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# Chemical and Functional Properties of Wheat, Pigeon Pea and Plantain Composite Flour

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***ABSTRACT:*** *This work was aimed at evaluating the proximate composition, some anti-nutritional factors and functional properties of composite flour produced from wheat, pigeon pea and unripe plantain. Four blends of composite flour were formulated by homogeneously mixing wheat flour, pigeon pea flour and plantain flour in the proportion of 95:5:0 (WPF), 85:10:5 ($WPU_1$), 75:15:10 ($WPU_2$), 65:20:15 ($WPU_3$), respectively, while WHF represented 100% wheat flour served as control. The result of proximate composition signified that there were significant ($p<0.05$) increases in crude protein (13.25-16.10%), moisture (6.30-10.41%), ash (0.62-1.69%) and crude fibre (0.42-1.13%) content with the inclusion of pigeon pea and plantain flours. Significance reductions in crude lipid (2.84-1.82%) and carbohydrate (76.56-68.85%) contents were observed while energy value was not significantly ($p>0.05$) different from the control. The anti-nutrient composition of the blends showed significant reduction of HCN (10.71-8.87 mg/100g), oxalate (180.08-90.04 mg/100g) and tannin (13.02-10.23 mg/100g) contents while highest value (1.35 mg/100g) of phytate was observed in $WPU_2$. Bulk density, foaming, water absorption and oil absorption capacities ranged 1.20-1.30 g/ml, 3.70-13.79%, 6.20-6.60 g/g, 6.00-6.40 ml/ml, respectively while swelling index ranged 28.50-32.00 ml/ml. This study showed that fortifying wheat flour with pigeon pea and plantain flours is a significant way of improving nutritive quality, especially the protein and also increased the functionality of the blends when compared with the control.*

***KEYWORDS***: blends, control, capacities, flour, unripe plantain

## INTRODUCTION

Flour is a powder produce from cereals or other starch based crops. The suitable flour for baking is wheat and its high level of utilization has resulted in overdependence especially in developing countries like Nigeria (Iwe *et al*., 2016). Wheat flour (*Triticum aestivum*) is a flour of choice in confectionary industries due to its elastic gluten protein which helps in producing a relatively large loaf volume with a regular, finely vesiculated crumb structure (Aluge *et al*., 2016; Dabels *et al*., 2016). Composite flour has been defined as a mixture of several flours obtained from roots, tubers, cereals and legumes with or without the addition of wheat flour (Adeleke and Odedeji, 2010; Julianti *et al*., 2015, Awolu *et al*., 2015). Composite flour technology is important because of the advantage of



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reducing the huge amount of money spent on wheat flour importation, coupled with the prospects of the utilization of underutilized crops (Chandra *et al*., 2015; Aluge *et al.*, 2016*;* Arise *et al.*, 2017*).* Formulation of composite flours therefore meant to enhance economic and nutrition and this necessitates continuous search for wheat supplements.

Legumes generally contain high amount of protein compared to other plant food stuffs. Legume proteins are mainly used in food formulations to complement for protein in cereal grains because of their chemical and nutritional characteristics (Okoye and Mazi, 2011). 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 (Adamu and Oyetunde 2013; Oke, 2014; Sangle, 2015). The use of pigeon pea in the supplementation of starchy foods has been reported (Sodipo *et al.*, 2018; Olagunju *et al*., 2018; Adeyanju *et al*., 2018) but lesser work has been done on incorporating plantain flour. Plantain (*Musa paradisiaca*) is a popular dietary staple due to its versatility and good nutritional value. It is starchy, less sweet variety of banana that can be used either ripe or unripe. It is a good source of energy having carbohydrate of about 32% of the total fruit weight comparable in nutritive value to yam or potato and also rich in iron, dietary fibre, calcium, vitamin A, $B_6$ and C (Abioye *et al*., 2011; Adegunwa *et al*., 2014). The objective of this study was therefore to evaluate the proximate composition, anti-nutritional factors and functional properties of composite flour from wheat, pigeon pea and unripe plantain.

## MATERIALS AND METHODS

### Procurement of Raw Materials

Wheat and unripe plantain bunches were procured at Akpanadem market in Uyo, Akwa Ibom state. While pigeon pea seeds were purchased at Ogige market in Nsukka, Enugu State Nigeria. All the chemicals used were of anal grade.

### Preparation of Flours

Flour was produced from wheat by cleaning the whole wheat, sorted, washed and dried in cabinet oven (model NAAFCO BS Oven: OVH-102) at 50 $^{o}$C for 24 h. It was then dry milled using attrition mill, sieved with 425µm aperture screen sieve and packaged in an air tight container. Pigeon pea was cleaned to remove dirt, stones, chaffs and damaged seeds. Cleaned seeds were washed with portable water and then dehulled, oven dried at 50 $^{o}$C for 24 h and milled. The pigeon pea flour was sieved to produce fine flour and packaged in an air tight container. Unripe plantain flour was produced by removing the fruits from the bunch with the aid of stainless steel kitchen knives, washed and blanched at 60 $^{o}$C to prevent enzymatic browning. The pulp was peeled and sliced in small size and oven dried at 50 $^{o}$C for 24 h. The dried samples were milled and sieved to produce fine flour and packaged in an airtight container.



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**Preparation of Flour Blends**

Wheat flour, pigeon pea flour and plantain flour were blended in the ratio of 100:0:0, 95:5:0, 85:10:5, 75:15:10, 65:20:15 as shown in Table 1.

**Determination of Proximate Composition**

Determination of crude protein**,** moisture, crude lipid, ash, crude fibre contents were carried out using the method described in (AOAC, 2005). Determination of carbohydrate was determined using difference method as suggested by Onwuka (2005). It was done by summing up the percentage crude protein, moisture, crude lipid, ash, crude fibre contents and subtracting from 100%. Estimation of energy value was obtained by multiplying the value of the crude protein, lipid and carbohydrate by 4, 9 and 4 (kcal), respectively and taking the sum of the product.

**Determination of Functional Properties of the Flour:** Bulk density, foaming, water and oil absorption capacities were determined by the method described by Onwuka (2005). While swelling capacity was determined using the method of Abbey and Ibeh (1988).

**Determination of Anti-nutrients:** Hydrogen Cyanide (HCN) was determined by the alkaline picrate colorimetric method of Bradbury *et al*. (1999). Phytate content was determined using spectrophotometric method as described by Pearson (1976). Oxalate content was determined using method described by Onwuka (2005). Tannin content was determined by the Folis-Denis colorimetric method described by Kirk and Sawyer (1998).

**Table 1: Sample Formulation**

| | Sample ID (%) | | | | |
|---|---|---|---|---|---|
| Flour | WHF | WPF | $WPU_1$ | $WPU_2$ | $WPU_3$ |
| Wheat | 100 | 95 | 85 | 75 | 65 |
| Pigeon pea | 0 | 5 | 10 | 15 | 20 |
| Unripe plantain | 0 | 0 | 5 | 10 | 15 |

**Statistical Analysis:** Data was subjected to Analysis of Variance (ANOVA) and a significant difference between the measured mean was analysed with Duncan's New Multiple Range Test (DNMRT) using SPSS software for Window version 20.0 statistical package (SPSS Inc.). All statistical tests were performed at a 5% significance level.



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## RESULTS AND DISCUSSION

### Proximate Composition and Energy value of Composite Flour and Wheat Flour

The result of proximate composition and energy value of the composite flour are shown in Table 2. Addition of pigeon pea and unripe plantain flour significantly ($p<0.05$) increased the crude protein, moisture and crude fibre contents of the blends which ranged from 13.25-16.10%, 6.30-10.41% and 0.42-1.13%, respectively, with $WPU_3$ having the highest value. Increase crude protein content in $WPU_3$ could be attributed to the increase in percentage value of the pigeon pea up to 20%. Mature pigeon pea seeds are reported to contain as much as 30.53% and 22.40% protein, respectively (Adamu and Oyetunde, 2013; Oke, 2014). These composite flours help provide needed dietary protein needed for infant and adult. Similar trends were observed by Bello *et al*. (2017) and Awolu *et al*. (2017). Moisture content of the flour blends, though higher than the control, fall within the range recommended for a good shelf life of flour. The increased amount of crude fibre could be attributed to the increase in unripe plantain flour. This result is in agreement with the finding of Adeola *et al*. (2017). Gradual reduction in crude lipid content was observed from 2.07% ($WPU_1$) to 1.82% ($WPU_2$). The result is within the range reported by Kaushal *et al*. (2012). The increase in the percentage amount of plantain flour in the samples increases the ash content. Carbohydrate content of the blends was significantly reduced from 76.56-68.85%. The reduction could be attributed to the decrease in wheat flour from 100% (WHF) to 65% ($WPU_3$). Similar findings were reported by Aluge *et al*. (2016) and Dabels *et al*. (2016). The energy value showed no significant ($p>0.05$) difference among the samples. WHF had the highest value of 377.60 kcal/100g while $WPU_3$ had the least at 356.18 kcal/100g. The high energy value in WHF could be attributed to the increase in carbohydrate and crude lipid contents. High fibre foods tend to be low in energy (Food Data Chart, 2012).

Table 2: Proximate composition (%) and energy value (kcal/100g) of composite flour and wheat flour

| Sample ID | Crude protein | Moisture | Crude lipid | Ash | Crude fibre | Carbohydrate | Energy value |
|---|---|---|---|---|---|---|---|
| WHF | $13.25^{d}\pm0.03$ | $6.30^{d}\pm0.03$ | $2.04^{ab}\pm0.01$ | $1.10^{b}\pm0.01$ | $0.75^{b}\pm0.02$ | $76.56^{a}\pm0.05$ | $377.60^{a}\pm2.11$ |
| WPF | $14.76^{c}\pm0.04$ | $8.25^{c}\pm0.02$ | $1.82^{b}\pm0.02$ | $1.14^{b}\pm0.02$ | $0.76^{b}\pm0.00$ | $73.27^{b}\pm0.04$ | $368.50^{a}\pm2.18$ |
| $WPU_1$ | $15.40^{b}\pm0.02$ | $9.36^{b}\pm0.04$ | $2.07^{a}\pm0.01$ | $0.62^{c}\pm0.00$ | $0.42^{c}\pm0.01$ | $72.13^{b}\pm0.03$ | $368.75^{a}\pm3.55$ |
| $WPU_2$ | $15.45^{b}\pm0.03$ | $10.05^{a}\pm0.02$ | $1.84^{b}\pm0.00$ | $1.55^{a}\pm0.02$ | $1.03^{ab}\pm0.02$ | $70.08^{c}\pm0.02$ | $358.68^{a}\pm2.65$ |
| $WPU_3$ | $16.10^{a}\pm0.02$ | $10.41^{a}\pm0.02$ | $1.82^{b}\pm0.01$ | $1.69^{a}\pm0.01$ | $1.13^{a}\pm0.01$ | $68.85^{c}\pm0.05$ | $356.18^{a}\pm1.98$ |

Values are means±SD of triplicate determination. Means in the same column with different superscript are significantly different at ($p<0.05$). WHF=Control (100% Wheat Flour), WPF=95% Wheat Flour/5% Pigeon Pea Flour, $WPU_1$=85% Wheat Flour, 10% Pigeon Pea Flour/5% Plantain Flour, $WPU_2$=75% Wheat Flour/15% Pigeon Pea Flour/10% Plantain Flour, $WPU_3$=65% Wheat Flour/20% Pigeon Pea Flour/15% Plantain Flour.



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**Anti-nutrient Composition of Composite Flour and Wheat Flour**

The result of the anti-nutrient composition of the composite flour is presented in Table 3. The HCN contents of $WPU_1$ (10.30 mg/100g) and $WPU_2$ (10.16 mg/100g) were not significantly ($p>0.05$) different from WHF (10.71 mg/100g). HCN level observed in this study was higher than the value (9.85%) obtained by Anuoye *et al*. (2012). According to Roseling (1987), the toxic level of cyanide is an intake above 20 mg/100g which makes the samples safe for usage.

Table 3: Antinutritional composition (mg/100g) of composite flour and wheat flour

| Sample ID | HCN | Phytate | Oxalate | Tannin |
|---|---|---|---|---|
| WHF | $10.71^{a}\pm0.03$ | $0.89^{b}\pm0.01$ | $108.05^{c}\pm0.06$ | $13.02^{a}\pm0.02$ |
| WPF | $8.87^{b}\pm0.02$ | $0.64^{b}\pm0.00$ | $180.08^{a}\pm0.05$ | $12.70^{a}\pm0.03$ |
| $WPU_1$ | $10.30^{a}\pm0.03$ | $0.64^{b}\pm0.02$ | $117.05^{b}\pm0.04$ | $12.00^{a}\pm0.02$ |
| $WPU_2$ | $10.16^{a}\pm0.02$ | $0.87^{b}\pm0.02$ | $90.04^{c}\pm0.03$ | $10.23^{b}\pm0.03$ |
| $WPU_3$ | $8.87^{b}\pm0.01$ | $1.35^{a}\pm0.01$ | $90.04^{c}\pm0.02$ | $11.64^{ab}\pm0.01$ |

Values are means±SD of triplicate determination. Means in the same column with different superscript are significantly ($p<0.05$) different. WHP=Control (100% Wheat Flour), WPF=95% Wheat Flour/5% Pigeon Pea Flour, $WPU_1$=85% Wheat Flour/10% Pigeon Pea Flour/5% Plantain Flour, $WPU_2$=75% Wheat Flour/15% Pigeon Pea Flour/10% Plantain Flour, $WPU_3$=65% Wheat Flour/20% Pigeon Pea Flour/15% Plantain Flour.

The phytate content of the blends had no significant ($p>0.05$) difference from WHF except $WPU_3$. It ranged from 0.64-1.35 mg/100g. Similar increasing trend was reported for nixtamalized maize-sprouted soy flour blends (Inyang *et al*., 2019). The increase value of phytate in the samples could be attributed to the higher amount of unripe plantain and pigeon pea flour in the blends. Bushway *et al*. (1984) reported that the maximum tolerable dose of phytate in the body is from 250-500 mg/100g. Therefore phytate levels of flour observed in this study may be considered safe. Oxalate content showed increases with increase in pigeon pea flour when compared with reduced amount as plantain flour addition was increased. WPF had the highest oxalate content of 108.08 mg/100g while the least value (90.04 mg/100g) was found in $WPU_2$ and $WPU_3$. No significant ($p>0.05$) different was observed in the tannin content of all samples except $WPU_2$ which had the least value of 10.23 mg/100g while WHF had the highest value of 13.02 mg/100g. Decrease in tannin content observed agrees with the report of Anuoye *et al*. (2012). However, these anti-nutrients have been to exhibit antioxidant activities, which have been shown to inhibit cardiovascular disease, blood cell clumping, decrease tumour growth and reduced blood cholesterol (Micheal and Maurray, 2005).



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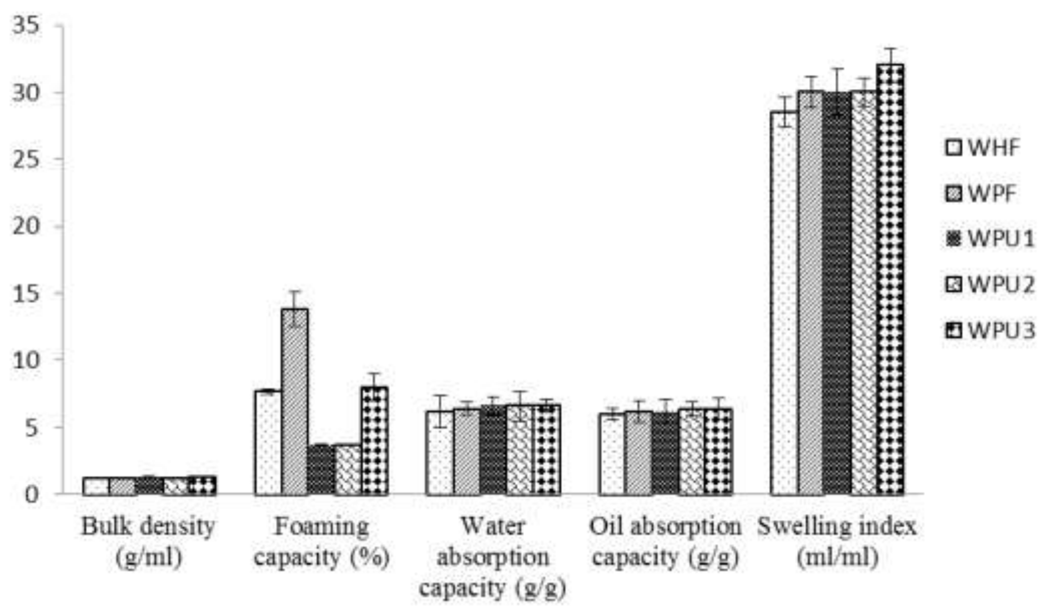
## Functional Properties of Composite Flour and Wheat Flour

The result of functional properties of the composite flour is presented in Figure 1. Bulk density of the flour blends was not significantly ($p>0.05$) different from the control (WHF). It ranged from 1.20-1.30 g/ml. These values are higher than the bulk density of malted sorghum-soy composite flour reported by Bolarinwa *et al.* (2015). The lower value in bulk density implied that samples would require more packaging space since the lesser the bulk density, the more packaging space is required. Also these flours can be used for food formulation with less fear of retrogradation. Foaming capacity ranged from 3.70-13.79% with the least value found in $WPU_1$ and $WPU_2$ while WPF gave the highest value. Water absorption capacity ranged from 6.20-6.60 g/g. Addition of unripe plantain flour had no significant effect on the water absorption capacity of the blends. The values gotten were higher than the findings of Aluge *et al.* (2016). Oil Absorption Capacity (OAC) ranged from 6.00-6.40 g/g with highest value found in $WPU_2$ and $WPU_3$. Increase in OAC of the samples describes high flour-oil association ability under limited oil supply (Singh, 2001). Swelling index signifies the degree of the water absorption of the starch granules in the flour. It ranged from 28.50-32.00 ml/ml. This increased trend could be associated with increase in pigeon pea/unripe plantain flour and decrease in wheat flour ratio in the samples. The result is higher that the findings of Bello *et al.* (2018) on yellow yam, unripe plantain and pumpkin seed flour blends.

## CONCLUSION

This study has shown that acceptable and quality flour blends of wheat, pigeon pea and unripe plantain flour could be produced. These composite flours were good source of crude protein, lipid, fibre, carbohydrate and energy. Flour formulation improved the nutritional values of the blends and reduced anti-nutrients drastically. The anti-nutrients values were within recommended acceptable level. Water and oil absorption capacities, foaming capacity, swelling index and bulk density also contribute to the quality and acceptability of the formulated samples. Higher level of enrichment with pigeon pea flour should be encouraged to increase the protein content of food products consumed.




Keys: WHF=Control (100% Wheat Flour), WPF=95% Wheat Flour/5% Pigeon Pea Flour, $WPU_1$=85% Wheat Flour/10% Pigeon Pea Flour/5% Plantain Flour, $WPU_2$=55% Wheat Flour/15% Pigeon Pea Flour/10% Plantain Flour, $WPU_3$=65%Wheat Flour/20% Pigeon Pea Flour/15% Plantain Flour.

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