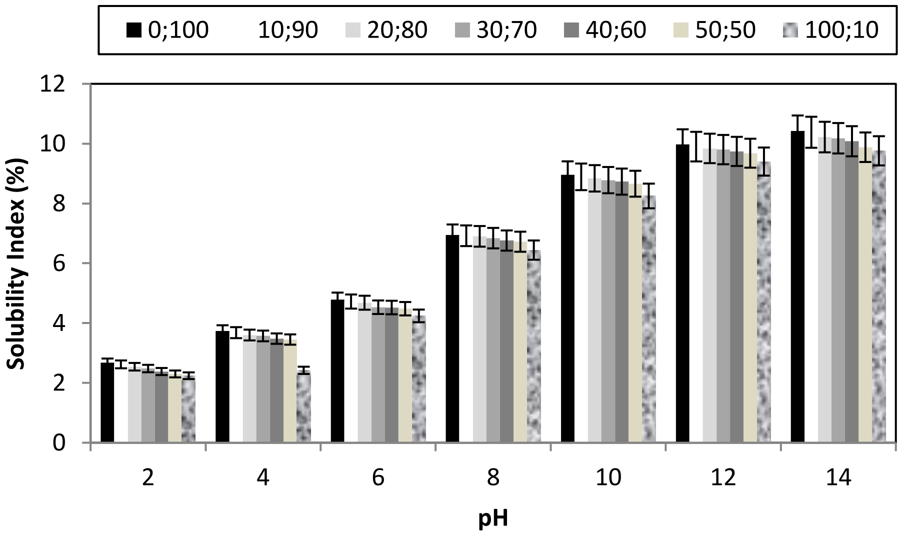

Figure 2. Effect of pH on solubility index of water yam cowpea composite flours, Error bars: Standard deviations.

Figure 1 shows that swelling capacity of all the water yam cowpea composite flours improved as the pH increased. It also showed that there is increased swelling for all the composite flours studied in the alkaline region (pH 8-14), while there is little increase in the acidic region (pH 2-5). This behaviour could be due to the interaction between the protein and starch at alkaline pH, when both starch and protein have negative charges as against acidic pH at when protein bear a positive charge (Shieldneck and Smith, 1971). Percentage swelling is therefore expected to be high at alkaline pH and low at acidic pH, depending on the amount of protein associated with the starch. Solubility of the composite flours also increased with increase in pH. The increased solubility at alkaline pH may be due to increased hydrophilic character of the starch at these pH values (Adebowale et al., 2002). At alkaline pHs, partial gelatinization of starches may occur and this probably resulted in increased swelling and solubility at these pHs.

Least Gelation Concentration (LGC)

Gelation is an aggregation of denatured protein molecules. Gelation properties of water yam cowpea composite flours are presented in Table 4.

Table 4: Gelation properties of water yam-cowpea composite flour

Concentrations (% w/v)			Wateryam	cowpea			
	0 : 100	10 : 90	20 : 80	30 : 70	40 : 60	50 : 50	100 : 0
3	-Liquid	-Liquid	-Liquid	-Liquid	-Liquid	-Liquid	-Liquid
6	+Gel	+Gel	+Gel	-Liquid	-Liquid	-Liquid	-Liquid
9	+Firm Gel	+Firm Gel	+Firm Gel	+Gel	+Gel	+Gel	+Gel
12	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel
15	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel	+Firm Gel
18	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel
21	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel	+Very Firm Gel
Least gelation							
concentration (LGC)	6	6	6	9	9	9	9

The least gelation concentration (LGC) was used as the index of gelation, the lower the LGC, the better the gelation property of the flours. The composite flours with 10 and 20% water yam flour and 100% cowpea flour had lower values than the composite flours with 50% water yam substitution and above which recorded higher values. Gelation properties are related to water absorption capacities hence the high water absorption capacity recorded for the water yam cowpea composite flours in this study could explain the good gel formation capacity. Adebowale et al. (2005) reported that gelation takes place more readily at higher protein concentration because of greater intermolecular contact during heating and that high protein solubility is always necessary for gelation. The low LGC observed in the water yam cowpea composite flour may be an advantage in respect to the production of some products such as curd since production of such, calls for materials with high gelation capacity like milk protein (casein) (Adebowale et al., 2005).

Pasting properties of water yam-cowpea composite flour

Results of the pasting properties of water yam-cowpea composite flour are presented in Table 5.

Table 5. Pasting properties of water yam-cowpea composite flour

Water yam-cowpea (%)	Peak (RVA)	Trough (RVA)	Breakdown (RVA)	Final viscosity (RVA)	Setback (RVA)	Peak Time (RVA)	Pasting Temperature (RVA)
0 : 100	115.8±1.11^{f}	54.17±2.14^{e}	61.67±0.17^{c}	75.58±0.31^{g}	21.42±0.08^{f}	4.00±0.35^{a}	81.65±0.44^{ac}
10 : 90	118.8±1.11^{f}	40.33±2.13^{f}	78.50±0.17^{a}	52.75±0.31^{f}	12.42±0.08^{g}	4.00±0.34^{a}	82.65±0.44^{a}
20 : 80	131.3±1.11^{d}	69.92±2.14^{d}	61.42±0.17^{c}	97.50±0.31^{d}	27.58±0.08^{d}	4.00±0.35^{a}	80.10±0.43^{b}
30 : 70	134.0±1.11	73.08±2.14	60.92±0.17	98.50±0.31	25.42±0.08	4.07±0.35	80.90±0.44^{cb}

	c	d	b	e	e	a	
40 : 60	123.6±1.11 e	79.17±2.14 c	44.50±0.15 d	119.9±0.31 c	40.75±0.08 c	4.07±0.35 a	82.30±0.44^{a}
50 : 50	253.6±1.11 b	147.3±2.14 b	75.24±0.17 e	222.6±0.31 b	73.14±0.08 b	4.20±0.33 a	80.00±0.44^{b}
100 : 0	280.9±1.11 a	179.0±2.14 a	79.08±0.17^{f}	258.2±0.31 a	80.03±0.08 a	4.40±0.35 a	80.95±0.44^{b}

Values are mean of triplicate determination. Values with different superscript within a column are significantly different (p>0.05).

When starch based foods are heated in an aqueous environment, they undergo a series of changes known as gelatinization and pasting. These are two 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 starchy foods (Adebowale et al., 2005). There were significant difference (P<0.05) in the pasting profile of the difference formulations of water yam-cowpea composite flours.

Pasting temperature of the 100% water yam flour was significantly different (P<0.05) from all samples with a mean value of 100% cowpea and 10:90% water yam. The 100% cowpea has a mean value of 81.65 ^{o}C and 10:90 water yam with 80.00 ^{0}C. Pasting temperature gives an indication of the gelatinization temperature during processing. It is the temperature at which the first detectable increase in viscosity is measured and is an index characterized by the initial change due to the swelling of starch. The pasting temperature provides an indication of the minimum temperature required for cooking (Ikegwu et al., 2010). Pasting temperature has been reported to relate to water binding capacity. A higher pasting temperature implies higher gelatinization, higher water binding capacity, and lower swelling property of starch due to a high degree of association between starch granules.

Peak viscosity, which is the ability of starch to swell freely before their physical breakdown (Sanni et al., 2004) ranged from 115.8 to 280.9 RVU. The 100% water yam flour had the highest peak viscosity value of 280.9 while 100% cowpea flour had the lowest value of 115.8 RVU. High peak viscosity is an indication of high starch content, it also indicates the water binding capacity of the flours (Ikegwu et al., 2010) and is often correlated with final product quality as well as providing an indication of the viscous load likely to be encountered by a mixing cooker (Maziya-Dixon et al., 2005). The relatively high peak viscosity exhibited by 100% water yam is indicative that the flour may be suitable for product requiring high gel strength and elasticity (Adebowale et al., 2005). The peak viscosity of the composite flours are lower than value reported for Pupuru (362-430 RVU) by Shittu et al. (2001), but higher than value reported for composite flour from wheat and sweet potato (131.42-271.08 RVU) by Odedeji and Adeleke (2010).

The trough, which is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling ranged between 40.33 and 179.0 RVU. The 100% water yam had the highest trough value of 179.0 RVU, while flour from 90% cowpea flour had the least value of 40.33 RVU. The trough values the composite flours exhibited lower values compared to those reported for corn flour (225.5 RVU) and *Brachystegia eurycoma* seed flour (229.25 RVU) (Ikegwu et al., 2010).

The breakdown viscosity value is an index of the stability of starch during cooking (Fenanadaz and Berry, 1989; Zaidhul et al., 2006). The 100% water yam flour had the highest breakdown viscosity of 109.8 RVU while flour from 30:70% water yam-cowpea had the lowest (44.50 RVU). Low stability of starch paste is associated with high value of breakdown (Maziya-Dixon et al., 2005). Ikegwu et al. (2010), reported that the lower the break down viscosity the higher the ability of the flour to withstand heating and shear stress during processing. Therefore flour from 30:70% water yam-cowpea might withstand heating and shear processes without significant change in consistence.

The final viscosity, which is the change in the viscosity after holding cooked starch at 50^{o}C ranged from 25.82 to 52.75 RVU. Final viscosity is the most commonly used parameter to define the quality of a particular starch based sample, as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear force during stirring.

Setback value of the 100% water yam flour was the highest (79.08 RVU) while the flour from 90:10% cowpea had the lowest mean value of 12.42RVU. Setback involves retrogradation or re-ordering of the starch molecules and has been correlated with the texture of various products (Maziya-Dixon et al., 2005). The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the flour. High setback value is also associated with syneresis, or weeping especially during freeze/thaw cycles (Maziya-Dixon et al., 2005).

Sensory qualities of composite flours

The mean sensory scores of akara prepared from water yam flour and cowpea flour are presented in Table 6.

Table 6. Sensory evaluation of akara made from water yam-cowpea composite flour

Water yam-cowpea (%)	Colour	Taste	Flavour	Texture	Shape	Overall acceptability
0 : 100	8.5±0.35[a]	8.0±0.37[a]	6.6±0.33[a]	7.1±0.40[a]	8.6±0.32[a]	8.7±0.25[a]
10 : 90	8.0±0.35[ab]	7.9±0.37[a]	7.8±0.33[b]	7.7±0.40[ac]	8.6±0.32[a]	8.1±0.25[b]
20 : 80	7.7±0.35[ab]	7.9±0.37[a]	7.2±0.33[ab]	8.7±0.40[b]	7.9±0.32[ac]	8.0±0.25[b]
30 : 70	7.5±0.35[bc]	7.3±0.37[ab]	7.6±0.33[b]	8.4±0.40[bc]	6.9±0.32[bd]	7.9±0.25[b]
40 : 60	7.3±0.35[bc]	6.7±0.37[bc]	6.9±0.33[ab]	7.0±0.40[a]	6.5±0.32[b]	7.2±0.25[c]
50 : 50	6.7±0.35[c]	6.7±0.37[bc]	7.2±0.33[ab]	6.8±0.40[a]	6.6±0.32[b]	6.8±0.25[c]
100 : 0	6.7±0.35[c]	6.3±0.37[c]	6.8±0.33[ab]	6.9±0.40[a]	7.6±0.32[cd]	7.1±0.25[c]

Values are mean of triplicate determination. Values with different superscript within a column are significantly different (p>0.05).

Generally, all the composite akara samples had better ratings in colour, taste, flavour, texture, shape and overall acceptability than akara from 100% water yam but comparable to akara made from 100% cowpea flour. Akara made from 10 to 30% water yam cowpea composite flours had better overall acceptability ratings among the composite flours having the highest score (8.0) in all the parameters measured. This observation implies that up to 30% water yam flour substitution might be used to produce akara of acceptable sensory qualities from water yam-cowpea composite flour.

CONCLUSION

The study showed that low nutritional quality of water yam akara can be improved through supplementation with cowpea flour. This is reflected particularly in the improved protein (1.85-18.56%) which increased with increase in cowpea flour. Akara from water yam cowpea blend can serve as a nutritious food or snack and help redress the problem of protein-energy malnutrition. This could also increase in the utilization of water yam which presently is underutilized. The addition of cowpea flour to water yam flour significantly improved the functional properties of the flour blends. The sensory attributes showed that acceptable akara could be produced from water yam cowpea composite flour at 30% maximum level of water yam flour.

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