CHEMICAL, FUNCTIONAL AND SENSORY PROPERTIES OF WATER YAM, PIGEONPEA AND CARROT POMACE FLOUR BLENDS

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Abstract
This study evaluated the chemical, functional and sensory properties of flour blends of water yam (WYF), pigeon pea (PPF) and carrot pomace (CPF). Simplex centroid mixture design was used to study the effect of flour combination on chemical, functional and sensory properties of the blends. Ten experimental runs were generated. Chemical and functional were determined using standard laboratory procedures. A 50-member panel assessed the sensory attributes of cooked pastes obtained from the flour blends using a 9-point hedonic scale. Data were subjected to analysis of variance and the means were separated using Duncan's Multiple Range Test (p<0.05). The proximate composition of the blends were significantly (p<0.05) different for moisture (9.14-10.97 %), ash (1.01-4.87%), protein (5.19-20.98%),crude fibre (2.15-5.70%),. The blends are rich in calcium (13.22-150.52mg/kg), potassium (192-248mg/kg) and phosphorus (76.35-196.65. The pH of the blends was between 4.97 and 6.56 while L, a* and b* ranged from 79.46-84.39, 2.0-6.21 and 14.20-24.84, respectively. mg/kg). The wettability (39-124s), water absorption (164.00 – 369.25%)and least gelation concentration (15-20%) of the blends increased while the bulk density (0.58-1.05g/ml), dispersibility (20-72%), swelling power(3.93-16.09%) and solubility index (2.90 – 18.11%) decreased as the CPF content increased. The peak, trough, breakdown, final and setback viscosities increased while the peak time and pasting temperature reduced, with increase in WYF content. Cooked paste from 100 % WYF was the most acceptable with a score of 7.0.*

Keywords: Functional food;Protein; Proximate composition; Mineral composition; Water absorption

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1. INTRODUCTION

Water yam (*Dioscorea alata*) is a staple starchy food crop for many resource-restricted Nigerians. It is a highly economical yam species, which is desirable for the diabetic due to its low sugar content (Hahn, 1995; Udensi *et al.*, 2010). Being a seasonal and perishable crop, it is pertinent to convert it to flour in order to extend its shelf life. The nutritional and functional properties of water yam flour and the influence of processing on these properties have been reported (Udensi *et al.*, 2010; Ezeocha and Ojimelukwe 2012; Harijono *et al.*, 2013; Oke *et al.*, 2013). Olapade and Akinyanju (2014) reported that soybean improved the protein, fat, ash and crude fibre contents of water yam.

Pigeon pea (*Cajanus cajan*) is a valuable source of low-cost vegetable protein, minerals and vitamins and occupies a very important place in human nutrition (Fasoyiro *et al.,* 2010; Okpala and Ekwe 2013). The protein content of pigeon pea ranges between 18.5 and 26.3% (Rampersad *et al.*, 2003). The use of pigeon pea in the supplementation of starchy foods has been reported (Rampersad *et al.*, 2003; Mbaeyi-Nwaoha and Onweluzo, 2013).

Pomace is the residue remaining when fruits have been processed (Shyamala and Jamuna, 2010). Carrot pomace, often discarded as waste, contains up to 80% of the carotene in whole carrot and a good residual amount of dietary fibre (Kumar *et al.,* 2010). Dried carrot pomace has β-carotene and ascorbic acid (important antioxidants) in the range of 9.87 to 11.57 mg per 100g and 13.53 to 22.95 mg per

100g, respectively (Kumar *et al.*, 2010). Carrot pomace has been reported to be hypocholesterolemic, improve blood lipid profile, reduce blood glucose and ideal for weight loss (Afify *et al.*, 2013).

2. MATERIAL AND METHODS

2.1 Source of Materials

Water yam tubers were obtained from Osiele market, Abeokuta, Ogun State. Pigeon pea and carrots were obtained from Bodija market, Ibadan, Oyo State.

2.2 Production of Water Yam Flour

The method of Babajide *et al.* (2008) was used. 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 slices of yam were blanched in water at 50 ºC for 2 h after which the slices were removed from water. The blanched yam slices were steeped for 24 h, drained and dried at 60 ºC in a cabinet dryer to dry. The dried yam slices were 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 polythene bag, prior to analysis.

2.3 Production of Pigeon Pea Flour

The method of Gayle *et al.* (1986) was used. Foreign materials, infected and wrinkled seeds were removed from pigeon pea seeds. The seeds were boiled in water for one minute before being soaked in fresh water for one hour. The seeds were dehulled, blended (1:2 w/v) in a Waring blendor to a slurry, dried at 75 ºC for 8 h and 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).

2.4 Production of Carrot Pomace Flour

The method of Kumar *et al.* (2012) was modified. Carrot roots were washed with clean water to remove adhering soil and undesirable materials. The carrots were cleaned by scrapping with a kitchen knife before being washed again. The carrots were thereafter blanched at temperature of 80 ºC for 6 min. The carrots were blended using a juice extractor (Panasonic, Model No: MK 8710N). The pomace was dried in a cabinet dryer at 50 ºC and ground with a Fritsch hammer mill (Glen Creston Ltd, Stanmore, Middx HA7, serial No. 950401) to pass through a 250 µm sieve (Endecotts Ltd, England). The pomace was packed in a polythene bag prior to analysis.

2.5 Blending of Composite Flour

Ten mixture blends of the composite flour were obtained using the simplex centroid mixture design. Water yam flour, pigeon pea flour and carrot pomace flour were mixed in a blender at ratios 100:0:0; 50:0:50; 0:50:50; 17:17:67; 50:50:0; 67:17:17; 17:67:17; 33:33:33; 0:0:100; 0:100:0.

2.6 Chemical Analyses

- Proximate and mineral composition was determined according to the method described by AOAC (2005)
- Anti-nutrient composition: Phytate was determined by the method described by Maga (1983). About 2 g of each sample was extracted with 100 mL of 2% HCl for 3 h, filtered and diluted with distilled water, with the addition of NH_4SCN solution. Titration was done with standard FeCl solution. Trypsin inhibitor was determined according to the method described by Kakade *et al.* (1974). Defatted sample was extracted with 50 mL of 0.01N NaOH for 3 h and diluted with distilled water. Further assay was done using standard trypsin and N-benzoyl-DL-arginine-p-nitroanilide.Tannin was determined by the method described by AOAC (2005). Sample was extracted with methanol, filtered, diluted with distilled water, with the addition of folin-Denis reagent and Na_2CO_3. The absorbance of standard tannic acid solutions and the sample was read on spectronic 21D spectrophotometer at a wavelength of 760 nm.

2.7 Color Determination

- Colour was determined as described by Szabo et al, (2016) using a Minolta Chromameter

CR-410 (Minolta Camera Co., Osaka Japan)and pH was determined according to AOAC (2005).

2.8 Functional Properties Determination

i. Bulk density was determined according to the method described by Adeleke and Odedeji (2010). A known weight of sample was put into a 100 mL graduated measuring cylinder and tapped several times on a laboratory bench to a constant volume. The bulk density was taken as the weight of the sample divided by the volume of sample after tapping.

ii. Wettability was determined according to the method described by Nwosu *et al.* (2010). A known weight of sample was placed in a clean, dry measuring cylinder (10 mL). The cylinder was inverted and clamped at height of 10 cm from the surface of a 600 mL beaker containing 500 mL distilled water. The flour in the cylinder was gradually spread on the water at a moderate speed. The time taken for the sample to be completely wet was noted as the wettability.

iii. Dispersibility was determined according to the method described by Kulkarni *et al.* (1991). A known weight of sample suspended in 100 mL of distilled water was vigorously stirred and allowed to settle for 3 h. The volume of the settled water was recorded and subtracted from 100, and the difference recorded as the dispersibility.

iv. Swelling power and solubility index were determined according to the method described by Leach (1959). About 1 g sample in a centrifuge tube was mixed with 50 mL distilled water and heated at 90 ^{o}C for 15 min, with frequent shaking during heating in order to prevent clumping of flour. The tube with its content was centrifuged at 3,000 rpm for 10 min. The supernatant was decanted immediately after centrifugation and dried to constant weight. The weight of the sediment was also taken.

Solubility power = (weight of starch paste/ weight of dry starch sample) x 100

Solubility index = weight of solid after drying x 100.

v. Water absorption capacity was determined according to the method described by Ruales *et al.* (1993). About 1.25 g sample was suspended in 15 mL distilled water, and centrifuged at 2,500 rpm for 30 min. The supernatant was decanted, and the weight of the sediment recorded. The water absorption capacity was taken as the sediment weight per sample weight.

vi. Least gelation property was determined according to the method described by Adeleke and Odedeji (2010). Dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20% (w/v) were prepared in 5 mL of water. The dispersions were heated in a water bath at 95 ^{o}C for 1 h, and then quickly cooled under running tap water. The test tubes were further cooled for 2 h at 4 ^{o}C. the least gelation concentration was taken as the concentration when the sample from the inverted test tube did not fall or slip.

vii. Pasting properties: This was determined using the Rapid Visco Analyser (Perten Instruments). A canister containing slurry of sample was inserted into the equipment. The heating and cooling cycles were set so that the slurry was held at 50 ^{o}C for 1 min, heated to 95 ^{o}C within 3 min, held at 95 ^{o}C for 2 min, and cooled to 50 ^{o}C within 3 min. It was then held at 50 ^{o}C for 2 min, while maintaining a rotation of 160 rpm. Parameters measured were peak viscosity, breakdown viscosity, setback viscosity, final viscosity, pasting temperature and peak time.

2.9 Sensory Attributes Determination

About 20 g of flour blend was stirred into 100 mL of boiling water to form a thick paste. The sensory attributes of the hot paste of the flour blendswere determined by a 50 member panel who were asked to rate the colour, aroma, texture, stickiness, taste and overall acceptability of the blends using a 9-point Hedonic scale.

2.10 Data Analysis

Data were subjected to statistical analysis using SPSS version 20, using analysis of variance to obtain the means and Duncan's multiple range test at 95% confidence level.

3. RESULTS

Table 1 shows a significant ($p<0.05$) difference in the proximate composition of the flour blends. Moisture content ranged from 9.14% in 100% pigeon pea flour (PPF) to 10.97% in 100% water yam flour (WYF).It was observed that 100% PPFhad the highest protein (20.98%) while 100% carrot pomace flour (CPF) had the highest ash (4.86%) content. The lowest protein (5.19 %) and ash (1.01%) contents were found in 100% WYF and 100 % PPF, respectively.

The mineral composition of the blends revealed that 100% PPF had the highest calcium (150.52 mg/kg), magnesium (75.55 mg/kg), potassium (248.00 mg/kg) and sodium (357.50 mg/kg)contents. The highest phosphorus (196.65 mg/kg) and iron (7.84 mg/kg) values were found in 100 %CPF. Except for potassium content, 100% WYF had the lowest mineral content as shown in Table 2.

Phytate, tannin and trypsin inhibitor contents were 2.1642-5.3900 g/kg, 0.0180-0.2430 g/kg and 2.4395-4.5700 g/kg, respectively. The highest values for phytate and tannin was found in 100% PPF while the highest value for trypsin inhibitor was found in 100% CPF. The pH ranged between 4.97 in 100% CPF and 6.56 in 100% PPF. The blends varied significantly ($p<0.05$) in terms of lightness (L* values), redness (a*) and yellowness (b*). The L* values ranged from 79.46 in 100% PPF and 84.39 in 33.3:33.3:33.3 blend (water yam: pigeon pea: carrot pomace), a* values varied between 2.0 in 100% PPF and 6.21 in 100% WYF, and b* valueranged between 14.20 in 100% water yam flour and 24.84 in the blend containing 50% PPF and 50 % CPF (Table 3).

Table 1: Nutrient composition of water yam-pigeon pea-carrot pomace flour blends

WYF:PPF:CPF	Moisture content %	Total ash content %	Protein content %	Crude fibre content %
100:0:0	10.97^{j}	1.67^{c}	5.19^{a}	5.70^{j}
50:0:50	10.04^{h}	3.26^{h}	5.47^{b}	3.92^{g}
0:50:50	9.23^{b}	2.93^{g}	13.38^{h}	2.40^{b}
17:17:67	9.61^{e}	3.47^{i}	8.29^{e}	2.85^{d}
50:50:0	9.96^{g}	1.34^{b}	13.09^{g}	4.16^{h}
67:17:17	10.36^{i}	2.12^{e}	8.02^{d}	4.63^{i}
17:67:17	9.54^{d}	1.79^{d}	15.92^{i}	3.11^{e}
33:33:33	9.64^{f}	2.49^{f}	10.53^{f}	3.56^{f}
0:0:100	9.30^{c}	4.86^{j}	5.74^{c}	2.15^{a}
0:100:0	9.14^{a}	1.01^{a}	20.98^{j}	2.65^{c}

Means within the same column with different superscripts are significantly different at $p<0.05$
WYF = water yam flour; PPF = pigeon pea flour; CPF= cowpea flour

Table 2: Mineral content of water yam-pigeon pea-carrot pomace flour blends

WYF:PPF: CPF	Calcium (mg/kg)	Magnesium (mg/kg)	Potassium (mg/kg)	Sodium (mg/kg)	Phosphorus (mg/kg)	Iron (mg/kg)
100:0:0	13.22^{a}	20.59^{a}	232.53^{g}	24.34^{a}	76.35^{a}	1.14^{a}
50:0:50	18.95^{b}	33.06^{b}	214.39^{c}	28.56^{b}	136.51^{g}	4.50^{d}
0:50:50	87.60^{h}	60.56^{h}	222.14^{d}	195.14^{h}	161.59^{h}	6.73^{i}
17:17:67	44.35^{e}	46.89^{f}	213.15^{b}	86.88^{e}	166.26^{i}	6.41^{h}
50:50:0	81.87^{g}	48.06^{g}	240.29^{i}	190.92^{g}	101.39^{b}	3.39^{c}
67:17:17	38.65^{d}	34.39^{c}	231.32^{f}	82.68^{d}	106.07^{c}	3.03^{b}
17:67:17	107.14^{i}	61.89^{i}	239.03^{h}	249.22^{i}	131.14^{e}	5.32^{f}
33:33:33	62.19^{f}	46.75^{e}	223.34^{e}	136.81^{f}	131.83^{f}	4.84^{e}
0:0:100	24.67^{c}	45.59^{d}	196.21^{a}	32.76^{c}	196.65^{j}	7.84^{j}
0:100:0	150.52^{j}	75.55^{j}	248.00^{j}	357.50^{j}	125.48^{d}	5.66^{g}

Means within the same column with different superscripts are significantly different at $p<0.05$
WYF = water yam flour; PPF = pigeon pea flour; CPF= cowpea flour

Table 4 shows that the functional properties of the flour blends varied significantly ($p<0.05$), suggesting different food applications for the blends. The bulk density ranged from 0.58 g/ml (100 % CPF) to 1.05 g/ml in water yam: pigeon pea: carrot pomace blend (0:50:50). The wettability of the flour blends varied from 32 s in blend containing water yam: pigeon pea: carrot pomace blend (17:67:17) to 124 s in 100% carrot pomace blend. Water yam: pigeon pea: carrot pomace blend (50:50:0) had the lowest (20%) dispersibility while 100% water yam recorded the highest (72.00%) dispersibility. The swelling power and solubility index were 3.93% (67:17:17; water yam: pigeon pea: carrot pomace blend) to 16.09% (17:17:67; water yam: pigeon pea: carrot pomace blend) and 2.90% (17:67:17; water yam: pigeon pea: carrot pomace blend) to 41.17% (67:17:17; water yam: pigeon pea: carrot pomace blend), respectively. The water absorption index ranged between 164.00% in 100% pigeon pea flour and 390.25 % in 100 % carrot pomace.

The pasting properties of the flour blends are presented in Table 5. The pasting time ranged from 5.17 s in 67:17:17 (water yam: pigeon pea: carrot pomace blend) and 7.00 s in 17:17:67 and 17:67:17 (water yam: pigeon pea: carrot pomace blend).

Table 6 shows the sensory attributes of the cooked paste obtained from theflourblends. Panelists rated 100 % water yam flour highest in terms of all the attributes. Most of the blends were poorly rated, indicating that the blends may not be suitable as cooked paste.

Table 3: Anti-nutritional content, pH and colour of water yam-pigeon pea-carrot pomace flour blends

WYF:PPF: CPF	Phytate (g/kg)	Tannin (g/kg)	Trypsin inhibitor (g/kg)	pH	Colour		
					L*	a*	b*
100:0:0	2.7950^{b}	0.0358^{a}	2.8400^{c}	5.75^{g}	82.28^{cd}	6.21^{e}	14.20^{a}
50:0:50	3.1715^{c}	0.1435^{c}	3.6900^{e}	5.04^{b}	81.58^{bc}	4.50^{d}	20.34^{c}
0:50:50	4.9565^{i}	0.1510^{c}	2.4395^{a}	5.35^{e}	81.41^{bc}	3.3^{b}	24.84^{f}
17:17:67	4.4380^{g}	0.1761^{e}	4.2700^{h}	5.15^{c}	82.82^{de}	2.9^{b}	21.28^{cd}
50:50:0	4.1250^{f}	0.1434^{b}	3.5868^{d}	6.12^{i}	80.91^{b}	4.30^{cd}	18.61^{b}
67:17:17	3.5272^{d}	0.0978^{b}	3.4166^{c}	5.45^{f}	83.32^{e}	4.5^{d}	16.94^{b}
17:67:17	2.1642^{a}	0.2039^{f}	4.1494^{g}	5.96^{h}	80.90^{b}	3.15^{b}	22.73$^{d\,e}$
33:33:33	4.2047^{f}	0.1625^{d}	3.8917^{f}	5.33^{d}	84.39^{f}	3.61^{bc}	21.90^{cd}
0:0:100	4.4765^{g}	0.0180^{a}	4.5700^{j}	4.97^{a}	84.37^{f}	3.37^{b}	24.09^{ef}
0:100:0	5.3900^{j}	0.2430^{g}	4.3190^{i}	6.56^{j}	79.46^{a}	2.0^{a}	24.63^{f}

Means within the same column with different superscripts are significantly different at $p<0.05$
WYF = water yam flour; PPF = pigeon pea flour; CPF= cowpea flour

Table 4: Functional properties of water yam-pigeon pea-carrot pomace flour blends

WYF:PPF: CPF	Bulk density (g/ml)	Wettability (s)	Dispersibility (%)	Swelling power (%)	Solubility index (%)	Water absorption capacity (%)	Least gelation concentration (%)
100:0:0	0.64^{b}	96^{f}	72.00^{h}	7.35^{c}	7.63^{a}	266.55^{e}	15.00^{a}
50:0:50	0.63^{ab}	66^{c}	40.00^{e}	14.01^{h}	14.56^{g}	369.25^{i}	19.00^{bc}
0:50:50	1.05^{f}	35^{a}	36.00^{c}	13.56^{g}	9.23^{d}	315.35^{g}	17.00^{ab}
17:17:67	0.67^{bc}	42^{b}	30.00^{b}	16.09^{j}	18.11^{h}	365.35^{h}	20.00^{c}
50:50:0	0.71^{cd}	42^{b}	20.00^{a}	5.55^{b}	9.20^{c}	187.75^{b}	15.00^{a}
67:17:17	0.70^{cd}	72^{d}	60.00^{g}	3.93^{a}	41.17^{j}	193.55^{c}	19.00^{bc}
17:67:17	0.75^{d}	32^{a}	60.00^{g}	12.13^{e}	2.90^{a}	264.80^{d}	20.00^{c}
33:33:33	0.70^{cd}	86^{e}	40.00^{e}	12.80^{f}	5.80^{ef}	286.80^{f}	19.00^{bc}
0:0:100	0.58^{a}	124^{g}	37.00^{d}	14.15^{i}	4.40^{cd}	390.25^{j}	20.00^{c}
0:100:0	0.85^{e}	39^{b}	48.15^{f}	7.52^{d}	4.75^{cde}	164.00^{a}	20.00^{c}

Means values having different superscripts within the same column are significantly different($p<0.05$)
WYF = water yam flour; PPF = pigeon pea flour; CPF= cowpea flour

Table 5: Pasting properties of water yam-pigeon pea-carrot pomace blends

WY:PP: CP	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (s)	Pasting temperature (°C)
100:0:0	441.60^{h}	307.20^{h}	134.42^{d}	572.92^{h}	265.67^{f}	5.07^{a}	82.50^{b}
50:0:50	153.13^{e}	153.58^{e}	2.88^{a}	189.25^{e}	35.67^{c}	6.27^{c}	84.38^{d}
0:50:50	6.38^{b}	5.9550^{a}	0.42^{a}	10.045^{a}	4.08^{a}	6.97^{d}	0.00^{a}
17:17:67	30.67^{c}	25.42^{c}	5.25^{ab}	53.08^{c}	27.67^{c}	7.00^{d}	0.00^{a}
50:50:0	183.30^{f}	173.88^{f}	9.42^{b}	219.92^{d}	46.04^{d}	5.40^{b}	84.38^{d}
67:17:17	236.25^{g}	207.25^{g}	29.00^{c}	277.55^{e}	70.30^{e}	5.17^{a}	83.53^{c}
17:67:17	23.54^{bc}	19.50^{bc}	4.04^{a}	38.42^{b}	18.92^{b}	7.00^{d}	0.00^{a}
33:33:33	72.63^{d}	70.34^{d}	2.29^{a}	98.13^{c}	27.80^{c}	6.93^{d}	87.70^{e}
0:0:100	14.42^{ab}	12.25^{ab}	2.17^{a}	28.84^{b}	16.58^{b}	6.80^{d}	0.00^{a}
0:100:0	5.67^{a}	5.34^{a}	0.33^{a}	9.05^{a}	3.71^{a}	6.37^{d}	0.00^{a}

Means with different superscripts within the same column are significantly different ($p<0.05$)
WYF = water yam flour; PPF = pigeon pea flour; CPF= cowpea flour

Table 6: Sensory properties of water yam-pigeon pea-carrot pomace cooked paste

WYF:PPF: CPF	Colour	Aroma	Texture	Stickiness	Taste	Acceptability
100:0:0	7.55^{c}	6.45^{c}	6.25^{e}	6.40^{f}	6.75^{af}	7.20^{d}
50:0:50	5.40^{ab}	5.65^{cde}	4.95^{bcde}	5.80^{ef}	5.10^{de}	5.85^{c}
0:50:50	4.90^{ab}	4.50^{abc}	3.45^{a}	3.25^{a}	3.25^{ab}	3.75^{a}
17:17:67	5.00^{ab}	5.40^{abcde}	5.00^{bcde}	4.95^{cde}	4.30^{bcd}	5.15^{c}
50:50:0	5.80^{b}	5.80^{de}	6.00^{de}	5.25^{def}	4.85^{cde}	5.85^{c}
67:17:17	4.50^{a}	4.25^{a}	4.35^{abc}	3.95^{abc}	3.80^{abc}	3.85^{ab}
17:67:17	4.20^{a}	4.35^{ab}	3.70^{ab}	3.65^{ab}	2.90^{a}	3.25^{a}
33:33:33	5.95^{b}	5.55^{bcde}	5.30^{cde}	5.55^{def}	5.80^{ef}	5.95^{c}
0:0:100	5.40^{ab}	5.10^{abcd}	4.90^{bcd}	4.45^{abcd}	4.40^{cd}	4.85^{bc}
0:100:0	4.95^{ab}	4.65^{abcd}	4.80^{bcd}	4.85^{bcde}	4.75^{cde}	5.05^{c}

Means with different superscripts within the same column are significantly different ($p<0.05$)
WYF = water yam flour; PPF = pigeon pea flour; CPF= cowpea flour

4. DISCUSSION

The moisture contents of the flour blends were less than 11 %. This signifies good storability of the products because milled food products with moisture content less than 13% are stable from moisture-dependent deterioration(Ayo-Omogie and Ogunsakin, 2013). The ash content which gives a measure of the mineral content of a food material increased as the amount of CPF inclusion increased. The protein content of the blends increased as the pigeon pea flour increased and this agrees with the findings of Olapade and Akinyanju (2014). Thus the inclusion of pigeon pea and carrot pomace improved the micronutrient composition of water yam flour. Crude fibre content increased as the inclusion of WYF increased in the blends.

The presence of calcium, magnesium, sodium, potassium, phosphorus and iron signifies that the flour blend is capable of providing essential mineral nutrients that are needed in the body to facilitate proper functioning of certain organs in the body (Amoakoah Twum *et al*., 2015). Potassium is a building block of body tissue and hence essential for infant growth. Magnesium helps regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control and blood pressure regulation. It also keeps bones strong and heart rhythm steady. Sodium is essential to stimulate cell proliferation, protein synthesis and increase cell mass. It also forms an essential component of the blood (Amoakoah Twum *et al*., 2015).

The amount of antinutrients present in the composite flour notwithstanding, it is expected that further processing (such as boiling) will reduce their level since they are heat-labile. From the result obtained from pH, most of the flour blends were acidic. The acidic nature of

the flour is suggestive of a shelf stable product since according to Frazier &Westhoff (1978) a food substrate with an inherently low pH tends to be more stable microbiologically than a neutral food. The pH of foods is known to affect both the rates of growth and survival of microorganisms during storage, heating, drying and other forms of processing (Frazier& Westhoff, 1978). However, the pH value alone may not be sufficient for predicting microbial responses since changes in titratable acidity are not always evident from pH measurements (Frazier &Westhoff, 1978).
High solubility indicates greater extent of starch degradation (Banu *et al.*, 2012). It has been reported that variation in water absorption index is caused by the polar amino acid residue in protein as well as polysaccharides (Banu *et al.*, 2012).
Addition of pigeon pea and carrot pomace resulted in a decrease in the viscosities (peak, tough, breakdown, final and setback) of water yam flour. Peak viscosity is the viscosity where the starch granules reach highest swelling while cooking (Banu *et al.*, 2012). Final viscosity is a good measure of the stability of cooked dough (Olapade and Akinyanju, 2014). The pasting temperature is the temperature above the gelatinization temperature at which the viscosity begins to rise, and it is an indication of the time required to cook a sample (Olapade and Akinyanju, 2014). It likewise determines the stability of the other components in a formulation, and also predicts the energy requirement for the preparation (Olapade and Akinyanju, 2014).
Panelists rated cooked paste obtained from 100% water yam flour highest in terms of all the attributes. Most of the blends were poorly rated, indicating that the blends may not be suitable as cooked paste. However, cooked paste obtained from 33.3:33.3:33.3, 50:0:50 and 50:50:0 (water yam: pigeon pea: carrot pomace) blends were 'liked slightly' (about 6.0) in terms of overall acceptability. In view of the increased protein content of the cooked paste obtained from 50:50:0 (water yam: pigeon pea: carrot pomace) and 33:33:33 (water yam: pigeon pea: carrot pomace), appropriate processing technology and additive could be employed to improve the sensory attributes of the paste.

5. CONCLUSION

An attempt has been made to improve the nutritional value of water yam flour. The addition of pigeon pea and carrot pomace improved some macro- and micro- nutrient composition of water yam flour. In view of the variation observed in the functional properties, the flour blends could be used for preparation of various or specific food items. The flour blends, however, may not be suitable as cooked paste.

6. REFERENCES

[1] Adeleke, R.O. andOdedeji, J.O. (2010). Functional properties of wheat and sweetpotato flour blends. Pakistan Journal of Nutrition 9(6): 535-538.
[2] Afify, A.M., Romeilah, R.R., Osfor, M.M.andElbahnasawy, A.S. (2013).Evaluation of carrot pomace (*Daucus carota* L.) as hypocholesterolemic and hypolipidemic agent on albino rats. Not Sci Biol. 5(1):7-14.
[3] Amoakoah Twum, L., Kottoh, I.D., Asare, I.K., Torby-Tetteh,W., Buckman, E.S. and Adu-Gyamfi, A. (2015). Physicochemical and elemental analyses of banana composite flour for infants. British Journal of Applied Science & Technology 6(3): 276-284.
[4] AOAC (2005). Official methods of Analysis. Association of Analytical Chemists, Washington, D.C.
[5] Ayo-Omogie, H.N.and Ogunsakin, R. (2013). Assessment of chemical, rheological and sensory properties of fermented maize-cardaba banana complementary food. Food and Nutrition Sciences 4: 844-850.
[6] Babajide, J. M., Henshaw, F.O. and Oyewole, O.B. (2008). Effect of yam variety on the pasting properties and sensory attributes of traditional dry-yam slices and their products. Journal of Food Quality31:295-305.
[7] Banu, H., Itagi, N. and Singh, V. (2012). Preparation, nutritional composition, functional properties and antioxidant activities of multigrain composite mixes. Journal of Food Science and Technology 49(1): 74–81.
[8] Ezeocha, V.C. and Ojimelukwe, P.C. (2012). The impact of cooking on the proximate composition and anti-nutritional factors of water yam (*Dioscorea alata*). Journal of Stored Products and Postharvest Research 3(13):172 – 176.

[9] Fasoyiro, S.B., Akande, S.R., Arowora, K.A., Sodeko, O.O., Sulaiman, P.O., Olapade, C.O. and Odiri, C.E. (2010). Physico-chemical and sensory properties of pigeon pea(Cajanus cajan) flours. African Journal of Food Science 4(3):120-126.
[10] Frazier, W.C. andWesthoff, D.C. (1978). Food microbiology. Tata McGraw-Hill Publishing Company Limited, New Delhi, pp 4-5.
[11] Gayle, P.E., Knight, E.M., Adkins, J.S. andHarland, B.F. (1986) Nutritional and organoleptic evaluation of wheat bread supplemented with pigeon pea. Cereal Chemistry, 63: 136 – 138.
[12] Hahn, S.K. (1995). Yams: *Dioscorea* Spp. (*Dioscoreaceae*) In: Smartt, J and N.W. Simmonds (Eds) Evolutionofcropplants. Longman Scientific and Technical, UK, pp 112-120.
[13] Harijono, T.E., Dinar, S.S. and Kusnadi, J. (2013). Effect of blanching on properties of water yam (*Dioscorea alata*) flour. Advance Journal of Food Science and Technology 5(10): 1342-1350.
[14] Kakade, M.L., Rackies, J.J., McGhee, J.E. and Puski, G. (1974). Determination of trypsin inhibitor activity of soy products: a collaborative analysis of an improved procedure. Cereal Chemistry 51: 376-382.
[15] Kulkarni, K.D., Kulkarni D.N. andIngle, U.M. (1991). Sorghum malted and soybean weaning food formulations: preparation, functional properties and nutritive value. Food and Nutrition Bulletin,13: 322-327.
[16] Kumar, N., Sarkar, B.C. andSharma, H.K. (2012). Mathematical modelling of thin layer hot air drying of carrot pomace. Journal of Food Science and Technology 49: 33-41.
[17] Leach, H.W., McCowen, D.L. and Schoch, T.J. (1959). Swelling and solubility patterns of various starches. Cereal Chemistry 36: 534-544.
[18] Maga,J A. (1983). Phytate: Its chemistry, occurrence, food interactions, nutritional significance and method of analysis. Journal of Agricultural and Food Chemistry 30: 1-9.
[19] Mbaeyi-Nwaoha, I.E. and Onweluzo, J.C. (2013). Functional properties of sorghum (*S. bicolor* L.) – pigeon pea (*Cajanus cajan*) flour blends and storage stability of a flaked breakfast formulated from blends. Pakistan Journal of Nutrition 12(4): 382-397.
[20] Oke, M.O., Awonorin, S.O. and Workneh, T.S. (2013). Effect of varieties on physicochemical and pasting characteristics of water yam flours and starches. African Journal of Biotechnology 12(11): 1250-1256.
[21] Okpala, L. C. andEkwe, O.O. (2013). Nutritional quality of cookies produced from mixtures of fermented pigeon pea, germinated sorghum and cocoyam flours. European Journal of Food Research & Review 3(1): 38-49.
[22] Olapade, A.A. andAkinyanju, F.T. (2014). Chemical and functional properties and performance of blends of water yam (*Dioscoreaalata*) and soybean (*GlycineMax*) flours for water yam ball (*Ojojo*) preparation. American Journal of Chemistry 4(3): 89-96.
[23] Rampersad, R., Badreie, N. and Comissiong, E. (2003). Physico-chemical and sensory characteristics of flavored snacks from extruded cassava/pigeon pea flour. Journal of Food Science 68: 363-367.
[24] Ruales, J., Valencia, S.andNair, B. (1993). Effect of processing on the physic-chemical characteristics of quinoa flour. Starch/Starke 45: 13-19.
[25] Szabo, R.T., Mezes, M., Szalani, T., Zajacz, E. and Weber, M. (2016). Colour identification of honey and methodical development of its instrumental measuring. Columella Journal of Agriculture and Environmnetal Science 3(1): 29-36.
[26] Udensi, E.A., Oselebe, H.O. and Onuoha, A.U. (2010). AntinutritionalAssessmentof *D. alata*Varieties.*Pakistan Journal of Nutrition* 9(2): 179-181.