FUNCTIONAL PROPERTIES OF WHEAT, PLANTAIN SORGHUM COMPOSITE FLOUR AND SENSORY EVALUATION OF THEIR CORRESPONDING CHIN-CHIN AND BISCUIT.

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ABSTRACT
The research was carried out to study the functional properties of flour blends produced from cheap and underutilised crops (plantain-sorghum blends and wheat flour). The study evaluated functional properties – dispersibility, bulk density, swelling power, water and oil absorption capacities, sedimentation volume, emulsion capacity and foaming capacity, pH and solubility index of the flours. The corresponding biscuits and chin-chin produced from the flour blends of plantain (P), sorghum (S) and wheat (W) in following proportions: 40P:60W, 30P:10S:60W, 20P:20S:60W, 10P:30S:60W, 40S:60W and 100% Wheat flour as control analysed for Sensory evaluation. The functional properties of the flour blends have moisture content (1.00 to 4.83%), dispersibility (63.26 to 78.33%), bulk density (0.41to 0.46 %), swelling power (1.09 to 1.12%), water absorption capacity (81.65 to 90.43 %), oil absorption capacity (14.77to 20.00%), sedimentation volume (17.33 to 35.87 %), emulsion capacity (28.63to 36.14 %), foaming capacity (36.14 to 16.18 %), and solubility index (45.10 to 47.07 %). Sensory evaluation results of the biscuits showed that the composite flour of sample A (40P:60W) could be used as a substitute for whole wheat flour due to its overall acceptability while that of chin-chin showed that sample B (30P:10S:60W) was highly rated. The study revealed that consumption of the biscuits and chin-chin would increase the nutrient intake of the people especially children and also increase the utilisation of plantain and sorghum in developing countries, including Nigeria.

Keywords: Functional properties; composite flour, plantain; sorghum; biscuit; chin-chin

INTRODUCTION

The protein (gluten) in wheat makes the dough to stick together and gives it the ability to retain gas. Therefore wheat is the primary cereal widely used for making bread than any other grain (Narayana, and Narasimga,1982). Wheat is a national staple in many countries, and it contributes about 20 per cent of the food calories for the world's people hence serve as the primary ingredient in most confessionary such as bread, rolls, crackers, cookies, biscuits, cakes, doughnuts, macaroni, spaghetti, puddings, pizza. (Oh, Seib, Ward, and Deyoe,1985).

Plantain known as *Musa paradisiaca* is a member of *Musaceae* family and genus *Musa*. It is a major staple food crop in the humid and sub-humid parts of Africa and provider of energy for millions of people in these regions. It is a tropical plant that is native to India and known in English as plantain, Yoruba as '*Ogede agbagba'*, Hausa *'Ayaba'* and Igbo '*Ogadejioke'* (Okareh, Adeolu and Adepoju. 2015). Plantain production in Nigeria in 2004, was estimated at 2.11 million metric tons, and the fruits grow in clusters, each fruit being about 1 inch in diameter and somewhat longer than a banana fruit (Adeniji, and Tenkouano A. 2007). Most plantain foods are eaten as boiled, fried or roasted, and flour produced from unripe plantain is used traditionally for the preparation of a thick paste (Amala). Nutritionally, plantain fruit possessed carbohydrates, minerals, amino acids, fibre, and carotenoids.

Sorghum is a major cereal in the semi-arid regions of the world where it is outstanding food and feed crop. Sorghum species (*Sorghum vulgare* and *Sorghum bicolor*) are members of the grass family. Sorghum is known as great millet and guinea corn in West Africa. In the semi-arid tropics of Africa and India, the grain forms the staple diet for large populations, where nearly all the produce is used directly as human food (Sanni, Kosoko, Adebowale, and Adeoye, 2004). The potential food and industrial applications of sorghum have been studied and reported by several authors (Delcour et al., 2000). The flour was found to have higher levels of lipids, ash, crude fibre, and protein. Adeyemi and Idowu, (1990) and Dhingra and Jood, (2004), studied the effects of different flour substitutions on gruel making physical qualities which include colour, texture, taste and overall acceptance of composite flours produced from cereals and leguminous seed. It can also be malted and processed into malted foods, beverages, and beer.

Composite flour is the mixture of different concentrations of non-wheat flours from cereals, legumes, roots and tubers with or without wheat. Composite flours are produced to improve nutritional composition and enhance the desired functional properties of the end product. (Amir, Mueen-ud-din , Abrar, Mahmood., Nadeem and Mehmood, 2015). Composite flours have been used widely and effectively in the production of baked goods. (Oluwafemi ,and Seidu, 2017)

Over the years, unripe plantain and wheat flour were recommended for regulating blood glucose due to their high fibre content and low glycaemic index. But the cost of importation associated with wheat, the need for production of functional composite flour using other readily available and inexpensive materials such as cereal and legumes with the proper nutritional value of proteins, carbohydrates, fibres, fat and ash contents is necessary. Therefore this study is to determine the functional properties of wheat, plantain and sorghum composite flour and sensory evaluation of their corresponding biscuit and chin-chin produced from the composite flour.

MATERIALS AND METHOD

Sample Procurement

The wheat flour, fresh plantains and sorghum grains, used for this study were bought from Sayedero market, Ilaro in Ogun State, Nigeria.

Preparation of Plantain Flour

The green plantain fingers (20kg) were thoroughly washed with water and sun-dried for 30minutes. The fruits were then hand peeled, sliced and stored in water to avoid browning before drying. The sliced pulp subjected to drying for 6 hours at a temperature of 80 ^oC using hot air oven immediately. The resultant dried pulp slices were milled with a hammer mill (Bentall Superb, Model 200L 09) and sieved through a 75µm mesh sieve and stored in airtight plastic containers at room temperature (28±2°C) for further use.

Preparation of Sorghum flour

Sorghum grains (5 kg) were screened of foreign bodies, washed with clean water and subjected to drying in an open-air for 4hours. The cleaned, dried grains were milled with a hammer mill (Bentall Superb Model 200L 09) and sieved through a 75µm mesh sieve and kept in airtight plastic containers at room temperature (28±2°C) for further use.

Composite Flour Formulation

Table 1: Percentage Composition of Plantain, Sorghum and Wheat Flour

SAMPLE	PLANTAIN (%)	SORGHUM (%)	WHEAT (%)
A	40	-	60
B	30	10	60
C	20	20	60
D	10	30	60
E	-	40	60
F	-	-	100

Production of Biscuit

The standardised formulations for biscuit had ingredients as 100 g flour, shortening 9.64, sodium bicarbonate 0.16g, salt 2.02g, yeast 3.48, water 50ml. Hot liquid Hydrogenated fat and sugar were taken and creamed to a uniform consistency. The required amount of water, sodium bicarbonate was added to creamed mixture and mixed for 10 minutes at medium speed in dough mixer to obtain a homogeneous mixture. The dough was rolled out into a thin sheet of uniform thickness and was cut into the desired shape using a mould (Baljeet, Ritika, and Reena, 2014). The cut pieces were placed in a perforated tray and transferred into a convective baking oven at 180 °C for 10–15 min till baked. The well-baked biscuits were removed from the oven, cooled to room temperature, and packed .

Production of Chin- chin

The standardised formulations for chin- chin had ingredients as 50g flour, margarine 1.25g, egg slurry 5g, sugar 2.5g, sodium bicarbonate 2.5g, water 75ml. The required amount of water and margarine were added to creamed mixture and egg and mixed for 10mins at medium speed in dough mixer to obtain a homogeneous mixture. The dough was rolled out into a thin sheet of uniform thickness and was cut into the desired shape using a knife and fried in a hot groundnut oil until it became crispy(Baljeet *et al.*, 2014). The well-fried chin- chin was allowed to cooled, packed and stored at room temperature for further studies.

Chemical Analysis

Determination of Functional Properties

Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined using the method reported by Awoyale, Maziya-Dixon, Sanni and Shittu (2011).

Bulk density determined using the procedure described by AOAC (2006) The swelling capacity determined using the method described by Adebowale, Adeyemi and Oshodi (2005). Emulsion, capacity evaluated by the procedure of Klompong Benjakul, Kantachote & Shahidi 2007. The technique described by Sze-Taco Sathe (2000) used for determination of foaming capacity and stability. The method reported by Adegunwa et al. (2015) used to analyse dispersibility.

Sensorial evaluation

Twenty (20) semi-trained panellists consisting of both gender of different age groups having different eating habits were constituted to evaluate the qualities of the biscuits and chin-chin. The judges selected from the staff and students of the Departments of Hospitality Management, Food Technology and Nutrition and Dietetics, rated the samples for their acceptability through the sense of organs using 9- point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like).

Statistical Analysis

All analysis performed in triplicates and results expressed as mean values ± standard deviation(SD). Using SPSS statistics (14.0) software, one-way analysis of variance (ANOVA and Duncan's multiple range test (DMRT) was performed on the data

RESULT AND DISCUSSION

Table 2 depicts the results of the functional properties of composite flour of plantain, sorghum, and wheat, and were significantly different (P<0.05). The moisture content ranged from 1.00 % to 5.14 %, with sample F having the highest and sample E has the lowest. Low moisture content ensures higher shelf stability. Dispersibility is an index of the ease of reconstitution of the flour sample in water, and dispersibility of the samples varied significantly (P<0.05), ranging between 63.26 % and 78.33 %, with 100% wheat flour having lower dispersibility than all the composite flour samples. Sample E has more ability to disperse faster in aqueous solution which quickly reconstitute to give fine consistency dough during food processing than other samples because of its highest percent dispersibility (Adebowale, Sanni and Onitilo, 2008; Adebowale, Adegoke, Sanni, Adegunwa and Fetuga, 2012).

Table 2: Functional properties of composite flour

Sample	A	B	C	D	E	F
Moisture	4.83 ± 1.16^{a}	3.50 ± 0.28^{a}	2.16 ± 0.44^{b}	1.36 ± 0.03^{c}	1.00 ± 0.03^{d}	5.14 ± 0.44^{a}
D.S	64.60 ± 0.17^{a}	71.00 ± 0.57^{b}	74.00 ± 0.57^{b}	76.33 ± 1.20^{c}	78.33 ± 2.71^{d}	63.26 ± 0.17^{a}
BD, g/cm	0.43 ± 0.11^{ab}	0.43 ± 0.06^{ab}	0.46 ± 0.03^{b}	0.46 ± 0.08^{b}	0.46 ± 0.21^{b}	0.41 ± 0.05^{a}
SP, ml	1.12 ± 0.07^{b}	1.12 ± 0.01^{b}	1.11 ± 0.02^{ab}	1.11 ± 0.01^{ab}	1.09 ± 0.04^{a}	1.14 ± 0.06^{c}
W.A,%	84.33 ± 0.16^{b}	86.43 ± 0.44^{c}	87.38 ± 0.44^{cd}	88.66 ± 0.76^{d}	90.43 ± 0.82^{e}	81.65 ± 0.45^{a}
OA,%	15.50 ± 0.28^{b}	16.06 ± 0.16^{ab}	16.94 ± 0.60^{c}	18.15 ± 0.33^{d}	20.00 ± 0.28^{e}	14.77 ± 0.17^{a}
SV, ml	24.66 ± 0.66^{e}	22.16 ± 0.66^{d}	21.04 ± 2.08^{c}	19.76 ± 0.88^{b}	17.33 ± 2.37^{a}	35.87 ± 2.19^{f}
EMC,%	28.63 ± 1.66^{a}	30.01 ± 3.33^{b}	31.50 ± 2.77^{c}	33.45 ± 1.27^{d}	36.14 ± 3.34^{e}	31.08 ± 1.55^{c}
FC,%	14.33 ± 1.79^{e}	13.00 ± 0.57^{d}	12.33 ± 0.33^{c}	10.33 ± 0.88^{b}	9.66 ± 0.66^{a}	16.18 ± 0.48^{f}
S.I,%	46.76 ± 2.49^{ab}	46.00 ± 1.34^{ab}	45.56 ± 0.52^{a}	45.93 ± 1.48^{a}	45.10 ± 2.86^{a}	47.07 ± 2.08^{b}

The bulk density properties decrease with increase in sorghum inclusion Bulk density is an index of the heaviness of flour materials and expresses the relative volume of packaging material needed, and is generally affected by the particle size. It has relevant application in the packaging, transportation and raw material handling (Adebowale et al., 2008; Adegunwa et al.; 2015; Ajanaku, Ajanaku, Edobor-Osoh and Nwinyi, 2012). The low bulk density result in less cost of packaging.

The swelling power of flour granules indicates the extent of associative forces within the granule, and it also affects the temperature at which a product forms a gel, and linked to the water absorption index of the starch-based flour during heating. (Finney 1994; Loos, Hood and Graham, 1981; Moorthy and Ramanujam1986). The swelling power decreased with increase in sorghum inclusion, 100 % wheat flour has the highest swelling power.
The water absorption capacity varied significantly (P<0.05), and it ranged from 81.65 % to 90.43 % and increased with the increase in sorghum inclusion. That of the 100% wheat flour has the lowest water absorption capacity than that of all the composite flours. The high water-binding capacity of the flour blends implicated upon the inclusion of sorghum and plantain to wheat flour hence enhances the reconstitution ability (Ajanaku *et al.*, 2012; Kulkarni, Kulkarni and 1991) and textural properties of dough obtainable from the composite flour. High water absorption capacity may be attributed to the loose structure of starch polymers while a low value indicates compactness of the starch structures (Yadav, Anan, Kaur and Singh, 2012).

The oil absorption capacity (OAC) followed a similar pattern as water absorption capacity, increasing with an increase in the amount of sorghum in the composite flours. Therefore, sample E with high OAC will favour flavour retention and improve the mouth feel and palatability of bakery products (Adegunwa et al. 2017).

Sedimentation volume (SV) is the indirect measurement of quality and composition of gluten protein and bread-making potential of the flour (Belderok, 2000). The results depicted in Table 2 showed that the sedimentation volume value for 100 % wheat flour (35.87 ml) was significantly higher than that of composite flour blends (17.33 ml to 24.66 ml), and replacement of wheat flour by plantain and sorghum flours caused gradual decreased at level of replacement increased since additives do not contain any gluten content. The outcome of this study confirms the findings of Deepika B. and Arti S. (2019) on functional properties of malted composite flour for biscuit production.

The result in Table 2 shows that the emulsion capacity decreased with increased content of plantain in flour blends while increased in sorghum content raised the per cent emulsion capacity of the composite flour samples. It ranged from 28.63 % to 36.14 % and differed significantly (P<0.05) from each other. The possibility of the high content of protein in sorghum might have caused the rise in emulsion capacity with an increase in sorghum proportion in the blends because the presence of proteins at the interface of water/oil plays an essential role in the emulsifying capacity due to increased hydrophobicity (Jayaprakasha and Brueckner, 1999)

The foaming capacity of the samples ranged from 9.66 -16.18 %, and were significantly different (P>0.05) Sample F had the highest forming capacity, while sample E had the lowest. The result showed that the presence of sorghum whose protein content is more than that of plantain could be responsible for the low forming capacity, because protein may cause a lowering of the surface tension at the water-air interface, due to protein which forms a continuous, cohesive film around the air bubbles in the foam (Kaushal, Kumar, and Sharm, 2012).
The water solubility index is commonly used to measure the amount of starch. Leaching of amylose is said to be responsible for solubility of starch in most starch-based products the solubility index of the composite flour presented in table 2 above ranged from 45.10% to 46.76% with sample A (40% plantain + 60% wheat). The solubility index of the flour blends decreased slightly as the amount of sorghum in the combinations increased.

Sensory Qualities
The sensory scores of the biscuit produced from the wheat, plantain-sorghum composite flour revealed various significant differences in all the parameters evaluated. All the samples were equally rated by panellist, in terms of colour, samples A and D are the most acceptable with the mean values of 4.35 each compared with control sample (100% wheat) at 3.76, however, samples substituted with quantity of sorghum flour were significantly different from sample A in terms of texture. The most acceptable sample in terms of texture is sample A. This could be due to the composition of the composite flour. Sample C is the most acceptable by the panellist in terms of aroma with a mean value of 4.65. The taste of the biscuit is best with sample A according to the panellist, and this has a mean value of 4.75 also, Sample A (40%plantain + 60%wheat) has the most acceptable after taste with the mean value of 4.65. The taste, after taste and overall acceptability of the biscuit is best with sample A (40%plantain + 60% wheat) according to the panellist with the mean values 4.75, 4.65 and 4.75 compared with that of the control sample F (100%wheat)

with the mean values 2.55, 3.15 and 2.00 respectively, Thus composite flour of the sample A could be used for the production of biscuit for everyone and substitute for a whole wheat flour.

Table 3; Sensory Evaluation of Composite Flour for Biscuit

Sample	Colour	Texture	Aroma	Taste	After Taste	Overall Acceptability
A	4.35±0.36 ^{a}	4.10±0.31^{a}	4.05±0.35 ^{a}	4.75±0.63 ^{a}	4.65±0.55^{a}	4.75±0.47 ^{a}
B	3.65±0.37 ^{b}	3.85±0.32 ^{b}	4.30±0.37 ^{ab}	4.05±0.36 ^{ab}	4.00±0.41 ^{b}	4.55±0.44 ^{ab}
.C	4.00±0.39 ^{b}	3.75±0.29 ^{b}	4.65±0.25 ^{ab}	3.95±0.37 ^{ab}	3.50±0.34 ^{b}	4.70±0.41 ^{b}
D	4.35±0.46 ^{b}	3.95±0.33 ^{b}	4.25±0.25 ^{ab}	3.55±0.40 ^{ab}	3.75±0.34 ^{b}	3.70±0.28 ^{b}
E	1.95±0.38 ^{b}	3.75±0.36 ^{a}	4.00±0.33 ^{b}	3.2±0.38 ^{bc}	3.50±0.35 ^{b}	4.15±0.36 ^{b}
F	3.76±0.18 ^{b}	3.67±0.13 ^{b}	3.20±0.41 ^{b}	2.55±0.32 ^{c}	3.15±0.30 ^{b}	2.00±0.49 ^{b}

The sensory score of the chin-chin produce from wheat, Plantain, sorghum composite flour revealed a significant difference in all the parameters evaluated. All the samples were equally rated by the panellist, in term of colours, and sample E (40% sorghum + 60% wheat) is the most acceptable with a mean value of 5.30 compared to that of the control, sample F (with the mean value of 7.40. However, this could be due to the sorghum substitution. The most acceptable sample in terms of texture is sample D (30%sorghum + 10%plantain + 60%wheat) with a mean value of 6.55 this could be due to the composition of plantain flour in the substitution. Sample C (20%plantain + 20% sorghum + 60% wheat) is the most acceptable in terms of aroma with the mean value of 5.75 compared to the control sample F (100% wheat) with the mean value of 6.90. The taste, after taste and overall acceptability of the chin-chin, is the best with sample B (30%plantain + 10% sorghum + wheat) according to the panellist and this has mean values of 6.10, 6.25, and 6.35 respectively. There is a significant difference when compared to that of the control sample F (100% wheat) with mean values of 7.65 for taste, after taste and overall acceptability attributes respectively, Thus, composite flour produced of sample B could be used to produced organoleptically acceptable product and can be used for the production of chin-chin for everyone especially the diabetic patients.

Table 4 for sensorial evaluation of composite flour for chin-chin

Sample	Colour	Texture	Aroma	Taste	After Taste	Overall Acceptability
A	4.10±0.44^{a}	5.05±0.31 ^{a}	5.45±0.43^{a}	4.45±0.48^{a}	4.95±0.53^{a}	5.45±0.33^{a}
B	5.10±0.39^{a}	5.70±0.32 ^{ab}	5.30±0.38^{a}	6.10±0.44^{ab}	6.25±0.52^{a}	6.35±0.39^{a}
C	5.05±3.28^{a}	6.30±0.29 ^{ab}	5.75±0.38^{a}	5.70±0.45 ^{ab}	5.92±0.46^{a}	6.00±0.39^{a}
D	4.95±0.41^{a}	6.55±0.32^{ab}	5.55±0.35^{a}	5.50±0.27^{ab}	5.70±0.36^{a}	6.00±0.33^{a}
E	5.30±0.33^{a}	5.40±0.38^{b}	4.95±0.38 ^{a}	5.25±0.35 ^{b}	5.60±0.37^{ab}	6.15±0.41^{a}
F	7.40±0.41^{b}	7.40±0.40^{b}	6.90±0.32^{b}	7.15±0.46^{c}	7.35±0.55^{b}	7.65±0.37^{b}

Conclusion

In recent research, there is a trend to use different sources of protein, fat, vitamins and mineral for bakery products to decrease the proportion of wheat flour by using locally available, cheap nutritional sources. Plantain-sorghum flour blend has excellent functional properties which enhance the nutritional quality of the value-added products which was processed by the addition wheat flour of them.

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