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Nutritional and sensory properties of cake made from blends of pigeon pea, sweet potato and wheat flours

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Abstract

Cake is becoming popular delicacy during celebration periods among little children and adult people in most urban cities in developing nations like Nigeria. Providing nutritious and healthy cake remains a major challenge due to high sugar content which predisposes the consumers to obesity. Potential of Wheat Flour (WF), Pigeon Pea Flour (PPF), and Sweet potato Flour (SPF) in the production of nutritional and healthy cakes were investigated. Five cake samples were produced with different formulations which include wheat flour and composite flour of wheat, pigeon pea and sweet potato in the ratio of 100:0:0, 70:20:10, 65:20:15, 60:20:20, 55:20:25 with other ingredients, respectively. The samples were analyzed for proximate content, β-carotene, anti-nutrients, minerals and sensory properties. Proximate content of the cake showed significant increases ($p>0.05$) with the inclusion of pigeon pea and the increase in sweet potato substitution levels. The tannin and trypsin inhibitor contents increased while phytate decreased with the increase in pigeon pea and sweet potato substitution level. There was no significant difference ($p<0.05$) in the panelist ratings for taste, color, flavor, texture, aroma, appearance and overall acceptability in the cake sample with ratio 70WF:20PPF:10SPF as it compares favourably with the control (cake produced from 100% wheat flour). The results indicate that a healthy and nutritious cake could be produced from composite flour of wheat, pigeon pea and sweet potato flour.

1. Introduction

Cakes are convenient food products which are sweet and often baked, usually prepared from wheat flour, sugar, shortening, baking powder and egg as principal ingredients (Atef *et al.,* 2011). The wheat which is the major ingredient, a cereal, is cultivated in many parts of the world, but imported by countries with unfavorable climatic conditions. Such importing countries such as Nigeria spend a lot of foreign exchange on the importation of wheat. There is a compelling need to develop an adequate substitute for wheat, as the demand and price of this product could further be increased by the unstable exchange rates.

In addition, there is an increasing trend among consumers for functional food products. This has greatly influenced the use of composite flours in which flours from locally grown crops and high protein seeds replace a portion of wheat flour for use in cake production. In the quest for a wheat substitute, flour with better nutritional quality than wheat would be highly desirable, especially in developing countries where malnutrition is prevalent. Composite flour is a mixture of flours obtained from roots, tubers, cereals and legumes with or without the addition of wheat flour with the aim of getting products that is better than the individual components. Cereal flours that are poor in lysine but rich in the sulfur-containing amino acids are improved by the addition of legume flours, and the nutritional value of root and tuber flours, which are poor in protein, is sufficiently improved by the addition of cereal flours (FAO, 1990). Cereals and legumes are good sources of protein, which complement each other with respect to their amino acid profile.

Pigeon pea (*Cajanus cajan*) is an important food legume cultivated mainly as a subsistence crop in the tropics and sub-tropics of Africa (ICRISAT, 2008). It can survive and reproduce in environments characterized by severe moisture stress and poor soil fertility. Pigeon pea contains about 25.83% of protein but they are underutilized. Sweet potato (*Ipomoea batatas*) is an economic and healthful food crop containing beta-carotene, substantial amounts of ascorbic acid, niacin, riboflavin, thiamin and minerals (Woolfe, 1992). It has a high potential to be used as a security food in developing

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countries with limited resources because of its short maturity time and ability to grow under diverse unfavourable conditions. Generally, sweet potatoes are consumed as boiled, roasted, fried and as raw material for the feed industry (Zuraida, 2003). It can also be used industrially as natural sweetener, dietary fibre, ingredients in bakery goods and beverages and as flavour to many other processed products (Woolfe, 1992). This study evaluated the potentials of the blends of these flours (wheat flour, pigeon pea flour and sweet potato flour) as composite flour in cake production to improve on the nutritional value of the populace and to increase the economic potentials of these indigenous crops. The aim of this work was to produce cake from the blends of these flours (wheat, pigeon pea and sweet potato) and to determine the nutritional composition and sensory properties of the cake samples.

2. Materials and methods

2.1 Materials

Wheat flour, pigeon pea, and sweet potato were procured from a local market in Ogbomoso, South West, Nigeria. Margarine, granulated sugar, butterscotch, egg, baking powder and evaporated milk were also obtained from the same source.

2.2 Preparation of pigeon pea flour, sweet potato flour and composite flour

Pigeon flour was processed into flour as described by Fasoyiro *et al.* (2010). Dried pigeon peas were washed with clean water, soaked in hot water (initial temperature 60°C) for 30 mins, dehulled by rubbing between the palms, drained and oven-dried at 50°C for 8 hrs. The dried seeds were milled using hammer mill and sieved (1 mm sieve size). The flour was then packed inside zip lock bags and stored at room temperature. The sweet potato tubers were washed in clean water, peeled, sliced manually, blanched at 100°C for 20 mins and dried at 65°C in a cabinet drier for 24 hrs. After drying, it was milled, sieved and stored in an airtight container Rodriguez *et al.* (2014). Four composite flour samples were formulated from wheat, pigeon pea and sweet potato flours in the ratios of 70:20:10; 65:20:15; 60:20:20 and 55:20:25, respectively.

2.3 Production of cake

Cake was produced from the flour samples as described by Ceserani and Kinton (2008) with slight modification. This includes creaming (fat and sugar) and the addition of other ingredients; eggs, milk, flavour, preservative and composite flour. The slurry was baked in a pre-heated oven at 220°C for 40 mins, cooled and depanned after 1hr. The cake samples were packaged in aluminum foils and stored at room temperature (about 32°C) until it is required for analyses. Cake sample was also produced from 100% wheat flour as control.

2.4 Analysis

Moisture, crude protein, fat, protein, crude fibre and ash contents were determined by the methods of AOAC (2005). Carbohydrate was determined by difference. Beta-carotene content was determined by the method of Kimura and Rodriguez-Amaya (2003). The method of AOAC (1990) was used to determine sodium, potassium, calcium. Phytate content was determined by the method of Nkama and Gbenyi (2001), while Trypsin inhibitor was determined using the method of Kakade *et al.* (1974). Tannic content was estimated by the method of Hoff and Singleton (1977).

2.5 Sensory evaluation

The method of Larmond (1977) was used for sensory evaluation. The samples of cake were subjected to sensory evaluation with 100% wheat flour cake (100% WWFC) as control. A nine-member experienced panelist drawn from Food Science and Department, LAUTECH, Ogbomoso was used to evaluate the samples. The panelists rated the samples for colour, smell, flavor, taste, texture, and overall acceptability using 9-point hedonic scale, where 1 was extremely acceptable and 9 was extremely unacceptable.

2.6 Statistical analysis

All experiments including organoleptic analyses were replicated. The means and standard deviations (SD) were calculated taking all the readings into consideration. Statistical analysis was performed using SPSS (Statistical Package for Social Sciences). One-way ANOVA (Analysis of variance at the level of significance $p\leq 0.05$) was performed using Duncan multiple range tests to ascertain the significance of the means.

3. Results

3.1 Proximate composition of flours

The results of the proximate composition of flours are shown in Table 1. The values were significantly different from each other (p<0.05). The values ranged from 5.68-9.72%, 5.86-22.74%, 0.58-3.90%, 0.32-3.28%, 0.84-3.18%, 61.74-82.47%, for moisture, protein, fat, fibre, ash and carbohydrate, respectively. The highest protein, fat and ash contents were recorded in the pigeon pea flour which could be attributed to the nutritional value of pigeon pea (Bugusu *et al.,* 2001). The highest content of fibre and β-carotene was recorded in sweet potato flour, which is a reflection of its composition.

Table 1. Proximate composition of the flours

Samples	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	CHO (%)	β-carotene (mg/100g)
SPF	5.68±0.7[b]	5.86±0.03[c]	1.50±0.2[b]	3.28±0.4[a]	1.22±0.1[b]	82.47±0.3[a]	0.01±0.00[a]
PPF	5.90±0.2[b]	22.74±0.6[a]	3.90±0.4[a]	2.66±0.6[b]	3.18±0.3[a]	61.64±0.1[c]	0.00±0.00[a]
WHF	9.72±0.5[a]	13.10±0.2[b]	0.58±0.04[c]	0.32±0.01[c]	0.84±0.01[c]	75.45±0.23[b]	0.00±0.00[a]

Values are expressed as mean ± standard deviation of duplicate determination. Mean with the same superscript along the same column are not significantly different ($p>0.05$). CHO: Carbohydrate; SPF: Sweet Potato Flour; PPF: Pigeon Pea Flour; and WHF: Wheat Flour

Table 2. Anti-nutrient composition of the flours

Samples	Tannin (mg/100 g)	Phytate (mg/100 g)	Trypsin inhibitor (mg/100 g)
SPF	76.53±0.14[b]	1.87±0.08[b]	15.48±0.19[c]
PPF	87.19±0.08[a]	2.06±0.06[ab]	57.48±0.90[a]
WHF	33.70±0.32[c]	2.18±0.05[a]	27.59±0.47[b]

Values are expressed as mean ± standard deviation of duplicate determination. Mean with the same superscript along the same column are not significantly different ($p>0.05$). CHO: Carbohydrate; SPF: Sweet Potato Flour; PPF: Pigeon Pea Flour; and WHF: Wheat Flour

Table 3. Proximate composition of the cake samples

Samples	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	CHO (%)
A	20.69±0.14[a]	8.10±0.01[c]	27.98±0.36[b]	0.69±0.04[e]	2.35±0.01[d]	40.21±0.45[d]
B	20.63±0.06[a]	8.34±0.04[a]	23.71±0.42[e]	0.93±0.02[d]	2.94±0.03[a]	43.46±0.47[ab]
C	17.85±0.28[b]	8.20±0.01[b]	25.02±0.70[d]	1.04±0.02[c]	2.84±0.06[b]	45.07±1.05[a]
D	17.74±0.12[b]	7.62±0.01[d]	29.39±0.56[a]	1.10±0.01[b]	2.70±0.01[c]	41.46±0.69[cd]
E	18.28±0.39[b]	8.05±0.01[c]	26.69±0.04[c]	1.19±0.03[a]	2.80±0.03[ab]	42.93±0.33[bc]

Sample A - Whole wheat cake
Sample B - Cake made of 70% wheat: 20% pigeon pea: 10% sweet potato
Sample C - Cake made of 65% wheat: 20% pigeon pea: 15% sweet potato
Sample D - Cake made of 60% wheat: 20% pigeon pea: 20% sweet potato
Sample E - Cake made of 55% wheat: 20% pigeon pea: 25% sweet potato

Table 4. Anti-nutritional analysis of the sample cakes

Samples	Tannin (mg/100 g)	Phytate (mg/100 g)	Trypsin inhibitor (mg/100 g)
A	17.95±0.07[d]	1.83±0.03[a]	14.11±0.56[e]
B	21.90±0.03[c]	1.71±0.01[b]	28.46±0.05[d]
C	22.04±0.06[c]	1.66±0.03[bc]	39.91±0.41[c]
D	22.63±0.34[b]	1.65±0.01[c]	41.49±0.01[b]
E	23.73±0.07[a]	1.48±0.02[d]	47.65±0.35[a]

Values are expressed as mean ± standard deviation of duplicate determination. Mean with the same Superscript along the same column are not significantly different ($p>0.05$)
Sample A -Whole wheat cake
Sample B - Cake made of 70% wheat: 20% pigeon pea: 10% sweet potato
Sample C - Cake made of 65% wheat: 20% pigeon pea: 15% sweet potato
Sample D - Cake made of 60% wheat: 20% pigeon pea: 20% sweet potato
Sample E - Cake made of 55% wheat: 20% pigeon pea: 25% sweet potato

Table 5. Mineral composition of cake samples

Samples	Ca (mg/100 g)	P (mg/100 g)	K (mg/100 g)
A	321±2.56[a]	221±0.07[a]	951±0.78[a]
B	132±0.35[e]	104±0.14[e]	222±0.59[e]
C	137±0.13[d]	107±0.84[d]	237±0.40[d]
D	142±0.96[c]	113±0.20[c]	256±0.55[c]
E	148±0.66[b]	119±0.40[b]	281±0.61[b]

Values are expressed as mean ± standard deviation of duplicate determination. Mean with the same Superscript along the same column are not significantly different ($p>0.05$)
Sample A -Whole wheat cake
Sample B - Cake made of 70% wheat: 20% pigeon pea: 10% sweet potato
Sample C - Cake made of 65% wheat: 20% pigeon pea: 15% sweet potato
Sample D - Cake made of 60% wheat: 20% pigeon pea: 20% sweet potato
Sample E - Cake made of 55% wheat: 20% pigeon pea: 25% sweet potato

Table 6. Sensory evaluation of the sample cakes

Samples	Taste	Colour	Texture	Aroma	Appearance	Overall acceptability
A	8.00±0.71[a]	7.20±0.84[a]	7.00±0.71[a]	6.80±1.10[a]	7.00±1.73[a]	7.80±0.45[a]
B	7.20±1.10[a]	7.20±0.45[a]	6.80±0.84[a]	7.00±0.71[a]	7.60±0.55[a]	7.00±0.71[a]
C	5.00±0.00[b]	5.80±0.45[b]	5.00±0.00[b]	5.20±0.45[b]	5.20±0.84[b]	4.80±0.84[b]
D	3.80±0.45[c]	5.20±0.84[b]	5.00±0.00[b]	4.60±0.55[b]	4.20±0.45[b]	4.20±0.84[b]
E	4.00±0.71[bc]	5.20±0.84[b]	5.00±1.00[b]	4.80±0.84[b]	5.00±0.00[b]	4.00±1.41[b]

Values are expressed as mean ± standard deviation of duplicate determination. Mean with the same Superscript along the same column are not significantly different ($p>0.05$)
Sample A -Whole wheat cake
Sample B - Cake made of 70% wheat: 20% pigeon pea: 10% sweet potato
Sample C - Cake made of 65% wheat: 20% pigeon pea: 15% sweet potato
Sample D - Cake made of 60% wheat: 20% pigeon pea: 20% sweet potato
Sample E - Cake made of 55% wheat: 20% pigeon pea: 25% sweet potato

3.2 Anti-nutritional composition of the flour samples

Table 2 shows the results of the anti-nutrient of the flour samples. The values ranged from 33.70-87.19 mg/100 g (SPF), 1.87-2.18 mg/100 g (PPF) and 15.48-57.48 mg/100 g (WHF), for tannin, phytate and trypsin inhibitor, respectively. The highest values for tannin, phytate and trypsin inhibitor content of the samples were 87.19±0.08 mg/100 g, 2.18±0.05 mg/100 g and 57.48±0.90 mg/100 g respectively, for PPF.

3.3 Proximate composition of cake samples

The proximate composition is shown in Table 3. The values ranged from 17.74-20.69%, 7.62-8.34%, 25.02-29.39, 0.69-1.19, 2.35-2.94 and 40.21-45.07% (for moisture, protein, fat, fibre, ash and carbohydrate (CHO)). Sample with ratio 70:20:10 had the highest values of 8.34±0.04% and 2.94±0.03%, respectively for protein and ash. The sample with the least protein content was the sample with a ratio 60:20:20 (7.62±0.01%). Cake sample made from the control had the least ash content (2.35±0.01%). The 70:20:10 sample showed significantly higher values for proximate principles

3.4 Anti-nutritional factors

The results of the anti-nutritional contents of the samples are shown in Table 4. The ratio 55:20:25 sample had the highest values ($p<0.05$) for tannin and trypsin inhibitor while the control sample has the lowest value of 1.83 mg/100 g. Tannin values ranged from 17.95±0.03 mg/100 g to 23.73±0.07 mg/100 g. Phytate ranged from 1.48 mg/100 g to 1.83 mg/100 g. The trypsin inhibitor content ranged from 14.11±0.56 mg/100 g (control) to 47.65±0.35 mg/100 g (55WF:20PPF:25SPF) for cake samples. The trypsin inhibitor content value was highest for the cake sample made from 55WF:20PPF:25SPF composite flour while the least values were recorded with the control (100%WF).

3.5 Minerals

The mineral content of the samples is as shown in Table 5. Calcium contents of the sample ranged from 132 mg/100 g to 321 mg/100 g. The phosphorus content of the samples was the least with values ranging from 104 mg/100 g to 221 mg/100 g for the cake sample. The potassium (K) value was highest in the sample and the values ranged from 222 mg/100 g to 951 mg/100 g for cake. In all the mineral elements, the control samples had higher values ($p<0.05$).

3.6 Sensory evaluation

The panelists mean ratings for the cake samples is shown in Table 6. It was found that the taste score ranged from 3.80 to 8.00. Colour rating of cake ranged from 5.20 to 7.20. The values for the cake samples ranged from 5.00 to 7.00 for texture. Aroma and appearance had the value that ranged from 4.60 – 7.00 and 4.20-7.60, respectively. The cake samples made from composite flour of 100 WF:0 PPF:0 SPF and 70% WF: 20% PPF: 10% SPF were the best rating of overall acceptability with values of 7.80±0.45 and 7.00±0.71, respectively.

4. Discussion

4.1 Proximate composition

The moisture content of the cake samples increased from 17.74% to 20.69% with the increase in the level of Sweet potato flour (SPF) (10-25%). Increase in moisture content has been associated with the increase in fibre content (Elleuch *et al.*, 2011; Maneju *et al.*, 2011). The protein content of cake samples indicated that Sample B (70WHF: 20PPF: 10SPF) had the highest value and was significant ($p<0.05$). This could be a reflection of the high protein content in pigeon pea flour. The varying protein content of the samples is as a result of the use of varying amounts of wheat and sweet potato flour in their formulation. A similar finding was reported by earlier workers (Okorie and Onyeneke, 2011). This indicates that consumption of this baked product produced from the composite flour would supply a significant amount of protein to the body. The values obtained for the fat content of the cake sample indicated the cake sample made from the composite flour (65:20:20) had the highest values of 29.39±0.56% while the cake sample with this formulation (70:20:10) had the least values among the composite samples. The general decrease in the fat contents of the products may be attributable to the addition of sweet potato flour. Sweet potato cultivar contains a lower level of mean crude fat content (Dako *et al.,* 2016). High-fat content could impact negatively on the shelf stability of a product due to rancidity development. Crude fiber values showed that the 55WHF: 20PPF: 25SPF ratio for cake sample had significantly ($p<0.05$) the highest values, while the least crude fiber values were the control samples. High fiber is of great benefit to the body, as it helps to maintain bowel integrity, lower blood cholesterol level, and control blood sugar level. The consumption of this product has potentials to provide an appreciable amount of fiber to the body for proper functioning of the digestive and excretory systems. The ash content of the cake sample increased from 2.35% to 2.94% with an increase in the proportion of SPF. The values for the control samples of the cake sample were significantly (p<0.05) lower than the composite samples. This is an indication that the inclusion of SPF may enhance the amount of mineral intake in the food product (Oyetoro *et al.,* 2007), and as such would contribute appreciable dietary amounts of the mineral. This result is in agreement with reports of Ayo *et al*. (2010) and Afolabi *et al.* (2001). The result showed that there was a significant difference ($p<0.05$) between all the samples in the carbohydrate values, where 65WHF:20PPF:15SPF ratios had the highest values of 65.07%, while the control had the least values of 40.21%. The general decreased value of the cake sample is similar to the reported value for cake (Okorie and Onyeneke, 2011).

4.2 Anti-nutritional factors

Significant ($p<0.05$) differences in the levels of the anti-nutrients in flour and cake samples were observed. Generally, higher levels of antinutrients were found in the PPF samples compared to those in the SPF and WHF. In the cake sample, tannin and trypsin inhibitor increased significantly ($p<0.05$) with the increase in SPF substitution, with the lowest values for the control. Trypsin inhibitor may hamper protein digestibility, trypsin inhibitor is thermoliable and may be destroyed with the application of heat (Ohizua *et al.,* 2016). The tannin amount in this study may not be as such harmful as expected for consumption. The high amount of tannins is well known to form complexes with proteins and reduced the solubility of proteins and make protein less susceptible to proteolytic attack than the same proteins alone (Hemert *et al.*, 2014). The level of phytate content significantly decreased ($p<0.05$) with the increase in SPF substitution for the cake. The levels of phytate in baked products were as low as to have the anti -effect to the body as it is far below the daily intake (150 -1400 mg) required by the body (Reddy, 2002). This reduction may be due to nutrient-nutrient interaction with increasing levels of SPF. High levels of phytates in human nutrition are toxic and limit the bioavailability of calcium, magnesium, iron and phosphorus by the formation of insoluble compounds with the minerals (Aletor and Omodara, 1994). The results showed that the concentrations of anti-nutrients in the composite flour were below toxic levels.

4.3 Mineral elements

The mineral contents of the samples were significantly ($p<0.05$) decreased. Calcium, Phosphorus and Potassium levels increased respectively in the cake samples produced from 70WF:20PPF:10SPF ratio compared to the control (100%WF). In all the products, mineral content differed significantly ($p<0.05$). Understandably, the lower mineral content of the experimental samples could be attributed to the increasing proportions of SPF which contain low mineral elements. This is in line with the report of Abubakar *et al.* (2010) which also observed a low level of elements in the mineral analysis.

4.4 Sensory evaluation

There was a significant decrease ($p<0.05$) in the sensory ratings of the cake with an increase in SPF level. However, the rating of colour, texture, taste, aroma, appearance and overall acceptability for 70:20:10 ratio and control for cake samples were not significant. The samples produced from 65:20:25 ratio was rated least by the panelists. This might not be unconnected with by-products of reaction between carbohydrate and protein which developed undesirable sensory attributes. The addition of 10% SPF and 20% PPF produced acceptable cake of comparable quality with the control in all the sensory indicators.

5. Conclusion

In conclusion, 10% SPF and 20% PPF flour substitution rate for wheat flour produced an acceptable cake with high nutritive and sensory quality compared to whole wheat flour. School lunch snacks based on SPF, PPF and WF would provide a healthy snack and also protect against obesity and diabetes in both children and adults. Consequently, production of cakes of different kinds from 10% SPF and 20% PPF composite with wheat flour would provide an extra-nutrition especially for growing children.

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