PHYSICOCHEMICAL, NUTRITIONAL AND ORGANOLEPTIC EVALUATION OF COOKIES FROM PIGEON PEA (*Cajanus cajan*) AND COCOYAM (*Xanthosoma sp*) FLOUR BLENDS

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ABSTRACT

Cookies were made from pigeon pea (*Cajanus cajan*) and cocoyam (*Xanthosoma sagittifolium*) flour blends. Pigeon pea flour (PPF) was mixed with cocoyam flour (CF) at ratios of 20:80, 30:70, 40:60, 50:50 and 60:40 respectively. The cookies were evaluated for proximate composition, saponins, oxalate, trypsin inhibitors, *in-vitro* protein digestibility, *in-vitro* carbohydrate digestibility, physical and sensory qualities. Standard experimental protocols were employed in the estimation of all indices. The protein contents of the cookies were significantly different ($p<0.05$) from each other and ranged from 10.89 to 11.60% with cookies from 60:40 PPF to CF having the highest value of 11.60% and cookies 20:80 PPF to CF having the least value of 10.89%. The levels of antinutrients analyzed were low with saponin content ranging from 0.05 to 0.08mg/100g; trypsin inhibitors ranging from 0.08 to 0.11mg/100g and oxalate content between 0.06 to 0.68mg/100g. There were significant differences ($p<0.05$) observed in the *in-vitro* digestibility (protein and carbohydrate) with cookies made from 20:80 PPF to CF having the highest protein and carbohydrate *in-vitro* digestibilities of 64.81% and 67.35%, respectively. Results from the physical evaluation of the cookies revealed that the diameter and spread ratio of the cookies were significantly different ($p<0.05$) from each other and decreased with increasing levels of pigeon pea flour. Data obtained from the sensory evaluation indicated that the mean scores for taste, colour, general acceptability and texture were generally high for cookies containing at least 50% cocoyam flour. However, cookies made from 20:80 PPF to CF had the highest mean scores for all the parameters assessed and were not significantly ($p>0.05$)different from the control (100% wheat). It may, therefore be concluded from the strength of this work that cookies produced from 20% pigeon pea flour and 80% cocoyam flour have great potential as they compared favourably with cookies produced from wheat. The use of this composite flour would go a long way in reducing dependency on wheat flour in countries that import wheat.

Key words: cookies, digestibility, antinutrients, composite, acceptability

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INTRODUCTION

The increase in the consumption of bread, pasta and cookies (also called biscuits) has led to the increase in wheat imports in developing countries including Nigeria; as a result, the cost of these products is fairly high [1].

Composite flour technology has been used as a means for extending scarce supplies of wheat or corn used in the production of bread or other baked goods [2]. In selecting the components to be used in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potential [3]. Ideally, the foods produced should look and taste like traditional foods [4].

Cookies have been suggested as a better use of composite flour than bread due to their ready- to -eat form, wide consumption, relatively long shelf life and good eating quality [5]. Cookies with high sensory ratings have been produced from blends of wheat and fonio [6], millet and pigeon pea [7], wheat and plantain [8] and maize and pigeon pea [9]. However no literature has been found on the production of cookies from cocoyam and pigeon pea flour. Pigeon pea, a legume is mainly a subsistence crop in the tropics of India, Africa, South- East Asia and Central America [10]. Cocoyam is a root crop grown in the tropics [11]. It has fine granular starch which has been reported to improve binding and reduce breakage of snack products [12]. Pigeon pea is relatively cheap and contains high amounts of protein (23%). Both cocoyam and pigeon peas are grown in large quantities in Nigeria. Okoye *et al.* [13] reported that Nigeria is the world's largest producer of cocoyams while pigeon peas are widely cultivated in Nigeria [14]. However, these are both grossly underutilized in Nigeria.

This study was carried out to determine the potential of cocoyam and pigeon pea flour blends in cookie making.

MATERIALS AND METHODS

Cocoyams (*Xanthosoma sp)* and pigeon peas (*Cajanus cajan)* were purchased from a local market in Enugu, Nigeria. Other ingredients used for baking were obtained from the same source.

Preparation of Samples

The cocoyam flour was prepared using the method described by Okaka [15]. The corms were washed, peeled, sliced and blanched at 80^0C for four minutes. They were dried, milled to pass through 40-mesh sieve (British standard) and packaged in airtight containers until needed. The pigeon pea flour was produced as described by Echendu *et al.* [9]. The pigeon peas were cleaned and soaked in water for 38 hours, after which they were dehulled manually. The loosened seeds were washed and sun-dried. During drying, the grains were stirred at 40 minutes intervals to ensure uniform drying. The dried grains were milled to pass through a 40-mesh sieve and packaged in airtight containers until needed. Wheat was purchased as already milled flour. The packaged flour samples were kept in airtight containers until needed for analysis.

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Flour Blending

Pigeon pea flour (PF) was mixed with cocoyam flour (CF) at ratios of 20:80, 30:70, 40:60, 50:50 and 60:40 respectively, in a Kenwood blender. The blends were kept in plastic airtight containers at room temperature pending their use.

Cookie Preparation

The basic formulation for the cookie was 100g flour, 40g fat, 25g sugar, 1½ teaspoonful powdered milk, 1g sodium bicarbonate, ½ teaspoonful liquid vanilla flavour, 0.3g nutmeg, 1g salt and ½ whole egg. The 100% flour was systematically replaced with the pigeon pea cocoyam flour blends. Wheat flour was used whole as a standard for comparison. After mixing, the dough was kneaded to a uniform thickness of 0.25cm and cut to a diameter of 4.6cm. Cookies were baked for 15-25 mins on aluminum sheets at $185^{o}C$ in an oven, cooled, packaged in polyethylene bags and stored at room temperature until evaluated later the same week.

Proximate Composition

The crude protein, fat, moisture, fibre, ash and carbohydrate were determined according to the AOAC [16] methods on triplicate samples of the cookies. Energy was calculated by the Atwater method (protein x 4; fat x 9; carbohydrate x 4) [17].

Physical analysis

The weight and the diameter of the baked cookies were determined by weighing on a weighing balance (Mettler PE160 Balance, Switzerland) and measuring with a calibrated ruler, respectively.

The spread ratio was determined using the method described by Gomez *et al.* [18]. Three rows of five stacked cookies were made and the height of the five stacked cookies was measured. The horizontal measurement of the three rows was measured as the diameter. The spread ratio was calculated as diameter/ height.

In-vitro Protein Digestibility (IVPD)

Protein digestibility in pigeon pea – cocoyam cookies were determined using the procedure of Mertz *et al* [19] and Aboubacar *et al*, [20]. Cookie flour samples (200mg) were weighed into an Erlenmeyer flask and mixed with 35ml of porcine pepsin (1.5g of pepsin in 0.1 M KH_2PH_4, pH 2.0). Samples were digested for 2 h at $37^{o}C$ in a shaking water bath. Digestion was stopped by addition of 2 ml of 2M NaOH. Samples were centrifuged (4900xg, $40^{o}C$) for 20 min and the supernatant discarded. The residues were washed and centrifuged twice with 20ml of buffer (0.1M KH_2PO_4, pH 7.0). Undigested nitrogen was determined using Kjeldahl method. Digestibility was calculated as % digestibility = (N in sample- Undigested N)/N in sample x 100.

In- Vitro Carbohydrate Digestibility (IVCD)

The method described by Shekib *et al.* [21] was used. The assay was carried out at room temperature ($27^{o}C$) in a test tube containing 5ml of starch (obtained from the cookie sample); 4ml of phosphate buffer (pH 6.6), 1ml of sodium chloride. One millilitre of α amylase enzyme was added and the whole solution mixed thoroughly to make the reaction mixture. Aliquots (0.2 ml) of the mixture were taken at zero and 1.0

hour (complete hydrolysis as predetermined) after addition of the enzyme and dispensed into 10 ml lugol's iodine solution (1:100 dilution) and the absorbance measured colorimetrically at 620 nm with Corning Colorimeter 253. In- vitro carbohydrate digestibility was calculated as:

$$\frac{\text{Absorbance at zero time} - \text{absorbance at 1 hour}}{\text{Absorbance at zero time}} \times 100$$

Antinutrients Determination
Saponins were determined according to AOAC [16] methods. Trypsin inhibitor was extracted by standard procedure [22] and evaluated as previously described [23]. Oxalate was estimated as follows. The sample was extracted with water for three hours and calibration curve of oxalic acid prepared by making serial dilutions of standard oxalic acid solutions and then taking absorbance at 420nm, from where the oxalic acid content of the samples were extrapolated as oxalate [24].

Sensory Evaluation
A panel of twenty consumers was recruited from staff and students of Ebonyi State University, Abakaliki. Criteria for selection were that panelists were regular consumers of cookies and were not allergic to any food. Panelists were instructed to evaluate colour, taste, texture, crispiness and general acceptability. A 9-point hedonic scale with 1 = dislike extremely, 5= neither like nor dislike and 9= like extremely was used. Samples were coded and presented in a random sequence to the panelists.

Statistical analysis
Data were analyzed using one-way analysis of variance (ANOVA). Mean separation was done by the Duncan's multiple range test using the Statistical Package for the Social Sciences (SPSS) 16.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

The proximate composition of the cookies is presented in Table 1. Cookies from wheat had the lowest protein content of 9.65% while those from the 60:40 pigeon pea flour to cocoyam flour composite had the highest protein content of 11.60%. Protein and ash contents of the composite cookies increased significantly ($p<0.05$) with increasing levels of pigeon pea flour in the blends while carbohydrate content decreased with increasing levels of pigeon pea flour. The fat and crude fibre contents of cookies from the 40:60 and 50:50 pigeon pea: cocoyam flour were not significantly ($p>0.05$) different from each other.

Data on the antinutrient content of the cookies are presented in Table 2. It was observed that for all the antinutrients studied, cookies from 20: 80 (w/w) % pigeon pea: cocoyam flour had the highest values while cookies from 60: 40 (w/w) % pigeon pea: cocoyam flour had the least values.

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The *in-vitro* carbohydrate (IVCD) and protein digestibility (IVPD) of the cookies are shown in Table 3. The differences in the values obtained for IVPD were all significant (p<0.05).

Results obtained for the physical properties of the cookies are shown in Table 4. It was observed that all the physical properties studied (weight, diameter and spread ratio) decreased with increasing levels of pigeon pea flour.

Presented in Table 5 are the sensory attributes of the cookies produced. Taste panel ratings for all the attributes studied, increased significantly (p<0.05) with increased contents of cocoyam flour in the composite. There was no significant difference in the panel scores for the control and cookies containing 70% and 80% cocoyam flour.

DISCUSSION

The increased protein and ash contents with increasing levels of pigeon pea flour were expected because pigeon pea has been reported to have relatively high protein and ash contents of 19.63% and 5.50%, respectively [25]. The fat content of the cookies was relatively low. Fat plays a role in determining the shelf life of foods. A high amount of fat can accelerate spoilage by promoting rancidity leading to the production of off flavours and odours. Also diets high in fat predispose consumers to different illnesses such as obesity, coronary heart disease etc. Therefore, the relatively low fat content observed in the cookies is desirable to both the processor and health conscious individuals. The observed increase in carbohydrate content with increase in cocoyam flour could be due to the high carbohydrate content of cocoyam. It has been reported that of all the solid nutrients present in roots and tubers (like cocoyam), carbohydrates predominate [26].

The saponin contents of the cookies were very low suggesting that in this regard, they pose no threat to human consumption. Saponins have been reported to lower plasma cholesterol concentrations [27]. Pigeon pea has been reported to be a source of saponins [28]. The low levels of saponins in the biscuits could be due to leaching when the pigeon peas were soaked in water during the preparation of pigeon pea flour. Soaking has been reported to reduce saponins content [29]. The trypsin inhibitor and oxalate contents were also very low. The oxalate level was observed to reduce with reduction in the cocoyam flour. Cocoyam has been associated with oxalate [11]. This might explain why the level of oxalate reduced with reduced levels of cocoyam flour.

Research has shown that nutrient composition of foods is not enough to determine nutrient bio-availability [30], hence the need for *in-vitro* digestibility. The *in-vitro* protein digestibility (IVPD) for all the cookies decreased with increasing levels of pigeon pea flour. The sample with the least protein content (20:80 pigeon pea to cocoyam flour) had the highest IVPD while the sample with the highest protein content (60:40 pigeon pea to cocoyam flour) had the lowest IVPD. This result shows that high protein content does not necessarily imply high protein digestibility. Protein digestibility is actually the amount of protein absorbed into the body relative to the

amount that was consumed [31]. Protein digestibility has been reported to be reduced by the presence of antinutritional factors such as trypsin inhibitors [32]. The levels of trypsin inhibitors in the cookies produced were too low to account for the observed decrease in IVPD. The decrease could have been due to non-enzymic browning reactions which involve interactions between inherent proteins and added sugar, resulting in non-reversible formation of compounds causing a decrease in the availability of protein for digestion [33]. The decrease could also have been due to thermal cross-linking of some of the protein making it unavailable for digestion [34]. Ayo *et al.* [35] produced cookies from Hungary rice ("acha"), soybean and wheat. They observed that the in vitro protein digestibility decreased as the level of soy bean flour was increased. This further corroborates the findings of this work whereby the increase in legume flour actually resulted in a decrease in the *in-vitro* digestibility.

Increase of pigeon pea flour resulted in reduction of spread ratio. It has been reported that hydrophilic starches have a negative relation with the spread ratio of cookies [36]. During baking, hydrophilic starch granules absorb moisture, become swollen and gelatinized. This gelatinization increases dough viscosity and thus reduces cookie spread [37]. This suggests that the starches of pigeon pea flour were more hydrophilic in nature than those of cocoyam flour. Controlling cookie spread is one of the most serious problems encountered in cookie production; a cookie which spreads so much that it cannot be filled in a package, or one that spreads too little, causing slack fill or excess height for the package, can create havoc on the packaging line [38].

The sensory evaluation (Table 5) revealed that for all the attributes except for taste, as the level of pigeon pea flour increased beyond 30% there was a significant decrease in the sensory scores. Cookies with 20% and 30% pigeon pea flour were not significantly different from the control for all of the attributes studied. Cookies with 60% pigeon pea had the least scores. From the general acceptance scores, it can be concluded that cookies with 20% to 30% pigeon pea can be baked with satisfactory acceptance.

CONCLUSION

Cookies from pigeon pea and cocoyam flour blends had improved protein content compared to cookies from wheat. The antinutrient levels of the cookies were also very low. Cookies with 20% pigeon pea had the highest *in-vitro* protein digestibility and the best sensory scores. This study has shown that cookies containing 20% pigeon pea flour and 80% cocoyam flour have great potentials and compare favourably with 100% wheat. Their use would go a long way in reducing dependency on wheat flour in countries that import wheat.
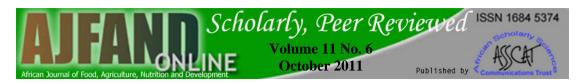
Table 1: Proximate composition of cookies produced from Pigeon pea flour (PPF) and Cocoyam flour (CF) blends

Sample PPF:CF	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Moisture (%)	Carbohydrate (%)
20:80	10.89[d]	5.29[d]	3.19[e]	2.20[d]	6.30[e]	72.13[a]
30:70	11.07[c]	5.65[c]	3.36[d]	2.48[c]	6.43[d]	71.01[b]
40:60	11.30[b]	5.76[b]	3.45[c]	2.60[b]	6.63[c]	70.26[b]
50:50	11.37[b]	5.77[b]	3.56[b]	2.66[b]	6.77[b]	69.87[b]
60:40	11.60[a]	6.05[a]	3.68[a]	2.86[a]	6.78[b]	69.03[b]
100% Wheat Flour	9.65[e]	5.64[c]	2.56[f]	2.41[c]	7.46[a]	72.28[a]

PPF= Pigeon pea flour

CF= Cocoyam flour

Values are the means of triplicate determinations.

Means with the same superscript in the same column are not significantly different (p<0.05).

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Table 2: Antinutrient content (mg/100g) of cookies produced from Pigeon pea flour (PPF) and Cocoyam flour (CF) blends

Sample PPF:CF	Saponins	Trypsin Inhibitor	Oxalate
20:80	0.08[a]	0.11[a]	0.68[a]
30:70	0.05[b]	0.09[b]	0.66[ab]
40:60	0.06[b]	0.09[b]	0.65[bc]
50:50	0.05[b]	0.08[b]	0.63[c]
60:40	0.05[b]	0.08[b]	0.60[d]

Values are the means of triplicate determinations.
Means with the same superscript in the same column are not significantly different ($p < 0.05$).

Table 3: *In-vitro* digestibility of cookies produced from Pigeon pea flour (PPF) and Cocoyam flour (CF) blends

Sample PPF:CF	% IVCD	% IVPD
20:80	67.35[a]	64.81[a]
30:70	67.14[a]	64.77[b]
40:60	67.08[a]	63.66[c]
50:50	65.92[b]	63.21[d]
60:40	63.55[c]	62.33[e]

Values are the means of triplicate determinations.
Means with the same superscript in the same column are not significantly different ($p < 0.05$).
IVCD= *In-vitro* carbohydrate digestibility
IVPD= *In-vitro* protein digestibility

Table 4: Physical Properties of cookies produced from Pigeon pea flour (PPF) and Cocoyam flour (CF) blends

Sample PPF: CF	Weight (g)	Diameter (cm)	Spread Ratio
20:80	10.61^a	5.50^a	8.46^a
30:70	10.45^a	5.40^b	7.70^b
40:60	10.43^{ab}	5.00^c	7.50^c
50:50	10.38^{ab}	5.00^c	7.04^d
60:40	9.95^b	4.90^d	6.52^e

Values are the means of triplicate determinations.
Means with the same superscript in the same column are not significantly different ($p < 0.05$).

Table 5: Sensory qualities of cookies produced from Pigeon pea flour (PPF) and Cocoyam flour (CF) blends

Sample PPF:CF	Taste	Texture	Colour	Crispiness	General Acceptability
20:80	7.26^{ab}	7.73^a	8.00^a	7.53^a	8.00^a
30:70	7.20^{ab}	6.86a	7.60^{ab}	6.53^{ab}	6.93^{ab}
40:60	6.93^b	6.40^b	6.60^{bc}	5.86^b	6.46^b
50:50	6.93^b	6.06^b	6.40^c	5.66^{bc}	6.40^b
60:40	6.86^b	5.80^b	5.46^c	4.93^c	6.20^b
100% Wheat Flour	8.20^a	7.95^a	8.00^a	7.65^a	8.35^a

Values are the means of triplicate determinations.
Means with the same superscript in the same column are not significantly different ($p < 0.05$).

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