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Development and Quality Characteristics of Cookies from Sprouted Sorghum, Pigeon Pea and Orange Fleshed Sweet Potato Flour Blends

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Authors' contributions

This work was carried out in collaboration among all authors. Authors FAB designed the study, supervised and wrote the first draft of the manuscript. Author EOEA carried out the laboratory work performed the statistical analysis and managed the literature searches. Author VEN wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

The present study was undertaken to produce cookies from readily available but underutilized Nigerian crops such as sorghum, pigeon pea and orange fleshed sweet potato. Different blends of sprouted sorghum, pigeon pea and orange fleshed potato flour were mixed and coded in the ratios (w/w) 100:0:0 (A), 95:5:0 (B), 85:10:5(C), 75:15:10(D), 65:20:15(E) while 100% wheat flour (F) was produced as control. The functional properties of the flour samples were determined while produced cookies were evaluated for their physical, proximate, selected vitamins, anti-nutrients and sensory properties using standard methods. Significant ($p < 0.05$) increases in water absorption capacity, bulk density and swelling index of flour blends were observed as the level of substitutions increased. Control sample had the highest weight (13.89 g) and spread ratio (1.22) while sample E had the least weight (7.31 g) and least spread ratio (0.92). Moisture, crude protein, crude lipid, ash, crude fibre contents as well as energy value of flour blends cookies were significantly ($p < 0.05$) higher with increased level of pigeon pea and potato flours addition. Significant ($p < 0.05$) reduction in the carbohydrate content of the cookies was observed. Vitamin A and C contents of sample E were significantly ($p < 0.05$) higher than the value obtained for sample F. Anti-nutritional factors in the cookies samples were within permissible levels. Sensory ratings showed that sample B compared favourably with sample F based on overall acceptability.

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1. INTRODUCTION

Cookies are confectionary products usually dried to low moisture content. They are ready-to-eat and convenient food product that is consumed in-between meal or as a breakfast item among all age groups in many countries [1,2]. They represent the most popular and largest category of snack item among bakery product because of their affordable price, shelf-stable, convenience and nutritive value [3]. Cookies are nutritious, contributing valuable quantities of iron, calcium, calories, fibre and some of the B-vitamins to our diet and daily food requirement. In Nigeria, reliance on wheat flour in the pastry and bakery industries has over the years restricted the use of other indigenous cereals and tuber crops available for domestic use, with a resultant detrimental effect on agricultural and technological development.

Sorghum (*Sorghum bicolor*) in many semi-arid and tropical areas of the world especially in sub-Saharan Africa, it is a staple food grain and has great potential to use in various industries. Sorghum can constitute major energy sources and starch as raw materials for several end uses such as in baking and brewing industries [4]. High fibre content and poor digestibility of nutrients are characteristic features of sorghum grains, which severely influences its consumer acceptability. Processing methods, such as soaking, sprouting and cooking has been found to improve the nutritional value of plant grains [5]. Sorghum products are deficient in essential amino acids such as lysine, methionine and tryptophan, therefore, attempts have been made to fortify these cereals with legumes to make it nutritionally superior and acceptable product.

Pigeon pea (*Cajanus cajan*) belongs to the *leguminoseae* family of flowering plants and is a drought tolerant pulse legume mainly grown for seeds in the semi-arid tropics. It is an important food security crop for local consumption and export for several African countries [6]. Lysine, which is limiting in cereals, is supplemented when cereals are combined with legumes rich in lysine. Pigeon peas regulate blood pressure levels.

Sweet potato (*Ipomoea batatas*) is a sweet-tasting tuberous root with an important alternative source of carbohydrates consumed in Nigeria as an energy giving food and is ranked the third after rice and wheat in terms of consumption [7]. Sweet potato is rich in dietary fibres, minerals, vitamins and anti-oxidants such as anthocyanins, phenolic acids, tocopherol and β-carotene. The most commonly obtainable sweet potato varieties have purple, yellow, and white root tubers because of the distinct contents of phenolic compounds and pigments in their root tubers [8,9]. Processing of sweet potato can be used as one of the ways to address the challenges faced with storing and transporting the raw sweet potato roots in developing countries [10]. Orange fleshed potato is a naturally bio-fortified crop that has a great potential for global fight against vitamin A. Vitamin A is an essential micronutrient for normal immune function of the body, it is essential for good health and eye sight. Based on the nutritional advantage, availability and economical value of sweet potato, orange fleshed potato is an excellent source of pro-vitamin A.

The use of composite flour has been identified by researchers as possible avenue of producing high-quality nutritious food products and a means of reducing the huge amount of foreign exchange spent by Nigeria in the importation of wheat flour [11,12]. Composite flour has the added advantages of improving the nutrient value of cookies and other bakery products especially when cereals are blended with legumes e.g. pigeon pea [13]. This study was aimed to evaluate the physical, chemical and sensory properties of cookies produced from sprouted sorghum, pigeon pea and sweet potato flour blends.

2. MATERIALS AND METHODS

2.1 Materials Procurement

The pigeon pea and the orange fleshed sweet potato tubers were purchased from Makurdi, Benue State, Nigeria. The sorghum grains and other ingredients such as baking powder, sugar, salt, margarine, powdered milk, vanilla essence and eggs were purchased from Itam Market, Akwa Ibom State, Nigeria. Chemicals used were of analar grade.

2.2 Materials Preparation

2.2.1 Production of sprouted sorghum flour

The sorghum grains were prepared into flour according to the method of Bello et al. [5]. Sorghum grains was sorted to get rid of foreign matter and damages, washed and steeped in tap water (1:3 w/v) for 16 h at 30ºC. The water was changed after every 6 h interval to prevent fermentation. Steeped grains were drained and spread out about 1 cm thick on a jute bag and covered with another sterilized jute bag. It was moistened and allowed to sprout for 72 h. The sprouted grains were washed and oven-dried (model NAAFCO BS Oven: OVH-102) at 60ºC for 12 h and cleaned to remove the vegetative parts (rootlets and shoots). The grains were milled using a laboratory mill (model Corona). The flour was sieved through a 500 µm sieve to obtain sprouted sorghum flour. The fine flour was packaged in an air tight plastic container, labeled and stored in a refrigerator (model Haier Thermocool) at a temperature of 4ºC for subsequent use.

2.2.2 Production of pigeon pea flour

The brown variety of pigeon pea was processed into flour using the method described by Olawuni et al. [14]. The pigeon pea seeds were sorted to get rid of foreign matter and damages, washed and steeped in tap water (1:3 w/v) for 48 h at 30 ºC. The water was changed after every 6 h interval to prevent fermentation. Steeped seeds were drained and the seeds were manually dehulled to separate the seed hulls from the cotyledon by applying a little pressure between the fingers. The dehulled seeds were dried in the oven (model NAAFCO BS Oven: OVH-102) at temperature of 60ºC for 12 h before ground with a laboratory mill (model Corona). The sample was sieved through a 500 µm sieve to obtain flour. The fine flour was packaged in an air tight plastic container labeled and stored in a refrigerator (model Haier Thermocool) at a temperature of 4ºC for subsequent for use.

2.2.3 Production of orange fleshed sweet potato flour

The orange fleshed sweet potato flour was produced by the method of FAO [15]. The sweet potato roots were trimmed and peeled manually, washed, sliced to about 2-3 mm thickness manually using kitchen knife. Two methods of pretreatments (blanching and soaking in NaCl) were applied on the sliced tubers. Blanching was done at 70°C for 20 min followed by soaking of the sliced tubers in 1% NaCl solution for 20 min. The pretreated sliced sweet potato were dried in oven (model NAAFCO BS Oven: OVH-102) at 60-65ºC for 12 h. The dried sweet potatoes chips were ground with a laboratory grinder (model Corona). The ground sweet potato was sieved through a mesh of 500 µm pore screen to obtain fine flour. The fine flour was packaged in an air tight plastic container, labeled and stored in a refrigerator (model Haier Thermocool) at a temperature of 4ºC for subsequent for use.

2.2.4 Formulation of composite flours

Five composite flours with different proportions of sprouted sorghum, pigeon pea, orange fleshed potato flour blends were formulated and designated as A, B, C, D and E while cookies from wheat flour served as control (F). The blending ratios are shown in Table 1.

2.2.5 Ingredients formulation for cookies production

Ingredients formulation and creamy method of cookies production as reported by Okpala et al. [16] were adopted as shown in Table 2. Margarine and granulated sugar were creamed together for 5 min. Eggs and powdered milk were added while mixing and continued to cream until light and fluffy. Flour, baking powder, salt and vanilla flavour were thoroughly mixed and added to the cream mixture and mixed in a bowel mixer to form dough. The dough was kneaded to a uniform thickness using a rolling board and a rolling pin, cut to a uniform diameter, left in a refrigerator (model Haier Thermocool) for 30 min to rest, baked in an oven (model NAAFCO BS Oven: OVH-102) at 160°C for 15-20 min, cooled at ambient temperature (27±2°C), packaged in high density polyethylene, labeled and stored at ambient temperature for various determinations.

2.2.6 Determination of Functional Properties of Flour Blends

Water absorption capacity, oil absorption capacity, bulk density and gelation temperature of flour blends were determination using the method described by Onwuka [17]. Emulsification capacity was determined according to the method described by Adeyeye et al. [18]. Swelling index determination was carried out using the method of Abbey and Ibeh [19].

2.2.7 Determination of physical properties of cookies

The method described by McWatters et al. [20] was used to evaluate the physical properties of cookies. Thickness of cookies was determined by measuring the diameter of four cookies samples placed edge to edge with a digital vernier caliper. An average of six values was

Table 1. Formulation of flour blends (%)

Samples	A	B	C	D	E
Sprouted sorghum flour	100	95	85	75	65
Pigeon pea flour	0	5	10	15	20
Orange fleshed potato flour	0	0	5	10	15
100% wheat flour (control) sample F	-	-	-	-	-

Table 2. Ingredients formulation for cookies production

Ingredients	A	B	C	D	E	F
Composite flour (g)	400	400	400	400	400	400
Butter (g)	200	200	200	200	200	200
Sugar (g)	120	120	120	120	120	120
Powdered milk (g)	150	150	150	150	150	150
Baking powder (g)	5	5	5	5	5	5
Salt (g)	1	1	1	1	1	1
Vanilla essence (g)	20	20	20	20	20	20
Egg (ml)	180	180	180	180	180	180

Source: Okpala et al. (2013)

taken for each set of samples. Average value for thickness was reported in millimeter. Diameter of cookies was determined by placing four cookies samples edge to edge and measuring with a digital vernier caliper. An average of six values was taken for each set of samples. Average value for diameter was reported in millimeter. Weight of cookies was measured as average values of six individual cookies with the help of an analytical weighing balance. Average value for weight was reported in grams. While spread ratio was calculated by dividing diameter by thickness**.**

2.2.8 Proximate composition of cookies

Moisture, ash, crude protein, crude fat and crude fibre contents of cookies were carried out according to the method described in [21]. Total carbohydrate was determined by difference method and was quantified based on the percentage difference of the other proximate indexes as follows: % carbohydrate = 100 - (%moisture + % ash + % crude protein + % crude fat + % crude fibre). The total energy was calculated using Atwater factor using the formula: energy value = (% crude protein×4) + (% crude fat×9) + (% carbohydrate×4).

2.2.9 Determination of selected vitamin contents of cookies

Vitamins A and C contents were determined using the method described by AOAC [21].

2.2.10 Determination of anti-nutritional factors of cookies

Hydrogen Cyanide, phytate and tannin contents were determined using alkaline filtration method as described by AOAC [21]. Total oxalate was determined using the method described by Onwuka [17].

2.2.11 Sensory evaluation of cookies

The sensory evaluation of produced cookies was performed by 20 semi-trained panels of judges drawn from the Department of Food Science and Technology, University of Uyo, Uyo, Nigeria. All panelists were regular consumers of cookies and were familiar with its quality attributes. All the panelists were briefed before the commencement of the evaluation process. The evaluation was conducted using the nine-point hedonic scale ranging from 1(disliked extremely) to 9(liked extremely) as described by Chandra et al. [22]. The samples were coded with three digit random numbers and presented in identical containers. Questionnaire for entering scores and portable water for mouth rinsing between tasting were made available to the panelists. Each of the samples was rated for appearance, taste, texture, crispiness and overall acceptability.

2.3 Statistical Analysis

Data were subjected to statistical analysis using Analysis of Variance (ANOVA). The means were then separated with the use of Duncan's New Multiple Range Test (DNMRT) using the Statistical Package for the Social Sciences (SPSS) 20.0 software.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Flour Blends and Wheat Flour

The functional properties of the flour blends and 100% wheat flour are shown in Table 3. Significant ($p < 0.05$) increase was observed in water absorption capacity between the flour blends samples as the levels of substitution increased and ranged from 1.13 g/g (sample B) to 1.47 g/g (sample E). Sample A had the least water absorption capacity of 1.00 g/g. High water absorption capacity of the flour suggests that the flours could be used in products where good viscosity is required such as sausage, dough and bakery products [23]. The oil absorption capacity of the flour blends values ranged from 0.79-1.15 g/g while the control sample had 0.69 g/g. It is an important property in food product development because fat improves the flavour and mouthfeel of foods. The ability of the flour protein to bind with oil makes it useful in food system where optimum oil absorption is desired. There was no significant ($p > 0.05$) different in the emulsification capacity of the flours. The capacity of protein to enhance the formation and stabilization of emulsions is important for many applications in food product [24]. The gelatinization temperature of the flour blends ranged from 77.33-80.33ºC while sample F had 71.00ºC and was significantly ($p < 0.05$) lower than the flour blends. The study showed that sample F has the least value as it took less time to gelatinize due to the absence of pigeon pea and orange fleshed potato flour. Variation in the gelation characteristics of composite flours could be attributed to the relative ratio of protein, carbohydrates and lipids that make up the flours and the interaction between such components [25]. Flour blends had significant ($p < 0.05$) increase in the bulk density which ranged from 0.73 g/ml (Sample B) to 0.82 g/ml (Sample E) while the highest value was found in sample F (0.85 g/ml). Reduction in bulk density of flour blends means that all the flours can be packaged the same way and this is advantageous [26]. Flour blends had significant ($p < 0.05$) increase on the swelling index and ranged from 1.13-1.24 ml/ml for samples C and E, respectively. The values were significantly lower than sample F whose value was 1.30 ml/ml. This increasing trend agrees with the findings of Ukeyima et al. [27] for watermelon wheat, soy flours and carrot flour blends.

3.2 Physical Properties of Cookies

Physical properties of flour blends cookies and 100% wheat flour cookies are shown in Table 4. The weight, diameter, thickness and spread ratio of the cookies ranged from 7.31-13.89 g, 49.06-65.54 mm, 40.25-66.64 mm and 0.92-1.22. The weight of flour blends cookies was significantly ($p < 0.05$) low compared to sample F (100% wheat flour). The difference in weight could be attributed to different water holding capacities of the flour [26]. Sample D had the highest diameter (65.54 mm) and thickness (66.64 mm) when compared to sample F with least values of 49.06 mm and 40.25 mm for diameter and thickness, respectively. Samples C and D were not significantly ($p > 0.05$) different in terms of thickness and spread ratio. The spread ratio of the flour blends cookies significantly lower than sample F. Cookies having higher spread ratios are considered the most desirable than those with lower values [16]. Similar findings with respect to weight, diameter, thickness and spread ratio were reported by Suriya et al. [28].

3.3 Proximate Composition and Energy Value of Cookies

Table 5 shows the proximate composition and energy value of cookies produced form the flour blends and wheat flour. Moisture content of flour blends cookies ranged from 4.87-5.13% while sample F had 5.10%. Moisture content in food is very important because it enhances the storage stability and low moisture inhibits the survival and growth of microorganisms in food products [29]. The moisture content acceptable limit is less than 10% for long term storage and the moisture contents of the cookies met the expected range. Flour blends cookies had significant ($p < 0.05$) increased in crude protein content whose value ranged from 5.12% (sample B) to 11.61% (sample E), samples D and E gave the highest value when compared with the sample F. The increased protein content in pigeon pea could have been responsible for the observed increase in protein content of fortified cookies with increasing levels of pigeon pea flour substitution. Similar results have been reported by Igbabul et al.[30] and Inyang et al. [31].

The flour blends cookies could be used to address the protein-energy malnutrition prevalence in most of our communities. Crude lipid of the cookies produced from flour blends increased significantly ($p < 0.05$) from 16.41% (sample B) to 18.13% (sample E). Crude lipid is an essential component of the tissues. It also acts as a flavour retainer and helps improve sensory properties of baked products [32]. The significant ($p < 0.05$) increase in levels of crude lipid with increasing level of pigeon pea flour addition indicates that the pigeon pea flour had higher lipid content compared to 100% sorghum and 100% wheat flour. The ash content of flour blends cookies ranged from 3.01% (sample B) to 3.65% (sample E) which was higher than the value (1.33%) obtained for sample F. The ash content in foods is an indication of certain amount of mineral elements in such foods. Therefore, producing cookies with sprouted sorghum, pigeon pea and orange fleshed potato flour could enhance the mineral intake of cookies consumers. The ash content in the product increased as pigeon pea and orange fleshed potato flour increases. Similar result was also reported by Amal [33] whose value ranged from 4-8% but higher than the values (1.50-1.95%) obtained by Inyang et al. [12] for rice, unripe banana and sprouted soybean flour blends cookies. Flour blends cookies had significant ($p < 0.05$) increased in crude fibre content from 2.14-2.51% for samples B and E, respectively. Crude fibre helps to lower the risk of constipation, it also serves as a useful tool in the control of oxidative processes in food products and as well as functional food ingredient which protect against cardiovascular disease and obesity [34]. Dietary fibre also decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes [35]. The crude fibre range observed is similar to 0.20-4.40% as reported by Obinna-Echem et al. [36]. Cookies produced from the flour blends resulted in a significant ($p < 0.05$) reduction in the carbohydrate content from 69.32% (sample A) to 58.97% (sample E) while highest value (69.35%) was observed in sample A. The significant reduction in the carbohydrate content of the products could be as a result of reduction in the sorghum flour as pigeon pea and orange fleshed potato flour was increased. The energy content of the cookies ranged from 440.69-460.83 kcal for sample A and F, respectively. Cookies produced from flour blends have lower energy value compare to cookies produced from unfortified flour. Similar observation was reported by Alhassan et al.[37] in peanut-pearl millet composite flour cookies.

3.4 Vitamin Composition of Cookies

The result of vitamin composition of cookies is shown in Table 6. Sample A had the least vitamin A (24.50 mg/100 g) followed by sample F (28.70 mg/100 g). The flour blends had significant ($p < 0.05$) increase in the vitamin A ranged from 32.60 mg/100g (sample B) to 67.60 mg/100g (sample E). The vitamin C contents of the flour blends ranged from 372.07 mg/100g (sample B) to 502.21 mg/100 g (sample E) while sample F had 294.70 mg/100 g and is significantly ($p < 0.05$) lower than the flour blends cookies. Vitamin is an organic substance essential for growth and tissue repair, as for wound healing and maintenance of cartilage, healthy gum, bone and teeth. The increased vitamin A and vitamin C contents in the cookies from the flour blends could be attributed to the increased inclusion of pigeon pea and orange fleshed potato. Similar results have been reported by Knowles et al. [38] but higher that the values reported by Dabels et al. [39] for wheat, acha and mungbean composite flour cookies.

3.5 Anti-Nutritional Factors of Cookies

The result of anti-nutritional factors of cookies is presented in Table 7. Flour blends cookies resulted in significant ($p < 0.05$) increased in hydrogen cyanide (HCN) whose value ranged from 2.64 mg/100 g (sample B) to 4.48 mg/100 g (sample E), when compared with the sample F which gave the lowest value (1.08 mg/100 g). According to FAO /WHO [40], 10 mg/kg is the maximum recommended safety level. The least phytate content was observed in sample F when compared with flour blends cookies whose value ranged from 4.54 mg/100 g (sample B) to 6.11 mg/100 g (sample E). The phytate content in the product is significantly low compared to the result (35.06 mg/100) presented by Elinge et al. [41] for pumpkin seed. Cookies produced from flour blends resulted in significant ($p < 0.05$) increased in tannins whose value ranged from 11.87 mg/100 g (sample B) to 14.21 mg/100 g (sample E) while sample F had the least value (0.31 mg/100 g). The values of tannin are lower than the permissible level of 90 mg/100 g [42]. Sample F exhibited the least oxalate content of 152.51 mg/100 g followed by sample A with 212.16 mg/100 g. Flour blends cookies had significant ($p < 0.05$) increase in the oxalate contents ranged from 264.28-452.00 mg/100 g for samples B and F, respectively.

3.6 Sensory Scores of Cookies Produced from Flour Blends and Wheat Flour

Sensory quality is considered a key factor in food acceptance because consumers look out for food with specific sensory characteristics. The result of sensory scores of samples B and C rated 7.40 and 7.30, respectively for appearance were not significantly ($p < 0.05$) different from sample F with sensory score of 7.55 (Table 8).

In terms of taste, control cookies was rated high with sensory scores of 7.90 when compared with samples C, D and E with sensory scores of 5.70, 5.85 and 5.90, respectively, except for sample B (6.95). The crispiness scores of the flour blends cookies were lower when compared to sample F except for sample B which was not differed significantly. Sample F (7.65) was rated high in flavour followed by flour blends samples B (6.95) and D (6.80). For overall acceptability, control cookies was rated to be significantly ($p < 0.05$) better with the score of 7.70 followed by samples B (7.35) and A (6.75). The acceptance of a food depends on whether it responds to consumer needs, and on the degree of satisfaction that it is able to provide [43]. Sample B compared favourably with whole wheat cookies in acceptability.

Table 3. Functional properties of flour blends and wheat flour

Blending ratio (S:P:O)	Water absorption capacity (g/g)	Oil absorption capacity (g/g)	Emulsification capacity (%)	Gelatinization temp. (ºC)	Bulk density (g/ml)	Swelling index (ml/ml)
A (10:0:0)	$1.00^{b}±0.00$	$1.22^{a}±0.11$	$43.05^{a}±0.17$	$80.00^{ab}±1.00$	$0.72^{c}±0.01$	$1.16^{c}±0.10$
B (95:5:0)	$1.13^{ab}±0.12$	$1.15^{a}±0.11$	$43.00^{a}±0.00$	$80.33^{ab}±0.58$	$0.73^{c}±0.01$	$1.17^{c}±0.14$
C (85:10:5)	$1.33^{ab}±0.23$	$0.87^{b}±0.08$	$43.03^{a}±0.16$	$81.67^{a}±0.58$	$0.74^{c}±0.01$	$1.13^{c}±0.06$
D (75:15:10)	$1.42^{ab}±0.38$	$0.83^{b}±0.13$	$43.07^{a}±0.08$	$81.67^{a}±2.52$	$0.81^{b}±0.02$	$1.21^{b}±0.04$
E (65:20:15)	$1.47^{a}±0.23$	$0.79^{b}±0.10$	$43.12^{a}±0.24$	$77.33^{b}±4.04$	$0.82^{b}±0.01$	$1.24^{b}±0.06$
F (Control)	$1.03^{ab}±0.21$	$0.69^{b}±0.03$	$43.12^{a}±0.14$	$71.00^{c}±1.00$	$0.85^{a}±0.03$	$1.30^{a}±0.12$

Values are means±SD of triplicate determination. Means in the same column with different superscript are significantly (p<0.05) different. S=Sprouted sorghum flour, P=Pigeon pea flour, O= Orange fleshed potato flour, Control=100% wheat flour

Table 4. Physical parameters of cookies

Blending ratio (S:P:O)	Weight (g)	Diameter (mm)	Thickness (mm)	Spread ratio
A (10:0:0)	$11.19^{b}±0.86$	$62.55^{b}±0.35$	$62.53^{a}±0.61$	$1.00^{bc}±0.02$
B (95:5:0)	$12.06^{b}±0.58$	$58.87^{c}±0.52$	$56.19^{b}±2.14$	$1.05^{b}±0.05$
C (85:10:5)	$11.14^{b}±0.14$	$61.75^{b}±0.57$	$62.44^{a}±1.58$	$0.99^{bcd}±0.06$
D (75:15:10)	$9.23^{c}±0.61$	$65.54^{a}±1.94$	$66.64^{a}±4.35$	$0.98^{bcd}±0.04$
E (65:20:15)	$7.31^{d}±0.34$	$51.69^{d}±0.18$	$56.44^{b}±4.25$	$0.92^{d}±0.06$
F (Control)	$13.89^{a}±1.02$	$49.06^{e}±0.82$	$40.25^{c}±2.69$	$1.22^{a}±0.05$

Values are means±SD of triplicate determination. Means in the same column with different superscript are significantly (p<0.05) different.S=Sprouted sorghum flour, P=Pigeon pea flour, O= Orange fleshed potato flour, Control=100% wheat flour

Table 5. Proximate composition (%) and energy value (kcal) of cookies

Blending ratio(S:P:O)	Moisture	Crude protein	Crude lipid	Ash	Crude fibre	Carbohydrate	Energy
A (10:0:0)	$4.92^{c}±0.02$	$4.38^{f}±0.00$	$16.21^{f}±0.01$	$3.11^{d}±0.01$	$2.06^{d}±0.05$	$69.32^{a}±0.02$	$440.69^{e}±0.02$
B (95:5:0)	$5.12^{b}±0.02$	$5.12^{e}±0.01$	$16.41^{e}±0.01$	$3.01^{e}±0.01$	$2.14^{c}±0.02$	$68.20^{b}±0.04$	$440.97^{e}±0.01$
C (85:10:5)	$4.87^{c}±0.01$	$5.81^{d}±0.01$	$16.96^{d}±0.01$	$3.52^{c}±0.03$	$2.17^{bc}±0.02$	$66.67^{d}±0.07$	$442.56^{d}±0.05$
D (75:15:10)	$4.90^{c}±0.02$	$8.12^{b}±0.01$	$17.42^{b}±0.01$	$3.58^{b}±0.01$	$2.21^{b}±0.00$	$63.77^{e}±0.02$	$444.34^{c}±0.02$
E (65:20:15)	$5.13^{a}±0.06$	$11.61^{a}±0.01$	$18.13^{a}±0.01$	$3.65^{a}±0.01$	$2.51^{a}±0.01$	$58.97^{f}±0.04$	$445.49^{b}±0.01$
F (Control)	$5.10^{b}±0.00$	$7.58^{c}±0.01$	$17.31^{c}±0.01$	$1.33^{f}±0.00$	$1.33^{e}±0.00$	$68.68^{c}±0.01$	$460.83^{a}±0.04$

Values are means±SD of triplicate determination. Means in the same column with different superscript are significantly (p<0.05) different. S=Sprouted sorghum flour, P=Pigeon pea flour, O=Orange fleshed potato flour, Control=100% wheat flour

Table 6. Vitamin composition (mg/100 g) of cookies

	A (100:0:0)	B (95:5:0)	C (85:10:5)	D (75:15:10)	E (65:20:15)	F (Control)
Vitamin A	24.50^{f}±0.00	32.60^{d}±0.01	45.33^{c}±0.57	60.10^{b}±0.01	67.60^{a}±0.01	28.70^{e}±0.00
Vitamin C	407.28^{c}±1.11	372.07^{e}±0.10	389.64^{d}±0.51	474.61^{b}±1.01	502.21^{a}±1.11	294.70^{f}±1.08

Values are means±SD of triplicate determination. Means in the same row with different superscript are significantly (p<0.05) different. S=Sprouted sorghum flour, P=Pigeon pea flour, O=Orange fleshed potato flour, Control=100% wheat flour

Table 7. Anti-nutritional factors of cookies

Blending ratio (S:P:O)	HCN	Phytate	Tannins	Oxalate
A (10:0:0)	2.12^{e}±0.00	4.01^{e}±0.00	5.12^{e}±0.02	212.16^{e}±0.12
B (95:5:0)	2.64^{d}±0.00	4.54^{d}±0.01	11.87^{d}±0.01	264.28^{d}±1.00
C (85:10:5)	3.13^{c}±0.00	5.18^{c}±0.00	12.05^{c}±0.01	352.51^{c}±1.02
D (75:15:10)	4.22^{b}±0.00	5.63^{b}±0.00	13.72^{b}±0.02	441.20^{b}±0.95
E (65:20:15)	4.48^{a}±0.01	6.11^{a}±0.00	14.21^{a}±0.01	452.00^{a}±0.85
F (Control)	1.08^{f}±0.00	3.11^{f}±0.00	0.31^{f}±0.00	152.51^{f}±1.10

Values are means±SD of triplicate determination. Means in the same column with different superscript are significantly (p<0.05) different. S=Sprouted sorghum flour, P=Pigeon pea flour, O=Orange fleshed potato flour, Control=100% wheat flour.

Table 8. Sensory evaluation of cookies

Blending ratio (S:P:O)	Appearance	Taste	Crispiness	Flavour	Overall Acceptability
A (10:0:0)	7.00^{b}±1.80	6.45^{bc}±1.85	6.10^{bc}±1.97	6.75^{abc}±2.05	6.75^{abc}±1.92
B (95:5:0)	7.40^{a}±1.42	6.95^{ab}±1.05	7.35^{a}±1.26	6.95^{ab}±1.15	7.35^{ab}±1.18
C (85:10:5)	7.30^{a}±1.45	5.70^{c}±1.98	5.45^{c}±2.11	6.50^{bc}±1.76	6.45^{bc}±2.42
D (75:15:10)	7.00^{b}±1.17	5.85^{c}±1.53	6.85^{ab}±1.27	6.80^{b}±1.32	6.60^{abc}±1.09
E (65:20:15)	6.80^{c}±1.64	5.90^{c}±1.77	5.90^{bc}±1.99	6.40^{c}±1.47	5.75^{c}±1.55
F (Control)	7.55^{a}±1.23	7.90^{a}±0.79	7.30^{a}±1.30	7.65^{a}±0.93	7.70^{a} ±1.13

Values are means±SD of triplicate determination. Means in the same column with different superscript are significantly (p<0.05) different. S=Sprouted sorghum flour, P=Pigeon pea flour, O=Orange fleshed potato flour, Control=100% wheat flour

4. CONCLUSION

The study has shown the possibilities of using the flour blends of sprouted sorghum, pigeon pea and orange fleshed potato to produce acceptable cookies of high nutritional value. The findings showed functional properties of sample D being compared favourably with the control in oil and water absorption capacities as well as bulk density. Significant ($p < 0.05$) increase was observed in crude protein, crude lipid, ash and crude fibre contents of all the formulated samples making the cookies high in nutritive values. Vitamins A and C content were high enough to address micronutrient deficiency in areas lacking vitamin rich food materials. All anti-nutrients analyzed (hydrogen cyanide, phytate, tannin and oxalate) were lower than the accepted permissible level for human health. Sample B (95% sprouted sorghum and 5% pigeon pea flour blends cookies) had acceptable physical properties and it was adjudged as the best among the formulated samples based on appearance, crispiness, flavour and overall acceptability which makes it compared favourably with the control.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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