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Physicochemical and Sensory Properties of Cookies Produced From Composite Flours of Wheat, Cocoyam and African Yam Beans

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Abstract

Cookies were produced from wheat, African yam bean and fermented cocoyam flour blends and their physicochemical and sensory properties were determined. Five flour formulations designated as samples A, B, C, D, E were produced. Sample A consisted of 100% wheat flour and served as the control. Samples B and C comprised of 80% wheat, 10% cocoyam, 10% African yam bean flours and 60% wheat, 20% cocoyam and 20% African yam bean flours. The composition of D and E were 40% wheat, 30% cocoyam, 30% African yam bean flours and 20% wheat, 40% cocoyam, and 40% African yam bean flours respectively. The result of the proximate composition showed that there was significant increase (P<0.05) in the protein, fat, fibre, ash content and energy values. The values range from 10.44-14.73%, 3.01-6.73%, 1.63-2.43%, 2.44-3.64% and 356.21-375.25% respectively. The carbohydrate content ranged from 63.94-71.84% while the values for moisture content vary from 8.54-10.68%. These values decreased significantly (P<0.05) with increase in cocoyam and African yam bean flours. The physical properties revealed the weight, diameter, thickness, and spread ratio ranges as; 18.01-20.15 g, 6.48-6.82 cm, 0.45-0.55 cm, and 11.78-15.16, respectively. The sensory scores showed that the cookies produced from 100% wheat flour compared favourably with the cookies from the composite flours of wheat, African yam bean and fermented cocoyam and therefore cookies could be successfully prepared from the composite flours of wheat, African yam bean and fermented cocoyam flour. This would enhance the utilization of these underutilized crops and help in alleviating protein energy malnutrition problems in developing countries.

Keywords: African yam bean, fermented cocoyam, cookies, composite flour, wheat

1. Introduction

Cookies are commonly consumed in most parts of the world and represent the largest category of snack foods (Lorenz, 1983). Urbanization has also increased the consumption of processed food and bakery products leading to high cost of production as well as increase in the demand for importation of wheat (Dotsey, 2009). Wheat which is the cereal of choice for producing cookies is not grown in tropical regions including Nigeria for climatic reasons. Therefore to produce baked goods, regions with limited supplies of wheat flour must rely on imports or exclude wheat from the diet (Holt et al., 1992) to reduce cost. The consumption of cereal based foods like cookies at affordable cost requires the development of an adequate substitute for wheat (Eneche, 1999). The substitute should be one that is readily available, cheap and able to replace wheat flour in terms of functionality. Flours produced from a combination of cereals, legumes or tubers will have a nutritional value superior to those produced from only either cereals, legumes or tubers and thus the advantage of improved overall nutrition (FAO, 1995). Composite flours produced from legumes and tubers have been reported to have higher protein content and caloric value (Chinma et al., 2007). The nutritional value of cereal flours that are poor in lysine but rich in the sulphur containing amino acids is improved by the addition of legume flours, and the nutritional value of root and tuber flours, which are poor in protein, is sufficiently improved by the addition of cereal flours (FAO, 1990). Also cereals will provide methionine which is low in legumes. 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 (Akobundu et al., 1998). Thus, the choice of cocoyam, African yam bean and wheat composite flour would produce nutritious and affordable cookies.

Cocoyam (*Colocasia esculenta*) is a staple food for millions of people living in the tropics and subtropics (Nwanekezi et al., 2010). Nutritionally, the tubers contain easily digestible starch and are known to contain substantial amounts of protein, fibre, vitamin C, thiamine, riboflavin, potassium, sodium, phosphorus, magnesium, calcium and niacin (FAO, 1990; Eka, 1990; Niba, 2003). The flour from cocoyam has been used in baking of products and it has been reported that cocoyam has fine granule-starch, which improves binding and reduces breakage of snack products (Huang, 2005). Anti nutritional factors such as alkaloid, saponin and calcium oxalate however have been reported to limit the use of cocoyam flour in food systems (Amanze, 2009). Fermentation processing of cocoyam is reported to produce safe and quality flour for utilization in food systems (Igbabul et al., 2014), hence the choice of fermented cocoyam flour.

African yam bean (*Sphenostylis stenocarpa*), an important legume in Africa with duo food product (seeds and tubers) and it is a lesser-known legume of the tropical and sub-tropical areas of the world which has attracted research in recent times (Azeke et al., 2005). African yam bean is rich in protein, carbohydrate, vitamins and minerals (Iwuoha & Eke, 1996). The protein of African yam bean is made up of over 32% essential amino acids, with lysine and leucine being predominant (Onyenekwe et al., 2000). Thus using it in conjunction with wheat for cookies production would provide the lysine lacking in wheat. This legume has also been reported to be of importance in the management of chronic diseases like diabetes, hypertension and cardiovascular diseases because of its high dietary fibre content (Enwere, 1998). Despite this, African yam bean is underutilized and rarely consumed in urban areas which are attributed to its elaborate preparation method. The use of African yam bean in composite flour for cookies production will make it readily available for consumption by all persons. Cocoyam and African yam bean are local staples in Nigeria; therefore their utilization in the production of cookies would; reduce importation of wheat and save foreign exchange, improve the nutritional value of cookies thereby fighting nutritional deficiencies, increase the economic power of local farmers and enhance food security in the developing countries. The aim of the research is therefore to produce cookies from composite flours of wheat, cocoyam and African yam bean and to determine their physicochemical, sensory properties.

2. Materials and Methods

2.1 Source of Raw Materials

The African yam bean and cocoyam were purchased from Akpan Andem market in Uyo, Akwa Ibom State. Wheat flour and other baking ingredients were purchased from the same source. All other chemicals were of analytical grade.

2.2 Preparation of Raw Materials

2.2.1 Preparation of African Yam Bean Flour

The African yam bean flour was prepared using the modified method described by Okoye et al. (2010) shown in Figure 1.The African yam bean seeds were removed from pods and cleaned to remove foreign materials like sticks, broken pods. The cleaned beans were soaked in 0.1% sodium metabisulphite ($NaHSO_3$) solution in the ratio of (1:5 w/v) for 12 hours. The soaked beans were manually dehulled, drained and boiled at 100 ºC for 20 min. The dehulled and boiled bean seeds were spread on the tray to dry in an air draught oven (Gallenkamp 300 plus series, England) at 60 ºC. The dried seeds were then milled using attrition mill (Globe p44, China) and sieved using a 100 µm mesh sieve. The flour was stored in a plastic container with lid in a refrigerator at 4 ºC prior to production of cookies.

2.2.2 Preparation of Cocoyam Flour

The cocoyam flour was produced using the method described by Igbabul et al. 2014 as shown in Figure 2. The cocoyam tubers were washed to remove soil particles and other debris and then peeled. The peeled tubers were washed using clean water, sliced into smaller pieces of 2.0 mm thickness using stainless steel kitchen knife. The slices were subjected to natural fermentation for 72 hours using deionized water in the ratio of 1:3 (w/v) at 30±2 ºC for 24hours using food grade high density polyethylene containers. The tubers were arranged randomly on a drying tray in a single layer to dry at 65 ºC in an air draught oven (Gallenkamp 300 plus series, England),until they were dry enough to break sharply between the hands. It was milled to obtain flour and sieved through a 100 µm mesh sieve. The flour was then stored in a plastic container with lid in a refrigerator at 4 ºC prior to production of cookies.

2.3 Sample Formulation

The wheat flour was sieved using 100 µm mesh sieve to obtain uniform particle size and mixed with the cocoyam and African yam bean flour in the proportions shown in Table 1. The proportions were based on preliminary work. Mixing was achieved with the use of Kenwood mixer at speed 6 for 3 min to obtain uniform blending.

2.4 Preparation of Cookies

The cookies were baked using the method of (Ceserani et al., 2008). The ratio of ingredients used for the preparation of cookies is shown in Table 2 and the flow chat for cookies production is shown in Figure 3. Fat and sugar were creamed to a smooth consistency; eggs and milk were added and mixed. The dry ingredients ; flour, baking powder and salt were mixed together and added to the cream followed by vanilla flavour and nutmeg and mixed to form dough**.** The dough was kneaded into uniform thickness and cut into different shapes. They were placed in greased pans and egg washed. The cookies were baked at 150 ºC for 20 min. The cookies were stored in a plastic container with lid in a refrigerator at 4 ºC prior to analysis.

2.5 Analyses

2.5.1 Determination of Proximate Composition of Cookies

The protein, fat, crude fibre, ash, moisture contents were determined using the method (AOAC, 2005), while the carbohydrate was determined by difference using the method of (Egounlety, 2001), by subtracting the total sum of the percentage of fat, moisture, ash, crude fibre, and protein content from hundred (100). The gross energy values were estimated by multiplying the values of crude protein, fat and carbohydrate by their respective physiological fuel value of 4, 9 and 4 respectively.

2.5.2 Determination of Physical Properties of Cookies

Cookies diameter (D) and thickness (T) were determined using vernier callipers, while cookies weight was determined using an electronic weighing balance (Mettler PE160 Balance, Switzerland). Spread ratio was expressed as diameter/thickness (D/T) (McWatters et al., 2003). The average values of 2 replicate determinations were reported.

2.5.3 Determination of Sensory Properties of Cookies

Twenty-four hours after preparation of the cookies, sensory evaluation was carried out. A total of 20 panelists who were familiar with the quality attributes of the cookies were recruited from staff and students of the Department of Food Science and Technology, University of Uyo, Uyo. Each panelist evaluated all the samples prepared for each treatment in one session. Criteria for selection of panelists was that panelists were regular consumers of cookies and not allergic to any cookies. Panelists were instructed to evaluate appearance, flavour, texture, crispness, and general acceptability of the cookies. A nine-point Hedonic scale was used with 1=dislike extremely, 5=neither like nor dislike, and 9=like extremely (Ihekoronye & Ngoddy, 1985). Samples were identified with three-digit code numbers and presented to panelists. The panelists were instructed to rinse their mouths with water after every sample. They were also asked to comment freely on samples on the questionnaires given to them.

2.6 Statistical Analysis

The data obtained from the work and sensory evaluation was subjected statistically to analysis of variance (ANOVA) and means were separated using Tukey's test. (Steele & Torrie, 1980). The least significance difference was used in determining significant differences between the means and separation of the means where significant differences existed at P, 0.05, using SPSS package version 16.0.

3. Result and Discussion

3.1 Proximate Composition of Cookies Produced From Wheat, Cocoyam and African Yam Bean Flour Blends

The proximate composition of cookies produced from wheat, cocoyam and African yam bean flour blends are presented in Table 3.There was significant increase ($P<0.05$) in the protein, fat, fibre , ash contents and energy values of the cookies. The values ranged from 10.44-14.73%, 3.01-6.73%, 1.63-2.43%, 2.44-3.64% and 356.21-375.25% respectively. The carbohydrate and moisture content decreased significantly ($P<0.05$) with increase in cocoyam and African yam bean flours. The carbohydrate values ranged from 63.94-71.84% while the values for moisture content vary from 8.54-10.68%. The increase in protein content could be attributed to the African yam bean which is reported to contain high percentage of protein (Enwere, 1998) and cocoyam flour which also contain high quantity of protein reported by (Ogunlakin et al., 2012). The fermentation processing of cocoyam flour too could have resulted in increased protein content. These protein content values are comparable with the values of 6.83-16.6% reported by (Chinma & Gernah , 2007) on cookies from composite flours of wheat, mango and soy beans. The significant increase in fat content could have contributed to the high energy values ranged from 356-375 kcal/100g observed in this work. These energy values are however less than the values of 503.48, 505.64 and 509.64 kcal/100g reported by (Noor et al., 2012) for mung bean, chick pea and wheat cookies respectively. The differences in these values could be explained on the differences in crops and their flours.

The decreased carbohydrate content of the cookies with addition of African yam bean and cocoyam flours would be useful to people that need low carbohydrate foods leading to enhanced health for over- weight and obese persons. The same trend was observed by (Chinma et al., 2012) with cookies made from unripe plantain and defatted sesame flour blends. The fibre contents of all the cookies were within the recommended range for diets of not more than 5g dietary fibre per 100g dry matter (FAO/WHO, 1994) and would enhance gastro intestinal tract and cardiovascular health. The ash content is an indication of the quantity of minerals in the product. The moisture contents of the cookies were generally low, this would prolong the shelf life of the cookies.

Table 1. Formulation of composite flour for cookies production

Samples	Wheat Flour (%)	Fermented cocoyam Flour (%)	African yam bean Flour (%)
A (CONTROL)	100	0	0
B	80	10	10
C	60	20	20
D	40	30	30
E	20	40	40

Table 2. Quantity of ingredients for cookies production

Ingredients	Percentage(%w/w)	Amount (g)
Vegetable fat	18.7	40
Sugar (granulated)	11.7	25
Egg (whole, fresh)	7	31
Milk (full fat)	0.5	7.8
Nutmeg	0.2	0.3
Vanilla flavour (liquid)	0.1	5.0 ml
Salt	0.5	1
Baking powder	14.6	1

Source: (Ceserani et al, 2008).

Table 3. Proximate composition of cookies produced from wheat, cocoyam and african yam bean flour blends

Parameters	A	B	C	D	E
Moisture%	10.68±0.01^{a}	9.87±0.01^{b}	9.74±0.03^{b}	9.02±0.00^{c}	8.54±0.04^{d}
Ash%	2.40±0.04^{d}	2.59±0.01^{c}	2.74±0.03^{c}	2.95±0.03^{b}	3.64±0.06^{a}
Crude fiber%	1.63±0.01^{e}	1.70±0.03^{d}	1.82±0.00^{c}	1.95±0.01^{b}	2.42±0.03^{a}
Protein%	10.44±0.01^{e}	10.45±0.01^{d}	10.45±0.01^{d}	12.50±0.00^{b}	14.73±0.00^{a}
Crude fat%	3.01±0.01^{d}	4.07±0.02^{c}	5.07±0.01^{b}	5.65±0.01^{b}	6.73±0.00^{a}
CHO%	71.84±0.14^{a}	71.32±0.01^{a}	70.14±0.03^{b}	67.93±0.04^{c}	63.94±0.01^{d}
Energy value (Kcal/100g)	356.21±0.01^{e}	363.71±0.00^{d}	368.15±0.02^{c}	372.57±0.01^{b}	375.25±0.01^{a}

*Values are means ± SD duplicate determinations

*Values with common superscript letters in each row are not significantly different ($p > 0.05$).

A = 100% wheat flour.

B = 80% wheat flour, 10% cocoyam flour, 10% African yam bean flour.

C = 60% wheat flour, 20% cocoyam flour, 20% African yam bean flour.

D = 40% wheat flour, 30% cocoyam flour, 30% African yam bean flour.

E = 20% wheat flour, 40% cocoyam flour, 40% African yam bean flour.

Table 4. Physical properties of cookies produced from wheat, cocoyam and african yam bean flour blends

Parameters	A	B	C	D	E
Weight (g)	18.01±0.00^{a}	18.45±0.00^{a}	19.15±0.01^{a}	19.67±0.00^{a}	20.15±0.03^{a}
Diameter (cm)	6.48±0.03^{a}	6.64±0.03^{a}	6.74±0.00^{a}	6.76±0.00^{a}	6.82±0.03^{a}
Thickness (cm)	0.55±0.00^{a}	0.53±0.01^{a}	0.49±0.01^{b}	0.47±0.03^{b}	0.45±0.01^{b}
Spread Ratio	11.78±0.03^{d}	12.53±0.03^{c}	13.76±0.01^{b}	14.38±0.01^{b}	15.16±0.04^{a}

*Values are means ± SD duplicate determinations.

*Values with common superscript letters in each row are not significantly different ($p > 0.05$).

A = 100% wheat flour.

B = 80% wheat flour, 10% cocoyam flour, 10% African yam bean flour.

C = 60% wheat flour, 20% cocoyam flour, 20% African yam bean flour.

D = 40% wheat flour, 30% cocoyam flour, 30% African yam bean flour.

E = 20% wheat flour, 40% cocoyam flour, 40% African yam bean flour.

Table 5. Sensory properties of cookies produced from wheat, cocoyam and african yam bean flour blends

Parameters	A	B	C	D	E
Appearance	7.65±0.01^{a}	7.60±0.01^{a}	7.550±0.00^{a}	6.85±0.01^{b}	6.55±0.03^{b}
Flavour	7.50±0.01^{a}	7.20±0.01^{a}	6.54±0.01^{b}	5.90±0.03^{c}	5.60±0.03^{c}
Texture	7.45±0.01^{a}	7.00±0.01^{b}	6.55±0.01^{c}	6.40±0.02^{c}	5.80±0.01^{d}
Crispness	7.15±0.01^{a}	6.75±0.03^{b}	6.70±0.02^{b}	6.65±0.01^{b}	6.40±0.03^{c}
General acceptability	7.50±0.01^{a}	7.43±0.01^{a}	7.40±0.03^{a}	6.90±0.01^{b}	6.55±0.03^{b}

*Values are means ± SD duplicate determinations.

*Values with common superscript letters in each row are not significantly different ($p > 0.05$).

A = 100% wheat flour.

B = 80% wheat flour, 10% cocoyam flour, 10% African yam bean flour.

C = 60% wheat flour, 20% cocoyam flour, 20% African yam bean flour.

D = 40% wheat flour, 30% cocoyam flour, 30% African yam bean flour.

E = 20% wheat flour, 40% cocoyam flour, 40% African yam bean flour.

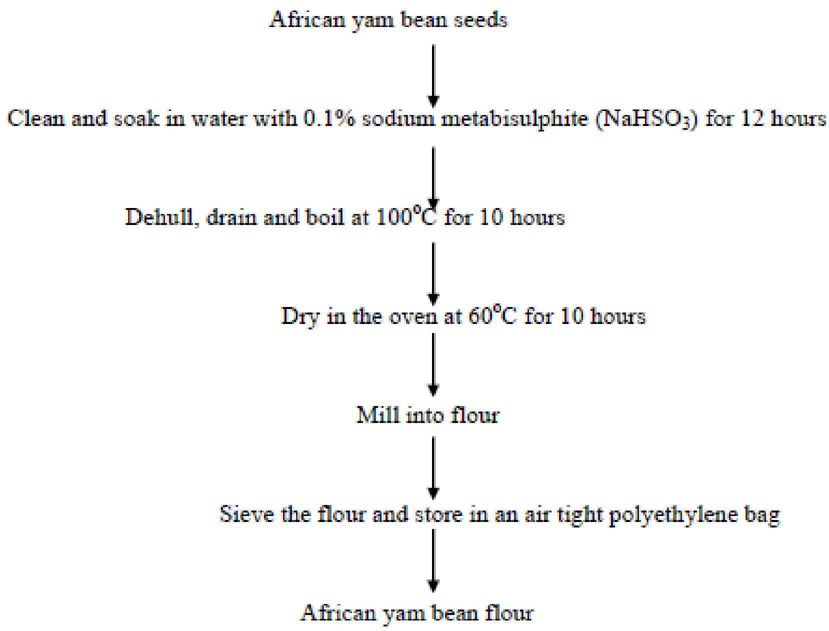

Figure 1. Flowchart for the production of African yam bean flour

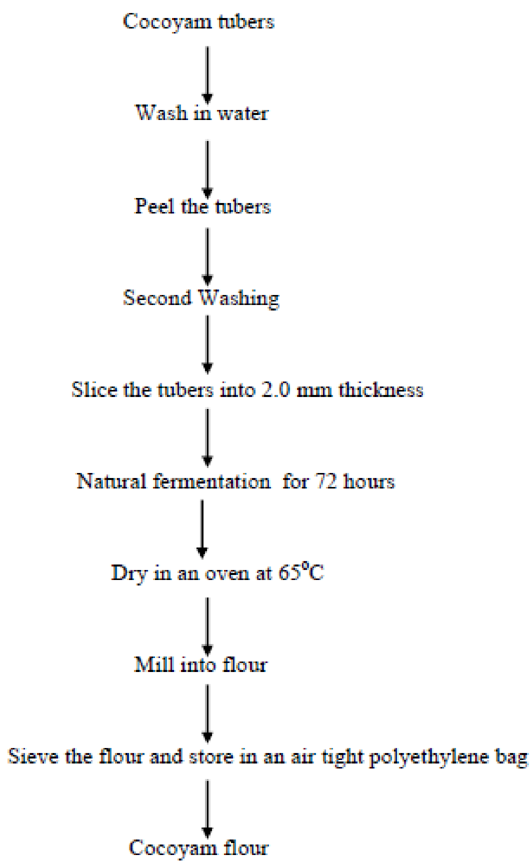

Figure 2. Flowchart for the production of cocoyam flour

Mix the fat and sugar

↓

Add egg and milk and mix

↓

Add the dry ingredients (flour, baking powder and salt) and vanilla flavour and mix to form dough

↓

Knead into uniform thickness and cut into different shapes

↓

Bake at 140-185^{o}C for 20 minutes.

↓

Store in an air tight polyethylene bag in a plastic container

Figure 3. Flowchart for the production of cookies

3.2 Physical Properties of Cookies Produced From Wheat, Cocoyam and African Yam Bean Flour Blends

The result of physical properties of cookies produced from wheat, cocoyam and African yam bean flour blends is presented in Table 4. The weight and diameter of the cookies increased with addition of cocoyam and African yam bean flours however the increment was not significantly different (P>0.05) from the control samples of 100% wheat flour. The lowest weight and diameter of 18.01 g and 6.48 cm were recorded for cookies from 100% wheat flour. This could be explained on the basis of increase in hydrophilic starch granules in cocoyam and African yam bean flours leading to moisture absorption and increase in diameter of the cookies. The increase in weight could be due to the higher bulk density of cocoyam and African yam flours. The thickness of the cookies from 100% wheat flour were significantly different (P<0.05) from the cookies made from composite flours of wheat, cocoyam and African yam bean and decreased with addition of cocoyam and African yam bean flours this could be due to increased protein content from the added flours and fermentation processing of cocoyam flour. The difference between the cookies from composite flours was not however significant (P>0.05). The spread ratio varied from 11.78-15.68 and increased significantly (P<0.05) with increase in cocoyam and African yam bean flours with cookies from 100% wheat recording the lowest value of 11.78 while the cookies from 20% wheat , 40% cocoyam and 40% African yam bean flours recorded the highest value of 15.16. The increase in the spread ratio could be attributed to the increased number of hydrophilic sites in the dough mixture leading to increased water absorption and swelling index. Various workers in contrast have reported decreased spread ratio with usage of composite flours for cookie production (Sathe et al., 1981) A decrease in spread ratio was reported by many workers including (Singh et al., 2008) and (Laura et al., 2012) who worked on the blends of germinated pigeon pea, fermented sorghum and cocoyam flours.

3.3 Sensory Scores of Cookies Produced From Wheat, Cocoyam and African Yam Bean Flour Blends

The sensory scores of cookies prepared from 100% wheat flour and composite flours of wheat, cocoyam and African yam bean are presented in Table 5. The sensory scores for appearance vary from 7.65-6.55 with the cookies from 100% wheat flour having the highest score of 7.65 and the values decreased with the addition of composite, however significant difference (P<0.05) was only observed in samples D and E. The scores for flavour, texture, taste and general acceptability ranged from 7.5-5.6, 7.45-5.8, 7.15-6.4 and 7.5-7.1 respectively. These values decreased with addition of the flour blends but significant differences (P<0.05) were observed mostly in samples C, D, and E. This observation could be attributed to the higher percentage of gluten in 100% wheat flour that support dough development and subsequent cookie quality. The highest sensory scores obtained in all the parameters studied were from cookies prepared from 100% wheat flour. As can be observed from the general acceptability scores, there was no significant difference (P<0.05) between the cookies prepared from 100% wheat flour and composite flours. All the cookies made from both the 100% wheat and the composite flours were generally well accepted and all the scores were higher than five which is the minimum acceptable value on a nine point hedonic scale.

4. Conclusion

This work has demonstrated that acceptable cookies with increased protein, ash and crude fibre could be successfully produced using composite flours of wheat, cocoyam and African yam bean. The cookies made with the flour blends of wheat, cocoyam and African yam bean competed favourably with the cookies produced from 100% wheat flour. Therefore its use for the production of cookies will go a long way in reducing dependence on wheat flour for cookies production. It would reduce foreign exchange used in importing wheat and improve the nutritional value of cookies. The use of these crops in cookies production would also increase its production, consumption, utilization, the economic power of local farmers and alleviate protein energy malnutrition in developing countries.

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