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Proximate composition, Physical Properties and Sensory Evaluation of Wheat-Cocoyam-Pigeon Pea Biscuits

Arukwe, D. C.
Department of Home Science/Hospitality Management and Tourism, College of Applied Food Science and Tourism,
Michael Okpara University of Agriculture, Umudike, Nigeria.

Abstract: *This study investigated the production of protein-rich biscuits from blends of wheat flour (WF), boiled cocoyam flour (CF) and fermented pigeon pea flour (PF) in the ratios of WF:CF:PF as 100:0:0, 90:5:5, 85:10:5, 80:10:10 and 70:20:10. The composites were used with other ingredients to produce biscuits which were analyzed forproximate composition, physical and sensory properties.The proximate result showed that their moisture ranged from 9.05-10.70%, protein 11.02-13.15%, crude fibre 1.05-3.20%, fat 3.10-4.60%, ash 2.45-4.05% and carbohydrate 65.95-71.68%.The physical properties ranges were,weight 17.05-17.15g, diameter 4.30-4.40cm, thickness 0.40-0.44cm and spread ratio 9.76-11.05. Furthermore, all the biscuit samples recorded above average in overall acceptability of the sensory evaluation result.*

Key words: *Fermented, boiled, composites, protein-rich biscuits, spread ratio*

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I. Introduction

There has been report of prevalence of protein malnutrition in the people of developing countries due to inadequate consumption of protein rich foods especially among children (UNICEF, 1996). The major source of protein which is from animals is very expensive and out of reach of the poor. It has therefore become necessary to harness plant protein in the production of various foods (such as biscuits and other bakery products)to meet the protein needs of the people.

Wheat flour is the flour of choice for producing biscuits but it is very expensive compared to flours of under-utilized crops such as cocoyam, pigeon pea, etc. The use of wheat flour for bakery products makes the products expensive and unaffordable to the poor. Therefore, composite flours for bakery can be produced from our local crops to reduce the cost of biscuits and other baked products. Akobundu *et al*. (1998) opined that in selecting components to be used in composite flour blends, the materials should be readily available, culturally acceptable and provide increased nutritional potential. FAO (1995) reported that composite flours produced from cereals and legumes have the advantage of improving overall nutrition. Also, Chinma *et al*. (2007) noted that composite flours from legumes and tubers have high protein content and high caloric value.

Pigeon pea has been tested and found to be a suitable protein source for supplementing baked products due to its high protein, iron and phosphorus content (Harrinder *et al*., 1999) and the sensory properties of the products are not affected (Torres *et al*., 2007). The presence of antinutrients in pigeon pea is a constraint to its utilization. To improve its nutritional composition, pigeon pea seeds are subjected to fermentation processing method. Fermentation is an economic method that could be used to improve the nutritional quality of plant foods (Obizoba and Nnam, 1992; Apata and Ologhobo, 1997). According to Lawal *et al*. (2009), fermentation improves digestibility and nutritional quality.

Cocoyam is rich in digestible starch, good quality protein, vitamin C, thiamin, riboflavin and niacin (Lewu *et al*., 2009). Owusu-Darko *et al*. (2014) reported that with appropriate processing methods, cocoyam could be a rich source of starch for food and industrial applications. The utilization of cocoyam (especially *Xanthosoma spp)* is hindered by the high calcium oxalate content which affects its palatability, confers acidity and a bitter-stringent taste (Owusu-Darko *et al*., 2014). This adverse effect of high oxalate content can be eliminated by boiling (Igbabul*et al*., 2014).

Some researchers have reported production of biscuits using different composite flours(Echendu *et al*., 2004; Giwa and Ikujenlola, 2010), but the main ingredient generally used for biscuit production is wheat flour with other ingredients such as margarine(shortening), sweeteners (sugar), leavening agents, eggs, milk, salt and flavor (Hui, 1992; Ghattas *et al*., 2008).

Theaim of this research was to produce protein-rich biscuits from wheat,boiled cocoyam(*Xanthosomasagittifolium*variety) and fermented pigeon pea composite flours and evaluate their proximate composition, physical and sensory properties.

II. Materials and Methods

Collection of materials

The pigeon pea seeds, cocoyam cormels (*Xanthosoma sagittifolium* variety), wheat flour and other bakery ingredients were purchased from 'Ahia Ohuu' in Aba, Abia State, Nigeria.

Sample preparation

Boiled cocoyam flour: One kilogram of *Xanthosoma sagittifolium*was washed with clean water to remove adhering soil and other extraneous materials. The cocoyamcormels were then hand-peeled under water using kitchen knife, and sliced into sizes of 2cm thickness. The slices were boiled in water at 100^{o}C for 10 minutes. The pieces of cocoyam were dried in an oven at 60^{o}C for 9 hours after which they were milled into flour, sieved with a standard sieve (1.0mm mesh) and packaged in polyethylene bags for further studies.

Fermented pigeon pea flour: One kilogram of pigeon pea seeds were sorted to remove dirt and extraneous materials, washed and wrapped in banana leaves and kept to ferment for 4 days as described by Ikemefuna (1998) after which the seeds were de-hulled and dried in an oven at 60^{o}C for 7 hours. The dried seeds were milled into flour using disc attrition mill (Asiko Al1, Addis Nigeria), sieved with a standard sieve (1.0mm mesh) and packed in polyethylene bag for further studies.

Table 1: Blends of composite flour samples prepared from wheat-cocoyam-pigeon pea flours

Sample	Wheat flour (%)	Cocoyam flour (%)	Pigeon pea flour (%)
A	100	0	0
B	90	5	5
C	85	10	5
D	80	10	10
E	70	20	10

Key: A = 100% wheat flour, B = 90% wheat, 5% cocoyam and 5% pigeon pea flours, C = 85% wheat, 10% cocoyam and 5% pigeon pea flours, D = 80% wheat, 10% cocoyam and 10% pigeon pea flours and E = 70% wheat, 20% cocoyam and 10% pigeon pea flours.

Production of biscuits from wheat-cocoyam-pigeon pea composite flours

The method described by Akpapunam and Derbe (1994) was used in the biscuit production. The ingredients used were 100g flour, 10g sugar, 31g margarine, 1g baking powder and 2 eggs. The wheat flour was substituted with cocoyam flourand pigeon pea flour in the ratio as shown in Table 1.All dry ingredients for each sample (A - E) were weighed and mixed manually in a bowl until well blended. The margarine was rubbed in and the egg was added and the dough formed was kneaded manually on a flat table until smooth. Then, the dough was transferred to a pastry board and a rolling pin was used to roll it into a 3mm thickness. The dough was then cut into round shapes using a biscuit cutter and the cut dough pieces were transferred into greased bakery trays and baked in hot oven (160^{o}C) for 15 minutes. The baked biscuits were then removed from the oven, cooled out in racks and packaged in polyethylene bags for further analysis.

Proximate analysis of biscuits produced from wheat-cocoyam-pigeon pea composite flours

The AOAC (2005) methods were used to determine the protein, moisture, crude fibre, fat, ash and carbohydrate content of the samples and their analysis was done in triplicates.

Physical measurements of biscuits produced from wheat-cocoyam-pigeon pea composite flours

The weights of the biscuits were measured with a weighing balance while the diameter and thickness were measured with a venier caliper. The spread ratio was calculated by the formula, diameter (cm) divided by thickness (cm) as described by Bose and Shams-UD- Din (2010).

Sensory evaluation biscuits produced from wheat-cocoyam-pigeon pea composite flours

The sensory evaluation was done using a twenty-member panel who were regular consumers of biscuits. The panelist rated the biscuit samples colour, aroma, taste, texture (crispiness) and general acceptability on a 9-point hedonic scale as described by Ihekoronye and Ngoddy (1985). The rating scale was 1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8- like very much and 9- like extremely.

Statistical Analysis

All data obtained was subjected to analysis of variance (ANOVA) and separation of means was done using pre-packaged computer software (MINITAB 15).

III. Results and Discussion

Proximate composition of biscuits produced from wheat-cocoyam-pigeon pea composite flours

Table 2 shows the proximate composition of biscuit samples produced from blends of wheat-cocoyam-pigeon pea. There were significant differences ($p<0.05$) in moisture, protein, crude fibre, fat, ash and carbohydrate contents of the samples. The highest (13.15%) protein content was recorded for sample (E) prepared with 70% wheat, 20% cocoyam and 10% pigeon pea flour substitution. The protein content was lowest (11.02%) in sample (A) prepared from 100% wheat flour (control). The protein values in this study are similar to the protein values (12.96-15.21%) reported by Giwa and Ikujenlola (2010) for biscuits produced from composite flours of wheat and quality protein maize.

Table 2: Proximate composition of biscuitsproduced from wheat-cocoyam-pigeon peacomposite flours

Sample	Moisture %	Protein %	Crude Fibre %	Fat %	Ash %	Carbohydrate %
A	10.70^{a}	11.02^{e}	1.05^{e}	3.10^{e}	2.45^{e}	71.68^{a}
B	10.25^{b}	12.15^{d}	2.10^{d}	4.15^{d}	2.60^{d}	68.75^{b}
C	9.78^{c}	12.50^{c}	2.25^{c}	4.20^{c}	2.82^{c}	68.45^{c}
D	9.25^{d}	12.55^{b}	3.0^{b}	4.50^{b}	3.0^{b}	67.60^{d}
E	9.05^{e}	13.15^{a}	3.20^{a}	4.60^{a}	4.05^{a}	65.95^{e}
LSD	0.00221	0.00958	0.00247	0.00226	0.00224	0.00976

Mean values with different letters within the same column are significantly different ($p<0.05$)
Key: A = 100% wheat flour, B = 90% wheat, 5% cocoyam and 5% pigeon pea flours, C = 85% wheat,10% cocoyam and 5% pigeon pea flours, D = 80% wheat,10% cocoyam and 10% pigeon pea flours and E = 70% wheat, 20% cocoyam and 10% pigeon pea flours.

The result showed that the protein content of the biscuit samples increased significantly ($p<0.05$) due to the substitution with cocoyam and pigeon pea flours. The increase in protein content of the wheat-cocoyam-pigeon pea biscuit samples is advantageous since protein helps to build and maintain body cells.

The moisture content showed that sample A (control) recorded the highest (10.70%) while sample E recorded the lowest (9.05%). It was observed that the moisture content of the biscuit samples decreased significantly ($p<0.05$) as their substitution of cocoyam flour and pigeon pea flour increased. This result is similar to that (9.37-10.03%) reported by Echendu *et al*. (2004) for biscuits produced from maize pigeon pea flour blends. The low moisture content recorded for the biscuit samples in this study is advantageous since it will hinder microbial spoilage of the products thereby enhancing their shelf life (Nnam, 2002).

The proximate results showed that the substitution of cocoyam flour and pigeon pea flour with wheat flour increased protein, crude fibre, fat, ash and decreased carbohydrate with increased level of substitution. The reason for the significant increases ($p<0.05$) in the nutrients could be because of the high protein, mineral and vitamin content of the pigeon pea andcocoyam flours because various plant protein sources can be combined to obtain products with improved protein quality (Weaver *et al*., 2014), even though cocoyam contains mainly carbohydrates. The decrease observed in carbohydrate content could be due to the calculation by difference andKure *et al*. (1998) noted that biscuits are a rich source of fat and carbohydrates and are energy giving food. Therefore the biscuit prepared from wheat-cocoyam-pigeon pea flours have higher nutrients than the one prepared from 100% wheat flour and will contribute to the daily nutritional need of the consumers who are mostly children.

The increase in fat, ash and crude fibre of the wheat-cocoyam-pigeon pea biscuit is an added advantage as fats supplies essential fatty acids and increased fibre is advantageous to consumers who prefer high fibre biscuits. The higher protein, ash and fibre contents of the biscuit samples produced with cocoyam - pigeon pea flour substitution is very important as this would make a significant contribution to the nutrient intake of the consumers who are mostly children. This result is in agreement with the reports of Onweluzo and Iwezu (1998) and Akubor and Ukwuru (2003) who developed high protein biscuits from cassava-soy flour.

Physical properties of biscuits produced from wheat-cocoyam-pigeon pea composite flours

The physical properties of the biscuit samples are shown in Table 3. There were no significant differences ($p<0.05$) observed in the weight, diameter and thickness of the biscuit samples which ranged from17.05-17.15g, 4.30-4.40cm and 0.40-0.44cm respectively. This suggests that there were no distortions in the shape of the biscuit samples.

The spread ratio of the biscuit samples ranged from 9.76 - 11.05 with sample A (100% wheat flour) recording the highest value (11.05). The spread ratio decreased for the composite flour samples. It was observed that, as the level of cocoyam-pigeon pea flours substitution increased, the spread ratio significantly ($p<0.05$) decreased. This is in agreement with the reports of Onweluzo and Iwezu (1998) and Akubor and Ukwuru (2003) who reported decreased spread ratio for biscuit made from cassava - soybean blends. The low spread ratio

observed in the biscuits made from the composite flours may be due to change in elastic behavior of the dough.

Table 3: Physical properties of biscuits produced from wheat-cocoyam-pigeon peacomposite flours

Sample	Weight (g)	Diameter (cm)	Thickness (cm)	Spread Ratio
A	17.15^{a}	4.40^{a}	0.40^{a}	11.05^{a}
B	17.12^{a}	4.35^{a}	0.41^{a}	10.61^{b}
C	17.10^{a}	4.39^{a}	0.42^{a}	10.45^{c}
D	17.10^{a}	4.35^{a}	0.44^{a}	9.88^{d}
E	17.05^{a}	4.30^{ab}	0.44^{a}	9.76^{e}
LSD	0.0	0.0	0.0	0.00232

Mean values with different letters within the same column are significantlydifferent ($p<0.05$)
Key: A = 100% wheat flour, B = 90% wheat, 5% cocoyam and 5% pigeon pea flours, C = 85% wheat, 10% cocoyam and 5% pigeon pea flours, D = 80% wheat, 10% cocoyam and 10% pigeon pea flours and E = 70% wheat, 20% cocoyam and 10% pigeon pea flours.

Sensory properties of biscuits produced from wheat-cocoyam-pigeon pea composite flours

Table 4 shows the result of the sensory properties of the biscuit samples. There were significant differences ($p<0.05$) in colour, aroma, taste, texture(crispiness) and overall acceptability of the biscuit samples.

The score for colour ranged from 4.72-7.15 and was significantly highest ($p<0.05$) for the sample A (100% wheat flour) followed by the sample B (90% wheat, 5% cocoyam and 5% pigeon pea flours) which recorded scores of 7.15 and 6.65 respectively. The scores for aroma ranged from 4.80-7.10 and showed significant ($p<0.05$) differences among the samples. This suggests that the consumers of the biscuits showed different levels of acceptance for the aroma of the samples. The score for taste, texture (crispiness) and overall acceptability were highest in sample A and were recorded as 7.10, 7.00 and 7.15 respectively and followed by sample B 6.40, 6.45 and 6.55 respectively. The mean sensory scores for all the biscuit samples were above average (4.5) and this suggests that the biscuit samples had high acceptability based on the parameters evaluated. This result is in agreement with the report of Echendu *et al*. (2004) who used maize and pigeon pea flour blends in doughnut and biscuit production.

Table 4: Sensory properties of biscuits produced from wheat-cocoyam-pigeon pea composite flours

Sample	Colour	Aroma	Taste	Texture(crispiness)	Overall acceptability
A	7.15^{a}	7.10^{a}	7.05^{a}	7.0^{a}	7.15^{a}
B	6.65^{b}	6.62^{b}	6.40^{b}	6.45^{b}	6.55^{b}
C	6.50^{c}	6.55^{c}	6.35^{c}	6.40^{c}	6.50^{c}
D	5.0^{d}	5.50^{d}	5.10^{d}	5.25^{d}	5.20^{d}
E	4.72^{e}	4.80^{e}	4.60^{e}	4.50^{e}	4.55^{e}
LSD	0.01596	0.00378	0.00210	0.00351	0.00179

Mean scores with different letters within the same column are significantly different ($p<0.05$)
Key: A = 100% wheat flour, B = 90% wheat, 5% cocoyam and 5% pigeon pea flours, C = 85% wheat, 10% cocoyam and 5% pigeon pea flours, D = 80% wheat, 10% cocoyam and 10% pigeon pea flours and E = 70% wheat, 20% cocoyam and 10% pigeon pea flours.

IV. Conclusion

The potential of the application of boiled cocoyam (*Xanthosoma sagittifolium*variety)and fermented pigeon pea composite flours with wheat flour for protein-rich biscuit production has been investigated in this study. The products were acceptable and highly rated by the consumers. Production of biscuits with these composite flours will increase the economic value of these crops and reduce their wastages during harvest season and equally increase the nutrient intake of the consumers.

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