Physico-Chemical and Functional Properties of Cookies Produced from Sweet Potato- Maize Flour Blends

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Abstract
This study was carried out to observe the physico-chemical and functional properties of cookies produced from sweet potato- maize flour blends. Substitution of maize flour with sweet potato flour reduced the protein from 6.8-4.4%, moisture from 5.3-5.0%, crude fibre 3.4-2.5% and fat 9.8-8.5% of the composite flours and the cookies. The ash and sugar contents were increased from 4.3-5.8% for ash and 2.1-3.9% for sugar with increase in sweet potato flour substitution. The calorific value of the cookies decreased from 457-397cal/100g as the percentage of sweet potato flour increased in the maize flour cookies. The water binding capacity increased from 0.9-1.7 and the starch swelling power decreased from 10.1-5.3 at 95^{0}C with increase in sweet potato flour content in the flour mixture. The bulk density and dispensability decreased from 4.6-3.3g/ml and 48.3-47.1ml/g respectively in the flour as the content of the sweet potato in the composition increased.
Keywords: cookies, sweet potato, maize, flour, quality.

1.0 INTRODUCTION

Cookies are small, flat dessert treats, commonly formed into a circular shape. They constitute an important component of the diet (Mishra *et al.,* 2012). Research into the use of tropical crops has shown that biscuits and other pastries such as meat-pie, cookies, cake etc could be made from flours of locally available crops such as sweet potato, cassava, corn, rice, millet, sorghum etc (IITA, 1985). Cookies are convenient snacks product dried to a very low moisture content taken among young people and adult to provide energy (Okaka, 1997). This food is made from unleavened dough (Fayemi, 1981). It is produced from a mixture of flour and water which may contain fat, sugar and other ingredients mixed together into dough which is rested for a period and passed between rollers to make a sheet (Mohamed, 2000).

Baking industry in Nigeria is flourishing day by day. A wide variety of baked goods is available in the market to fulfill consumer demand for nutritional requirements. Besides other baked products, cookies are one of the most popular bakery products, widely consumed due to its ready-to-eat nature, good nutritional quality, low cost and longer shelf life that has also been enriched with dietary fibre (Adeleke, and Odedeji. 2010).

Maize (*Zea mays* L., Poaceae) is the most important cereal in the world after wheat and rice with regard to cultivation areas and total production (Purseglove, 1992; Osagie and Eka, 1998). In Nigeria, maize is known and called by different vernacular names depending on locality like ‘agbado’, ‘igbado’ or ‘yangan’ (Yoruba); ‘masara’ or ‘dawar masara’ (Hausa); ‘ogbado’ or ‘oka’ (Ibo); ‘apaapa’ (Ibira); ‘oka’ (Bini and Isha); ‘ibokpot’ or ‘ibokpot union’ (Efik) and ‘igumapa’ (Yala) (Abdulrahaman and Kolawole, 2006). Maize is prepared and consumed in a multitude of ways which vary from region to region or from one ethnic group to the other. For instance, maize grains are prepared by boiling or roasting as paste (‘eko’), ‘abado’, and ‘elekute’ in Nigeria and ‘kenke’ in Ghana, or as popcorn which is eaten all over West Africa. Traditional methods of preparations and uses of maize are restricted to definite localities or ethnic groups (Abdulrahaman and Kolawole, 2006).

Sweet potato (*Ipomoea batatas* L.) is an important alternative source of carbohydrates and attains fourth place after rice, corn and cassava. Presently, this crop is considered as having low economic value but it has significant social importance. It is most versatile for snack food, but it is used as staple food or as a rice substitute in many countries (Zuraida, 2003). Sweet potato has a large potential to be used as food in developing nations with limited resources because of short maturity time, ability to grow under diverse climatic conditions and on less fertile soil (Zuraida, 2003). Blending of sweet potato flour with wheat flour can be used for production of bakery goods with improved functional properties and reduced retro-graduation, staling rate and production time (Adeleke, and Odedeji. 2010) and also helps in making a good baking product with increased economic value.

This study was conducted to find out the effect of sweet potato flour substitution on the physico-chemical and functional properties of cookies produced from sweet potato- maize flour blends.

2.0 METHODOLOGY

2.1 Materials

The yellow cultivar of sweet potato and white cultivar of maize used for this experiment were purchased from

Kuto market in Abeokuta, Ogun State, South Western part of Nigeria. Other ingredients, e.g. fat (Breadeen brand), sugar, salt, baking powder (sodium acid pyrophosphate and sodium bicarbonate) and eggs were also purchased at Kuto market in Abeokuta, Ogun State, South Western part of Nigeria.

2.2. METHODS

2.2.1 Preparation of Sweet Potato Flour

Sweet potato flour was prepared by the method reported by Kabira (1991). Sweet potato tubers were sorted, washed in water to remove dirts and adhered soil, peeled and sliced to 1-3mm thick slices. The slices were dipped in a 0.2N Potassium meta-bisulphite solution for 10 minutes and drained. The sulphited sweet potato slices were blanched in hot water to inactivate the enzymes in the tubers at 80^0 C for 5 minutes. After blanching the sweet potato slices were drained and dried at 60^0C for 24hours in a forced air oven (cabinet dryer). The dried slices were grounded in a hammer mill to pass through 0.3mm opening. The flour was packaged in cellophane bag until used (Fig. 1).

2.2.2 Preparation of Maize Flour

The maize flour was prepared by the method reported by Asiedu (1989) and De Ruiter (1978). Maize grains were sorted, conditioned by spray 35cl of water into the grains and allowed to stay for 15minutes. This is done for easy dehulling and degerming. The degermed and dehulled maize was milled in a disc attrition mill and allowed to pass through 300mm opening. The floor was packaged in cellophane bag until used (Fig. 2)

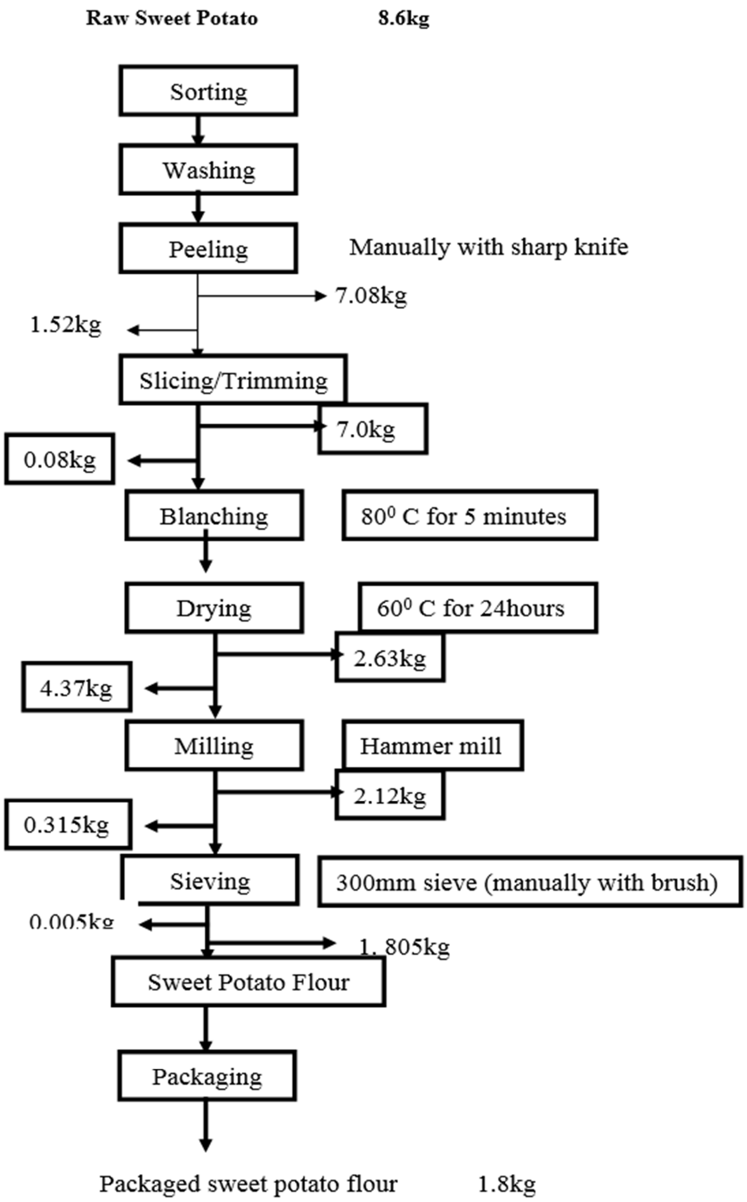

Fig. 1: Flow and mass balance diagram for sweet potato flour processing.

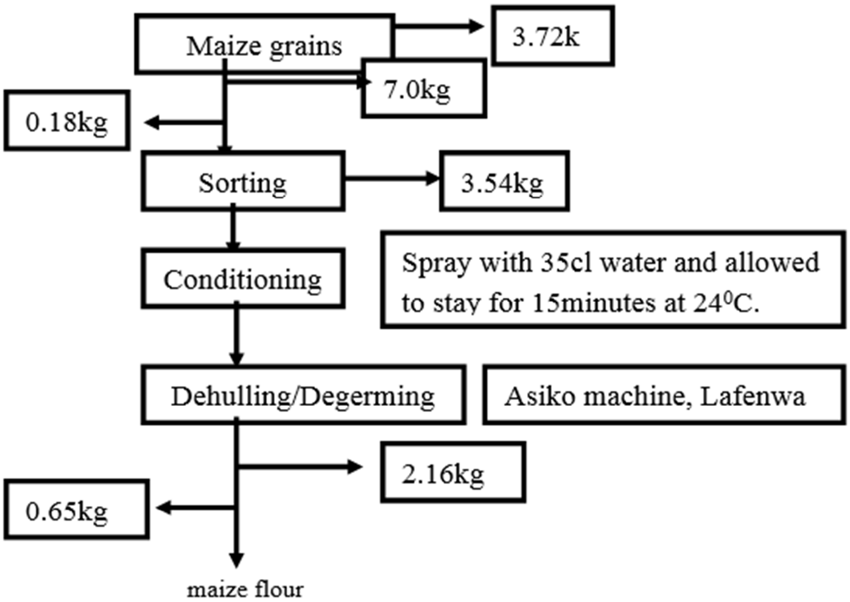

Fig. 2: Flow and mass balance diagram for maize flour processing.

2.2.3 Preparation of Cookies

Cookies were prepared by the method reported by Okaka and Isieh (1990). Flour (200g) from each sample of different flour blends was used for the experiment. Sugar (80g) was creamed with margarine (100g) until light and fluffy constituency was obtained using kenwood chef with initial minimum speed and the speed increased step wise until the mark of 6 on the chef indicator was attained. Whole egg (60g) was added, then flour (200g), powdered milk (20g), baking powder (0.1g), and salt (1g) were added and mixed until a stiff paste (batter) was obtained. The batter was rolled on a floured board using rolling pin to a thickness of 0.2 – 0.3cm. The rolled batter was cut into shapes and arranged on a greased tray and baked at 150^0C for 20minutes. The cookies were brought out, cooked and packaged in cellophane bag until used (Fig.3)

2.3.1 CHEMICAL ANALYSIS OF SAMPLES

2.3.1.1 Moisture content of the flour samples

Moisture content of sweet potato tubers, maize grains, sweet potato flour, maize flour, their blends and cookies samples were determined by oven method described in AOAC (1990) and Joslyn (1970).

2.3.1.2 Protein content of the flour samples

Crude protein was determined by the Kjeldahl nitrogen method where:

% Crude protein = % total nitrogen X 6.25 described by AOAC (1990).

2.3.1.3 Fat content of the flour samples

Fat content was determined by the soxhlet extraction method described in AOAC (1990) and Josyln (1970). A 2g sample was extracted with 240ml of petroleum either in a soxhlet extraction apparatus for 8hours. The either was distilled off and the flask dried.

$$\% \text{ Fat} = \frac{W_3 - W_2 \text{ X } 100}{W_1}$$

Where W_3 is the weight of the flash with the extracted oil

W_2 is the weight of the empty flash

W_1 is the weight of the sample.

Ash was determined by AOAC (1990) method. A 2g sample was ignited at 600^0C in a muffle furnace for 6hours. The residue was cooled in a desicator and weighed.

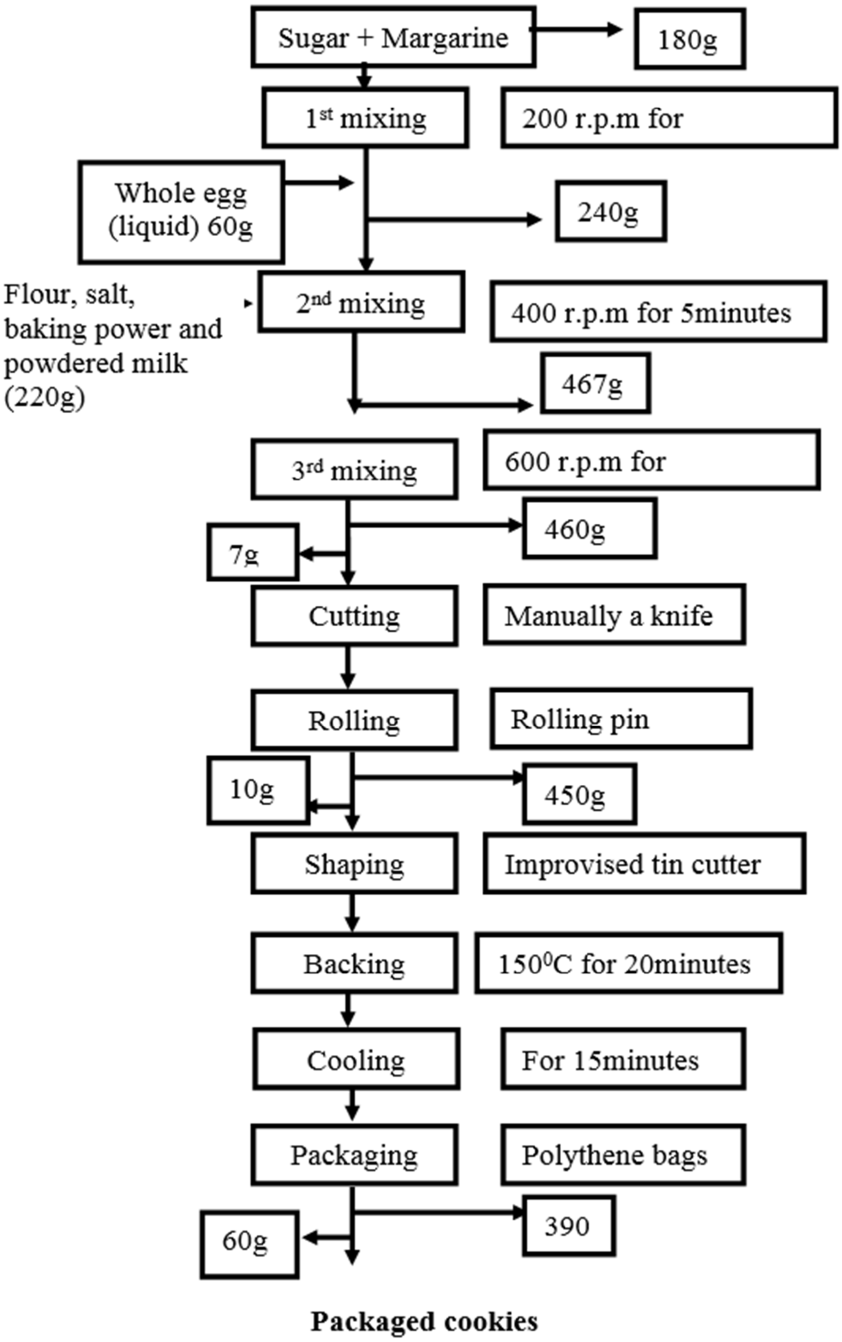

Fig. 3: Flow and mass balance diagram of cookies processing

2.3.1.4 Crude fibre content of the flour samples

Crude fibre was determined by AOAC (1990) method. A 1g sample was weighed into 600ml of erlenmeyer flask, 100ml of Trichloroacetic acid (TCA) digestion reagent was added. The solution was brought into boil and reflux for exactly 40minutes at 50 - 60^{0}C counting from the time boiling started. The flask was removed from the heater, cooled a little bit and was filter through a 15.0cm, No. 4 Whatman filter paper of 1.0g the residue was washed six times with hot water and once with methylated spirit. Residue was removed by spatula from the opened out filter paper and the fibre was transferred into a porcelain dish and was dried overnight at 500^{0}C. The sample was transferred to a desicator and weighed when cool; it was ashed in a muffle furnace at 600^{0}C for 6hours. This was cooked again and reweighed.

$$\% \text{ Crude fibre } = \frac{weight\ of\ digit\ after\ drying - Weight\ after\ ashing}{Sample\ Weight}\ X\ 100$$

2.3.2 PHYSICO-CHEMICAL ANALYSIS OF SAMPLES

2.3.2.1 Bulk density of the flour samples

The bulk density of the floor samples was determined by Wang and Kinsella method (1976). Sweet potato flour, maize flour, and their blends (10g) each was weighed into 50ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top 10times from a height of about 5cm. the volume of each sample was recorded.

$$\text{Bulk density (g/ml)} = \frac{Weight\ of\ Sample}{Volume\ of\ Sample\ after\ tapping}$$

2.3.2.2 Water binding capacity of flour samples

Water binding capacity was determined by method described by Sosulki (1962), Sweet potato flour, maize flour and their blends (4kg) was weighed into 25ml centrifuge tube and 15ml of distilled water was added into it. This was agitated intermittently for 1hour with a glass rod. This was centrifuged at 4,000 r.p.m for 20minutes. The clear supernatant was decanted and discarded. The adhering drops of water was removed and the tube was reweighed. The water binding capacity was expressed as the weight of water bound by 100g dry flour.

2.3.2.3 Dispersability of Samples

The method described by Kurkarni *et al* (1991) was used. 10g of flour of sweet potato, maize and their blends was placed in a 100ml measuring cylinder. Distilled water was added to it to reach a volume of 100ml. this was stirred rigorously and allowed to settle for three hours. The volume of the settled particles was recorded and subtracted from 100. The difference was recorded as percentage dispersability.

2.3.2.4 Swelling power for Samples

The swelling power of starches of the sweet potato flour, maize flour and their blends was determined by the method described by Leach *et al* (1959).

2.3.2.5 Starch Content Determination

Starch was described by the method descended by Hassid and Neufield (1964). Each flour sample was refluxed with boiling ethanol at 80^0C for 6hours in a soxhlet extractor. The ethanol insoluble residue was refluxed with 10% HCl for 4hours in a soxhlet extractor. The resulting hydrolysates was neutralized with 105 NaOH and quantitatively estimated by the anthrone-sulphuric acid method (Caroll *et al,* 1956). The value of glucose was multiplied by 0.9 to obtain the starch value (Hassid and Neufield, 1964).

2.3.2.6 Sugar Content Determination

This was determined by refractometry method with the ABBE 60 Refractometer (Bellingham _ Starvley Limited, Kent, England).

2.3.3 Sieve Analysis of the Sample

Particle size distribution of the floor samples was determined by the method reported by Akingbala (1982). This was done by placing flour (50g) of each sample into a three sets of sieves apertures 300, 210 and 150mm which was done manually with fine brush to move the particles over each screen to prevent matting of the screen surface for 15minutes before the quantity of the flour collected on each sieve was determined and expressed as percentage of the total weight.

2.3.4 Cookie Flow and Break Strength

Cookie flour was determined by method described by Okaka and Isieh (1990). The cookie flour which is the increase in volume of unbaked stamped out batter after baking was determined by measuring the diameter with a ruler and the circumference with a thread and the thickness of the cut-out cookie dough and baked cookies. For the cookie break strength, cookie of known thickness (0.41 – 0.58cm) was placed centrally between two parallel metal bars 5cm apart. A load (1g) was placed on the cookie and weights added on the bar in increments of 10g and 20g respectively until the cookie shaped. The least weight that caused the breaking of the cookies was regarded as break strength of the cookies.

2.3.5 Calorific Value Determination

Calorific values of the cookie samples were determined by using Gallenkamp Ballistic Bomb Calorimeter (Coded CBB 330). 1g of each sample of the cookies was ignited electricity and burnt in excess oxygen in the bomb. The maximum temperature rise of the bomb was measured with the thermocouple and galvanometer system.

2.4 STATISTICAL ANALYSIS

The results of proximate composition, physico-chemical analysis and sensory evaluation were analyzed using SPSS 16.0. Means and standard deviations were determined using descriptive statistics. Comparison between samples were determined using analysis of variance (ANOVA) and multiple range tests. Statistical significance was defined at $P \leq 0.05$.

3.0 RESULTS AND DISCUSSION

3.1 The proximate composition of maize grain and sweet potato tubers

The proximate composition of the maize grains and sweet potato tubers used for the production of flour are presented in table 1. The moisture, crude protein, crude fibre, ash and fat contents of the maize grains are consistent with the range of those reported in the literature (Miracle, 1966; Oyenuga, 1968, Purseglove, 1985, David and Dickerson, 1991). The moisture, crude protein, crude fibre, ash and fat contents of sweet potato tubers are also consistent with the range of those components reported in the literature (FAO, 1968; Onwueme, 1978, Oboh, 1986; Oboh *et al,* 1989, Woolfe, 1989 and David and Dickerson, 1991).

The carbohydrate contents of the maize grains and sweet potato tubers were obtained by difference. The values of 69.7% and 30.5% agreed with the values if 70.1 – 83.9% and 32.2% reported by Oyenuga (1968), and David and Dickerson (1991) for maize grains and sweet potato tubers respectively.

Table 1: The proximate chemical composition of maize grains, sweet potato tuber, flour and their blends.

Samples	Moisture %	Ash %	Crude fibre %	Fat %	Crude Protein %	Carbohydrate %	Starch %	Sugar %
Wheat flour (control)	8.5C	1.9b	1.46	2.3b	8.4b	N.D	78.1a	1.9f
Maize grains	10.4bc	2.9a	2.0a	4.1a	9.9a	69.7a	N.D	N.D
Sweet potato tubers	61.4a	1.9b	1.8ab	0.8d	1.6c	32.5b	N.D	N.D
Maize flour (100%)	9.26	1.3e	1.3b	1.4c	8.0b	N.D	69.16	2.1e
9:10	8.8bc	1.4e	1.1bc	1.2c	7.4bc	N.D	65.4c	2.6d
80:20	8.8bc	1.6c	1.2bc	1.2c	7.3bc	N.D	64.4c	2.6d
70:30	8.6c	1.6c	1.2bc	1.1c	7.3bc	N.D	6.17c	2.8c
60:40	8.6c	1.6c	1.2bc	1.4c	6.8c	N.D	57.6d	3. 0b
50:50	8.5c	1.7bc	1.1.bc	0.6d	6.6c	N.D	52.0e	3.1b
0:100	8.3cd	1.9b	1.0c	0.5d	5.9d	N.D	38.6f	3.9a

(1) N.D = Not Determined
(2) All data are means of 3 replicates expressed on dry weight basis
(3) Means with the same subscripts are not significantly difference at P≤0.05.

3.2 The proximate chemical composition of maize flour, sweet potato flour, and their blends.

The proximate composition of maize flour, sweet potato flour, and their blends are presented in table 1. The moisture and protein contents of maize flour were 9.2% and 8.0% respectively. These values agreed with 9.6 – 13.5% and 9.6 – 10.7% reported by Oyenuga (1968). The moisture and protein contents of sweet potato flour were 8.3% and 5.8% which are within the values of 1.4-9.4% and 5.0% reported by Onwueme, (1978); Oboh, (1986) and Oboh *et al,* (1989). The fat and crude fibre contents of the maize flour were 1.4% and 1.3% respectively. The crude fibre value agreed with 1.3% reported by Oyenuga (1968) but the fat content did not agree with 4.0 – 4.1% reported by Oyenuga (1968). This may be due to the degerming of the maize grain before milling. The fat and crude fibre contents of sweet potato flour, 0.5% and 1.0% agreed with 0.4 – 3.0% and 1.0% reported by FAO (1968) and Oboh (1986) respectively. The ash content of maize flour and sweet potato flour were 1.3% and 1.9% which are within the range of 1.3% and 1.2% reported by Oyenuga (1968), and Horton (1988).

The starch contents of the maize flour and sweet potato flour were 69.1% and 38.6% respectively. These values agreed with 77% and 30.8 – 41.8% reported by Pulseglove, (1985) and Oboh 91986). The sugar contents use 1.2% and 3.9% for maize flour and sweet potato flour respectively. These values agreed with 2.0% and 3.7 – 10.4% reported by Purseglove, (1985) and Oboh, (1986).

The moisture, ash, crude fibre, fat, protein, starch and sugar contents of maize flour, flour substituted with 10%, 20%, 30%, 40%, 50% and 100% sweet potato flour were significantly different (P≤0.05). The moisture, crude fibre, protein and starch contents of the mixture decreased as the percentage substitution of sweet potato flour increased. While the ash, fat and sugar contents increased as the sweet potato flour substitution increased.

3.3 Physico-Chemical Properties of the Flour Samples

The physic-chemical properties of the flour samples are presented in table 2. The bulk density of wheat flour (control) was 5.3g/ml. the bulk density of maize flour decreased with increasing substitution of sweet potato flour. The maize flour exhibited highest bulk density 4.6g/ml and sweet potato flour the least 3.3g/ml, while the bulk densities of the blends decreased as sweet potato flour substitution increased.

The water binding capacity of the wheat flour (control) 0.8ml/g was higher that 0.62ml/g reported by Adeyemi and Idowu (1990) and it may be due to different methods applied for the water binding capacity. The water binding capacity of 100% maize flour was 0.9ml/g. The water binding capacities of the maize flour increased as the level sweet potato flour substitution increased. The dispersability of the flour to 17.1% for 100% sweet potato flour. Greater dispersability indicates greater reconstitution ability of the flour.

Wheat flour has highest swelling power followed by the maize flour and the least was sweet potato flour. Substitution of maize flour with sweet potato flour reduces the swelling power of the flour. Generally, tuber starches have greater swelling power than cereal starches (Schoch, 1964). However, in sweet potato flour, the sugar content may have depressed the swelling of these starches as well as starch granules of the maize – sweet potato flour blends.

Table 2: Physico-chemical properties of the flour samples

Ratio of maize flour: Sweet potato flour	**Bulk density**	**Dispersability**	**Water binding capacity**	**Swelling power at 95^{0}C**
Wheat flour (control)	5.3a	47.8a	0.8d	11.0c
100:0	4.6b	48.3a	0.9cd	10.1a
90:10	4.4b	40.3b	1.0cd	9.1bc
80:20	4.1c	36.1c	1.2bc	3.8c
70:30	4.1c	30.9d	1.4ab	8.5cd
60:40	3.7d	27.7e	1.5ab	7.0d
50:50	3.5e	25.9f	1.6a	5.9e
0:100	3.3e	47.1g	1.7a	5.3e

(1) All data are means of 3 replicates
(2) Means with the same subscripts are not significantly different at P≤0.05.

3.4 Particle size distribution of maize flour and sweet potato flour.

The particle size distribution of maize flour and sweet potato flour are presented in table 3. Sweet potato flour had a higher consent of small sized flour particles (≤0.15mm) of 68.1%. Other particles sizes were (≤0.21mm) 19.8% and (≤0.15mm) 48.5%.

Table 3: Particle size distribution of maize flour and sweet potato flour.

	Particle size distribution		
Samples	≤0.3mm (%)	≤0.21mm(%)	≤0.15mm (%)
Maize flour	22.8	28.7	48.3
Sweet potato flour	12.1	19.8	68.1

All data are means of 3 replicates.

3.5 Effect of Sweet potato flour substitution on the proximate composition of maize flour cookies.

The effect of sweet potato flour substitution on the proximate composition of maize flour cookies are presented in table 4. The wheat flour cookies had the highest values for all the components analyzed except for protein and sugar contents. The moisture, crude fibre, fat and protein contents of the cookies from different flour blends decreased as the percentage of sweet potato flour in the blends increased. The ash and sugar contents increased from 4.3 to 5.8% and 6.0 to 9.8% respectively as the percentage of sweet potato flour in the blends increased.

Table 4: The proximate composition of cookies from different flour substitution

Ratio of maize flour: Sweet potato flour	Moisture %	Ash %	Crude fibre %	Fat %	Protein %	Sugar %
Wheat flour (control)	6.1a	4.7c	3.4c	9.8a	6.4a	4.8f
Maize flour 100:0	5.3b	4.3d	3.0b	9.9a	5.4b	6.0e
90:10	5.2bc	4.6c	2.9bc	9.3b	5.4b	6.4de
80:20	5.1c	5.0c	2.8cd	9.2b	5.3b	6.8cd
70:30	5.2bc	5.0b	2.8cd	9.0c	4.8bc	7.1bc
60:40	5.1c	5.1b	2.7e	8.9c	4.9bc	7.4bc
50:50	5.0cd	5.1b	2.6ef	8.7d	4.7bc	7.7b
0:100	5.0cd	5.8a	2.5f	8.5e	4.4c	9.8a

(1) All data are means of 3 replicated expressed on dry weighed.
(2) Means with the same subscripts are not significantly different at P≤0.05.

3.6 Cookie flow and break strength properties

Data of cookie flow or increased in volume of cookie dough after baking and the break strength of the cookie samples are presented in table 5. The cookies from wheat flour had the highest increase in volume of 69.9%. Substitution of maize flour with sweet potato flour reduced the flow. Addo *et al* (1987), and Okaka and Isieh (1990) reported similarly findings cookies from wheat flour also had the highest break strength of 3.7kg. Substitution of maize flour with sweet potato flour increased the break strength of maize flour cookies possibly due to the binding property of sugar.

Table 5: Cookie flow and break strength properties

Ratio of maize flour: Sweet potato flour	Cookie flow %	Cookie break strength (kg)
Wheat flour (control)	69.9a	3.7a
100:0	59.4b	1.4f
90:10	55.9c	1.4f
80:20	52.0d	1.6ef
70:30	48.7e	1.8de
60:40	46.2f	2.0d
50:50	41.7g	2.3c
0:100	36.4h	2.7b

(1) All data are means of 3 replicates
(2) Means with the same subscripts are not significantly different at $P \leq 0.05$.

3.7 Calorific value of sweet potato flour substituted maize flour cookies

The calorific values of samples from sweet potato flour substituted maize flour cookies are presented in table 6. Cookies made from wheat flour (control) had the highest energy (491cal/100g). This value agreed with the value of 493 cal/100g reported by Mc- Cance and Widdowson (1991) for digestive biscuits. The calorific value of maize flour cookies decreased with increasing concentration of sweet potato flour substitution. The expected increase in calorific value due to greater concentration of sugar in cookies with increase in sweet potato content is offset by the lower concentration of fat in these samples (Table 3). The greater energy of the wheat flour cookies over that of 100% maize flour cookies which had grater oil and sugar contents (Table 3) was due to the greater starch content of the wheat flour (Table 1).

The calorific values of the cookies from maize flour and sweet potato flour substituted maize flour showed that they are comparable with similar products from wheat, barley and sorghum (McCance and Widdowson, 1991). The high calorific values of sweet potato flour substituted maize flour cookies will increase the calories intake of consumers especially children. This reduces the shortage of calories among the most vulnerable group (children) in Nigeria.

Table 6: Calorific values of sweet potato flour substituted maize flour cookies.

Ratio of Marie Flour: Sweet Potato Flour	Energy (Cal/100g)
Wheat Flour (control)	491a
100:0	457b
90:10	443bc
80:20	445bc
70:30	429c
60:40	421c
50:50	413cd
0:100	397d

(1) All data are means of 3 replicates
(2) Means with the same subscripts are not significantly different ($P < 0.05$)

4.0 CONCLUSION

Substitution of maize flour with sweet potato flour reduced the protein, moisture, crude fibre, starch and fat contents of the flours and the cookies. The ash and sugar contents were increased with increase in sweet potato flour substitution. The water binding capacity increased and the swelling power decreased with increase in sweet potato flour content in the flour mixture. The bulk density and dispensability decreased as the contents of sweet potato flour in the composition increased. The calorific value of the cookies decreases as the percentage of sweet potato flour increases in the maize flour.

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