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PHYSICAL, CHEMICAL AND SENSORY PROPERTIES OF COOKIES PRODUCED FROM SWEET POTATO AND MANGO MESOCARP FLOURS

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ABSTRACT

This study was a result of the need for utilization of local raw materials for food production and diversification as well as an attempt to reduce the rising cost of wheat imports. The objective of this study was to investigate the physical, chemical and sensory properties of cookies produced from sweet potato and mango mesocarp composite flours. Sweet potato tubers and partially ripe mango fruits were processed into flours. Cookies were prepared from blends of 90:10, 80:20, 70:30 and 60:40 sweet potato flour (SPF) to mango mesocarp flour (MMF), with cookies prepared from 100% sweet potato flour (SPF) and 100% wheat flour (WF) serving as control and standard respectively. Thereafter, all the cookie samples were subjected to chemical, physical and sensory analyses using standard methods. The moisture, fat, fibre, ash, energy values as well as beta carotene contents increased significantly ($p < 0.05$) as the level of substitution increased. The standard recorded the highest protein value with the control having the least value. However, the control had highest value in terms of carbohydrate. The crude protein increased significantly ($p < 0.05$) between the blends with increasing levels of mango mesocarp flour. Conversely, the carbohydrates content decreased as substitution levels increased. The diameter and spread ratio of the cookies decreased with increased substitution levels while the thickness increased. Cookies prepared from whole sweet potato flour were rated higher in terms of colour (8.1), crispiness (8.8), flavour (7.9), texture (7.2), taste (7.1) and overall acceptability (8.5) followed by cookies from whole wheat flour. Preference for the cookies decreased significantly ($p<0.05$) as the percentage of mango mesocarp flour (MMF) increased. Cookies from 60% SPF: 40% MMF had the least acceptability, though they had the highest β – carotene content. Generally, cookies produced from 100% SPF and the blends had good nutritional value except for protein which decreased with increasing levels of substitution with MMF.

Key words: Cookies, sweet potato, mango mesocarp, physical, Chemical, Sensory, Beta carotene

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INTRODUCTION

Cookies, which represent the largest category of snack foods in most parts of the world [1] are a form of confectionery product dried to a low moisture content and widely consumed by individuals in all age groups [2]. The projected global market for cookies in 2016 is reported to be around $1,825.00 billion dollars in 2016 [3]. In Nigeria, like many other developing countries, the increasing phenomenon of urbanization, coupled with the growing number of working mothers, have contributed greatly to the popularity and increased consumption of snack foods such as cookies and biscuits.

However, wheat flour, which is the flour of choice for producing cookies and other baked food products, is either unavailable or uneconomical in many regions of the world. Therefore, to produce baked goods, regions with limited supplies of wheat flour must rely on imports or exclude wheat products from the diet [4]. The production of cereal-based baked products like cookies at an affordable cost therefore requires the development of an adequate substitute for wheat [5]. The substitute should be one that is readily available, cheap and able to replace wheat flour in terms of functionality.

Flours produced from only either cereals, legumes or tubers will have a nutritional value inferior to those produced from a combination of cereals, legumes or tubers. For instance, composite flours produced from cereals and legumes have the advantage of improving the overall nutrition [6] while composite flours produced from legumes and tubers will have high protein content and high calorific value [7]. In selecting the components to be used in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potentials [8].

Sweet potato *(Ipomoea batatas* Lam) is the seventh most important food crop in the world [9]. It has a high potential to be used as a food in developing nations with limited resources because of its short maturity time and ability to grow under diverse climatic conditions and on less fertile soil. Options for sweet potato products are numerous and based on recent diagnostic assessments carried out in developing countries; dried chips, starch, and flour were identified as among the most promising [9]. Sweet potato flour can serve as a source of energy and nutrients (carbohydrates, beta- carotene), minerals (Ca, P, Fe and K) and can add natural sweetness, colour, flavour and dietary fibre to processed food products [10].

Mango (*Mangifera indica L.)* is cultivated in many tropical regions and distributed widely in the world, and is one of the most extensively exploited fruits for food, juice, flavour, fragrance and colour, making it a common ingredient in new functional foods often called "super fruits" [11]. Mango fruit is a good source of provitamin A (with reported value of 2,400µg/100g) and vitamin C [12].

Work has also been done on production of cookies from composite flours of wheat and many other local crops, including sweet potato, with varying degrees of success [9]. However, there is little record of mango mesocarp flour being used in cookie type products. Given the above nutritional information and the quest for sourcing of local raw materials for nutritional benefits and food diversification, this study was designed to investigate the possibility of producing acceptable cookies from composite flours of sweet potato and mango mesocarp, with improved nutritional value.

MATERIALS AND METHODS

Source of raw materials

Sweet potato *(Ipomoea batatas* Lam) tubers (Pale yellow-fleshed variety), Ripe mango (*Mangifera indica L.)* fruits (local variety known as Opioro), granulated sugar, fat, salt, baking powder and eggs were purchased from Wurukum Market, Makurdi, Benue State.

Preparation of sweet potato flour

Sweet potato tubers were washed, trimmed, peeled and manually sliced to an average thickness of 5.32mm. The slices were dried in an oven (Model: Binder ED53, Germany) at 70°C for 12h to a moisture content about 10%. The dried chips were milled into flour using disc attrition mill (Model: AII Asiko, Nigeria) and sieved to obtain sweet potato flour (SPF) of 0.5mm particle size.

Preparation of mango mesocarp flour

The method of Sengev *et al.* [13] was adopted with slight modification. Five kilograms of ripe mango fruits were sorted, washed, peeled and the mesocarp was manually sliced to an average thickness of 2.0mm. The slices were spread on a tray covered with aluminum foil and oven-dried at 70 ± 1°C for 24h to a moisture content of about 10%. The slices were milled using a disc attrition mill (Model: AII Asiko, Nigeria) and sieved through a 0.5mm sieve to obtain mango mesocarp flour (MMF).

Formulation of composite flours for cookie production

Blends with different proportions of sweet potato flour (SPF) and mango mesocarp flour (MMF) were prepared, with 100% SPF and wheat flour (WF) as control and standard, respectively. A digital weighing balance (Model: FA2004) and Philips blender (HR 1702) were used for weighing and mixing the flours, respectively.

Cookie preparation

Cookies were prepared using the method described by Singh *et al*. [9] based on the formulation shown in Table 1 with slight modifications. Fat and sugar were creamed together until fluffy. The flour, baking powder, whole egg and salt were added and manually mixed in a bowl to form dough. The mixing was done manually because the quantity of mixture was too small for the use of a laboratory mixer. The dough was rolled to a uniform thickness on a rolling board and cut to a uniform diameter of 50 mm using a cookie cutter and baked in an oven at 170°C for 20 min. The cookies were removed and allowed to cool on a rack, after which they were packaged in low-density polyethylene bags and kept in a plastic container at ambient temperature 30±1°C for 12h before further analyses.

Analyses

Physical properties

The diameter (D) and thickness (T) of the cookies were determined using the method of AACC [14]. This involves arranging six cookies in a row and taking their average

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diameter using ruler and thickness using a Vernier caliper with 0.01 mm accuracy (Cappera Precision, China). The spread ratio (SR) was calculated as in the formula:

$$SR = \frac{D}{T}$$

Chemical properties

Moisture, fat, protein, fiber and ash contents of the cookie samples were determined using the methods of AOAC [15] while carbohydrate was determined by difference, according to Ihekoronye and Ngoddy [16] and energy values were calculated using the Atwater Factors.

Beta-carotene was determined using the methods of Rodriguez-Amaya and Kimura [17], and [18] with slight modifications. Five grams (5.0g) of the sample was poured into a separating funnel and a solution containing 140 mL ethanol:hexane (4:3) instead of petroleum ether and acetone was added. About 2mL of 2% sodium chloride (NaCl) solution was also added to avoid formation of an emulsion. The mixture was manually shaken vigorously for about 3min., allowed to settle for 30min. and the lower layer was run off. The absorbance of the top layer was determined at the wavelength of 452nm using a spectrophotometer (Spectro Sc 20, Labomed, Inc. USA) and the concentration of β-carotene was calculated using Beer-Lambert law as follows:

$$\text{Beta-carotene } (\mu g/100g) = \frac{A \ x \ V \, x \, 10^6}{A_{1cm}^{1\%} \ x \ W(g)}$$

Where, A = Absorbance, V = Total volume of extract, W = Weight of sample, $A_{1cm}^{1\%}$ = 2590 (Absorption coefficient of β –Carotene in hexane)

Sensory evaluation

Sensory quality characteristics of the cookies such as colour, taste, texture, flavour, crispiness as well as overall acceptability were evaluated using a 20–member semi-trained panel, made up of staff and students of the University of Agriculture**,** Makurdi. A 9-point hedonic score system [19] was used with the following ratings: 9=Like extremely, 8=like very much, 7=like moderately, 4=Like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much and 1=Dislike extremely.

Statistical analysis

The data generated were analyzed using analysis of variance (ANOVA), and means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of probability [20].

RESULTS

Physical properties of cookies

The results of the physical properties of cookies are presented in Table 2. The diameter and spread ratio of the cookies decreased significantly ($p < 0.05$) while the thickness of cookies increased. There was no significant difference ($p > 0.05$) between cookies from 100% wheat and sweet potato flours. However, there was a significant difference (p <

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0.05) in the diameter of the 100% wheat and sweet potato cookies and the composite flour cookies. There were also significant differences ($p < 0.05$) in diameter between the composite flour cookies themselves as the level of supplementation increased.

Chemical composition of flours

Results of the proximate composition of wheat, mango mesocarp and sweet potato flours are presented in Table 3. There were significant differences ($p < 0.05$) in the values of the different nutrients in the different flours. Wheat flour had the highest moisture and protein contents –followed by mango mesocarp flour and sweet potato flour . Mango mesocarp had the highest fibre, fat, ash and β - carotene contents compared to sweet potato and wheat flour. Carbohydrate and energy values ranged from about 77 to 85% and 394 to 427 Kcal/100g sample respectively with mango mesocarp flour having the highest values.

Chemical composition of cookies

Results of the chemical composition of the cookie samples are presented in Table 4. The moisture, fat and fibre contents increased significantly ($p < 0.05$) with increase in level of supplementation with mango mesocarp flour. Ash, protein, and beta carotene contents of the sweet potato-based cookies also increased significantly ($p < 0.05$) with the standard (WF) having a protein content of 9.5 %. Conversely, the carbohydrate content of sweet potato-based cookies decreased significantly ($p < 0.05$) from about 73 to 64% with the standard recording nearly 69% while the energy values ranged 415 to 494 kcal/100g with the composite cookies having the highest values.

Sensory evaluation of cookies

The sensory scores of the cookie samples are presented in Fig. 1. Cookies from 100% sweet potato flour had the highest ratings, ranging from 7.2 to 8.8 in all the attributes (colour, crispiness, flavour, taste and overall acceptability), followed by 100% wheat flour. The preference for the cookies decreased as the level of substitution of mango mesocarp flour increased.

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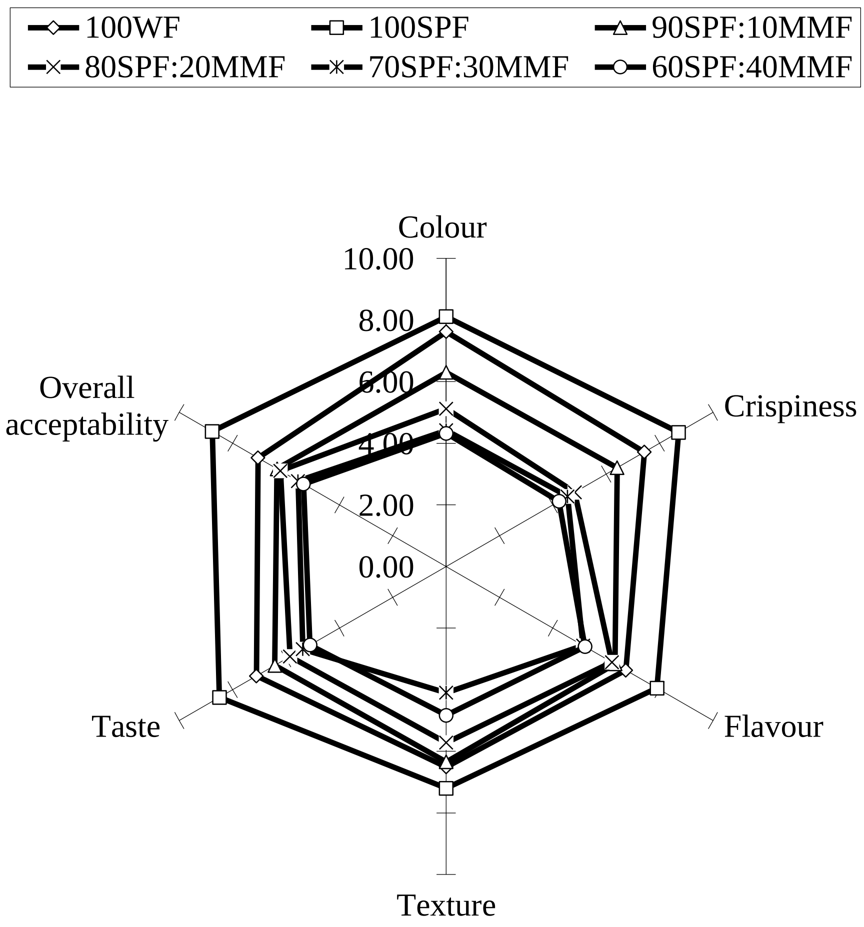

Figure 1: Sensory scores of cookies produced from wheat and composite flours of sweet potato and mango mesocarp

Key: WF: Wheat flour
SPF: Sweet potato flour
MMF = Mango mesocarp flour

DISCUSSION

Physical properties of cookies

The diameter of the cookies decreased as the proportion of mango mesocarp increased. This could be due to the fact that, though there was reduction in gluten content as a result of substitution, the high sugar, fat and fibre contents of the MMF absorbed much water, leading to swelling, gelling and binding together, thus preventing spreading. This finding is in agreement with the observation of Imran *et al*. [21], who reported a decrease in cookie diameter with addition of different sweeteners to wheat flour. Singh *et al*. [9] also reported similar observations when wheat flour was substituted with 20 – 80% sweet potato flour.

The increase in the thickness of cookies with increase in mango mesocarp flour substitution could be due to the swelling and binding of the cookie components due to water absorption. This is consistent with the findings of Chinma and Gernah [22], who reported a similar observation when wheat was substituted with cassava/soybean/mango flour. Djantou *et al*. [23] reported high sugar content in MMF, which probably competes for the limited free water due to the presence of hydrophilic sites, thereby increasing the thickness.

Chemical composition of cookies

The moisture content of cookies increased significantly ($p < 0.05$) with increase in the level of supplementation. This may be ascribed to the hygroscopic nature of mango mesocarp flour due to the presence of reducing sugars. However, there was no significant difference ($p > 0.05$) in the moisture content of the cookies from 20 – 40% MMF blends. This is consistent with the findings of Gernah *et al*. [24] with cookies from composite flours of wheat and locust bean fruit pulp.

The significantly ($p < 0.05$) higher fat content of cookies from composite flours as compared to cookies made from whole wheat and sweet potato flours could be due to substitution effect, as a result of the higher fat content of mango mesocarp flour. This is in agreement with the report of [22] when wheat was substituted with cassava/soybean/mango flour.

Although the crude fibre content of the cookies varied significantly ($p < 0.05$) between whole wheat, sweet potato (SPF) and 90SPF:10MMF blend, there was no significant difference ($p > 0.05$) between the cookies from the blends. The increase in ash content of cookies with increasing levels of substitution may be attributed to high ash content of the MMF. This implies that the blends have high mineral content.

The protein content of whole wheat cookies was higher than 100% SPF and the blends from SPF and MMF. The low protein content of the blends could be ascribed to the low protein content of both SPF and MMF. The significant variation ($p < 0.05$) in carbohydrate content may be attributed to alterations in other constituents (protein, fat, ash fibre and moisture) [25]. The energy values were slightly higher than the values reported by [22]. This variation may be ascribed to product composition.

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The beta carotene values of the cookies from the blends were significantly ($p < 0.05$) higher than those of 100% wheat and sweet potato flours. This could be due to substitution effect of the high amount of beta carotene in mango mesocarp flour. This is in agreement with the findings of Badifu *et al.* [26].

Sensory evaluation of cookies

Cookies from 100% sweet potato flour (SPF) had a higher overall acceptability than 100% wheat flour. However, the acceptability as well as all the other attributes of the cookies decreased with increase in the level of substitution with mango mesocarp flour (MMF). The decline in taste and colour could be ascribed to the effect of non-enzymic browning reactions (caramelization) resulting from the reaction between amino acids and free sugars leading to intense colour and slight bitterness during baking [24]. The decrease in crispiness with increase in substitution levels may be due to moisture uptake by mango mesocarp flour (MMF). It has been reported that moisture uptake leads to loss of crispness of food products [27]. The decline in texture of the composite flour cookies may be attributed to the high crude fibre content of MMF, which makes the texture less tender and unacceptable. The decline in acceptability of texture was observed when wheat flour was partially substituted with SPF [9]

CONCLUSION

The results of this study revealed that acceptable cookies of high nutritional content could be produced from 100% sweet potato flour (SPF) and its blends with mango mesocarp flour (MMF). Though there was a decrease in carbohydrate and energy values, the moisture, protein, fat, fibre and ash as well as beta carotene contents increased with increase in MMF. Cookies produced from 100% SPF had higher acceptability than 100% wheat flour (Standard). Though acceptability decreased with increase in the percentage of mango mesocarp flour, all the cookies were acceptable, thus indicating that acceptable cookies could be produced from blends of up to 30% substitution of sweet potato flour (SPF) with mango mesocarp flour (MMF).

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Table 1: Recipe for cookie production

Material	Quantity (g)
WF/SPF/MMF	100
Fat	45
Egg	56
Sodium Chloride	1
Sugar	30
Baking powder	0.5
Water	Variable

Key: WF: Wheat flour

SPF: Sweet potato flour

MMF = Mango mesocarp flour

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Table 2: Physical properties of cookies from wheat and composite of sweet potato and mango mesocarp

Blend	Diameter (mm)	Thickness(mm)	Spread Ratio
100WF	50±0.25[a]	6.1±0.01[a]	8.2±0.10[a]
100SPF	48±1.60[a]	6.4±0.58[b]	7.5±1.17[b]
90SPF:10MMF	44±0.30[b]	7.3±0.29[b]	6.0±1.30[c]
80SPF:20MMF	40±1.05[c]	7.3±0.58[b]	5.5±0.45[d]
70SPF:30MMF	49±1.45[c]	7.5±0.58[b]	5.3±1.15[d]
60SPF:40MMF	36±1.30[d]	7.6±2.44[b]	4.8±0.30[e]

Values are means ± standard deviation of triplicate determinations

Means in the same column not followed by the same superscript are significantly different ($p < 0.05$)

KEY:

WF: Wheat flour

SPF: Sweet potato flour

MMF = Mango mesocarp flour

Table 3: Proximate composition of the different flours on dry weight basis

Sample	Moisture	Fibre	Ash	Protein	Fat	Carbohydrate	Energy value (Kcal/100g)	Beta carotene (µg/100g)
WF	10±0.11[a]	3.0±0.01[c]	1.7±0.04[b]	8.4±0.05[a]	2.8±0.11[c]	84±0.03[b]	394±0.13[c]	197±0.06[c]
MMF	9.1±0.04[b]	5.3±0.01[a]	2.7±0.01[a]	3.3±0.03[b]	11±0.04[a]	77±0.42[c]	427±1.01[a]	404±0.11[a]
SPF	7.9±0.11[c]	2.9±0.01[b]	2.6±0.05[a]	2.3±0.01[c]	6.8±0.04[b]	85±1.07[a]	410±0.05[b]	304±0.17[b]

Values are means ± standard deviation of triplicate determinations

Means in the same column not followed by the same superscript are significantly different ($p < 0.05$)

Key: WF: Wheat flour

SPF: Sweet potato flour

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Table 4: Chemical composition of cookies from wheat and composite flours of sweet potato and mango mesocarp on dry weight basis

Blend	Moisture (%)	Fat (%)	Fibre (%)	Ash (%)	Protein (%)	Carbohydrate (%)	Energy value (Kcal/100g)	Beta carotene (µg/100g)
100WF	5.8±0.02^{c}	11±0.17^{c}	2.1±0.05^{d}	2.4±0.01^{f}	9.5±0.07^{a}	69±0.13^{b}	415±0.14^{d}	102±0.03^{f}
100SPF	6.4±0.57^{c}	18±0.12^{b}	2.5±0.07^{c}	2.9±0.10^{e}	3.4±0.14^{d}	73±0.54^{a}	472±0.20^{c}	178±0.50^{e}
90SPF:10MMF	7.3±0.12^{b}	23±0.40^{a}	2.8±0.12^{ab}	3.2±0.05^{d}	4.5±0.17^{c}	66±0.29^{c}	492±0.05^{b}	219±0.06^{d}
80SPF:20MMF	7.9±0.09^{a}	23±0.11^{a}	2.8±0.08^{a}	3.4±0.23^{c}	4.6±0.12^{c}	66±0.71^{c}	494±0.31^{a}	416±0.13^{c}
70SPF:30MMF	8.0±0.02^{a}	23±0.04^{a}	2.9±0.10^{a}	3.6±0.06^{b}	5.0±0.06^{b}	65±0.66^{d}	493±1.03^{a}	419±0.11^{b}
60SPF:40MMF	8.3±0.58^{a}	24±0.62^{a}	3.0±0.07^{a}	3.9±0.06^{a}	5.1±.012^{b}	64±0.29^{d}	493±0.18^{ab}	428±0.12^{a}

Values are means ± standard deviation of triplicate determinations

Means in the same column not followed by the same superscript are significantly different ($p < 0.05$)

KEY:

WF: Wheat flour

SPF: Sweet potato flour

MMF = Mango mesocarp flour

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