

**FUNCTIONAL PROPERTIES AND SENSORY EVALUATIONS OF ‘CHIN-CHIN’,
BREAD AND BISCUITS PRODUCED FROM COMPOSITE FLOURS FROM AFRICAN
YAM BEAN, ORANGE FLESHED SWEET POTATOES, PLANTAIN, COCOYAM,
MAIZE, AND WHEAT**

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ABSTRACT: *The aim of this study was to produce ‘chin-chin’, bread and biscuit from composite flours of African yam bean (AYB), plantain, maize, orange fleshed sweet potatoes (OFSP), wheat and cocoyam. AYB seeds were fermented in citric acid medium (0.5%). Maize seeds were fermented in tap water for 48hrs. Green matured plantain fruit, cocoyam corm and OFSP tubers were processed into flour. The functional properties of the flours were determined using standard laboratory methods. Products were developed from the composite flours using conventional methods. Sensory properties of the products were assessed using a 9-point hedonic scale. Descriptive statistics was used to analyze data. Bulk density, water absorption capacity, swelling index, foaming capacity, Potential of Hydrogen, oil absorption capacity, gelation capacity and solubility of the flours differed, while the products had variable degree of acceptability. The standardized recipes will ensure products of predictable quantity and quality.*

KEY WORDS: functional properties, sensory properties ‘chin-chin’, bread, biscuit, composite flour

INTRODUCTION

Malnutrition is on the increase in Nigeria, especially Nutrition-related Non-Communicable Diseases (NCDs) and calls for behavioral change in the dietary habits of individuals throughout the life span. Under nutrition arising from hunger is also on the rise. According to the survey conducted by the Food and Agriculture Organization of the United Nations, the International Fund for Agricultural Development (IFAD), the United Nations Children’s Fund, the World Food Programme (WFP) and the World Health Organization (WHO), eradicating total hunger by 2030 might not be achieved because the number of people in the world affected by chronic food deprivation is on the increase from about 804 million in 2016 to about 821 million in 2017 [1]. In Africa, sub-Saharan Africa has the highest prevalence of hunger estimated at 23.2%. This figure shows that one out of four people in the region is suffering from chronic food deprivation in 2017. As of 2017, Sub –Saharan Africa had the highest number of undernourished people in Africa [1]. To fight this menace, indigenous foods must be employed leveraging on their nutritional advantages. The use of indigenous raw food materials as against highly refined staples and also

the appropriate combination of legumes, cereals and or starchy fruits/roots and tubers have been proposed as ways of improving food use for sustainable food and nutrition security [2].

Food and nutrition security can only exist when everyone have physical, social and economic access to food at all times, the food should be cooked in such a way that the nutrients are conserved or enhanced so that dietary needs of the consumers will be met. It will be imperative to add variety to the methods of preparation to meet food preferences. The environment where the food is prepared and consumed should be well sanitized. The health services and care are not left out in ensuring a healthy lifestyle [3].

Indigenous raw foods like African yam bean, cocoyam and biofortified potatoes can go extinct and are cited as some of the underutilized crops or development opportunity crop in Nigeria [4,5]. Neglected indigenous crops are staple crops recognized in the regions where they are grown because they are not traded around the world, as a result, they are lesser known and receive little or no attention globally. Most times, developing countries rely on these crops to alleviate poverty and hunger [6]. Underutilized crops are more easily adapted to their origin of cultivation than most crops of economic importance. They can withstand drought and other harsh environmental conditions. To withstand the stressful environment, they develop a lot of secondary metabolite to adapt [7]. Non-inclusion of the under-utilized crops in the diet contributes to food insecurity, especially in sub-Saharan Africa. There is a need for crop diversification to meet the increasing population growth and food demand in sub-Saharan Africa [8]. The diversified crops when used in preparing varietal diets will help improve food systems. Therefore, the reintroduction of these plants to the system by adding value to them is imperative, but before then, the problems that made them under-utilized needs to be identified and dealt with. The problems that lead to their limitations can be due but not limited to inadequate availability as a result of inefficiency in production, storage, processing and inadequate baseline data on their preparation method [9]. Processing of most of these underutilized crops is usually through undocumented traditional methods [10]. Recipes for food preparation vary from individuals, families, communities, tribe, and religion, among others. There is a need for standardization of the diet. In addition, there is need to process these crops into flour to extend their shelf life as farmers might not have a cool storage system that can keep these crops [11]. This study seeks to standardize these by processing AYB, OFSP, plantain, maize and cocoyam to flour, determine the functional properties of the flour; combine the flours to make 'chin-chin', bread and biscuit and determine the acceptability of the products.

Preparation of African Yam Bean (AYB) flour.

The method used has been described in Aburime, Ene-Obong and David-Oku [12]. Cream coloured AYB seeds were sorted to remove impurities and weighed. The sorted AYB (20kg) was washed and fermented in citric acid medium (0.5%) for 24 hrs at room temperature (28°C) in a ratio of 1:4 (w/v). At the end of the fermentation, AYB seeds were washed and divided into two. One-half of the fermented portions dehulled, while the remaining were left whole. They were dried (4 hrs) using a food dehydrator (40-70 °C) and milled into fine flour and stored in an airtight container and refrigerated until needed for chemical analysis and product development.

Preparation of plantain flour

A slight modification of the method described by Adebayo-Oyetoro, Ogundipe and Adeeko [13] was used in preparing the plantain flour. Green matured plantain fruits were washed, peeled, and sliced into a thin thickness (2cm) and then dried in a food dehydrator (40- 50°C) for 24hr and hammer milled into fine flour. The flour was sealed in polyethylene bags and stored in a refrigerator for further uses.

Preparation of Cocoyam (*Xanthosoma sagittifolium*) flour.

A slight modification of the method described by Okpala, Okoli and Udensi [14] was used to prepare the cocoyam flour. Matured cocoyam tubers were washed, peeled, and sliced (2 cm) and dried in a food dehydrator (50°C) for 48hrs and milled into fine flour. The flour was sealed in polyethylene bags for further use.

Preparation of maize flour

Using the traditional method of fermenting maize. Sorted maize grains were washed and fermented in tap water for 24hrs at room temperature (28°C) in a ratio of 1:3 (w/v). At the end of fermentation, the grains were washed, drained, and dried for 24hrs using a food dehydrator (40-50°C) and milled into fine flour.

Preparation of Orange-fleshed sweet potatoes (*Ipomoea batatas*) flour.

Using a modified method described by Rangel *et al* [15], Matured OFSP tubers were washed, peeled and sliced (2 cm) and dried using a food dehydrator (40-50°C) for 48hrs; milled into fine flour and sealed in polyethylene bags for further uses.

Functional properties determination

Bulk density (BD)

The bulk density of the flours was determined using the method as described by [16].

Procedure

The bulk density was done by passing the test flour through a sieve with apertures equal to 1.0 mm, 100g of the flour sample (M) weighted with 0.1% accuracy was gently introduced into a dry graduated cylinder of 250 ml, the unsettled apparent volume (V0) was read to the nearest graduated unit.

Water absorption capacity

The water absorption capacity of the flours was determined using the method described by International Code Council [17] . One gram of sample was mixed with 10 mL distilled water and allowed to stand at ambient temperature (30 ± 2°C) for 30 min, and then centrifuged for 30 min at 3000 rpm.

The volume of free liquid was measured and retained liquid expressed as ml of water.

Swelling index (S.I)

The swelling index was determined using the method described by Okaka and Potter [17]. Ten gram (10g) of the flour was dispensed in a calibrated 100ml measuring cylinder, 10mls of distilled water was added and the volume was noted. This cylinder was left to stand undisturbed for 1hr. The volume which the sample then occupied was recorded. The swelling index was determined by calculation as follows:

Calculation

Swelling index= v_2/v_1 ; Where v_1 = initial volume occupied by the sample , v_2 =volume occupied by the sample after swelling

Gelation-properties

This was determined according to the method described by Coffmann and Garcia [18]. Sample solutions of 2-20% (w/v) were prepared in 5ml distilled water in test tubes. The sample test tubes were heated for 1 hour in a boiling water bath followed by rapid cooling under running cold tap water. The tubes were later cooled at 4^oC for 2hrs. The gelation capacity is the least concentration determined as the concentration when the sample from the inverted test tubes will not fall or slip.

The foaming capacity (FC)

The FC of the flour samples was determined using the method as described by Narayana and Narasinga [19]. One-gram (1g) flour sample was added to 50 mL distilled water at 30 ± 2°C in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The volume of foam at 30 sec after whipping was expressed as foam capacity using the formula:

$$\text{Foam capacity} = \frac{\text{Volume of foam AW} - \text{Volume of foam BW}}{\text{The volume of foam BW}} \times 100$$

Where, AW = after whipping, BW = before whipping.

The volume of foam was recorded one hour after whipping to determine foam stability as per percent of initial foam volume.

Oil absorption capacity

The oil absorption capacity was determined by mixing one gram of the sample with 10 ml of soybean oil (Sp. Gravity 0.9092) and allowed to stand at ambient temperature (30 ± 2°C) for 30 min, then centrifuged for 30 min at 300 rpm. The supernatant was discarded, the tube and its content were then re-weighed. The gain in mass expressed as a percentage of oil bound is the oil absorption capacity of the sample.

pH

The pH was measured by making a 10% w/v suspension of the sample in distilled water. The suspension was mixed thoroughly in a Sorex blender and the pH was measured with a Hanna checker pH meter (Model HI 8314.) after calibrating the pH meter with buffer 4 and 7. (The pH

electrode was rinsed with demineralized water, and dried with tissue paper before putting it into the sample). The pH meter reading was taken when the display became stable.

Product development

The quest to use composite flours from legumes, cereals, roots and tubers/starchy fruits for products with better nutrient quality leveraging on their comparative nutrient advantage(s) informed the combination of AYB (the principal food material), corn, cocoyam, wheat, plantain and orange fleshed sweet potatoes. A pilot study was conducted using a six-member trained panelist to check the suitable ratio for the combination of the flour and the following combination was deemed suitable. Since AYB was the crop of interest, 70% of its flour was used

The composition of flours and composite flours used for the preparation of bread

Wheat bread (control) ----- 168g wheat flour

Wheat & whole AYB bread ----- 118g wheat flour, 50g whole AYB flour

Wheat & dehulled AYB bread ----- 118g wheat flour, 50g dehulled AYB flour

Wheat & cocoyam bread ----- 118g wheat flour, cocoyam flour

Wheat & corn bread ----- 118g wheat flour, 50g corn flour

Wheat & plantain bread ----- 118g wheat flour, 50g plantain flour

Bread

A modification of the recipe described by Ceserani and Kinton was used.

Bread was made from wheat flour (control), whole AYB and wheat flour (30:70), dehulled AYB flour and wheat flour (30:70), wheat and cocoyam flour (70:30), wheat and plantain flour (70:30) and wheat and corn flour (70:30).

Recipe for the bread

Ingredients	Quantity (g)
Wheat flour	118
Composite flour	50
Margarine	8
Yeast	5
Water	100
Salt	0.25
Yield	250

Method of preparation

- i. The flour was warmed slightly and sifted with the salt into a warm bowl.
- ii. The yeast was creamed with tepid water
- iii. A well was made in the middle of the flour; the creamed yeast was poured in, a little flour was sprinkled on it and left in a warm place until it bubbled and broke through the flour.
- iv. It was mixed together with the hand; water was added until a soft elastic dough was formed.

- v. The dough was beaten by hand until it came away from the sides of the bowl readily and cleanly.
- vi. The dough was turned on to a lightly floured pastry board and kneaded with a firm steady motion.
- vii. The dough was returned to a floured bowl (A bowl sprinkled with flour). It was covered with a slightly dampened cloth to prevent a skin forming. It was kept in a warm place to proof until it doubles its bulk. This took about 1 hour.
- viii. The risen dough was transferred onto a floured pastry board and again kneaded lightly
- ix. The dough was put into greased, warmed bread tins.
- x. It was kept in a warm place to proof for 25 minutes
- xi. It was baked in a hot oven (230-250°C) the heat was reduced after 5 minutes and allowed to bake for another 5 minutes.

Biscuit

Biscuit was prepared using wheat flour (Control), whole and dehulled flours AYB flours, whole and dehulled

The composition of flours and composite flours used for the preparation of biscuits

100% Wheat (control) ----- 83g wheat flour

Whole AYB biscuit ----- 83g whole AYB flour

Whole AYB and cocoyam biscuit ----- 58g whole AYB flour and 25g cocoyam flour

Whole AYB and corn biscuit ----- 58g whole AYB flour and 25g corn

Whole AYB and plantain biscuit ----- 58g whole AYB flour and 25g plantain flour

Dehulled AYB biscuit ----- 83g dehulled AYB flour

Dehulled AYB and cocoyam biscuit ----- 58g dehulled AYB flour and 25g cocoyam flour

Dehulled AYB and corn biscuit ----- 58g dehulled AYB flour and 25g corn flour

Dehulled AYB and plantain biscuit ----- 58g dehulled AYB flour and 25g plantain flour

Recipe for biscuit

Ingredients	Quantity (g)
AYB flour	58
Composite flour	25
Cinnamon flavour	0.4
Canderel zero calorie sweetener	0.3
Water	15
Yield	100

Method of preparation

- i. The flour, cinnamon flavor and salt were sifted, sweetener was added and mixed thoroughly
- ii. Margarine was rubbed in
- iii. Water was added

- iv. All the ingredients were mixed to a smooth paste
- v. The mixture was rolled on a floured table and cut to a round shape of ½ cm in thickness
- vi. The cut dough was placed on a lightly greased baking sheet and was marked into the desired size and pricked with a fork
- vii. It was baked in a hot oven for (230 -250⁰C) for 15 minutes.

“Chin-chin”

“Chin-chin” was made from dehulled AYB and OFSP (50;50) and dehulled AYB and OFSP (70:50). The traditional method of preparing “chin-chin” was used

The composition of flours and composite flours used for the preparation of “chin-chin”.

Wheat ‘chin-chin’ (control) ----- 127g wheat flour

Dehulled AYB & OFSP ‘chin-chin’ (70:30) - 89g dehulled AYB flour & 38g OFSP flour

Dehulled AYB & OFSP ‘chin-chin’ (50:50) – 63.5g dehulled AYB flour & 63.5g OFSP flour

Recipe for the preparation of “chin-chin”

Ingredients	Quantity (g)
AYB Flour	63.5
Composite flour	63.5
Margarine	27
Cold Water	42
Salt	0.14
Egg	5
Vegetable oil	23
Cinnamon flavour	3
Yield	270

Method of preparation

- i. The flour and salt were mixed and margarine was rubbed in
 - a. Sugar was dissolved in water and added to the flour mixture, beaten eggs were added
- ii. The mixture above (1&2) was mixed to a fairly stiff dough, then turned on a floured table and roll out
- iii. It was kneaded gently and doubled turned and allowed to rest for 5 minutes
- iv. The dough was given three more double turns and allowed to rest for 5minutes
 - v. It was rolled out and cut into cubes and was allowed to rest for 5 minutes
 - vi. Oil was heated in a deep pan till hot.
 - vii. The cut dough was deep fried till golden brown in colour

Sensory evaluation

The sensory evaluation was carried out using the methods described by American Society for Testing Materials [21,22]. Multiple comparison tests were done, using trained panelist at the preliminary stage to screen treatments and select the best ratio of flour to use for final product

development. After the products were developed, Consumer acceptability of the products was carried out using the Affective tests. The affective test is based on individual acceptability or preferences and involves the rating/acceptance test on a 9- point hedonic scale to determine the degree of acceptability of the new products

Description of method of test

This test involves an emotion for a stimulus, liking, acceptance or preference of a product over another. For a food product to be termed acceptable or successful in the market, consumers must prefer it over other products. Therefore, consumer panels often are used to indicate the preference of one sample over another. The panelist rates his or her preference for one of the samples on a specific quality on the score sheet. Hedonic rating scales were used to measure the degree of acceptability experienced with each sample. Sometimes, the frequency that a panelist might desire to eat the sample is measured to determine the acceptability of the various samples [23]

Test panel

For the preliminary test, a six (6) member trained panelist who were familiar with sensory test were selected to evaluate the products to enable the researcher to select the best ratio of flour, recipe and methods to be used for the final product development. After the products were developed using the best ratio and method of preparation, a thirty-member untrained panelist consisting of staff and students at the University of Calabar was engaged to evaluate the sensory characteristic of the products. The test procedure was explained to the panelist until they became familiar with the test format, the meaning of the scale, and the fact that some of the products were entirely new. It was also indicated to the subjects that some of the test samples may be the same as the control, while some might be different.

Test environment

Panelists were seated individually in a well-ventilated room to reduce odour build up. The room was well lighted to permit visual cues to contribute to the assessment. Subjects were not allowed to communicate to avoid influence. The doors were separated to ensure a separate entrance and exit. This is to avoid any communication that could interfere with the test result

Procedure for consumer test

The biscuits, bread and “chin-chin” were displayed for sensory evaluation on separate days. In this evaluation, a 30-member panelist (each diet) was selected to rate the sample on a 9- point hedonic scale, where 1 represents lowest and 9 represents the highest for colour, consistency, flavour, texture and general acceptability. The products were presented separately on separate days in an appropriate food warmer and coded. On arrival, the judges were served a coded product using a side plate. An evaluation form was also given immediately to each of the judges. A glass of water was given to rinse the mouth after each tasting; this is to avoid a carryover taste from preceding samples.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 20.0 computer was used to analyze the data. Means was used to analyze the continuous variables and standard deviations were calculated to show the statistical variability. Descriptive statistics was performed and the generated means were compared using the least significant ($P < 0.05$) difference (LSD).

RESULT

Functional properties of the flours

Table 1 presents the functional properties of wheat flour and other flour samples used in this study. Loose packed density (LPD) of the flours varied significantly from wheat (0.62) flour ($P < 0.05$), except the wheat and corn composite flour (0.64g/ml) which had the highest value among the treated sample while 100% whole AYB had the least value (0.42g/ml). Wheat and corn composite flour had the highest Packed Bulk Density (PBD) value ($P < 0.05$) of 0.81g/ml while dehulled AYB and potatoes composite flour had the least ($P < 0.05$) value of 0.58g/ml. Water Absorption Capacities (WAC) of the flours all varied significantly ($P < 0.05$) from the 100% wheat flour (1.56g/g) ($P < 0.05$). It ranged from 1.28g/g in wheat and corn composite flour to 4.18g/g in 100% whole AYB flour. Swelling index (SI) of the flour followed the same trend with WAC except that 100% wheat and corn flour (1.59) had the least but comparable ($P > 0.05$) value with 100% wheat flour (1.64) while other flours had significantly different values (2.27- 4.97). Whole AYB had significantly ($P < 0.05$) the highest SI value compared to all other flour samples. Similarly, 100% whole AYB flour had the highest value (16%) for Gelation Capacity (GC) while whole AYB and cocoyam composite flour had the lowest value (8.67%). All the flours were significantly different from 100% wheat flour (11.40%).

The foaming capacity (FC) of the composite flours varied from the wheat flour which also had the highest value (13.62%). The FC values of 100% whole AYB flour and the composite flours ranged from 9.57% in dehulled AYB and potatoes composite flour to 13.02% in wheat and corn composite flour. The solubility of the flour followed contrary trend with other functional properties as 100% whole AYB flour (8.54%) had the least significant ($P < 0.05$) value while 100% wheat flour had the highest 11.92%) significant ($P < 0.05$) value from other flour samples. Whole AYB and plantain composite flour and whole AYB and cocoyam composite flour had similar Potential of Hydrogen (pH) value of 6.6 which is comparable ($P > 0.05$) to that of 100% wheat flour (6.7).

The pH values of the composite flours varied significantly ($P < 0.05$) from 100% wheat flour with 100% whole AYB flour having the least pH value of 5.4. The Oil Absorption Capacity (OAC) of whole AYB and cocoyam composite flour (1.67) was significantly ($P < 0.05$) higher than all other samples. Dehulled AYB and plantain composite flour had the least (1.25) OAC. All other composite flour samples had comparable OAC value with that of 100% wheat flour (1.44). The Gelation Temperature (GT) of 100% wheat flour (60) was significantly ($P < 0.05$) lower than all other flour samples except that of wheat and corn composite flour. Whole AYB and plantain

composite flour (81) had the highest GT which is comparable ($P>0.05$) to the GT of dehulled AYB and potatoes composite flour (79) but significantly ($P<0.05$) different from other flour samples.

Table 1: Functional properties of 100% wheat, 100% AYB and the composites from wheat, whole and dehulled AYB, cocoyam, wheat, orange fleshed sweet potatoes, plantain, and corn flours

	Wheat (100)	DPL (70:30)	WPL (70:30)	WTCO (70:30)	WCO (70:30)	WAYB (100)	DPO (50:50)
LPD (g/ml)	0.62 ±0.00 ^a	0.54 ±0.00 ^b	0.51±0.00 ^b	0.64 ±0.00 ^a	0.49 ±0.00 ^b	0.42 ±0.00 ^c	0.48±0.0 ^b
WAC (g/g)	1.56 ±0.02 ^e	2.47 ±0.02 ^b	2.16 ±0.01 ^c	1.28±0.02 ^f	1.9 ±0.12 ^d	4.18 ±0.02 ^a	2.08±0.02 ^c
SI	1.64±0.01 ^e	2.37±0.02 ^d	2.27 ±0.03 ^d	1.59 ±0.01 ^e	2.64±0.01 ^c	4.79 ±0.01 ^a	3.15±0.01 ^b
GC (%)	11.40±0.64 ^e	10.67±0.94 ^d	12 ±0.0 ^c	12 ±0.00 ^c	8.67 ±0.94 ^f	16 ±0.00 ^a	13 ±1.0 ^b
FC (%)	13.62±0.57 ^a	10.75 ±1.24 ^d	10.69 ±0.04 ^d	11.7 ±0.03 ^c	13.02±0.3 ^b	12.62±0.12 ^b	9.57±0.03 ^e
pH	6.7 ±0.03 ^a	6.2 ±0.01 ^b	6.6 ±0.01 ^a	6.2 ±0.00 ^b	6.6 ±0.01 ^a	5.4 ±0.0 ^c	6.1 ±0.00 ^b
OAC	1.44 ±0.02 ^b	1.25 ±0.02 ^c	1.44 ±0.01 ^b	1.37±0.01 ^b	1.7 ±0.02 ^a	1.46 ±0.0 ^b	1.35±0.01 ^{bc}
GT (°C)	60±0.79 ^d	74 ±0.47 ^b	81 ±1.00 ^a	63±0.00 ^{cd}	76 ±1.69 ^b	65 ±0.25 ^c	79 ±1.0 ^a

*Means of 3 replicates. Values are expressed as mean ± S.D. ^{a-c} values with different superscripts on the same row are significantly different ($P<0.05$).

DPL—Dehulled AYB and plantain flour (70:30), WPL--whole AYB and plantain flour (70:30), WCO-- whole AYB and cocoyam flour (70:30), DPO- Dehulled AYB and sweet potatoes flour (50:50), WTCO--- Wheat and corn flour (70:30). LPD---- Bulk Density, , SI—Swelling Index, FC---Foam Capacity, GC- Gelation Capacity, P^H- Potential Of Hydrogen, OAC- Oil Absorption Capacity, GT- Gelation Temperature

Sensory characteristics of bread from wheat, wheat composites flours (70:30) of AYB, cocoyam, corn, and plantain.

Table 2 presents the sensory characteristics of bread from wheat, wheat composites flours (70:30) of AYB, cocoyam, maize, and plantain.

Bread made from composites of wheat and corn compared favourably with the control (wheat bread) in all the measured parameters of aroma (7.10), colour (8.07), taste (6.80), texture (7.07) and general acceptability (7.01). The Bread made from wheat and AYB composites had significantly ($P<0.05$) the lowest score for aroma (4.59), taste (3.48) texture (5.87) and general acceptability (3.90). Colour (6.03), taste (4.81), and texture (5.87) scores for wheat and dehulled AYB composite bread were statistically ($P<0.05$) higher than those of wheat and whole AYB composite bread.

Table 2: Sensory characteristics of bread from 100% wheat, wheat composites flours (70:30) of AYB, cocoyam, corn and plantain

Products	Aroma	Colour	Taste	Texture	General acceptability
Wheat bread	7.00±1.46 ^a	7.93±1.05 ^a	6.90±1.30 ^a	7.77±1.07 ^a	7.07±1.62 ^a
Wheat and whole AYB bread (70:30)	4.59±1.92 ^c	5.83±1.79 ^{±c}	3.48±1.90 ^c	5.46±1.99 ^b	3.90±2.40 ^b
Wheat and dehull AYB bread (70:30)	4.97±1.80 ^c	6.03±1.52 ^b	4.81±2.12 ^b	5.87±1.80 ^b	4.61±2.08 ^b
Wheat and cocoyam bread (70:30)	6.03±1.82 ^b	5.40±2.04 ^c	5.63±1.67 ^b	5.87±2.09 ^b	4.80±2.02 ^b
Wheat and corn bread (70:30)	7.10±1.52 ^a	8.07±1.23 ^a	6.80±1.79 ^a	7.07±1.68 ^a	7.01±2.16 ^a
Wheat and plantain bread (70:30)	5.10±2.11 ^c	5.10±2.19 ^c	5.50±1.59 ^b	5.87±1.96 ^b	4.93±2.21 ^b

*mean of 30 panelist response on a 9-point hedonic scale with 9 = like extremely to 1 = dislike extremely. ^{a-d} values with different superscripts on the same column are significantly different ($P < 0.05$). Sensory Scores/rating 1. Dislike extremely, 2. Dislike very much, 3. Dislike moderately, 4. Dislike slightly, 5. Neither like nor dislike 6. Like slightly 7. Like moderately 8. Like very much, 9. Like extremely

Sensory characteristics of biscuits made from 100% wheat, 100% AYB, AYB composites of cocoyam, corn, and plantain flours.

Table 3 presents the sensory characteristics of biscuits made from wheat, AYB, cocoyam, corn and plantain flours. The biscuits made from dehulled AYB and its composites had comparable ($P > 0.05$) value for aroma with the biscuit made from 100% wheat flour (7.27). The biscuits made from 100% whole AYB flour had the least value for aroma (5.97). Among the developed biscuits, the one made from dehulled AYB and plantain composite flours had the best value (7.17) for colour. This value was statistically similar (7.63) to biscuit made from 100% dehulled AYB flour (7.07) and biscuit from dehulled AYB and cocoyam composite flours (7.00). Biscuit made from Whole AYB and corn composite flours had the least value for colour (5.90), texture (5.90), taste (5.30) and general acceptability (5.29). Biscuit made from Dehulled AYB and plantain composite flours had the best significant ($P < 0.05$) value for taste (6.80). The texture of the biscuits was similar ($P > 0.05$) (except that made from AYB and corn flour) to that of the control. The only biscuit that was comparable ($P > 0.05$) to wheat biscuit (7.70) in terms of the general acceptability was the biscuit made from dehulled AYB and plantain composite flour (6.77).

Table 3: Sensory characteristics of biscuits made from wheat, AYB, and AYB & cocoyam (70:30), AYB & corn (70:30) and AYB & plantain (70:30) composite flours.

Products	Aroma	Colour	Taste	Texture	General acceptability
Wheat biscuit	7.27±1.62 ^a	7.63±1.65 ^a	7.53±1.72 ^a	7.43±1.43 ^a	7.70±1.58 ^a
Whole AYB and cocoyam biscuit	6.03±1.81 ^b	6.43±1.69 ^b	5.97±2.16 ^{cd}	7.17±1.07 ^a	6.00±2.12 ^{bc}
Whole AYB and corn biscuit	6.20±1.54 ^b	5.90±1.33 ^c	5.03±1.84 ^e	5.90±1.49 ^b	5.37±1.88 ^c
Whole AYB and Plantain biscuit	6.23±1.47 ^b	6.67±1.73 ^b	5.70±2.36 ^{cd}	6.93±2.23 ^a	5.97±2.248 ^{bc}
Dehulled AYB biscuit	6.57±1.52 ^{ab}	7.07±1.27 ^{ab}	6.13±1.92 ^{cd}	7.33±1.31 ^a	6.47±1.65 ^b
Dehulled AYB and cocoyam biscuit	6.67±1.55 ^{ab}	7.00±0.98 ^{ab}	5.77±1.55 ^{cd}	7.27±1.69 ^a	6.17±1.85 ^{bc}
Dehulled AYB and corn biscuit	6.67±1.82 ^{ab}	6.70±1.39 ^b	6.10±2.22 ^{cd}	6.97±1.53 ^a	5.27±2.06 ^c
Dehulled AYB and plantain biscuit	6.80±1.90 ^{ab}	7.17±1.82 ^a	6.80±1.99 ^b	7.53±1.47 ^a	6.77±2.59 ^{ab}

*mean of 30 panelist response on a 9-point hedonic scale. ^{a-d} values with different superscripts on the same column are significantly different (P< 0.05). Organoleptic Scores/rating 1. Dislike extremely, 2. Dislike very much, 3. Dislike moderately, 4. Dislike slightly, 5. Neither like nor dislike, 6. Like slightly, 7. Like moderately, 8. Like very much, 9. Like extremely

Sensory characteristics of “Chin-chin” made from wheat (100%), dehulled AYB and potatoes (50:50) and dehulled AYB and OFSP (70:30) composite flours

Table 4 presents the Sensory characteristics of “chin-chin” made from wheat (100%), dehulled AYB and potatoes (50:50) and dehulled AYB and potatoes (70:30)

Apart from the general acceptability, “chin-chin” made from the composite flours and the control (wheat) all differed significantly (P<0.05) from one another in all the parameters measured. “Chin-chin” made from dehulled AYB and potatoes composite flour (70:30) was statistically (P>0.05) similar to the ‘chin-chin’ made from wheat flour (7.70 and 7.87 respectively). On all other parameters (aroma, colour, taste & texture) wheat “chin-chin” had the highest score. This was followed by the “chin-chin” made from dehulled AYB and potatoes composite flour (50:50).

TABLE 4: Sensory characteristics of “Chin-chin” made from wheat (100%), dehulled AYB and OFSP (50:50) and dehulled AYB and OFSP (70:30) composite flours

Products	Aroma	Colour	Taste	Texture	General acceptability
Dehulled AYB and potatoes “chin-chin” (50:50)	7.03±0.95 ^b	6.97±1.47 ^b	6.53±2.32 ^b	6.37±2.21 ^b	7.70±2.63 ^a
Dehulled AYB and potatoes “chin-chin” (70:30)	5.03±1.79 ^c	6.23±1.25 ^c	5.13±1.55 ^c	5.47±1.81 ^c	5.33±1.92 ^c
Wheat “chin-chin”	7.53±0.90 ^a	7.63±0.77 ^a	8.20±0.76 ^a	7.87±1.54 ^a	7.87±1.25 ^a

*mean of 30 panelist response on a 9-point hedonic scale. ^{a-d} values with different superscripts on the same column are significantly different (P< 0.05). Organoleptic Scores/rating 1. Dislike extremely, 2. Dislike very much, 3. Dislike moderately, 4. Dislike slightly, 5. Neither like nor dislike, 6. Like slightly, 7. Like moderately, 8. Like very much, 9. Like extremely

DISCUSSION

In this study, functional properties were used to determine or describe the behaviour of the flours during preparation and cooking and also predict how they will affect the finished products in terms of appearance, taste and texture [24].

The lower bulk density values of AYB composite flours implies that less quantity these flour samples would be packaged in constant volume thereby ensuring an economical packaging [25]. Nutritionally, low bulk density promotes easy digestibility of food products, particularly among children with weak digestive system [26].

The differences observed in the WAC of the flours showed that the flours have a variable degree of availability of water binding sites among the starches and also indicates different protein concentration and their degree of interaction with water [27]. This might also be due to various factors such as the particle size of the flour and molecular structure [28]. The water absorption capacity observed in most of the flours (except wheat and corn composite flours (WTCO) showed that they can be used for baking more variety of products. The observed values were higher than the values observed for wheat flour and other flours made from plantain, sweet potatoes among others [29; 30]. They can also be used as thickeners because they can absorb water and swell for improved consistency in food [31]. The WAC in whole AYB flour was higher than those reported for fermented maize used for gruel. Reports have shown that flours with high WAC may not be able to keep well because WAC is an indication of the maximal water which foods can absorb and retain [32]. So proper storage of such flours should be ensured. On the other hand, all the studied AYB and AYB composite (cocoyam, plantain and OFSP) flours had higher WAC and lower solubility value from that of wheat and this indicates that care must be taken when dissolving it in water to avoid the formation of lumps, since WAC and solubility of flours are associated with the ability of flours to disperse in aqueous solution and the vicious load that is likely to be encountered during the mixing of the flours. So, care should be taken in reconstituting the AYB flours and AYB composite (cocoyam, plantain and OFSP) flours in water to avoid the formation of lumps [33].

Whole AYB flour had the highest Swelling Index, which indicates that the flour will combine well with other flours and can be used for the formation of variable products, because SI of flours suggests the level of crystalline packing of the starch granules, reflecting the extent of the association forces within the granules [34].

The high value observed in the GC of whole AYB flour was not surprising because it also had the highest SI and viscosity value. These parameters are good determinant for the increase in the energy density of the flours during cooking and the ability of the fluids to resist flow [35]. The GC is also an indication that lower flour concentration will be needed to form gel [36].

The FC of whole AYB and cocoyam composite flours compared well with wheat flour despite fermentation of the AYB flour prior to the combination with the cocoyam flour. This could be an advantage for combining the flours because fermentation is known to reduce the FC of flours [37]. Foaming properties of flours are important parameters in the food industry; good foaming capacity helps in maintaining the structure and texture of the products developed [38]. The foaming capacity of flours also indicates the rate at which the surface tension of absorbed air or water decreases as a result of protein molecule absorption during whipping or bubbling, and also its ability to form a cohesive viscoelastic film by way of intermolecular interactions [39]

The flours had similar pH values except for whole AYB flour which was more acidic, while others were near neutral. This is an indication that whole AYB flour will have better keeping quality as microbial growth will be inhibited. The flour will also have better flavour than its counterparts. This better explains why AYB fermented in citric acid solution had better flavour than its counterparts. Moreso, fermentation is known to lower the pH of its products [40]. As a result of this finding, the extension of storage life of the other flours with neutral pH may necessitate preservation that will aid reduction of water activity, and also adding chemicals that would antagonize the activities of micro-organisms [41].

The OAC observed in this study especially in whole AYB and cocoyam composite flour is an indication that the flours can bind fat physically by capillary attraction, therefore can enhance the flavour of the food, increase mouthfeel and act as flavour retainer, as well as giving soft texture to food [42]. The whole AYB and cocoyam composite flours can be added to foods to help retain flavour. This might have been the reason behind the higher acceptability of the pudding made from the flour.

The gelation temperature of the flours indicates the time and energy required to cook using the flour samples. Whole AYB and AYB composite (cocoyam, OFSP and plantain) flours will require higher energy and time to gelatinize the starch for food preparation than all other flours [42]. This is an important consideration in food preparation using this flour sample.

The most accepted score in terms of taste and general acceptability observed in this study for whole AYB and cocoyam pudding could be attributed to the high OAC observed for the composite flour over other composite flours used for the pudding. High OAC of flours is known to improve flavour and general acceptability of foods [44]. AYB and other composite flours produced bread of low acceptability and may not be considered suitable for bread. The consumer acceptability of 30% AYB flour is poor, researcher have recommended inclusion of 10% soya bean flour to wheat flour [45] this may also apply if AYB must be used for bread making.

The acceptability of biscuits made from dehulled AYB and plantain could be attributed to the textural quality of the biscuit and the paste stability of the flour [46]. The texture of food has a lot to do with the visual, audio, and tactile stimuli which influences the consumers' liking and preference of a food product [47]. The acceptability of the "chin-chin" made from dehulled AYB

and orange fleshed sweet potatoes flour in the ratio of 50:50 might be due to the percentage of OFSP to AYB flour and also the sweet taste and colour of the OFSP. 'chin-chin made from equal quantities of dehulled AYB and OFSP flours should be given attention in the food industry. OFSP is a biofortified potatoes that is rich in beta carotene a precursor of vitamin A which could help reduce vitamin A deficiency disorders like night blindness, this can easily be achieved in Africa especially in areas where the production is high [48,49].

The acceptability of the colour of almost all the products is encouraging as colour is an important parameter to consumers as initial quality of products can be assessed through their colour. Colour equally serves as a cue for the doneness of foods and is correlated with changes in aroma and flavour [50].

CONCLUSION

Indigenous raw foods like AYB, OFSP, plantain, cocoyam and corn were processed into fine flour using standard methods. Functional properties of the composite flours were compared with those of wheat flour. The result showed wide variability, and this provided a comparative advantage that aided their combination for better product outcome. These combined flours were used to develop different new products like bread, 'chin-chin' and biscuit. These products have shown mutable sensory attributes, likes and dislike. With the acceptability status of the products, consumers and food processors can make informed choices. Also, the outlined, tested, and retested methods of preparing these products can serve as standardized method of formulation for reproducibility.

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