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Effect of Soybean Addition on the Quality of Plantain-Based Biscuits

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ABSTRACT

The quality of plantain-based biscuits supplemented with soybean flour has been evaluated. Biscuit samples were obtained from plantain/soybean ratios (%) of 100: 0 (A) the control, 90: 10 (B), 80: 20 (C), 70:30 (D, 60:40 (E) respectively and 100 % wheat flour (F) was used as standard. The functional properties, proximate composition, physical properties of the biscuit samples were determined and sensory attributes evaluated using standard methods. Results showed significant difference (p<0.05) in water adsorption capacity and swelling index while no significant difference was observed in the foaming capacity and bulk density with increasing levels of substitution with soybean flour. Protein and fat content increased significantly in sample E (60:40) with the values of 15.99 and 6.27 respectively. Least values were recorded for sample A (100:0) as 3.22 and 1.94 respectively. Crude fibre and carbohydrate decreased with corresponding increase in soybean flour. Physical properties of samples showed that there was a significant difference (p<0.05) in spread factor diameter and thickness. They decreased with increase in soybean flour. There was no significant difference in the appearance and aroma between sample F and sample E in texture, taste and general acceptability. Sample B was the most preferred in all the attributes tested. It was therefore possible to prepare biscuits from plantain and soybean flour, which has potentials to be used as specialty food for celiac, diabetic and obsessed people.

Keywords
Biscuits, Plantain, Soybeans, Quality.

Introduction
Biscuits are ready to eat, cheap and convenient food products that is consumed among all age groups in many countries [1]. They are nutritive snacks produced from unpalatable dough that is transformed into appetizing products through the application of heat in the oven [2].

Wheat (*Triticumae sativum* Desf.) flour of both hard and soft category has been the major ingredient of baked products for many years because of its functional proteins. Wheat has to be imported, since the climatic conditions and soil types in most developing countries do not permit its cultivation. As a result of this problem, there has been constant importation of wheat which has adverse effect on balancing trade. For this reason, the FAO and developing countries have the interest of replacing the wheat needed for making baked goods and pasta, wholly or partially with flour from other products [3].

Food compositing especially in the flour industry has proved to add essential micronutrients such as vitamins, minerals elements and macronutrients to food products and has been practiced in many countries for long with considerable success. It is an effective, affordable means to improve socio–economic development, which eradicates most of the vitamin and mineral deficiencies when these composite products are accepted by the populations for which they are processed. According to United States Department of Agriculture [4], Nigeria imported 4.1 million metric tonnes of wheat in as far back as 2011. Literature report by Nwosu et al. [5] revealed that, wheat importation increased from 3600 tones/annum in 1934/38 to over 4 million tonnes in 2010, which declined slightly to 3.9 million in 2012. With the 13% annual growth rate, it is estimated that wheat importation into Nigeria could reach 17 million tonnes/annum by 2020 [6]. Several researchers have attempted producing baked products such as biscuits and bread from wheat less composite flours with properties that compared favourably with baked products of wheat flour. Ohimain [7] prepared biscuits from flour blends of unripe cooking banana, pigeon pea and sweet potato. The author compared the physical, chemical and sensory properties of the blends with the wheat counterpart. Mesfin and Shimelis [8] produced bread from blends of soybeans, cassava and quality protein maize where the proximate composition of the blends was evaluated.

Soybean (*Glycine Max*) has undoubtedly attained a lofty status among the world food crops, owning to its high protein and oil contents. The usefulness of the grain legumes in developing high protein foods in meeting the needs of the vulnerable groups of the population is now well recognized and several high protein energy foods have been developed industrially in different parts of the world [9].

Plantain (*Musa paradisiaca*) is an important staple food in Central and West Africa. It is a basic food crop and cheap source of energy in Nigeria. Several food consumption surveys in Nigeria identified plantain among the major starchy staples [10]. According to Odenigbo [11], over 2.11 million metric tons of plantains is produced in Nigeria annually. An average plantain has about 220 calories and is a good source of potassium [12]. Plantain is rich in dietary fibre (8.82%), resistant starch (16.2%), and low in protein and fat [13]. Dietary fibre in human diets lowers serum cholesterol, reduces the risk of heart attack, colon cancer, obesity, blood pressure, appendicitis and many other diseases [14]. Rehinan et al. [15], it is rich in iron, vitamins, and minerals. This nutritious food is ideal for diabetics, children, and pregnant women. Plantain contains small amount of serotonin, which has the ability to dilate the arteries and improve blood circulation. Its regular consumption helps to prevent anaemia (low blood level) and maintain a healthy heart. It can also be a good supplement for marasmus patients [16]. Plantain flour has good potentials for use as a functional agent in bakery products on account of its high water absorption capacity and the use of plantain flour as base ingredient for production of baked goods would help to lessen our total dependence on imported wheat. Plantain is a cheap staple crop in Nigeria and has the potentials to be used in baking biscuits owing to its high water absorption capacity. However, it has low protein content. Nigeria being one of the tropical countries cannot grow wheat due to the country's climatic conditions; it has therefore become necessary to use local crops such as plantain which can either partially or completely substitute wheat in biscuit without adversely affecting its quality. Using plantain flour to bake biscuits can be beneficial for managing several health problems among target populations such as lowering serum cholesterol, reducing the risk of heart attack, colon cancer, obesity, blood pressure, and appendicitis as well as gluten intolerant (celiac) individuals. Protein malnutrition is widely recognised as a major health problem worldwide. The objective of this work was to formulate a composite biscuit with functional, chemical and sensory properties by the addition of soybean flour to plantain flour that can compare favourably with wheat flour biscuits.

Materials and Methods

Material Procurement

Unripe Plantain Fruits of 58.39 % moisture content and 0º Brix, soybean seeds, wheat and other baking ingredients such as eggs, baking powder, sugar, salt and fat were purchased from North bank market in Makurdi, Benue State Nigeria.

Sample Preparation

Soybean seeds were cleaned and sorted to remove foreign materials such as dust, dirt and immature seeds. The cleaned and sorted seeds were blanched in hot water at 90 ºC for 15 minutes and soaked in cold water for 24 hours after which the seeds were dehulled manually and dried at 50 ºC for 5 hours. The sample was milled with hammer mill and sieved through 400 µm sieve. Flour was wrapped in high-density polyethylene bags and stored in air tight containers at room temperature (27 ºC ± 2). The green plantain fingers (30 kg) were thoroughly washed with water, quickly peeled and sliced manually using a stainless steel knife. The pulp was subjected to drying for 6 hours at a temperature of 80 °C using hot air dryer immediately after peeling. After drying, the dried slices were milled with hammer mill (Bentall Superb, Model 200 L 09) and sieved through 400 µm mesh sieve. The plantain flour produced was packaged in high density polyethylene bags and stored until used for analyses and diet formulation. All analyses were carried out in duplicates.

Methods

Functional properties

Functional properties have been defined by Matil [17] as those characteristics that govern the behavior of nutrients in food during processing, storage and preparation as they affect food quality and acceptability. Some important functional properties that influence the utility of certain food are water absorption capacity, foaming stability, swelling capacity, oil absorption, viscosity, emulsion etc.

Bulk density (BD)

The bulk density was determined using the method described by Onwuka [18]. A graduated cylinder of 10 mL capacity was weighed. 2.5g of the sample was filled in a 10 mL graduated cylinder and its bottom was tapped gently on the laboratory bench until there was no decrease in volume of sample.

$$The\ bulk\ density\ (g/ml) = \frac{weight\ of\ sample\,(g)}{Volume\ of\ sample\ (ml)}$$

Water absorption capacity (WAC)

The water capacity of the flour blends was determined as described by Onwuka [18]. Sample weight of 1 g was weighed into a conical graduated centrifuge tube. Using a warring whirl mixer, the sample was mixed thoroughly with 10 mL of distilled water in a centrifuge tube for 30 minutes at 16000 rpm. The volume of free water (the supernatant) was read directly from the graduated centrifuge tube.

$$Mass = \frac{Density\ of\ water\ x\ Volume\ absorbed}{Weight\ of\ sample}$$

Foaming Capacity (FC)

The foaming capacity was determined using the method described by [19]. Two grams of sample was blended with 100 ml distilled water in a blender and the suspension was whipped at 1600 rpm for 15 minutes. The mixture was poured into a 250 ml measuring cylinder and the volume was recorded after 30 seconds. Foaming capacity is expressed as percentage increase in volume using the formula.

$$Foa\min g\ capacity = \frac{Volume\ after\ whipping\ - Volume\ before\ whipping}{Volume\ before\ whipping}\ x\frac{100}{1}$$

Emulsification Capacity (EC)

The method of [18] was employed. Sample weight of 2 g was weighed 25 ml of distilled water at room temperature for 30 seconds in a warring blender at 1600 rpm. 25 ml of vegetable oil was added after complete compression and blending continuous for another 30 seconds. The mixture was transferred into centrifuge tube at 1600 rpm for 5 minutes. The volume of the vegetable oil separated from the sample after centrifugation was read directly from the centrifuge tube.

$$Emulsification\ capacity = \frac{x}{y}\ x\ \frac{100}{1}$$

Where, x = height of emulsified layer, y = height of whole solution of the centrifuge tube.

Swelling Index

Swelling index was carried out based on the method described by [18]. Sample weight of 10 g was poured into a 10 ml cylinder and the volume it occupied was recorded. Distilled water was added to the 10 ml mark of the measuring cylinder and was allowed to stand for 45 minutes in a water bath maintained at 60 ^{o}C, after which the new volume was recorded. The ratio of the initial volume to the final volume gave the swelling index.

$$Swelling\ index = \frac{Change\ of\ \ volume\ of\ \ sample}{Original\ weight\ of\ \ sample}$$

Physical Characteristics of Biscuits

Biscuits characteristics were evaluated by measuring the weight, length, thickness, break strength and spread ration.

Diameter: Five biscuits were placed edge by edge. The total diameter was measured using a meter rule and the reading reported in millimeter (mm). Biscuits were then rotated at 90^0 for duplicate reading, the procedure was repeated for triplicate reading, and a mean value was taken.

Spread Ratio Determination: The spread ratio was determined by measuring the length and the height of three rows and column respectively of five biscuits. The spread ratio is calculated as diameter divided by height [20].

Spread Factor: Spread factor was determined from the diameter (D) and thickness using the formula D/T×CF×10. Where, D=diameter, T=thickness and CF=correction factor.

Break Strength: The break strength was determined by adapting Okaka and Isiel [21] method. Biscuit of known thickness was placed centrally between two parallel metals (3cm apart). Weights were added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

Weight of the Biscuit: The weight was determined using electronic weighing balance. (S2400ZP made in India).

Length: The length was measured using a venire caliper (Satt V-2, made in China).

Thickness: The thickness was also evaluated using a venire caliper (Satt V-2, made in China).

Proximate Composition

The biscuit samples were subjected to proximate analysis to obtain values for the moisture content, crude protein, crude fibre, crude fat and ash content following the procedures described by AOAC [22].

Sensory Evaluation

Coded samples biscuits were presented to (15) panelists. They were instructed to state the following attributes; appearance, flavor, texture, taste and overall acceptability of the products using a seven-point descriptive scale. Numerical scale used ranged from 7 (like extremely), 1 (dislike extremely) with 100% plantain flour and 100% wheat flour as a controls. The panelists were instructed to rate the attributes indicating their degree of liking or disliking by putting a number as provided in the descriptive scale according to their preference. Each panelist were provided with enough water to rinse their mouth in between taste and privacy to avoid biased assessment.

Results and Discussion

Functional properties of plantain and soybean flour blends

The water absorption capacity of the flours ranged from (1.96 -2.34%) with sample F (100% wheat) having the least value and sample B having the highest value. All the samples are not significantly different ($p \geq 0.05$), except for sample B and E. The major chemical composition that enhances the water absorption capacity of flours is carbohydrates and protein, since they contain hydrophilic parts such as polar or charged chains [23]. Water absorption capacity is important in bulking and consistency of products. In foaming capacity, there is a significant difference ($p<0.05$) except for sample E and F. sample B had the highest value, [24] reported that food ingredients with good foaming capacity can be used in baking products. The swelling index had no significant difference ($p \geq 0.05$) in all the samples except sample F having (100 %) wheat flour. Sample F had the highest value which shows that it is one of the criteria for good quality products, this report agrees with Wang and Ballington [25]. The bulk density is a very important parameter in the production of expanded and formed food products [26]. There was no significant difference ($p \geq 0.05$) in sample A, B and F and no significant

Table 1: Functional Properties of Plantain and Soybean Flour Blends.

Samples	WAC (g/ml)	Foaming capacity (g/ml)	Swelling index	Bulk density (g/cm^3)
A	2.08 ± 0.06^{ab}	10.82 ± 0.62^{c}	1.00 ± 0.20^{b}	0.83 ± 0.01^{a}
B	2.34 ± 0.07^{a}	15.28 ± 0.28^{a}	1.05 ± 0.05^{b}	0.80 ± 0.03^{a}
C	2.24 ± 0.02^{ab}	6.46 ± 0.21^{e}	1.25 ± 0.15^{b}	0.69 ± 0.02^{b}
D	2.26 ± 0.39^{ab}	6.84 ± 1.28^{d}	1.33 ± 0.03^{b}	0.63 ± 0.04^{b}
E	2.00 ± 0.06^{b}	13.46 ± 0.43^{b}	1.40 ± 0.10^{b}	0.62 ± 0.06^{b}
F	1.96 ± 0.01^{ab}	13.44 ± 1.37^{b}	6.50 ± 1.80^{a}	0.73 ± 0.10^{ab}
LSD	0.78	1.66	1.48	0.11

Values are means of triplicate determination ± standard deviation Means on the same column with the same superscripts are not significantly different at ($P \leq 0.05$). WAC=Water adsorption capacity.

Table 2: Proximate composition of Biscuits from Plantain and Soybean Flour Blends (%).

Samples	Moisture	Ash	Fat	Protein	Fibre	Carbohydrates
A	2.73 ± 0.15^{c}	1.73 ± 0.15^{a}	1.94 ± 0.01^{f}	3.22 ± 0.01^{f}	3.39 ± 0.01^{a}	87.37 ± 0.25^{a}
B	4.17 ± 0.15^{b}	1.47 ± 0.15^{bc}	2.41 ± 0.01^{d}	10.31 ± 0.01^{d}	3.19 ± 0.02^{c}	78.47 ± 0.31^{c}
C	5.00 ± 0.10^{a}	1.50 ± 0.10^{abc}	3.16 ± 0.01^{c}	14.07 ± 0.01^{c}	2.28 ± 0.02^{e}	73.40 ± 0.20^{d}
D	5.57 ± 0.06^{a}	1.63 ± 0.15^{ab}	4.91 ± 0.01^{b}	15.09 ± 0.01^{b}	2.92 ± 0.02^{d}	70.80 ± 0.10^{e}
E	5.10 ± 0.10^{a}	1.57 ± 0.15^{abc}	6.27 ± 0.01^{a}	15.99 ± 0.01^{a}	1.97 ± 0.01^{f}	68.73 ± 0.06^{f}
F	2.73 ± 0.06^{c}	1.37 ± 0.06^{c}	2.02 ± 0.01^{e}	10.56 ± 0.01^{d}	3.27 ± 0.02^{b}	79.63 ± 0.06^{b}
LSD	0.67	0.25	0.01	0.01	0.03	1.16

Values are means of triplicate determination ± standard deviation. Means on the same column with different superscripts are significantly different $P \leq 0.05$

Table 3: Physical Properties of Biscuits from Plantain andSoybean Flour Blends

Sample	Diameter	Thickness	Spread factor	Spread ratio	Weight
A	$50.38^{a} \pm 0.57$	$6.60^{ab} \pm 1.52$	$76.33^{b} \pm 0.04$	$8.62^{a} \pm 0.03$	$1.63^{b} \pm 1.48$
B	$50.00^{a} \pm 2.35$	$5.80^{b} \pm 0.84$	$86.21^{a} \pm 0.14$	$7.68^{b} \pm 0.06$	$12.11^{bc} \pm 2.08$
C	$48.00^{a} \pm 1.00$	$6.80^{ab} \pm 0.84$	$70.59^{c} \pm 0.06$	$7.63^{b} \pm 0.04$	$13.96^{a} \pm 0.96$
D	$49.20^{a} \pm 1.92$	$6.40^{ab} \pm 0.55$	$76.87^{b} \pm 0.03$	$7.06^{c} \pm 0.07$	$12.43^{bc} \pm 0.52$
E	$47.80^{a} \pm 1.92$	$6.80^{ab} \pm 0.84$	$70.29^{c} \pm 0.06$	$7.03^{c} \pm 0.04$	$14.38^{a} \pm 1.70$
F	$40.00^{b} \pm 2.00$	$7.80^{a} \pm 0.03$	$51.28^{d} \pm 0.02$	$5.13^{c} \pm 0.04$	$11.53^{c} \pm 0.79$
LSD	3.36	1.83	2.93	0.12	1.14

Values are means of duplicate determinations ± standard deviation. Means on the same column with the same superscripts are not significantly different at $P \leq 0.05$

Table 4: Means Scores of Sensory Evaluation of Biscuits from Plantain and Soybean Flour Blends.

Sample	Appearance	Aroma	Texture	Taste	General accptability
A	5.40a	5.47a	5.40ab	5.07bc	5.40ab
B	4.47a	5.27a	4.73ab	5.53ab	5.67ab
C	4.47a	4.93a	4.67ab	5.00bc	5.33ab
D	4.33a	4.87a	4.60b	4.87bc	4.93bc
E	5.00a	4.73a	4.80ab	4.40c	4.33c
F	5.40a	6.00a	5.67a	6.13a	6.13a
LSD	1.25	1.43	1.02	0.84	0.99

Values are means of duplicate determination ± standard deviation Means on the same column with the same superscripts are not significantly different at $P \leq 0.05$.

difference ($p \geq 0.05$) in C, D, E and F. Sample E had the least value of (0.62), The reduction in the bulk density is usually affected by the particle size and density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in the food industry [27].

Proximate composition of biscuit from plantain and soybean flour blends

The moisture content of the biscuits in sample C, D, and E, have no significant difference ($p \geq 0.05$) with the addition of soybean flour. Sample A having (100%) plantain flour is not significantly different from sample F having (100%) wheat flour but are both significantly different from other samples. Increase in sample D having the highest value of moisture content may be attributed to the increase in protein content which agrees with Okeke et al. [28]. The ash content ranged from 1.37 -1.73%. Sample A had the highest value which indicates that plantain is a good source of minerals compared to sample F. [29]. The fat content differed significantly and it increased with the addition of soybean flour. The protein content of the biscuits increased from (3.22-15.99 %) with increase in soybean flour. Hence, sample A had the lowest protein content which agrees with Adebowale et al. [30]. The fibre content ranged from 1.97- 3.39 %, also the samples are significantly different ($p<0.05$). Sample A has the highest value of crude fibre. This is an indication that when incorporated in human diet would help in lowering serum cholesterol, reduction of risk of heart attack, colon cancer, obesity, blood pressure and many other diseases as reported by Adebowale et al. [30]. In the carbohydrate content, there is a significant difference among the samples with increase in soybean flour and sample A having the highest carbohydrate content.

Physical properties of biscuit from plantain and soybean flour blends

The physical properties of biscuits samples are presented in Table 3. The diameter has no significant difference ($p \geq 0.05$) for all the samples except for sample F. The thickness has no significant difference except for sample D which is significantly different ($p \geq 0.05$) from sample F, the variation in the thickness could be attributed to the cutting process. In the spread ratio which is the function of the biscuits flow in the increase in volume of unbaked, stamped out dough after baking. The spread ratio decreased with increase in the proportion of soybean, sample B and C had no significant difference ($p \geq 0.05$), Sample D and E had no significant difference ($p \geq 0.05$), this result is in agreement with some other earlier works on biscuits from composite flours where the control (100 % plantain flour) stands out better than other blends [30, 31, 32]. In the weight, sample C and E had no significant difference ($p \geq 0.05$).

Means scores of sensory evaluation of biscuit from plantain and soybean flour blends

The mean scores for the sensory evaluation of the biscuits samples were as shown in Table 4. The most acceptable by the panellists is sample F which contains (100% wheat flour) followed by sample B. Sample E is the least acceptable with the addition of (40% soybean flour). For Aroma, the values ranged from 6.00 to 4.13 with sample A (100% wheat flour) having the highest value. There was no significant difference ($p \geq 0.05$) among the samples. The texture ranged from (5.67- 4.67) with sample F having the highest value and sample C having the least value. Sample A, B, C, E had no significant difference ($p \geq 0.05$).

Conclusion

In conclusion, the results of the study showed that acceptable biscuits could be produced from different blends of plantain and soybean flours which compare favourably with the wheat flour counterpart. However, 90% plantain flour with partial substitution to 10% level using soybean flour was most accepted. Biscuits production using this formulation can be a sure technique to encourage the use of local raw materials such as unripe plantain and soybean flour in other to reduce total dependence on wheat importation, in the same manner that 10% inclusion of cassava in bread has been approved by National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria.

The composite biscuits could as well serve as additional source of ash (minerals), protein and dietary fibre, solving any challenge that may be posed by diabetic diets that require high fibre and protein, low sugar and starch. Composite flour from soybean and plantain can be used to manufacture baked products such as biscuits for special people which include; celiac patients, diabetic and obese individuals. This type of biscuits formulated from 90% plantain flour by partial substitution of 10% (sample B) level with soybean flour should be encouraged in other to increase the nutritional content of biscuits for celiac patients.

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