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Research Article

Nutrient assessment of gluten free biscuit from African pear and orange flesh sweet potato flour blends

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Abstract

Nutrient assessment and sensory attributes of gluten free biscuit from African pear and orange flesh sweet potato flour blends was assessed. African pear and orange flesh sweet potato were processed into flour and blended at different levels of 50:50, 60:40, 70:30, 80:20 and 90:10. The control sample was produced from 100% wheat flour. A total of six biscuits recipes were formulated, prepared into dough and baked into biscuit using rubbing in method. The flour blends were assessed for their functional properties and the biscuits were analyzed for nutrient and sensory qualities. Findings showed that increasing proportion of African pear flour from 50% to 90% improved the water absorption (1.13 – 1.60 g/ml), oil absorption (0.93 – 1.37 g/ml) and emulsifying (47.44 – 61.69%) capacities. Moisture and carbohydrate contents decreased progressively from 5.21 - 4.99% and 60.48 - 57.17% respectively while protein, fat, fibre and ash contents increased from 7.35 – 8.09%, 13.35 - 21.05%, 3.07 - 3.18% and 4.87 - 4.98% respectively with increasing substitution of African pear flour. Micronutrient (mineral and vitamin) composition improved as well with acceptable sensory properties. African pear and orange flesh sweet potato could be exploited as valuable dietary sources to enrich bakery products like biscuits in Nigeria.

1. Introduction

Biscuits are baked products made from wheat flour, sugar, milk, fat, flavouring agents and other raising agents [1]. They are ready-to-eat, convenient and inexpensive food products [2] with appreciable quantities of fat and carbohydrate [3]. They represent a fast growing segment of food because of consumer demands for convenient and nutritious food products with improved taste, safety [3] and good shelf life at ambient temperature [4]. This has necessitated renewed interest and attempts to improve the nutritional quality and functionality of biscuits [5] by enriching, supplementing or substituting wheat flour with a wide variety of nutrient rich cereals, pulses, fruits, tubers [6, 7] such as African pear and orange flesh sweet potato.

African pear *(Dacryodes edulis)* is a fruit tree native to Africa, sometimes called *Safou, atanga, ube* [8], African bush pear or plum, *nsafu*, bush butter tree or butter fruit. It serves as food for direct consumption and raw material for food production if properly harnessed [9]. It has the ability to improve food nutrition and food security [9]. The seeds of African pear are rich in different proportions of carbohydrates, proteins, crude fiber, and appreciable amount of potassium, calcium, magnesium and phosphorus [10]. It is also rich in essential amino acids such as lysine, phenylalanine, leucine, and isoleucine [11]. It contains a considerable amount of fatty acids such as palmitic acids, oleic acids and linoleic acids [11]. An important natural product like gallic acids is found in significant quantity in the seed of African pear [12].

Orange-fleshed sweet potato (OFSP) is one of the sweet potato varieties being promoted in sub-Saharan Africa as a food-based measure to complement other efforts in reducing the occurrence of vitamin A deficiency (VAD) in this region [13]. Studies have proven that consumption of boiled roots improved the vitamin A marker in adults and children [14]. OFSP has been found to be a good flour substitute for wheat flour in composite flour formulation which is grown in many tropical and subtropical regions. Among the world's major food crops, sweet potato produces the highest amount of edible energy per hectare per day [15]. Among the root and tuber crops, sweet potato is the only crop that has a positive per capita annual rate of increase in production in sub-Saharan Africa [16]. and it also has considerable potential to contribute to food-based approach to tackle the problem of vitamin A deficiency, a major public health concern of the poorer nations [13].

The conventional use of wheat flour in baking has been confronted with numerous challenges such as increasing cost of importation, non-conducive growing conditions in Nigeria, allergy to gluten-sensitive individuals and non-functional contribution to health. The adoption of composite flour intended to replace wheat flour totally or partially in bakery and pastry products has been recommended. This will save money for the country, promote high yielding native plant species, better supply of protein for human nutrition and overall use of domestic agriculture. Therefore, the objective of this study was to evaluate the quality of biscuits produced from African pear and orange flesh sweet potato composite flour.

2. Materials and methods

2.1 Source of raw materials

Wheat flour (Nigeria Flour Mill Ltd), baking powder, eggs, sugar, margarine, salt (Dangote Nigeria Ltd) and African pears (*D. e. var. edulis* variety) were purchased from commercial stockers at Ubani main market, Umuahia, Abia state, Nigeria. Fresh orange flesh sweet potato tubers were purchased from National Root Crops Research Institute (NRCRI) Umudike, Ikwuano Local government area, Abia state in Nigeria. All reagents used in this study were of analytical grade and were sourced from the Laboratory Department of Biochemistry, National Root Crops Research Institute, Umudike, Abia State, Nigeria.

2.2 Processing of African pear (Dacryodes edulis) into flour

Fresh African pears were sorted to remove extraneous substances like stones, pebbles and spoilt fruits before washing with potable tap water. The fruits were washed, deseeded and diced (2 cm). The diced fruits were dried in a hot air oven (Model no.SX3-4.5-15: made in China) at 60°C for 24 hours to a moisture content of 10%. The dried diced fruits were milled into powder using a commercial hammer mill. The subsequent flour was sieved through a 500 µm mesh and stored in an air tight container under refrigeration temperature of 4°C prior to use.

2.3 Processing of orange flesh sweet potato (OFSP) tubers into flour

OFSP tubers were sorted for wholesomeness, washed with portable water for dirt removal and peeled to remove the outer layers. The peeled tubers were washed again with portable water and subjected to size reduction by dicing for ease of drying. The diced OFSP were spread out on trays and dried in a hot air oven (Model no.SX3-4.5-15: made in China) at 55°C for 36 hours. The dried OFSP was milled using SFSP 56 x 40a hammer mill, sieved through a 500 µm mesh and stored in air tight containers under refrigeration condition of 4°C prior to use.

2.4 Composite flour formulation

The composite flours were formulated as shown in Table 1. Biscuits produced from 100% wheat flour served as the reference sample.

2.5 Determination of functional properties of composite flour

The bulk density, water absorption and oil absorption capacities, emulsion capacity, swelling index, and gelatinization temperature were determined using the method described by Onwuka [17].

2.6 Production of biscuit samples

Biscuits were produced using the rubbing in method as described by Ahmed et al. [18] with some

Table 1. Formulation of composite flours.

Sample codes	African pear flour (AP) (%)	OFSP flour (%)
AP90	90	10
AP80	80	20
AP70	70	30
AP60	60	40
AP50	50	50

modifications in the recipes. First, all the ingredients contained in the recipe as presented in Table 2 were accurately weighed or measured as the case may be. The dry ingredients (flour, sugar, salt and baking powder) were mixed manually in a bowl for about 3 minutes. Vegetable shortening (baking margarine) was added and mixed until uniform. Egg, milk and water were then added and the mixture kneaded. The batter was rolled and cut with a 20 mm diameter biscuit cutter. The biscuits were placed on greased baking trays, leaving 25 mm spaces in between and baked at 180°C for 10 minutes in the baking oven (Gallenkamp, Model OV 160, England). Following baking, the biscuits were cooled within 1 h in the open air to ambient temperature and then packed in an airtight high density plastic transparent containers before being stored at 23°C prior to subsequent analysis and sensory evaluation.

2.7 Proximate determination of biscuit samples

The moisture, ash, crude protein, crude fibre and crude fat were determined according to AOAC [19]. A protein conversion factor of 6.25 was used to convert N content to crude protein, while carbohydrate was estimated by difference [i.e. 100% – protein (%) + fat (%) + crude fibre (%) +Ash (%)].

2.8 Mineral content determination

Mineral content of the test samples was determined by the dry ash extraction method followed by the determination of specific mineral content. Two (2) grams of each sample was dried and burnt to ash on a digital muffle furnace (model no: Sx2 -2.5-12; made in China). The resulting ash was dissolved in 100 ml of dilute hydrochloric acid (2M HCL), heated for 30 min and made up to 100 ml with distilled water. The digest obtained was used for the analysis of the various minerals. Calcium (Ca) and magnesium (Mg) contents were determined by the EDTA versanate complexometric titration method; potassium (K) and sodium (Na) contents by the flame photometer with appropriate standards while phosphorus (P) was determined by the vanado-molybdate yellow method using spectrophotometer [19].

2.9 Vitamin content determination

Ascorbic acid (vitamin C), thiamin (B_1), riboflavin (B_2), and niacin (B_3) contents of the biscuit were determined following the method of AOAC [19] while vitamin A content was determined following the method described by Onwuka [17].

2.10 Sensory Evaluation

A 25-member semi trained panelists conducted a descriptive sensory evaluation on the biscuit samples from different combinations. The panelists were trained using ISO 8586-1 [20] and Iwe [21] with some modifications. Each sample was placed on white saucer, coded with random 3 or 4-digit numbers as the case may be and presented to the panelists for analysis. The biscuits were analysed for appearance, texture, aroma, taste, mouth-feel and over-all acceptability, using 9-point hedonic scale with 1 for disliked extremely and 9 for liked extremely. Panelists were provided with distilled water to rinse mouths between tasting to avoid carrying over taste. Biscuit samples that scored 5 and above (neither liked nor disliked to extremely liked) for over-all acceptability were considered acceptable.

2.11 Experimental Design

This was a completely randomised design (CRD) with all the components given equal treatment.

2.12 Statistical Analysis

Data obtained were subjected to descriptive statistics and means of one-way analysis of variance (ANOVA). Means, where significantly different at $p < 0.05$ were separated using Duncan's Multiple Range Test (DMRT) with Statistical Package for the Social Science Version 21.0.

3. Results and discussion

3.1 Functional properties of composite flours

Table 3 shows that formulation of composite flour with different levels of African pear flour and orange flesh sweet potato flour blends significantly ($p<0.05$) affected the functional properties of the composite flour. The control sample (100% wheat flour), had a relatively higher water absorption capacity (1.93 g/ml) and oil absorption capacity (1.47 g/ml) than composite

Table 2. Biscuits recipe with different levels (%) of African pear and orange flesh sweet potato flour blends.

Ingredients	AP0	AP90	AP80	AP70	AP60	AP50
Wheat flour (g)	500	0	0	0	0	0
African pear (g)	0	450	400	350	300	250
OFSP (g)	0	50	100	150	200	250
Margarine (g)	100	100	100	100	100	0
Sugar (g)	250	250	250	250	250	250
Baking powder (g)	7.5	7.5	7.5	7.5	7.5	7.5
Salt (g)	2	2	2	2	2	2
Egg (g)	60	60	60	60	60	60
Milk (ml)	75	75	75	75	75	75
Water (ml)	75	75	75	75	75	75

AP0 = 100% wheat flour,
AP90 = 90% African pear flour: 10% orange flesh sweet potato flour, AP80 = 80% African pear flour: 20% orange flesh sweet potato flour, AP70= 70% African pear flour: 30% orange flesh sweet potato flour, AP60= 60% African pear flour: 40% orange flesh sweet potato flour, AP50= 50% African pear flour: 50% orange flesh sweet potato flour.

Table 3. Functional properties of African pear-orange flesh sweet potato flour blends.

Samples	Bulk density (g/ml)	Swelling index (%)	Water absorption capacity (g/ml)	Oil absorption capacity (g/ml)	Gelatinization temperature (°C)	Emulsion capacity (%)
AP0	0.66^{a}±0.003	1.19^{c}±0.03	1.93^{a}±0.12	1.47^{a}±0.06	89.0^{d}±1.73	55.97^{c}±0.12
AP90	0.66^{a}±0.001	1.32^{bc}±0.03	1.60^{b}±0.10	1.37^{b}±0.06	95.66^{a}±0.58	61.69^{a}±0.43
AP80	0.64^{a}±3.382	1.35^{bc}±0.01	1.53^{bc}±0.16	1.27^{c}±0.06	93.67^{b}±0.58	59.76^{b}±0.39
AP70	0.66^{a}±0.001	1.27^{c} ±0.23	1.43^{bc}±0.06	1.10^{d}±0.00	91.67^{c} ±0.58	55.72^{c}±0.74
AP60	0.66^{a}±0.001	1.50^{b} ±0.62	1.40^{c} ±0.10	1.03^{d}±0.06	90.67^{cd} ±1.15	52.08^{d}±0.84
AP50	0.67^{a}±0.001	1.71^{a}±0.02	1.13^{d} ±0.16	0.93^{e}±0.06	90.33^{cd} ±0.58	47.44^{e}±0.63

a-d: Values are means ± s.d of duplicate determination. Mean value in the same column but with different superscripts are significantly different (P<0.05). AP0 = 100% wheat flour. AP90 = 90% African pear flour: 10% orange flesh sweet potato flour. AP80 = 80% African pear flour: 20% orange flesh sweet potato flour. AP70= 70% African pear flour: 30% orange flesh sweet potato flour. AP60= 60% African pear flour: 40% orange flesh sweet potato flour. AP50= 50% African pear flour: 50% orange flesh sweet potato flour.

flours. Decreased proportion of African pear flour from 90% to 50% with the concurrent increase in orange flesh sweet potato flour from 10% to 50% resulted to a corresponding increase in the swelling index and gelatinization temperature while the water absorption capacity, oil absorption capacity and emulsion capacity decreased. The bulk density of the composite flours was significantly ($p < 0.05$) not affected.

Bulk density (BD) is influenced by the structure of the starch polymers [17]. The values obtained in this study ranged from (0.64 to 0.67 g/ml) and were lower than 0.72 to 0.85 g/ml reported by Florence *et al*. [22] and 0.65-1.07 g/mL reported by Oppong *et al.* [23], but higher than 0.50 to 0.55 g/ml reported by Olosunde *et al*. [24] and 0.55 - 0.57 g/mL reported by Siddiq *et al*. [25]. There was no significant ($p < 0.05$) difference in the values of bulk density obtained in this study which suggests that the composite flours and the control flour sample may possess similar starch structures. The values obtained were below 1.00 g/ml, suggesting loose structure of starch polymers [25]. This is ideal for good biscuit quality with high specific volume [26], and may encourage bulk packing of the flour samples using compact packaging material [27]. Water absorption capacity (WAC) is an important property in food. The ability of protein in flour to bind water is a result of its water absorption capacity [28]. Decreasing WAC in the composite flours may be attributed to decreasing amount and nature of hydrophilic constituents [29] as the proportion of African pear decreased. Butt and Batool [30] reported that increased concentration of protein, degree of association and conformational characteristics positively influence the WAC of flours. Consequently, increasing the proportion of orange flesh sweet potato

Table 4. Proximate composition of composite biscuits samples (%).

Samples	Moisture content	Protein content	Fat content	Fibre content	Ash content	Carbohydrate content
AP0	8.54^{a}±0.12	7.58^{bc}±0.20	18.45^{a}±0.19	3.01^{b}±0.09	5.02^{a}±0.03	57.39^{d}±0.47
AP50	5.21 ^{b}±0.02	7.35 ^{c}±0.26	13.35^{a}±9.88	3.07 ^{b}±0.30	4.87^{ab}±0.01	60.48^{a}±0.22
AP60	5.19^{b}±0.03	7.25 ^{c}±0.38	19.00^{a}±0.08	3.08^{ab}±0.03	4.59 ^{b}±0.51	60.26^{a}±0.41
AP70	5.09^{bc}±0.01	7.67^{abc}±0.03	19.99 ^{a} ±0.28	3.11^{ab}±0.01	4.93^{ab}±0.01	59.21^{c}±0.25
AP80	4.95^{c} ±0.03	7.82^{ab} ±0.10	20.60^{a} ±0.10	3.11^{ab}±0.01	4.95^{ab}±0.01	58.57^{c}±0.03
AP90	4.99^{c} ±0.12	8.09^{a} ±0.24	21.05^{a} ±0.23	3.18^{a} ±0.07	4.98^{ab}±0.02	57.71^{d}±0.21

a-d:Values are mean standard deviation for duplicate determination. Values with different superscripts within the same column are significantly different ($p<0.05$). AP0 = 100% wheat flour. AP90 = 90% African pear flour: 10% orange flesh sweet potato flour. AP80 = 80% African pear flour: 20% orange flesh sweet potato flour. AP70= 70% African pear flour: 30% orange flesh sweet potato flour. AP60= 60% African pear flour: 40% orange flesh sweet potato flour. AP50= 50% African pear flour: 50% orange flesh sweet potato flour.

flour affected the concentration of protein content negatively. Water absorption capacity suggests a good baking quality [31]. WAC obtained in this study were below 2.40 to 2.67 g/ml reported by Olosunde *et al.* [24], lower than 7.6 mL/100 g reported by Siddiq *et al.* [25], but higher than 1.00 to 1.47 g/ml reported by Florence *et al*. [22]. A water absorption capacity of 1.25 g/g (125 mL/100 g) and above is an indication of good bakery properties that required high water imbibition [25].

Oil absorption capacity (OAC) and emulsifying capacity (EC) is an important parameter of flour used in baking [32] since it is an important property in food formulation. Ability of flour to absorb oil improves the mouth feel and flavour retention [33]. The emulsion capacity is the extent to which the dietary protein will mix with oil [34]. Decreasing oil absorption and emulsifying capacities of the composite flours may be influenced by the decreasing Lipophilic nature associated with decreasing proportion of African pear flour. Composite flour with high African pear flour concentration had higher OAC and indicates desirable flavour retention ability and palatability [35]. The oil absorption capacity (OAC) of this study was higher than 0.27 to 0.82 g/ml reported by Kwaghsende *et al.* [4] but is in agreement with 1.39 to 1.57 g/ml reported by Olosunde *et al.* [24]. Also, the oil absorption capacities of this study were below 26.91 mL/g and 21.94 mL/g respectively for pigeon pea flour reported by Oppong *et al.* [23].

The swelling index is a measure of hydration capacity which defines the wettability of flour samples [36]. The higher the swelling index, the lower the wetting time [36]. As orange flesh sweet potato flour substitution increased from 10 - 50%, swelling index of the composite flours increased which may be due to increased hydrophilic sites. Swelling index values for this study were lower than 3.00 to 9.40% reported by [4] but higher than 0.53 to 0.71% recommended for wheat flour [38]. Gelatinization temperature (GT) increases as African pear flour substitution increases and vice versa. Control sample gelatinized at a lower temperature. The high gelatinization temperature of composite flours suggests starch dilution [39], hence, requiring higher temperature to gelatinize.

3.2 Proximate composition of biscuit samples

Table 4 shows the proximate composition of the biscuit samples. Crude protein, fat, crude fibre and ash contents of the biscuit samples increased progressively with increasing proportion of African pear flour from 50% to 90% while moisture and carbohydrate contents decreased concurrently. Control samples had higher moisture and ash contents than the composite samples. Orange flesh sweet potato (OFSP) contains higher moisture [40] compared to African pear. Higher moisture content in biscuit samples containing higher proportion of orange flesh sweet potato flour can be attributed to the high moisture content present in orange flesh sweet potato tuber, which consequently influences the moisture rise, suggesting lower shelf stability, since baked foods with high moisture content encourage bacterial, yeast and mould growth that could lead to spoilage [41]. The moisture content obtained in this study (4.99-8.54%) was lower than 11.09-15.10% reported by Ezeocha and Onwuneme [42], 19.57-21.03% reported by Angela *et al.* [43], 13.80-14.70% reported by Ade-Omowaye *et al.* [44] and 23.49-28.62%

reported by Adeyeye *et al.* [45]. Increased ash content implies increased mineral contents [46] with increased proportion of African pear flour. Ash content is the fraction of biomass that is composed of incombustible mineral material, which is a representation of mineral availability in food [47]. It is a measure of mineral content or inorganic residue remaining after water and organic matter have been removed by open air incineration [48]. The higher ash content present in the composite samples suggests possible improvement in the mineral contents compared to the control sample. African pear has been reported to be high in useful minerals such as iron and calcium [49], which may have contributed to the increase. The ash content of this study (4.59-5.02%) was higher than the 1.61 -1.85% reported by Ezeocha and Onwuneme [42], 0.45-1.60% reported by Ade-Omowaye *et al.* [44], 0.83-1.39% reported by Adeyeye *et al.* [45] but lower than 5.65-8.00% reported by Angela *et al*. [43]. These variations may be attributed to compositional variations, processing methods, and raw material differences among others.

Proteins are the building blocks of life. About 23-56 g of protein was recommended by [50] to meet the protein needs of the human body and combat protein deficiency. The higher protein content of composite biscuits as the proportion of African pear flour increased suggests valuable contribution in combating protein energy malnutrition, especially for low income earners. However, the values obtained (7.35–8.09%**)** in this study were below the recommended intake value (23-56 g) as well as the value (9.45-15.10%) reported by Ade-Omowaye *et al.* [44], 7.69-10.64% reported by Adeyeye *et al.* [45] and 10.79-15.30% reported by Angela *et al*. [43] but higher than 3.50-6.97% reported by Ezeocha and Onwuneme [42]. Composite biscuits had significantly higher fibre contents than the control sample. Composite biscuits containing higher proportion of African pear flour had higher fibre content. OFSP has low crude fiber content [51]. In the present study, a fibre content of 3.01-3.18% was recorded which was higher than 2.29-2.80% reported by Ezeocha and Onwuneme [42], 0.56-1.80% reported by Angela *et al.* [43], 0.30-3.20% reported by Ade-Omowaye *et al*. [44] and 0.78-1.31% reported by Adeyeye *et al*. [45]. Fibre offers a variety of health benefits. It is essential in reducing the risk of chronic diseases such as diabetes, obesity, cardiovascular diseases and diverticulitis, helping in bowel movement, lowering blood cholesterol, and reducing the risk of colon cancer [52]. Higher fat content in composite biscuits containing at least 60% African pear flour suggests the possible presence of a higher amount of fat-soluble vitamins (A, D, E and K). African pear contains about 18 to 70% of oil and there was a notable increase ($p<0.05$) in fat content as the African pear quantity increased. According to the reported data of Ariyo *et al*. [53], lipids play very important roles in the human body such as in brain function, joint mobilization, and energy production and helps the body to absorb fat-soluble vitamins A, D, E, and K which keep the body healthy. Dietary fat increases the palatability of food by absorbing and retaining flavor although excess fat is also implicated in certain cardiovascular diseases [4]. Findings from this study suggest that OFSP has a low fat content and may signify that flour blends with OFSP may likely not undergo rapid oxidative rancidity during storage if suitably packaged [54]. The fat content obtained in this study (13.35-21.05%) was higher than 1.30-17.30% reported by Ade-Omowaye *et al.* [44], 1.38-1.74% reported by Adeyeye *et al*. [45], 1.64-3.15% reported by Eweocha and Onwuneme [42] and 6.76-7.97% reported by Angela *et al*. [43]. Reduced carbohydrate contents in the composite samples with increasing proportion of African pear flour may be due to starch reduction with the concurrent increase in ash, fat and protein. However, the carbohydrate contents in the biscuits are considerably high and may be good source of energy for the body. Findings from this study relative to carbohydrate content (57.39-60.48%) were lower than 73.47-79/2% reported by Ezeocha and Onwuneme [42], higher than 45.91-56.71% reported by Angela *et al.* [43] but in agreement with 54.70-68.70% and 57.78-64.38% reported by Ade-Omowaye *et al.* [44] and Adeyeye *et al.* [45] respectively.

3.3 Mineral content of biscuit samples

The result of the mineral content of biscuit samples is presented in Table 5. Development of biscuits from blends of African pear and orange flesh sweet potato flours progressively and significantly ($p<0.05$) improved the calcium, potassium, sodium and phosphorous contents of the samples. The control sample had higher magnesium contents than the composite samples. Increasing the proportion of African pear flour with concurrent reduction of

Table 5. Mineral content (mg/100 g) of composite biscuit samples

Samples	Calcium	Magnesium	Potassium	Sodium	Phosphorous
AP0	$26.72^{d}±2.31$	$25.50^{a}±1.31$	$179.67^{d}±6.64$	$10.82^{a}±0.57$	$46.16^{c}±1.10$
AP50	$33.40^{bcd}±2.32$	$22.40^{b}±1.39$	$194.93^{c}±1.40$	$8.80^{bc}±0.27$	$72.73^{c}±3.30$
AP60	$30.74^{cd}±9.23$	$20.800^{bc}±1.39$	$200.40^{bc}±1.56$	$8.32^{c}±1.05$	$89.77^{bc}±1.32$
AP70	$38.74^{abc}±2.31$	$20.00^{bcd}±1.39$	$203.50^{b}±1.91$	$9.11^{bc}±0.02$	$76.57^{bc}±56.26$
AP80	$41.42^{ab}±2.31$	$18.43^{cd}±1.42$	$205.87^{b}±1.10$	$9.08^{bc}±0.09$	$118.47^{ab}±5.08$
AP90	$42.75^{a}±2.31$	$17.60^{d}±1.39$	$212.50^{a}±2.60$	$9.48^{b}±0.32$	$138.80^{a}±2.61$

a-d:Values are mean standard deviation for duplicate determination. Values with different superscripts within the same column are significantly different ($p< 0.05$). AP0 = 100% wheat flour. AP90 = 90% African pear flour: 10% orange flesh sweet potato flour. AP80 = 80% African pear flour: 20% orange flesh sweet potato flour. AP70= 70% African pear flour: 30% orange flesh sweet potato flour. AP60= 60% African pear flour: 40% orange flesh sweet potato flour. AP50= 50% African pear flour: 50% orange flesh sweet potato flour.

orange flesh sweet potato flour resulted in increased calcium, potassium, sodium and phosphorous owing to the rich source of these minerals in African pear fruit [55, 56], while magnesium decreased progressively. OFSP has higher magnesium content [57], hence, its reduction in proportion resulted to decrease in magnesium in the final product. Mineral content obtained in this study was lower than 117.50 to 130.50 mg/100 g for calcium, 218 to 343.00 mg/100 g for phosphorous but higher than 114 to 126.50 mg/100 g for potassium reported by [4]. [22] reported lower values for potassium (61.90 – 92.84 mg/100 g), calcium (3.28-8.25 mg/100 g) and magnesium (1.98 – 4.56 mg/100 g) contents but higher values for sodium (123.90-184.86 mg/100 g) content. The values obtained for calcium are below the FAO/WHO recommended daily intake for calcium of different target consumers such as infants and children of 0 to 9 years (300 to 700 mg/day), adolescents of 10 to 18 years (1300 mg/day), adults of 19+ years (1000 to 1300 mg/day), pregnant women (1200 mg/day) and lactating women (1000 mg/day) [58]. Increase of African pear flour in composite biscuits, although, below the FAO/WHO recommended daily intake might contribute to the calcium needs of the body. Also, the magnesium content of the biscuit samples is below the recommended intake for infants and children (26 to 100 mg/day), adolescents (230 mg/day for females and 220 mg/day for males) and adults (220 mg/day for females and 260 mg/day for males) [58]. Consequently, the magnesium content of the samples may not be adequate to meet the needs of magnesium in the body. Potassium content was many times higher than sodium contents in the biscuit samples and suggests safe and low incidence of hypertension from consuming such biscuits. Calcium is necessary for growth and helps in the calcification of strong bones for optimal growth and development [59]. Sodium is an important electrolyte in every living cell, essential in balancing fluid and muscle contraction in the body. However, excess sodium in the cell induces hypertensive condition in the cells [60]. Fortunately, the high relative potassium to sodium content in these biscuit samples is of high health benefit to consumers since both are involved in sodium-potassium ATPase in the cell system. Increased magnesium contents when orange flesh sweet potato flour was increased is of health benefit since magnesium is an essential component of all cells and is necessary for the functioning of enzymes involved in energy utilization and it is present in the bone [61]. Increased phosphorous content as the level of African pear flour substitution increases from 50 to 90% will also be beneficial in bone health. Phosphorus works closely with calcium to build strong bones and teeth. These two minerals combine to form calcium phosphate, the predominant mineral of bone. Most of the phosphorus in the body is found in the bones and teeth [62].

3.4 Vitamin content of biscuit samples

Table 6 shows the vitamin composition of the biscuit samples. The studied vitamins were significantly ($p<0.05$) different among the samples as wheat flour was completely substituted with African pear and orange flesh sweet potato flour blends. The control sample had the lowest vitamin content in all samples. By increasing the proportion of African pear flour, there was notably increase in the vitamin C content of the biscuit samples while vitamin A reduced progressively. African pear fruit contains a good

Table 6. Vitamin contents of composite biscuit samples

Samples	Vitamin A (ug/g)	Vitamin B_1 (mg/100g)	Vitamin B_2 (mg/100g)	Vitamin B_3 (mg/100g)	Vitamin C (mg/100g)
AP0	$562.00^{e}\pm4.00$	$0.01^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.07^{d}\pm0.01$	$1.70^{f}\pm0.04$
AP50	$1117.66^{a}\pm19.09$	$0.01^{a}\pm0.01$	$0.00^{a}\pm0.00$	$0.13^{a}\pm0.01$	$3.92^{e}\pm0.06$
AP60	$1040.00^{b}\pm12.12$	$0.31^{a}\pm0.51$	$0.01^{a}\pm0.00$	$0.13^{ab}\pm0.01$	$4.01^{d}\pm0.10$
AP70	$1009.00^{c}\pm9.54$	$0.02^{a}\pm0.01$	$0.01^{a}\pm0.00$	$0.12^{ab}\pm0.01$	$4.12^{c}\pm0.01$
AP80	$988.33^{d}\pm2.52$	$0.03^{a}\pm0.01$	$0.01^{a}\pm0.00$	$0.12^{b}\pm0.01$	$4.23^{b}\pm0.02$
AP90	$888.67^{a}\pm4.62$	$0.03^{a}\pm0.01$	$0.87^{c}\pm1.50$	$0.10^{b}\pm0.01$	$4.30^{a}\pm0.11$

a-f:Values are mean standard deviation for duplicate determination. Values with different superscripts within the same column are significantly different ($p< 0.05$). AP0 = 100% wheat flour. AP90 = 90% African pear flour: 10% orange flesh sweet potato flour. AP80 = 80% African pear flour: 20% orange flesh sweet potato flour. AP70= 70% African pear flour: 30% orange flesh sweet potato flour. AP60= 60% African pear flour: 40% orange flesh sweet potato flour. AP50= 50% African pear flour: 50% orange flesh sweet potato flour.

proportion of vitamin C [63] while orange fleshed sweet potato has been reported to be highly rich in beta-carotene [64], hence, the reported increase in vitamin A as the proportion of orange flesh sweet potato flour increases. Ascorbic acid and vitamin A were relatively higher in comparison to the B-complex vitamins. Akujobi [65] reported lower vitamin A (2.46 to 3.17 mg/100 g) but higher vitamin C (4.70 to 5.40 mg/100 g) contents than the values obtained in this study.

Vitamin A improves growth, promotes resistance to disease, delays ageing and promotes healthy eyes, skin, nails and hair [66, 67]. It also acts as an antioxidant and as free radical scavenger. Ascorbic acid helps in healthy lungs and bronchia, strong teeth and gum formation; and reduces several inflammatory disorders [68]. Both thiamine (B_1) and riboflavin (B_2) are involved in release of energy in the cells, help to keep the eyes, skins around mouth and nose smooth and healthy. Deficiency in riboflavin causes glossitis in men. Vitamin B_3 aids in cholesterol production and conversion of food carbohydrates into energy, digestion and nervous system functioning [69]. It aids in absorption of iron from the intestines, healing of wounds and in teeth and bone formation. However, the vitamins B_1, B_2 and B_3 obtained in this study are too low to significantly contribute to human health.

3.5 Sensory characteristics of biscuit samples

Table 7 shows the sensory scores of the biscuit samples by the panelists. The 25-member semi-trained panelists assessed the biscuit samples on appearance, texture, aroma, taste, mouthfeel and overall acceptability. Appearance is an important sensory feature of any food product as it influences acceptability. Consumers use the appearance to predict the quality of food products like biscuits. Taste is the sensation of flavour perceived in the mouth and throat on contact with a substance, food or non-food [70]. Aroma is a distinctive, typically pleasant smell perceived by the olfactory sense while mouthfeel refers to the rheological perception of food material [70]. It is one of the vital organoleptic properties of food products.

Increasing proportion of African pear flour from 50% to 90% significantly increased the scores for taste and aroma while the appearance, texture, mouthfeel and general acceptability scores increased with increasing proportion of orange flesh sweet potato flour. All the experimental biscuits had sensory scores significantly ($p<0.05$) lower than the control sample. The scores of the control sample for appearance, texture, aroma, taste and mouthfeel include 7.87, 7.87, 7.83, 7.87, and 7.70, respectively. The sensory score for each parameter decreased progressively as the level of substitution increased which is similar to the observation of [71]. Biscuits containing increasing proportion of African pear flour had lower sensory scores, indicating poor sensory preference.

Generally, in terms of the assessed sensory parameters, AP0 was most acceptable, followed by AP50 and AP60, then other experimental samples in their order of increasing African pear flour substitution. Hence, among the composite biscuit samples, biscuit samples produced from 50% African pear flour: 50% orange flesh sweet potato flour and 60 % African pear flour:40% orange flesh sweet potato flour were rated highest (6.39) among the samples

Table 7. Sensory characteristics of composite biscuit samples

Samples	Appearance	Texture	Taste	Aroma	Mouth feel	General acceptability
AP0	7.87 ^{a}±1.01	7.87^{a}±0.97	7.87^{a} ±0.97	7.83^{a}±0.94	7.70^{a} ±1.06	7.73^{a} ±0.96
AP50	6.61^{b}±0.99	6.39^{bc}±1.03	5.43^{d}±1.56	5.96^{b}±1.38	6.52^{bc} ±1.27	6.39^{a} ±1.78
AP60	6.48^{b} ±1.27	5.78^{bc}±0.99	5.61^{cd}±1.62	5.96^{b}±1.32	6.34^{c} ±1.87	6.39^{a} ±1.70
AP70	4.87^{c} ±1.84	5.39^{bc}±1.08	6.00^{cd}±1.28	6.00^{b}±1.17	6.17^{bc} ±1.24	5.70^{a} ±9.96
AP80	4.57^{b} ±1.93	4.87^{b} ±1.18	6.96^{b} ±1.52	6.13^{b}±1.58	5.30^{b} ±1.69	5.43^{a} ±1.20
AP90	4.17^{b} ±1.77	4.52^{c} ±1.95	6.52^{bc}±1.95	6.41^{b}±1.67	5.00^{bc} ±1.88	5.09^{a} ±1.93

a-d: Values are mean standard deviation for duplicate determination. Values with different superscripts within the same column are significantly different ($p< 0.05$). AP0 = 100% wheat flour. AP90 = 90% African pear flour: 10% orange flesh sweet potato flour. AP80 = 80% African pear flour: 20% orange flesh sweet potato flour. AP70= 70% African pear flour: 30% orange flesh sweet potato flour. AP60= 60% African pear flour: 40% orange flesh sweet potato flour. AP50= 50% African pear flour: 50% orange flesh sweet potato flour.

with respect to general acceptability and was liked slightly while the control sample with a rating of 7.73 was liked very much.

4. Conclusions

Substitution of wheat flour with blends of African pear flour and orange flesh sweet potato flour in biscuit production improved the nutrient composition. Proximate composition of composite biscuits improved over biscuits baked with 100% wheat flour. Micronutrients such as calcium, potassium, phosphorous, vitamin A and vitamin C were significantly improved in the composite samples with an appreciable reduction of detrimental sodium. The sensory properties and the overall acceptability of composite biscuits were acceptable to the panelist with a general acceptability score of not less than 5.0. African pear fruit and orange flesh sweet potato tuber should be valued as a dietary source to enrich bakery products like biscuits in the country with the intent of developing healthier products. substantially, the industrial value of the product is high and economically feasible due to the availability of its raw materials locally, thereby saving importation costs and generating more revenue for farmers and producers.

Authors' contributions

Designed the study, conducted the statistical analysis and proofread the final copy of the manuscript, O.U.A.; Procured the raw material, and processed them into composite flour, O.N.D.; Produced the gluten free biscuit samples and wrote the first draft of the manuscript, U.U.C.

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Availability of data and materials

All data will be made available on request according to the journal policy.

Conflicts of interest

The authors declare no conflict of interest

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