Original Research Article

EVALUATION OF MACRONUTRIENTS, FUNCTIONAL PROPERTIES OF COMPOSITE FLOUR AND SENSORY PROPERTIES OF THE DEVELOPED BISCUITS

ABSTRACT

Aim: This study evaluated the macronutrients, functional properties of composite flour and sensory properties of biscuits made from the blends of composite flour.
Study design: This study is an experimental study.
Place and Duration of Study: Department of Food Engineering, Faculty of Engineering and Technology, Ladoke Akintola University of Technology, Ogbomoso, Oyo state, Nigeria.
Methods: African yam bean seeds and bambara groundnut were sorted, soaked, dehulled, dried, milled and sieved while soybeans were boiled after the unit operation. 70: 30% was used for composite flour while 100% wheat flour was used as control. Proximate composition and functional properties were determined on formulated flour, physical and sensory attributes were evaluated on biscuits. Data obtained were statistically analyzed by Analysis of Variance (ANOVA) and means were separated using Duncan Multiple Range Test ($p<0.05$) at 5% level of significance.

Results: The results obtained for moisture, ash, protein, fat, fiber and carbohydrate for the composite flour ranged from 7.827 to 10.234%, 1.529 to 2.415%, 12.101 to 18.092%, 0.501 to 1.035%, 1.939 to 2.488% and 68.142 to 73.697% respectively. Functional properties of flour: bulk density, water absorption capacity, solubility and swelling capacity ranged from 0.55 to 0.620%, 2.308 to 3.024%, 2.323 to 2.697% and 6.836 to 7.448%, respectively. Biscuits made from 70% wheat flour + 30% African yam bean had the highest general acceptability score (7.75±0.716).

Conclusion: The incorporation of soybean, bambara groundnut and African yam bean flour in biscuits production increased the nutritional composition of biscuits.

Keywords: Soybean, Bambara groundnut, African yam beans, Composite flour, Healthy Snack

1. INTRODUCTION

The availability of high-energy, low-nutrient foods (such as potato chips and sugary drinks) has expanded due to advancements in food technology (Almoraie et al., 2021). Overweight and obesity are among the effects of these changes; they have become widespread, affecting both industrialized and developing countries (Chooi et al., 2019). One of the biggest health concerns nowadays is obesity, especially in children and adolescents. Over 18% of children and adolescents (5-19 years) were overweight or obese in 2016 (WHO, 2021). It is estimated that by 2030, over half (57.8%) of the world's population will be overweight (Kelly et al., 2008).

The term "snack foods" tends to connote energy-dense, nutrient-poor foods usually containing sugar, sodium, and/or saturated fat, for example cakes, cookies, chips and other salty snacks and sugar-sweetened beverages (Hess et al., 2016). Snacks are generally eaten between main meals, often with the intention of reducing or preventing hunger until the next meal (Verduci et al., 2019). However, not every food consumed as a snack is thought to be low in nutrients (Hess and Slavin, 2018).

Healthy snacks can include fresh fruits and vegetables, natural fruit juices, nuts (like walnut, hazelnut, pistachio, and almond), and simple biscuits [61,62]. Biscuits are a popular snack that people of all ages consume. Biscuits (also known as cookies) are baked flour confectionery dried down to low moisture content (Misra and Tiwani, 2014). They contain many of the same ingredients as cakes except that they have a lower percentage of liquid with a higher percentage of sugar and fat compared to cakes (Onwuka, 2014).

Soybean (*Glycine max*) is a good source of plant protein which also contains lecithin, polyunsaturated fatty acids, isoflavones, and dietary fiber. It contains active ingredients like isoflavone and flavonoids which help improve endothelial function, lower blood pressure (Kim, 2021) and possess anti-inflammatory, anti-oxidative qualities that help reduce the risk of diabetes and cardiovascular diseases (Zuo et al., 2023).

African yam bean (*Sphenostylisstenocarpa*) is an underutilized leguminous plant (Adewale and Abberton, 2024) that is also abundant in antioxidants and free-radical scavengers (Enujiagha et al., 2012). It contains phytochemicals and bioactive compounds like flavonoids and phenolic acids, which may help lower the risk of certain diseases like cardiovascular disease, diabetes and diseases linked to an imbalance in antioxidants within the body system (Soetan et al., 2018).

Bambara groundnut (*Vigna subterranea*) is also an indigenous crop (Hillocks et al., 2012) and an important nutritious food source especially when food is scarce (Mboso et al., 2020) due to its climate-smart features, including ability to fix nitrogen, and grow under adverse environmental conditions such as poor soils and drought (Paliwal et al., 2020). This nutrient-dense legume is sometimes referred to as a “complete food” because of its balanced macronutrient composition; it contains approximately 64.4% carbohydrate, 23.6% protein, 6.5% fat, and 5.5% fiber and is rich in minerals (Azman et al., 2019).

2. MATERIAL AND METHODS

2.1 Materials

Soybean, bambara groundnut, African yam bean seed and wheat flour and other ingredients were purchased from Odo-Oba and Wazo Market, Ogbomoso, Oyo State, respectively.

2.2 Preparation of Materials

The method of Akubor *et al.* (2013) was modified to produce soybean flour by hand cleaning, sorting and washing prior to being placed in boiling water at 100℃ for 30 min in order to get rid of any anti-nutritional elements and the beany flavor. After boiling, the soybeans were thoroughly cleaned and dehulled. The grains were dried to a moisture content of 10% in an oven set at 60 ℃ for 48 h. Using an Attrition milling machine, the dried grains were ground into a fine flour with uniform particle size. The flour was then packed into polyethylene bags and stored at room temperature.

African yam bean flour was produced according to Alugwu et al. (2023) (modified). After sorting the seeds, they were soaked for 45 min in cold water to remove the seed coats. The loosen testa was removed by floating in water after the seeds were rasped between the palms. After being de-hulled, the seeds were dried, ground into fine flour, and sieved through a 0.4 mm sieve. The flour was then packed into polyethylene bags and stored at room temperature.

Bambara groundnut seeds were hand-cleaned, sorted, boiled and soaked overnight for easy removal of seed coat. The dehulled seeds were sun dried for 3 days and were thereafter winnowed and dry milled in an attrition milling machine. The flour was allowed to cool and sieved to obtain smooth and fine texture, and were packaged for further use (Adebanke et al., 2017).

2.3 Formulation of Flour Blend

The four flours were formulated in ratio with each ratio containing the same proportion of wheat flour; whole wheat flour was used as control (100:0%). The blended flours were thoroughly mixed using a blender (BLG 450 Blender/Grinder) to achieve uniform blending. The formulations of the flours are:

A = 70% of wheat flour, 30% of bambara groundnut flour
B = 70% of wheat flour, 30% of soybean flour
C = 70% of wheat flour, 30% of African yam bean

D = 100% of wheat flour

2.4 Proximate Analysis of flour

All analyses (except carbohydrate) were determined using the method described by Association of Official Analytical Chemists (AOAC) (AOAC, 2005) and individually calculated as follows:

2.4.1 Moisture Content Determination

% Moisture Content (M.C) = $(W_2 - W_3 \ / (W_2 - W_1))$ X 100

Where: W_1 = weight of dish in g; W_2 = weight of dish + sample weight; W_3 = weight of dish + sample weight after drying.

2.4.2 Crude Fat Determination

% Crude Fat = (Weight of boiling flask + oil-weight of boiling flask/Weight of sample) X 100

2.4.3 Crude Protein Determination

%Nitrogen= ((Molecular weight of Nitrogen x 0.1 x titre value)/(Initial weight of sample taken)) X 100

%Crude protein = % Nitrogen x Factor

2.4.4 Ash Content Determination

% Ash Content = ((W3-W1)/(W2-W1)) x 100

2.4.5 Carbohydrate Determination

Carbohydrate content was determined by difference.

Percentage carbohydrate = 100 - (%Crude Fat + %Crude Protein + %Moisture Content + %Ash +%Crude Fiber)

2.5 Functional Properties of Flour

2.5.1 Bulk Density

Bulk density was determined by the method described by Onwuka (2018) and was calculated as described below:

Bulk density g/cm^3=((Weight of sample (g) –Volume of free water)/(Volume occupied (cm^3))

2.5.2 Water Absorption Capacity

This was determined by using the method of Ikpeme *et al.* (2010) and was calculated as describe below:

WAC= ((Volume of water used-Volume of free water)/(Weight of sample)) X 100

2.5.3 Swelling Power and Solubility

The method described by Oladele and Aina (Oladele and Aina, 2007) was used to determine both the swelling power and solubility index. Swelling power was calculated as follow:

SP = Weight of the paste/Weight of dry sample

2.6 Production of Biscuits

The biscuits were prepared using composite flours produced and100% of wheat flour which was used as control. The method used by Mabogo *et al.* (2021) was modified and used for the production of biscuits. All samples of biscuits contained 150g of flour, 40 g sugar, 40 g fat (margarine), 2 g baking powder, 4 g vanilla flavor, 1 g salt, 25 g whole egg and small quantity of water. Each sample was mixed with sugar, salt, baking powder, egg, margarine and vanilla flavor manually for 3-5 min to get creamy dough. A measured amount of water was added gradually while mixing and was continued until a slightly firm dough was obtained. The dough was then kneaded on a flat cleaned stainless metal table for 4 min. The kneaded dough was manually rolled into sheets and cut into shapes using cookies cutter. The dough was baked in an oven at 50℃ for 10 min. The biscuit was allowed to cool and then packaged.

2.7 Sensory Evaluation

The acceptability of the biscuits was evaluated after preparation using an assessment questionnaire. The consumer panelists comprised of 20 semi-trained panelists who were biscuits consumers and familiar with the quality attributes of biscuits. The biscuits were served with coded plates containing the biscuits, bottle of water and cup for rinsing their mouth to avoid bias. They were asked to rate the sample for sensory properties (appearance, crispness, aroma, color and taste) and acceptability. A standard nine-point hedonic scale was used for the acceptability test, where 1=dislike extremely, and 9=like extremely.

2.8 Statistical Analysis

All laboratory analysis was carried out in triplicates and the results were presented as mean and standard deviation of the replicate analysis. Data were analyzed using Statistical Package for Social Sciences (SPSS) Version 20.Analysis of variance (ANOVA) was used to compare the results at $P<0.05$.

3. RESULTS AND DISCUSSION

3.1 RESULTS

3.1.1 PROXIMATE ANALYSIS

Results from proximate analyses are presented below (Table 1). No significant difference (*P*>0.05) exists for the moisture, crude fat and carbohydrate contents of samples A and B.

Table 1: Proximate composition of wheat, bambara groundnut, soybean and african yam bean flours

Sample	%Moisture	%Crude Fibre	%Crude Fat	%Ash	%Crude Protein	%Carbohydrate
A	7.827±0.037^{a}	2.488±0.055^{b}	1.035±0.000^{c}	2.415±0.019^{c}	18.092±0.056^{d}	68.142±0.169^{a}
B	8.207±0.000^{b}	2.384±0.024^{b}	1.021±0.004^{c}	2.204±0.003^{b}	17.744±0.054^{c}	68.440±0.079^{a}
C	10.070±0.064^{c}	1.995±0.059^{a}	0.834±0.016^{b}	2.237±0.000^{b}	15.886±0.058^{b}	68.977±0.069^{b}
D	10.234±0.028^{d}	1.939±0.052^{a}	0.501±0.029^{a}	1.529±0.025^{a}	12.101±0.036^{a}	73.697±0.171^{c}

Values represent means of triplicate reading with standard deviation, followed by different lowercase superscript. Means within the same column with different superscripts are significantly different (P≤0.05).

3.2.2 FUNCTIONAL PROPERTIES OF FLOUR

The results presented below (Table 2) show that no significant difference (*P*>0.05) exist for the bulk densities and solubility of samples B, C, D and samples B, C respectively.

Table 2: Functional properties of flour

Samples	Bulk Density (g/ml)	Water Absorption Capacity (kg/m^{2})	Solubility (g/l)	Swelling Capacity (mlH$_2$O/gdm)
A	0.55±0.325^{a}	3.02±0.000^{c}	2.70±0.013^{c}	6.84±0.000^{a}
B	0.61±0.005^{b}	2.56±0.016^{b}	2.53±0.008^{b}	6.92±0.023^{b}
C	0.62±0.004^{b}	2.32±0.003^{a}	2.52±0.002^{b}	7.45±0.011^{c}
D	0.61±0.016^{b}	2.31±0.004^{a}	2.32±0.007^{a}	6.88±0.036^{ab}

Values represent means of triplicate reading with standard deviation, followed by different lowercase superscript. Means within the same column with different superscripts are significantly different (P≤0.05).

3.2.3 SENSORY EVALUATION OF BISCUITS

The results of sensory evaluation are as presented on Table.3. No significant difference (*P*>0.05) exist for the aroma, texture, general acceptability of samples A, C, D; the crispiness of sample C,D and the texture of samples A, D.

Table 3: Sensory analysis of biscuits

Sample	Appearance	Crispness	Aroma	Taste	Texture	General Acceptability
A	7.95±0.825^{d}	7.60±0.995^{b}	7.85±0.988^{b}	8.05±0.759^{b}	7.80±0.695^{b}	8.25±0.636^{b}

B	7.35±0.089^{a}	6.75±0.164^{a}	5.85±0.598^{a}	6.00±0.025^{a}	6.90±0.011^{a}	6.40±0.353^{a}
C	7.60±0.883^{b}	7.25±0.786^{ab}	7.50±0.000^{b}	7.75±0.786^{b}	7.60±0.754^{b}	7.75±0.716^{b}
D	7.75±0.850^{c}	7.40±0.940^{ab}	7.50±0.827^{b}	7.80±0.768^{b}	7.55±0.887^{b}	7.65±0.975^{b}

Values represent means of triplicate reading with standard deviation, followed by different lowercase superscript. Means within the same column with different superscripts are significantly different (P≤0.05)

3.2 DISCUSSION

This study evaluated the macronutrients, functional properties of composite flour and sensory properties of biscuits made from blends of bambara groundnut, soybean and African yam bean composite flour. The results of the proximate composition (fat, protein, ash, crude fibre and carbohydrate content) of the composite flour showed that the moisture content ranged from 7.83 to 10.23%. This is similar to what was reported for pearl millet, teff and buckwheat composite flour which had a moisture content of 8.13 - 8.47 % (Anberbir et al., 2024) but different from that of wheat and African yam bean composite flour to be 11.04-11.17% (Idowu, 2014). The composite flour's moisture content fell between 12 and 14%, which is the permitted range for flour storage over an extended period of time (Singh et al., 2005). Moisture content and water activity have been reported to have great effects on the keeping quality and shelf life of foods (Barber et al., 2017).
The fat content of the composite flour of this study ranged from 0.50 to1.04%. An earlier study similarly reported that cassava and bambara groundnut composite flour had a fat content of 0.51to 1.55% (Eke-Ejiofor et al., 2022) but another differently opined that wheat and bambara groundnut composite flour had a higher fat content (3.84-4.63%) (Okoye and Obi, 2017). Although, flour high in fat content have been reported to be good as flavor enhancers and useful in improving palatability when included in foods (Rietjens and Krammer, 2007), low-fat composite flour offers a healthier alternative for consumers concerned about fat intake and overall health (Zhang et al., 2020). Also, in dough making, higher fat content in flour reduces their swelling power owing to inhibition of the process of starch gelatinization. Thus, the decreased swelling index caused by low fat content can cause a decrease in loaf volume and loaf height of the composite flour breads (Menon et al., 2015).

The result from this study also highlighted that the crude protein content of the composite flour ranged from 12.10 to 18.09%; an increase in protein content of the composite flour was observed as bambara groundnut flour substitution increased. This was different from the protein content of cassava and bambara groundnut composite flour reported in an earlier study (Eke-Ejiofor et al., 2022), which ranged from 1.74 to10.45%; an increase in the protein content of the composite blends was observed as addition of bambara groundnut flour increased. However, it is similar to the findings reported for wheat, bambara groundnut and orange fleshed sweet potato composite flour which had a protein content ranging from 9.62to 11.93% (Ubbor et al., 2022). High protein content contributes to the formation of gluten, which is essential for dough elasticity and strength. This result in better dough handling properties, increased volume, and improved crumb structure in baked goods (Shewry and Hey, 2015). It can also boost the nutritional profile of food products, providing essential amino acids necessary for overall health and well-being (Wu et al., 2020).
The crude fibre content of the flour ranged from 1.94 to 2.49%. This is in contrast with that reported for wheat, bambara groundnut and orange sweet potato composite flour to be 2.33 - 4.03% (Ubbor et al., 2022) and that of wheat and African yam bean composite flour to be 4.84- 5.21% (39). High fiber content promotes regular bowel movements, prevents constipation, and supports a healthy digestive system by adding bulk to stool and promoting intestinal motility (Verduci et al., 2020). It also helps to control appetite and reduce calorie intake, which can support weight management efforts and aid in achieving and maintaining a healthy body weight (Slavin, 2013).
Furthermore, the ash content of the composite flour was reported to range from 1.53 to 2.42%. This is divergent from ash content reported for cassava and bambara groundnut composite flour as 0.51-0.56% (Eke-Ejiofor et al., 2022) and that of wheat, bambara groundnut and orange sweet potato composite flour to be 1.23%- 1.54% (Ubbor et al., 2022). Ash content represents the total mineral content in the flour, including essential minerals such as calcium, magnesium, potassium, and trace elements. High ash content indicates a higher mineral presence, which can enhance the nutritional value of the flour (Shittu et al., 2007).
The results for the functional properties of the composite flour showed that the solubility ranged from 2.32g/l - 2.70 g/l; this contradicts that reported for tigernut and soybean flour which ranged from 13.59 to 29.32% (Obinna-Echem et al., 2024) and that of pearl millet, teff, and buckwheat grain composite flour ranged from 6.63to 7.00% (Anberbir et al., 2024). Solubility of composite flours affects the digestibility and bioavailability of nutrients. Higher solubility can enhance the breakdown and absorption of nutrients during digestion, thereby improving the nutritional value of the food product (Kaur et al., 2010).
Swelling capacity of the studied composite flour ranged from 6.88 to 7.45 mlH_2O/gDM. 70:30 of wheat and African yam bean flour had the highest value while 100% wheat flour had the lowest value; thus, there was an increase in the swelling capacity of the composite flour with African yam bean flour substitution. An earlier study reported the composite flour from cassava, rice, potato, soybean and xanthan gum had a swelling capacity of 4.27 - 12.21g/g (Tharie et al., 2014). Swelling

capacity can influence the bioavailability of nutrients. Higher swelling capacity can lead to better digestibility and more efficient nutrient absorption (Wang and Copeland, 2013). It can also affect the moisture retention and shelf-life of baked products as higher swelling capacity flours may contribute to better moisture retention, which can extend the freshness and shelf-life of the final product (Lazaridou and Biliaderis, 2009).

The bulk density result of this study ranged from 0.55to 0.62 g/ml with 70:30 of wheat and African yam bean flour having the highest value while 70:30 of wheat and bambara groundnut flour had the lowest value – an indication that there was increase in bulk density of the flour blend with addition of African yam bean flour. These finding contrasts that of wheat, African yam bean and tigernut composite flour to be 0.71-0.77g/ml (Dada et al., 2023) with a significant difference existing among the bulk densities of all samples. Bulk density is important for the formulation of nutrient-enriched or fortified composite flours. Adjusting the bulk density can help in incorporating and evenly distributing micronutrients such as vitamin and minerals, ensuring consistent nutritional benefits in each serving (Onyeka and Dibia, 2002).

Water absorption capacity (WAC), the amount of water absorbed by food or flour in order to achieve the desired consistency and also to produce a high-quality food product, was reported to be 2.31- 3.02 kg/m^2 with 100% wheat flour having the lowest value while 70:30 of wheat and bambara flour had the highest value; this showed that there was an increase in water absorption capacity of the composite flour with bambara groundnut flour substitution. A study differently reported the WAC of tigernut and soybean composite flour to be 1.23 -2.13g/g (Obinna-Echem et al., 2024). Increase in the water absorption of composite flours might be due to the increase in protein level as protein has both hydrophilic and hydrophobic nature, and therefore can interact with water in foods (Suresh et al., 2015).

The sensory properties including appearance, texture, taste, aroma, crispness and general acceptability of the biscuits sample. The appearance scores of the biscuits ranged from 7.35 to 7.95% with 100% of wheat flour biscuits having the best value while 70:30 of wheat-bambara groundnut had the lowest value. The appearance for both biscuits was liked slightly. This could be due to the natural inherent pigment of the bambara groundnut. It could also be due to enzymatic browning, which might have given an impression of the products been over baked to the panelists hence the less liking effect. Previous studies reported similar findings for biscuits produced from composite flour of wheat, African yam bean and tigernut and those made from maize and tigernut flour to have appearance value ranges of 5.90 - 7.50 and 6.90-7.60, respectively (Dada et al., 2023; Obinna-Echem an Robinson, 2019). Unique and attractive appearance can differentiate a product from competitors. This includes innovative shapes, appealing colors, and decorative elements that make the product stand out on the shelves (Fellows, 2009).

The crispness scores of the biscuits ranged from 6.75 to7.60 with 100% wheat flour biscuits having the highest value while 70:30 wheat-bambara groundnut flour biscuits having the lowest value. The crispness for both biscuits was moderately liked by the panelists with no significant difference between crispness of samples. The observed decrease in crispiness with substitution with non-wheat flour levels may be due to moisture uptake by such flour (Torbica et al., 2019). Similar to this, an earlier study reported the crispness of biscuits produced from composite flour of wheat, African yam bean and tigernut to be 6.20 - 6.75 (Obinna-Echem an Robinson, 2019). Contrary to that, another study reported the crispness of biscuits made from wheat, bambara groundnut and orange flesh sweet potato to be 5.20 – 6.50 (Ubbor et al., 2022). Crispness significantly contributes to the overall texture and mouth feel of biscuits (Laguna et al., 2013).

The aroma scores of the biscuits ranged from 7.85 - 5.85 with 70:30 of wheat-bambara groundnut biscuits having the lowest value while 100% of wheat biscuits had the highest value. The aroma for wheat-bambara groundnut biscuits was liked slightly while 100% wheat biscuits liked moderately. A study similarly opined that addition of composite flour blends decreased the aroma of biscuits made from bambara groundnut, ground bean seed and moringa seed from 6.54% - 4.53%, as percentage of flour blends increased (Origbemisoye and Ifesan, 2019). Pleasant aromas associated with nutritious ingredients can promote flavor-nutrient learning, where consumers develop a preference for foods that are both aromatic and nutrient-dense. This can help in promoting healthier eating habits (Yeomans, 2012).

The taste scores of the biscuits ranged from 8.05 to 6.00% with 100% wheat biscuits having the highest value while 70:30 of wheat- bambara groundnut biscuits had the lowest value. The taste of wheat-bambara groundnut biscuits were neither liked nor disliked while 100% wheat biscuits were moderately liked by panelists. Similarly, it was reported that biscuits produced from 100% wheat flour tasted better than all other samples in the sensory analysis of biscuits made from wheat, sweet potato and African yam bean composite flour (Ibrahim and Stephen, 2022). Biscuits with a balanced and appealing taste can be used as tools in nutritional education and health promotion, encouraging the consumption of healthier snacks among various age groups, including adolescents (Nicklas et al., 2014).

The textures of food products reflect the mouth feel. The texture scores of the biscuits ranged from 6.90 - 7.80 with 100% wheat biscuits having the highest value while 70:30 wheat-bambara groundnut biscuits had the lowest value. Both textures of the biscuits were slightly liked by panelists. Similarly, some other studies all reported that texture of composite biscuits decreased with increasing addition of composite flour and there exist no significant difference in texture of produced biscuits (Ubbor et al., 2022; Makinde and Adeyemi, 2018). The decline in texture of the composite flour biscuits may be attributed to the high crude fiber content of other flour apart from wheat, which makes the texture less tender (Makinde and Adeyemi, 2018). Texture plays a crucial role in the acceptability of healthier biscuit formulation, such as those with reduced sugar or fat content (Ibrahim and Stephen, 2022).

The biscuits' acceptability scores ranged from 6.4 - 8.25 with 100% of wheat biscuits having the highest value while 70:30 had the lowest value. Similarly, it was reported that the general acceptability sores of cookies made from wheat, bambara groundnut and orange flesh sweet potato ranged from (6.35 - 7.50) with 100% wheat flour being the most preferred with its scores ranging from 7.50- 8.0 on hedonic rating (Ubbor et al., 2022). Also, a study reported a similar finding for biscuits made from bambara groundnut, ground bean seed and moringa seed; the addition of bambara groundnut-ground bean seed-moringa seed flour decreased the mean score of the general acceptability from 4.87 to 7.20 as the concentration of the blends increased (Origbemisoye an Ifesan, 2019)s. Biscuits that meet consumer expectations in terms of taste, texture, and aroma can promote healthier eating habits as it can encourage the substitution of healthier biscuits for less nutritious snacks (Sudha et al., 2007).

4. CONCLUSION

The composite flour has a better nutritional composition compared to whole wheat flour. The high protein content in the bambara groundnut, soybean and African yam bean flour would be of nutritional importance in many developing countries like Nigeria where many people can hardly afford highly proteinous foods. It will also enhance the usage of the underutilized legumes. The functional properties of the composite flour showed a good compliance to flour properties. Therefore, addition of soybean, bambara groundnut and African yam bean flour to wheat flour will enhance the nutritional composition of biscuits. However, there is a decrease in the acceptability of wheat-bambara groundnut composite biscuits compared with other biscuit samples; thus, there is a need to improve its sensory properties.

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