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RESEARCH ARTICLE

PRODUCTION, PROXIMATE COMPOSITION AND SENSORIAL ATTRIBUTES OF FLOUR BLEND *CHIN-CHIN* FROM ORANGE FLESHED SWEET POTATO AND RED BAMBARA GROUNDNUT FLOURS

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ABSTRACT

Inadequate supply of vitamin A is among the most pressing challenges facing developing countries including Nigeria. This study was undertaken to develop an acceptable *chin-chin* from orange fleshed sweet potato (OFSP) and red bambara groundnut (RBG) flours. Orange fleshed sweet potato contain beta carotene which is a precursor of vitamin A. Red bambara groundnut have potential to supply high protein to food products. The OFSP and RBG flours were blended in ratios 60:40, 50:50, 40:60, and 30:70, respectively. Established recipe was used to prepare *chin-chin* from the blends and 100% wheat flour (control). The *chin-chin* samples were analysed for sensory attributes, oiliness, proximate composition, anti-nutrients, minerals, vitamins and energy contents using standard methods. Data were analyzed using ANOVA at $\alpha_{0.05}$. There were no significant differences among 50:50, 60:40 and 100% wheat *chin-chin* in overall acceptability. The values of the oiliness ranged between 1.37±0.10 % and 3.92±0.86%. The breaking energy ranged between 0.035±0.007 N.m and 0.167±0.022 N.m. Crude protein contents for *chin-chin* were 13.78±0.03% (30:70), 12.87±0.01% (40:60), 11.79±0.07% (50:50), 10.71±0.05% (60:40) and 10.79±0.29% (control). Alkaloids contents were 0.02%, 0.03%, 0.06%, 0.04%, and 0.03% for 60:40, 50:50, 30:70, 40:60, and control, respectively. Trypsin inhibitors were not detected in the *chin-chin*. Calcium contents of all the samples ranged between 23.14±0.15% and 24.83±0.07% and iron between 1.01±0.03 and 1.65±0.04 mg/100g. The beta carotene contents ranged between 0.85±0.06mg/100g and 5.27±0.09mg/100g. Metabolizable energy for the *chin-chin* ranged between 100.07±0.48 and 101.25±0.43 KJ. *Chin-chin* produced from blends of orange fleshed sweet potato and red Bambara groundnuts are rich in protein and pro-vitamin A and are low in anti-nutrients.

INTRODUCTION

Vitamin A deficiency is a major public health threat of developing countries and it is associated with the millions of deaths which occur yearly in infants and young children (Mitra, 2012). The rates of Nigeria's malnutrition and intense wasting are known to be very high at about 1.9 million infants and children yearly (CIFF, 2016). The Community-based Management of Acute Malnutrition (CMAM) said that about one thousand children in Nigerian die of causes related to malnutrition daily (Itrealms, 2015). Studies have shown that children often do not get enough Vitamin A-rich and high protein foods in their diets (National Food Service Management Institute, 2012). A numbers of children survival tactics that have been known to decreased deaths among infants and children, include Vitamin A supplementation among others (Rachelfriends, 2016). Flour blends are a mixture of different vegetable flours that are rich in starch or protein, with or without wheat flour, for making certain types of bakery products (Chandra *et al*, 2015).

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The use of non-wheat flour mixed with flour from high protein food sources for making snack foods and other bakery products in Nigeria may be justified from nutritional, economic and agronomic perspectives. The improvement and utilization of food blends is an economic option in an attempt to reduce the risk of chronic diseases associated with food malnutrition (Twum and Pare, 2019). Combining agricultural produce has been known to improve the nutritional, functional, pasting and sensorial attributes of some food products (Obomeghei and Olorunda, 2018, Obomeghei, 2019). The materials utilized in food blends are normally foods composed of high levels of one or more essential nutrients which are available at comparatively lower cost and underutilized. The *chin-chin* available in commercial circle are made from refined wheat flour which is lacking in vitamin A and good quality protein as it is limiting in lysine. Orange fleshed sweet potato clones contains high amount of β (beta)-carotene that is known to be a precursor of vitamin A (Sakamoto *et al*, 1987; Yamakawa, 1997; Akoroda and Egeonu, 2009). It has four times United States Recommended Dietary Allowance for beta-carotene if it is eaten with the skin (Ray and Tomlins, 2010; Antonio *et al*, 2011). The chemical analysis of sweet potato storage roots shows that they are high in carbohydrates of between 13.4 – 29.2% (Platt, 1962; Antonio, *et al*, 2011; Chandy, 2011), 4.8 – 7.8% reducing sugars and having about 110 to 125 calories/ 100g (Platt, 1962; Antonio *et al*, 2011; Chandy, 2011). It also exhibit a good amounts of moisture (59.1 – 77.7%) (Platt, 1962; Antonio *et al*, 2011; Chandy, 2011), with low protein (1.5 – 2.9%) (Platt, 1962; Antonio *et al*, 2011; Chandy, 2011) and fat (0.3 – 0.8%) contents (Platt, 1962; Antonio *et al*, 2011; Chandy, 2011). Sweet potato is a an excellent source of vitamin A and vitamin C, some of the vitamin B complex such as thiamine, riboflavin and niacin (Platt, 1962; Odebode, 2009; Antonio *et al*, 2011; Chandy, 2011). It also supplies the following amounts of minerals/ 100g: calcium (17 – 46 mg) (Platt, 1962; Odebode, 2009; Antonio *et al*, 2011; Chandy, 2011), phosphorus (31 – 49 mg) (Odebode, 2009; Antonio *et al*, 2011; Chandy, 2011), potassium (273 mg) (Antonio *et al*, 2011), magnesium (24 mg) (Antonio *et al*, 2011; Chandy, 2011), sulphur (26 mg), sodium (13 mg) (Antonio *et al*, 2011) and iron (0.8 – 1.0 mg) (Platt, 1962; UNIFESP, 2008 as cited by Antonio *et al* (2011); Soares *et al*, 2002 as cited by Antonio, *et al*. 2011; Chandy, 2011).

Sweet potato is considered the sixth most useful food crop in the world (CIP, 2010) and will play a role in solution of world problems of energy, food and natural resources and the environment of 21st century. People have a great need to improve and maintain their health through the foods they eat every day. Orange flesh sweet potato could be amoung the natural and most important sources of beta (β)-carotene. Lots of new researches have made clear the higher capability of sweet potato to improve the supply of vitamin A to our blood (Whfoods, 2012; Thrive Global, 2017). This benefit is mainly true for infants and children. In very many researches conducted in Africa, sweet potato have been established to have about 100 – 1,600μgRAE vitamin A in 3.5 ounce which is enough to meet about thirty five percent (35%) vitamin A requirements, and in some other instances high enough to meet more than ninety percent (90%) vitamin A requirements (Whfoods, 2012). Since the orange flesh sweet potato contain considerable amount of β-carotene, a source of vitamin A, then it follows that developing a product out of it for children will assist in alleviating vitamin A deficiency among them. Bambara groundnut seed is described as a standard food, since it possesses enough quantities of protein, carbohydrate and fat (Brough and Azam-Ali, 1993). According to Ibrahim and Ogunwusi (2016), the oil from Bambara groundnut is composed of predominantly unsaturated fatty acid and of high iodine value index. The fatty acid composition is mainly linoleic, linolenic and palmitic acid (Minka and Bruneteau, 2000; Bamishaiye *et al*, 2011). The carbohydrate content is mainly starch and non-starch polysaccharides with lower quantities of reducing and non-reducing sugars. Bambara groundnut has a higher quantity of lysine than all other legumes and the seed possesses higher amounts of methionine than all other grain legumes (Addo and Oyeleke 1986). Nigeria is considered a major producer of bambara groundnut in Africa (Ibrahim and Ogunwusi, 2016). According to Azam-Ali *et al* (2003), the FAO quantity worldwide of bambara groundnut produced in the year 2002 stood at 58,900 metric tonnes. FAO production value from Burkina Faso, Cameroon, Mali and Democratic Republic of Congo estimated in 2008 stood at over 100,000MT (FAO, 2009). Alhassan and Egbe (2013) and PROTA (2006) estimated bambara yearly world production at approximately 330,000 MT. But the Food and Agriculture Organization's Bambara groundnut world production as at 2014 stood at 287,793.00 MT (FAO, 2015). Individual country production statistics are unavailable. Bambara groundnut production is mainly established in the northern and western parts of Africa, in addition to tropical rain forests zones and the dry savanna areas. According to Quinn (1998), *chin-chin* is a likable West African pastry product that can serve both as a snack and a sweet, depending on the way it was prepared. There are about as many recipes for chin-chin as there are ethnic groups in Nigeria (Quinn, 1998), and the ingredients and variations are endless. Some persons may like it hard and crunchy while others will prefer the light and softer ones. Shaping is a personalized preference; it can be in square, round, or cylindrical shape. Some may have a hole poked at the center of flattened dough already cut to size and pulling one end through to form a knot. Little work has been reported on the nutritional and sensorial attributes of *chin-chin* made from blends of orange fleshed sweet potato and red bambara groundnut flours.

MATERIALS AND METHODS

Four months old freshly harvested improved variety of sweet potatoes namely Umuspo 3 (orange fleshed) were obtained from an experimental farm of the Nigerian Root Crops Research Institute (NRCRI), Umudike, Nigeria. Bambara groundnuts were purchased from a local dealer in Auchi, Edo State, Nigeria. Cholesterol-free "Grand pure soya" oil of UAC was obtained from Uchi Market, Auchi, Etsako West Local Government Area of Edo State, Nigeria.

Sweet potato flour: A Modified Singh *et al* (2008) was used to prepare the flour. The sweet potatoes were sorted to remove damaged and infected roots, cleaned using safe and clean water to remove soil and peeled manually using potato peelers. The peeled roots were sliced into pieces of about 2mm thick, dried using cabinet drier (60 ^{o}C; 8 hrs) and milled using a laboratory attrition mill (Franky DM-WP 200 Electric Cereal Mill). The flours were sieved using 210μm sieve to obtain the flour, and sealed in a high density polyethylene (0.08mm thick) and stored in a deep freezer (-10^{0}C).

Bambara groundnut flour: A modified method of Olapade and Adetuyi (2007) was used to produce Bambara groundnut flour. The seeds were soaked in water at 50 ^{o}C for 30 minutes, manually dehulled by rubbing them in between hands and decanting off the seed coats. The cotyledons were dried using cabinet drier (60^{o}C;8 hrs). The dried Bambara groundnuts were pulverized and sieved through a 210 μm sieve in the attrition mill and packaged in high density polyethylene (0.08mm thick) and stored in a deep freezer (-10^{0}C).

Particle size distribution analysis: Determination of particle size distribution in orange fleshed sweet potato and red Bambara groundnut flours were carried out using sieve analysis technique. One hundred gram samples were weighed into the top sieve and vibrated for thirty (30) minutes. Sample parts retained on each sieve was weighed, recorded and expressed as percentage of the original samples weighed. Determinations were done in triplicate

Formulation of flour blends: The flour blends used for this study was formulated as shown in table 1.

Table 1: Percentage composition of flour blends

Sample	Sweet potato flour	Bambara groundnut flour
A	60	40
B	50	50
C	40	60
D	30	70
E	Control	100% Wheat flour

Production of *chin-chin* from flour blends: A modified method of Aniedu and Oti (2007) was used to produce chin-chin (Table 2). In a mixing bowl was added 350g flour blends, 50g sweet potato starch, 50g sugar, 5g baking powder, 0.25g nutmeg, and .5g salt. The margarine (50g) was rubbed into the ingredient in the bowl. No egg was whisked into the mixture as this was replaced by the protein source (Red Bambara groundnut flour). The starch was cooked in 200 ml water until it has properly gelatinized. The gelatinized starch was then mixed into the rest of the ingredients until a stiff pastry was formed. It was then rolled on a wooden board on which some flour have been added using the rolling pin. The rolled paste was then cut in beats, 1.90±0.23 mm x 1.20±0.23 mm x 0.58±0.04 mm (LxBxH). These were then deep-fried using the method of Onyejegbu and Olorunda (1995) at a temperature of 181.67±12.58 °C for 5 minutes in a restaurant type deep-fat fryer (Hobart Frymaster MJ1CF) of Hobart Cooking Solutions, Peterborough, UK. About 3 L of “Grand” cholesterol-free refined vegetable oil of UAC were used at a time. Batches of approximately 130 g were added at a time to minimize temperature drop during frying until brown and crispy with dimension 1.93±0.28mm x 1.53±o.31mm x 1.23±0.36 mm (LxBxH).

Table 2: Ingredients used for *chin-chin* production

Ingredient	Amount (g)
Flour blend	350
Potato starch	50
Sugar	50
Baking powder	5
Nutmeg	0.25
Sodium chloride	5
Margarine	50
Egg	Nil

Source: A modified Aniedu and Oti (2007)

Sensory evaluation

Multiple comparison difference analysis test for chin-chin: The five samples of chin-chin made using the four flour blends and the control sample of 100% wheat flour were analysed for sensory attributes using the method of Lamond (1977). The quality of the sensory attributes were determined using a panelist of 10 children and 10 food professionals employing a 9-point Hedonic scale whereby 9 equals like extremely; 8 equals like very much; 7 equals like moderately; 6 equals like slightly; 5 equals neither like nor dislike; 4 equals dislike slightly; 3 equals dislike moderately; 2 equals dislike very much; 1 equals dislike extremely. Quality parameters analysed for are; appearance, aroma, flavor, taste, texture, and overall acceptability. The data obtained were evaluated for significant differences in their means using analysis of variances (ANOVA) at $p \leq 0.05$. These were computed using the scores allocated by the panel members using SPSS software.

Colour measurement: Colour of the dough and chin-chin produced were determined using a colour measuring instrument, Hunter-lab colour difference meter (Color Tee-PCM, model SN 3000421, USA). The colorimeter operates on the Commission Internationale de l'Eclairage (CIE) colour scheme, and values are expressed on the L^*, a^*, b^* tristimulus scale. The instrument was standardized (L= 87.68, a= 2.15, b= 4.16) using a white reference standard (Onward white printing paper sheet, 80g/m^2). Triplicate measurements were taken on samples packaged in transparent polythene films; with the meter-sensor touching the sample surface. Readings were recorded in the meter and defined in three directions as: Light to Dark direction, called ‘L’, Red to Green direction called ‘a’ and Blue to Yellow direction called ‘b’ (AOAC, 2006).

Determination of oilliness of chin-chin: Oilliness of *chin-chin* was estimated by a modified method of Mallikarjunan and Mittal (1994). The fried samples (0.6g) were placed on pre-weighed pieces of cloth (instead of Whatman filter paper). After pressing, the chin-chin samples were removed and the pieces of cloths were re-weighed again. The oiliness was calculated as:

$$Oiliness\ \% = 100x(Wa - Wb)/Ws$$

Where, Wa = weight of cloth after compression
Wb = weight of cloth before compression
Ws = weight of chin-chin sample

Texture profile analysis of chin-chin: After cooling the chin-chin produced of dimension 1.93±0.28mm x 1.53±o.31mm x 1.23±0.36 mm were subjected to texture profile analysis (TPA) food compression test using the Testometric Material Testing Machine No. 0500 – 100AT, of Magnus Taylor, United Kingdom. The determinations were done at a speed of 102 mm/min, probe diameter of 75 mm and a depth of 25% of original height. Three samples of chin-chin were selected from each batch at random for the TPA compression test. The test heading was selected from the computer monitor to set the required parameters. The probe speed was set at 102mm/min, for both compression and withdrawal; the probe diameter was 75mm and the pre-load depth of 25% strain. The samples were placed in between the stationary plate and the probe plate. The “Start Test” was clicked to trigger the downward movement of the probe at the predetermined speed until it touches the sample and automatically starts reading till it gets to the predetermined depth. The test results were automatically generated and recorded and displayed in a tabular form on the screen.

Chemical analysis of *chin-chin*

Proximate composition: The proximate analyses of the raw materials and the flours from sweet potatoes and all the seeds were conducted in accordance with the methods described in AOAC (2010).

Sugar content determination: The method of AOAC (2004) was used in determination of sugar content.

Anti-nutrients: The anti-nutrients that were determined are Phytate, Tannin, Alkaloids, Cardiac glycosides, and Trypsin inhibitors. Phytate was extracted from the flours by the method described in Harland and Oberleas (1977). The phytate content was estimated using the spectrophotometric analysis, with an absorbance (A) and wavelength at 640 nm. (AOAC, 2005). The method described by Swain (1979) was used to determine the tannin content. The trypsin inhibitor activity (TIA) was measured in terms of the extent to which an extract of the defatted flour retarded the action of bovine trypsin [EC3.4.21.4] on the substrate benzoyl-DL-arginine-p-nitrianilide [BAPNA] hydrochloric as described by Kakade *et. al*, 1974. The alkaloids contents were measured using alkaline precipitation gravimetric method as described by Harborne (1998). Cardiac glycoside contents in the samples were estimated by the Baljet's reagent (95 ml of aqueous picric acid + 5 ml of 10% aqueous NaOH) method as described in El-Olemy *et.al* (1994).

Mineral composition: The ash obtained after the determination of ash content was first dissolved in 5 ml concentrated HCl (11.8M) and filtered into a 50 ml volumetric flask (modification of AOAC 985.35, 2005). The concentrations of the minerals, Ca, Fe, Mn, Mg, Zn and Cu in the samples were measured by atomic absorption spectrophotometer (Pye-Unicam, England). The amounts of K and Na in the samples were determined using Flame Photometry. At the end of the analysis the output obtained were employed to determine the concentrations of the analytes in the actual samples using a standard calibration curve plotted for each mineral. The preparation of standards was based on AOAC method 969.23 (2005). The equations of the lines obtained from the graphs by interpolation and extrapolation were used to determine the concentrations of each of the analytes in the sample.

Vitamin content determination: Beta-carotene contents were estimated by the method described by Rodriguez-Amaya and Kimura (2004). Beta-carotene contents are converted to vitamin A using USDA (2016). The titration method described by Pongracz *et al* (1971) was employed for the determination of Vitamin C. Vitamin B1 (Thiamin) was determined as described by the method of Sadashivam & Manickam (1992). The method of Hodson & Norris (1931) was used to determine vitamin B2 (Riboflavin). The method described by Melnick & Field, (1940) was used to determine vitamin B3 (Niacin).

Determination of energy content: The energy contents of the chin-chin produced was estimated using the Atwater general factor system as follows: Energy values for protein, fat and carbohydtrates are 16.74, 37.66 and 16.74 KJ/g respectively.

Statistical analysis: All the values obtained were analyzed statistically using the SPSS version 17.0 software package.

RESULTS AND DISCUSSION

Sensory Evaluation: The sensory characteristics of fresh chin-chin samples are as shown in Table 3. The taste of the *chin-chin* produced ranged between 6.90±0.40 (like moderately) and 7.80±0.42 (like very much). Tasters preferred the taste of sample produced from the 50:50 blend, followed by that of 60:40, 40:60, the control and lastly that of 30:70 blend. However significant difference did not exist among the taste of all the samples. The flavor ranged between 6.10±0.59 (like slightly) and 7.40±0.43 (like moderately). The tasters prefered the flavours of the 60:40 and 30:70 blends, followed by that of 40:60, 50:50 and lastly that of control. The flavours for all blends are significantly different from that of the control.

Aroma ranged between 5.40±0.48 (neither like nor dislike) and 6.80±0.25 (like moderately). The tasters prefered the aroma of sample from 60:40 blend, followed by that of 30:70, 50:50, 40:60 and lastly that of control. However, there is no significant difference between all test samples. But significant differences existed between the test samples and the control in terms of aroma at P≤0.05 levels. Colour of samples ranged between 6.50±0.23 (like moderately) and 8.00±0.30 (like very much). The panelists prefered the colour of the control sample, followed by that of 50:50 blend, 60:40 blend, 40:60 blend and lastly 30:70 blend. Significant difference does not exist between the control sample, 60:40, and the 50:50 blends samples in terms of colour. But the samples from 60:40 and 30:70 blends are significantly lower than other samples at P≤0.05 levels. Texture ranged between 7.00±0.30 (like moderately) and 8.40±0.50 (like very much). The panelist prefered the texture of the control, followed by that of 50:50, 60:40, 30:70, and lastly 40:60 blend in that order. However significant difference did not exist among the samples in terms of texture at P≤0.05 levels. The acceptability ranged between 7.40±0.31 (like moderately) and 8.60±0.27 (like extremely). There is no significant difference among the samples made from the 60:40, 50:50 blends and the control. These samples are significantly more acceptable than the samples 40:60 and the 30:70 blends at P≤0.05 levels.

Colour Parameters of Chin-chin samples: Color is known to be one of the most important sensory quality attributes of deep fat fried products (Sobukola *et al*, 2013; Omidiran *et al*, 2015). The colour parameter of the dough and the fried chin-chin produced are presented in Table 4.45. The colour is constituted by L^*, a^*, and b^*, in which L^* values ranged from black (0) to white (100), a^* values ranged from green (-) to red (+), and b^* values ranged from blue (-) to yellow (+). As indicated in Table 4.37; for the dough, a reduction in percent of sweet potato results in increase of the lightness of samples. The control sample was found to be significantly lighter than the rest samples, followed by the 30:70, 40:60, 50:50 and lastly the 60:40 sample. Significant difference in lightness does not exist among samples 40:60 and 30:70, but these samples are significantly lighter than the 50:50 sample which is also significantly lighter than the 60:40 sample.

For the fried products, the lightness value for the control was noted to be significantly higher than all values for the rest samples. Significant differences did not exist in the lightness values of all the test samples. There appeared to be a general decrease in the lightness from dough to fried products. This might be attributed to browning due to Maillard reaction which depends on the amount of reducing sugars and amino acids present at the surface of the dough (Marquez and Anon, 1986; Omidiran *et al*, 2015). The increased amount of Bambara groundnut flour could have caused an increase in the amount of amino acid in the flour blends used for the production of the chin-chin leading to the browning reaction which resulted in decrease in lightness value. This observation is similar to the findings of Sobukola *et al*. (2013). Also a decrease in the percentage of sweet potato flour results in decreases of the redness of dough samples. Differences which are significant exist among the samples at P≤0.05 with the value for 60:40 sample being significantly higher than other samples. There is a general decrease in redness of samples from dough to fried products with the value for the 60:40 sample being significantly higher than the values for all other samples. There were no significant differences among the redness of the 50:50 and the 30:70 samples. The redness of the control sample was more pronounced and significantly higher than the redness of all other samples. There is a decrease in yellowness as the percentage of sweet potato drops from 60:40 to 50:50 samples and then increased in 40:60 and 30:70 samples. The yellowness of the control sample was noted to be significantly lesser than the values for all other samples at P≤0.05 level. There is a general reduction in yellowness of samples from dough to fried products with the exception of the control sample which increases from 17.82±0.06 to 26.22±0.77. The 30:70 sample had the lowest "L" value, which indicates the high level of browning which may be attributed to browning reactions between the reducing sugars and amino acids in

Table 3. The mean sensory attribute scores of fresh chin-chin

Parameter	AAA	BBB	CCC	DDD	EEE
Taste	7.70±0.30^{a}	7.80±0.42^{a}	7.50±0.22^{a}	6.90±0.40^{a}	7.30±0.47^{a}
Flavour	7.40±0.43^{a}	7.10±0.31^{ab}	7.20±0.39^{ab}	7.40±0.31^{ab}	6.10±0.59^{b}
Aroma	6.80±0.25^{a}	6.50±0.18^{a}	6.50±0.27^{a}	6.70±0.26^{a}	5.40±0.48^{b}
Colour	7.30±0.34^{a}	7.90±0.22^{a}	6.60±0.34^{b}	6.50±0.23^{b}	8.00±0.30^{a}
Texture	7.90±0.18^{a}	8.20±0.29^{a}	7.00±0.30^{a}	7.30±0.30^{a}	8.90±0.50^{a}
Acceptability	8.50±0.27^{a}	8.60±0.27^{a}	7.50±0.31^{b}	7.40±0.31^{b}	8.20±0.42^{a}

Means with same superscript along rows do not differ significantly at P ≤ 0.05 ±SD
Sample AAA = 60% sweet potato flour, 40% Bambara flour
Sample BBB = 50% sweet potato flour, 50% Bambara flour
Sample CCC = 40% sweet potato flour, 60% Bambara flour
Sample DDD = 30% sweet potato flour, 70% Bambara flour
Sample EEE = 100% wheat flour (control); SD=Standard deviation.

Table 4. Colour Parameters of Chin-chin

Parameter	60:40	50:50	40:60	30:70	Control
L (lightness)	50.03±1.09^{d}	51.09±0.17^{c}	53.08±0.08^{b}	53.53±0.56^{b}	70.99±1.76^{a}
a (redness)	12.45±0.05^{a}	10.63±0.02^{b}	9.52±0.06^{c}	7.88±0.05^{d}	0.71±0.01^{e}
b (yellowness)	19.85±0.04^{c}	19.56±0.02^{c}	20.99±0.76^{a}	20.82±0.01^{b}	17.82±0.06^{d}
L (lightness)	31.26±0.23^{b}	30.92±1.97^{b}	30.79±0.07^{b}	30.09±0.25^{b}	60.06±0.47^{a}
a (redness)	10.19±0.08^{a}	8.73±1.21^{b}	7.58±0.02^{c}	8.93±0.08^{b}	11.21±0.37^{a}
b (yellowness)	16.03±1.25^{b}	12.51±1.71^{c}	13.60±0.40^{c}	12.81±0.18^{c}	26.22±0.77^{a}

Means with the same superscript along same row are not significantly different at P≤0.05±SD
60:40 = 60% sweet potato flour, 40% Bambara flour
50:50 = 50% sweet potato flour, 50% Bambara flour
40:60 = 40% sweet potato flour, 60% Bambara flour
30:70 = 30% sweet potato flour, 70% Bambara flour
Control = 100% wheat flour; SD=Standard deviation

Table 5. The Oilliness of Chin-chin samples produced

Sample	Oilliness (%)
60:40	3.92±0.86^{a}
50:50	2.95±0.33^{ab}
40:60	3.65±0.69^{a}
30:70	1.92±0.79^{bc}
Control	1.37±0.10^{c}

Values represent mean of 3 determinations
Means with the same superscript in a column are not significantly different at P≤0.05±SD
60:40 = 60% sweet potato flour, 40% Bambara flour
50:50 = 50% sweet potato flour, 50% Bambara flour
40:60 = 40% sweet potato flour, 60% Bambara flour
30:70 = 30% sweet potato flour, 70% Bambara flour
Control = 100% wheat flour
SD=Standard deviation

Table 6. Texture Profile Analysis of Chin-chin

Sample	60:40	50:50	40:60	30:70	Control
Peak Force (N)	29.10±4.30^{c}	32.04±2.60^{c}	20.33±3.80^{c}	56.35±3.35^{b}	92.59±23.62^{a}
Break Energy (N.m)	0.035±0.007^{c}	0.045±0.002^{bc}	0.052±0.005^{b}	0.062±0.005^{b}	0.167±0.022^{a}
Adhensiveness (N.S)	2.90±0.38^{a}	3.24±0.11^{a}	4.30±2.31^{a}	4.13±0.71^{a}	5.34±2.11^{a}
Chewiness (N)	22.89±2.62^{b}	9.62±1.24^{bc}	15.11±2.90^{ab}	39.00±7.06^{a}	4.09±5.13^{c}
Cohensiveness (%)	0.57±0.02^{b}	0.88±0.04^{a}	0.83±0.06^{a}	0.81±0.50^{a}	0.19±0.01^{c}
Fracturability (N)	29.10±4.30^{c}	22.04±2.59^{c}	27.51±8.40^{c}	56.35±3.35^{b}	71.97±13.43^{a}

Means with the same superscript in same row are not significantly different at P ≤ 0.05±SD
60:40=60% orange fleshed sweet potato flour:40% Bambara groundnut flour
50:50=50% orange fleshed sweet potato flour:50% Bambara groundnut flour
40:60=40% orange fleshed sweet potato flour:60% Bambara groundnut flour
30:70=30% orange fleshed sweet potato flour:70% Bambara groundnut flour
Control = 100% wheat flour SD=Standard deviation

sweet potato and Bambara groundnut respectively. The "L" value is highest in 100% wheat chin-chin indicating that the colour is lighter, followed by the 60:40 and 50:50 sample chin-chin respectively. Photograph of the samples of fried and packaged chin-chin is shown in plate 4.1

Oilliness of Chin-chin Produced: The results of the oiliness of the chin-chin produced are shown in Table 5. The values of the oiliness ranged between 1.37±0.10 % and 3.92±0.86%. Significant differences exist among all samples produced. There was no significant difference between 60:40 and 40:60 blend chin-chin samples but the values were significantly higher than all other samples.The value obtained for the 50:50 sample was not significantly different from the 30:70 sample but higher than the control. The value of 30:70 blend chin-chin was found not to be significantly different from the control sample.

Texture Profile Analysis (TPA) of Chin-chin: The texture of any food product is closely related to consumers' sensory accept abilities (Texture Technologies, 2016). The TPA of the chin-chin samples are presented in Table 6. The peak force ranged between 20.33±3.80 N and 92.59±23.62N. Significant differences exist in the peak force among the samples with value of the control sample being significantly higher than all other samples, followed by the 30:70 chin-chin which is also significantly higher than the values for the 40: 60, 50:50 and 60:40 samples. There are no significant differences among the values for 40: 60, 50:50 and 60:40 samples. Breaking force diminishes if fried snacks become crispier (Sobukola *et al*, 2013; Omidiran *et al*, 2015). The breaking energy ranged between 0.035±0.007 N.m and 0.167±0.022 N.m. There are significant differences in the values for the breaking energy with the value for the 60:40 sample being significantly lower and the control sample value being significantly higher than other samples. It appears that as the amount of bambara groundnut flour is increased, the breaking force increased. Adhensiveness values for the chin-chin ranged between 2.90±0.38 N.S and 5.34±2.11 N.S. Significant differences did not exist among the values for all the samples including the control. The chewiness values for the samples ranged between 4.09±5.13 N and 39.00±7.06 N. The control sample value was not significantly different from the value for the 50:50 chin-chin but significantly different from other samples. A product is known to be cohesive when the particles adhere to themselves under some compressive or tensile stresses. In foods cohesion is the energy required to masticate (crush) a food product until it is in a good state to be swallowed. A product with high cohesive force is more resistant to production, packaging and transportation stresses and so can be delivered to the consumers in the intended state (Texture Technologies, 2016).

Values for the cohesiveness of chin-chin ranged from 19±0.01% to 88±0.04%. The control was found to be significantly lower than all other samples, followed by the value of 60:40 sample. Significant differences does not exist between the values for the 50:50, 40:60 and 30:70 samples. The fracturability or brittleness values for the chin-chin samples ranged between 22.04±2.59N and 71.97±13.43N. Significant differences exist among the values obtained for the samples with the control sample being significantly higher. The value obtained for 30:70 chin:chin was also found to be more brittle than other samples except the control sample. Significant differences did not exist among the values recorded for the 60:40, 50:50 and the 40:60 samples

Conclusion

The protein contents of the chin-chin produced ranged between10.71±0.05% and 13.78±0.03%. The protein contents of chin-chin made from the 60:40 blend and that of the control sample are significantly less than the protein values for chin-chin made from 50:50, 40:60 and 30:70 blends. The best flour blend that gives the highest quality attributes chin-chin that can effectively replace the conventional/ traditional 100% wheat flour is the 50:50 flour blend. The best chin-chin sample is the 50:50 with the highest sensory attributes. It contained about 12% protein which is higher than the control (wheat) and very low anti-nutrients compared to wheat chin-chin. Its beta-carotene content (5.17mg/ 100g) is far higher than that of wheat chin-chin (0.85mg/100g).

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