Original Research Article

Nutritional Composition of Flour Blends of Wheat, Mushroom (*Pleurotus ostreatus*) and Unripe plantain (*Musa paradisiaca*) Flour Blends

ABSTRACT

Aims: This research aimed at determining the chemical and nutritional properties of flour blends from wheat, mushroom and unripe plantain composite flour in order to explore its potentials in food formulation.

Study design: The experiment followed a completely randomized design.

Methodology: Different formulations were obtained using optimal mixture design of response surface methodology from the blends of wheat, mushroom and unripe plantain. The proximate, mineral and vitamin contents were determined for the formulated samples. The results were further optimized using optimal design of response surface methodology.

Results: The values for moisture, ash, protein, fat, fibre, carbohydrate and energy for the flour blends ranged 8.46-11.82%, 0.80-1.87%, 8.65-14.01%, 0.95-4.98%, 0.35-0.59%, 70.04-78.64% and 354.04-381.02 kcal/100g, respectively. The values obtained for calcium, magnesium, potassium, sodium and iron of the flour blends ranged 26.60-29.95, 0.91-4.05, 1.62-2.01, 80.50-108.14 and 0.88-1.16 mg/100g, respectively. The values obtained for vitamins B_1, B_2, B_3, B_6 and C of the flour blends ranged 150.36-160.60, 7.10-20.25, 6.04-23.92, 7.12-7.23, and 2.02-3.05 mg/100 g, respectively. The two optimum blends that gave overall best results using nutritional compositions as dependent variables were 80:12.68:7.32 and 80:13.21:6.79 (wheat, mushroom and unripe plantain).

Conclusion: The result of the proximate and nutritional content showed that the composite flour of wheat, mushroom and unripe plantain flour is a good source of ash, protein, fat, dietary fibre and carbohydrate and relevant in food application especially in the production of baked food products especially in developing countries.

Keywords: *Proximate composition, Vitamins, Minerals, Flour blends*

1. INTRODUCTION

Composite flour is a mixture of several flours obtained from legumes, tubers, cereals, roots and other ingredients with the intention of replacing wheat flour totally or partially in bakery and pastry products [1]. Composite flours have been used extensively and successfully in the production of baked foods. Several researches have also been reported on the functionality of composite flour from cereals, tubers and legume combination and it was deduced that the composite flour showed good functionality than the individual flour [2-5].

Mushroom is also called white vegetables or boneless vegetarian meat. They fall between the best vegetables and animal protein source [6]. Mushroom is rich in fibres, protein, vitamins and minerals and abundant in essential amino acid [7]. It is a good source of quality protein especially rich in lysine, and thus will supplement well a cereal-based diet. Mushroom could be a good source of protein that can be used to battle protein malnutrition in cereal-dependent developing countries [8]. The value of mushroom protein is two times as that of potatoes and asparagus, four times as that of carrots and tomatoes [9]. Mushrooms have been used for centuries as human food, being valued predominantly for their array of textures and flavours.

Plantain (*Musa paradisiaca*) is traditionally grown in West Africa as a source of food and local staple diets it can be processed into more durable products such as flour which can be stored for future use [10]. Plantain is a major source of energy and carbohydrate for millions of people in these regions [11]. Plantain is a source of starchy staple for millions of people in Nigeria. Apart from the dietary fiber, plantains contain essential minerals such as sodium, potassium and various vitamins like A, B_1, B_2 and C. Plantains, when processed to flour or chips, could be possible food options for obese individuals [12]. It is a popular dietary staple due to its versatility and good nutritional value and is consumed in Nigeria mainly as snacks in form of chips. Unripe plantain is by tradition processed into flour in Nigeria and other African countries [13].

The dependence on the use of wheat flour due to its gluten content in baking industry makes the demand for wheat flour high which has rendered our local crops underutilized. The ability to meet this demand calls for research into alternative local sources of flour to substitute the usage of wheat flour for baking products [14]. It is possible to improve the nutritional quality of cereal proteins by combination with other plant protein sources [15], such as mushrooms, unripe plantain, cowpea and soybeans amongst others. This research therefore is aimed at developing composite flour comprising wheat, mushroom and unripe plantain flour to be able to explore its potentials in food formulation and confectionary industries.

2. MATERIALS AND METHODS

2.1 Materials

Fresh mushrooms were obtained from balance diet cold store, Ibadan while unripe plantain, wheat flour (Honeywell brand), margarine, baking powder, table salt, granulated sugar, and eggs were purchased from a local market in Ibadan.

2.2 Preparation Mushroom flour

The fresh mushrooms were processed to remove dirt and other field damaged portion. The cleaned and fresh mushrooms were chopped into small pieces with a knife and blanched in hot water at 80 ℃ for 3 min. The water was drained and mushrooms were spread in trays and dried in a dryer at 55 ℃ for 9 h. After cooling to room temperature, the dried mushroom was ground into powder in a grinder, sieved (200 µm) and packaged in an air- tight container until ready for use [16].

2.3 Preparation Plantain flour

Plantain flour was prepared with slight modification as described by Falade and Olugbuyi [17]. Matured unripe plantain fruits were peeled manually with the aid of stainless-steel kitchen knives and the pulp were cut into uniform slices with thickness of about 1.5 mm. The slices were blanched at 80 ℃ for 5 min to prevent browning. The drained samples were dried in a dryer at 55 ℃ for 24 h [18]. The dried chips were milled using a hammer mill sieved (200 µm) and stored in an air tight container until ready for used.

2.4 Experimental Design and Flour Formulation

Optimal mixture design of response surface methodology (RSM) (Design expert 6.0. Stat Ease Inc Minneapolis, USA) was used for the experimental design. The independent variables were wheat flour (80-100%), mushroom flour (0-20%) and unripe plantain flour (0-20%) Further optimization was done using optimal design of response surface methodology and the responses, protein, ash, fibre content and energy, vitamins and minerals were optimized to select the best sample (s) from the 10 flour blends.

Table 1: Composite flour obtained from the optimal mixture model of RSM

Run	Wheat flour (%)	Mushroom flour (%)	Plantain flour (%)
1	86. 67	6.67	6.67
2	80	0	20
3	83.33	13.33	3.33
4	90	10	0
5	90	0	10
6	93.33	3.33	3.33
7	83.33	3.33	13.33
8	80	10	10
9	80	20	0
10	100	0	0

2.5 Proximate Analysis of Wheat, Mushroom and Unripe Plantain Composite Flour

The moisture, ash, crude protein, fat and crude fibre were determined as described by Official Method of Analysis [19] while the carbohydrate was calculated by difference. Moisture content (%MC) was determined by drying samples in an oven at 105 °C for 16 h. Crude protein percentage (% CP) was determined by Kjeldahl method and the percentage nitrogen obtained was used to calculate the% CP using the relationship: %CP = %N × 6.25. Fat content (%) was determined using Soxhlet extraction technique and percentage ash (%) was determined by incinerating the samples in a muffle furnace at 600 °C for 6 h. The ash was cooled in a desiccator and weighed. Crude fibre percentage (% CF) was determined by dilute acid and alkali hydrolysis and the carbohydrate was determined by difference that is, % Carbohydrate = 100 - (moisture + ash + fat + protein + fiber). The energy value was calculated in kJ/100g as described by Iombor e*t al*. [20]. It was calculated using the equation:

Energy value = $(4 \times CHO) + (4 \times Protein) + \ (9 \times Fat)$

2.6 Determination of Mineral and Vitamin Contents of Wheat, Mushroom and Unripe Plantain Composite Flour

The mineral content of the formulated samples was determined using the method described by AOAC [19]. The samples were ashed at 550 °C. The ash was boiled with 10 cm^3 of 20% hydrochloric acid in a beaker and then filtered into a 100 cm^3 standard flask. This was made up to the mark with deionized water. The minerals (phosphorus, potassium, iron and sodium) were determined from the resulting solution was determined using Atomic Absorption Spectrophotometer (AAS Model Bulk Scientific Accuzy 211). Magnesium and calcium were determined using a spectrophotometer UV/V Spectrophotometer model 752N.

The vitamin B_1 B_2 and B_3 were determined using the method described by of Okwu and Josiah [21] while vitamin B_6 was determined using the method of AOAC [19]. Ascorbic acid was determined according to the method used by Benderitter *et al.* [22].

2.7 Statistical Analysis

The experiment followed a completely randomized design (CRD). One way analysis of variance (ANOVA) was conducted, and the means were separated by Duncan's New Multiple Range Test (DNMRT) using the Statistical Package for Social Sciences (SPSS) version 16. The level of significance was accepted at 0.05 probability level.

3. RESULT AND DISSCUSSION

3.1 Chemical Composition of Composite Flours

The results of proximate composition of wheat, mushroom and unripe plantain flour is presented in Table 2. The moisture content of the flour formulation ranged from 8.46 to 11.82%. The blend containing 80:20:0 (wheat, mushroom and unripe plantain) had the least percentage moisture value while blend 83.33:3.33:13:33 (wheat, mushroom and unripe plantain) had the highest moisture value. Low moisture content in flour retards mould growth and other biochemical reactions and also enhances storage stability [23]. The values obtained in this study were higher than values (4.68 to 7.52%) reported by Arise *et al*. [24] for wheat, plantain and bambara groundnut composite flour.

The protein content of the flour blend ranged from 8.65 to 14.01%. The lowest protein content value was found in the 90:0:10 (wheat, mushroom and unripe plantain) blend while the highest value was found in the 80:20:0 (wheat, mushroom and unripe plantain) blend. Significant difference ($p<0.05$) was observed among the various flour blends. The values obtained were indicative of high protein content in the blends. Mushroom flour basically contributed to the protein content as it has been reported to have higher protein content than wheat and unripe plantain flour. Protein is required for growth, repair, and maintenance of the body. Similar results were obtained by Okafor *et al*. [25] with substitution of wheat flour for mushroom powder, which resulted into increasing the protein content of the bread. Foods that are high in protein are of great nutritional importance in developing countries such as Nigeria where there is a prevalence of protein malnutrition [26-27].

The fat content of the blends ranged from 0.95 to 4.98 %. The sample containing 90:0:10 (wheat, mushroom and unripe plantain) had the lowest fat content while the blend with 80:20:0 (wheat, mushroom and unripe plantain) had the highest value. The fat content results were found to be significantly different ($p<0.05$) from each other. The increase of fat content in this study was due to increase in proportion of mushroom in the flour blend. Flours high in fats have been reported to be good as flavour enhancers and useful in improving palatability when included in foods [28]. The fat contents obtained in this study are low compared with the values (4.44 – 8.80%) obtained in the blends of wheat, cocoyam and bambara groundnuts [29].

The crude fibre ranged from 0.35 to 0.59%. The flour blend containing 90:0:10 (wheat, mushroom and unripe plantain) had the lowest fibre content value while flour blend containing 80:20:0 (wheat, mushroom and unripe plantain) had the highest fibre content. Low crude fibre (0.35%) value was obtained for wheat flour but the values obtained from the composite flour was however higher than that of wheat flour. The presence of high dietary fibre in food products is essential owing to its ability to bulk addition to food and to facilitate bowel movement (peristalsis) [30]. The values obtained in this study are lower than values reported by Bamigbola *et al*. [31] for wheat flour, plantain flour and tigernut flour.

Ash content, a reflection of the mineral element presents in the samples ranged from 0.80 to 1.87% with 90:10:0 (wheat, mushroom and unripe plantain) having the lowest ash content and 80:20:0 (wheat, mushroom and unripe plantain) the highest. Significance ($p<0.05$) difference were observed in the values of ash in the flour blends. Plantain and mushroom flour contributed to total ash content as both have higher ash content than wheat flour with regards to previous researchers. Mineral element in the flour blend could be of immense benefit to the body. The values in this study were less than with values (0.71-2.85%) reported by Ekunseitan *et al.* [32] for wheat, mushroom and high-quality cassava flour.

The carbohydrate content ranged from 70.04 to 78.64% which are relatively high in 80:20:0 and 93.33:3.33:3.33 (wheat, mushroom and unripe plantain) flour blends respectively. Significant ($p<0.05$) difference was observed in the carbohydrate values of the various flour blend. The result showed that the flour blends are rich sources of carbohydrate. David *et al.* [33], Evanson-Inyang and Ekop [34] and Oladele and Aina [35] had reported that wheat, plantain and mushroom flours, respectively are good sources of carbohydrate. The high carbohydrate content of the flour blends indicated that it could be used in managing protein-energy malnutrition. The values obtained in this study were higher than values (54.37-60.99%) reported by Arise *et al*. [24] for wheat, plantain and bambara flour.

The energy content ranged between 354.04 and 381.02 kcal/100 g in all wheat, mushroom, unripe plantain flour blends samples. The energy value of food is very important as it helps in determining the fuel value of food. Energy is not a nutrient but is required in the body for metabolic processes [36].

3.2 Mineral Composition of Wheat- Mushroom-Plantain Composite Flour

The mineral composition of the wheat-mushroom-plantain composite flour is shown on Table 5. The calcium content obtained from the flour samples ranges between 25.60 and 29.95 mg/100 g. In this study, the lowest calcium content was observed in sample 80:0:20 (wheat, mushroom and unripe plantain flour) while the highest calcium content was observed in sample 83.33:3.33:13.33 (wheat, mushroom and unripe plantain flour). The result indicates that mushroom and unripe plantain flours are good source of calcium than the wheat flour.

Calcium is essential in maintaining body's total health; it also ensures proper functioning of nerves and muscles [37]. The calcium contents observed in this study were lower than values observed Awolu *et al*. [29], for maize, soybean and tiger-nut blends and value obtained by Bamigbola *et al*. [31] for plantain and tiger nut flour.

The phosphorous content obtained from the sample ranges between 1.82 and 1.95 mg/100 g. The least values were observed in sample 83.33:3.33:3.33 (wheat, mushroom and unripe plantain flour) while the highest phosphorous content was observed in sample 86.67:6.67:6.67 (wheat, mushroom and unripe plantain flour). Addition of mushroom and unripe plantain flour increased the phosphorous content of the flour blend. This indicates that phosphorous is present in both the mushroom and unripe plantain flour.

The potassium content obtained from the sample ranges between 1.62 and 2.01 mg/100 g. The lowest potassium was observed in sample 80:10:10 (wheat, mushroom and plantain flour) while the highest potassium content was observed in sample 93.33:3.33:3.33 (wheat, mushroom and plantain flour). Increase in the addition of mushroom and unripe plantain flour increased the potassium content of the flour blend. Potassium together with sodium is required in the maintenance of osmotic balance and consequently protect against arterial hypertension [38].

The magnesium content obtained from the sample ranges between 0.91 and 4.05 mg/100 g. The highest magnesium content was observed in sample 90:0:10 (wheat, mushroom and unripe plantain flour). Magnesium aids in muscle contraction, helps keep blood pressure normal, strengthen bones and also keep the heart rhythm steady [6].

The iron content obtained from the sample ranges between 0.88 and 1.16 mg/100 g. The highest iron content was observed in sample 83.33:3.33:13.33 (wheat, mushroom and plantain). The iron in this study is lower than the recommended daily allowance (RDA) of iron, 15 mg/day for females 14-18 years and 11 mg/day for males 14-18 years [39]. Iron is a cofactor in enzymes and a major component of myoglobin and hemoglobin. Iron is needed for the formation of hemoglobin [40].

The sodium content obtained from the sample ranges between 80.50 and 108.14 mg/100 g. The lowest value was observed at 93.33:3.33:3.33 (wheat, mushroom and unripe plantain flour) while the highest sodium content was observed in sample 90:10:0 (wheat, mushroom and unripe plantain flour). Some of the important functions of sodium in the body are maintenance of water balance, absorption and transportation of some nutrients; it has been recommended to be taken in reduced quantity.

3.3 Vitamin Contents of Wheat Mushroom and Unripe Plantain Composite Flour

The vitamin content of the wheat, mushroom and unripe plantain composite flour is shown on Table 6. The vitamin B_1 content obtained from the sample ranged between 7.10 and 20.25 mg/100 g. The highest thiamine content was observed in sample 90:0:10 (wheat, mushroom and plantain). This B_1-vitamin is a vital nutrient which is needed by the body for proper functioning of the nervous system [41].

The vitamin B_2 content obtained from the flour blends ranged between 8.00 and 30.52 mg/100 g. The highest riboflavin content was observed in sample 83.33:3.33:13.33 (wheat, mushroom and unripe plantain flour) Riboflavin is important in maintaining healthy red blood cells and also promotes healthy skin and vision [42].

The vitamin B_3 content obtained from the flour blends ranged from 6.04 to 23.92 mg/100 g. The highest niacin content was observed in sample 86.67:6.67:6.67 (wheat, mushroom and unripe plantain flour). Niacin prevents pellagra and it helps in controlling blood cholesterol and in release of energy from carbohydrate fat and protein which keeps the bodies nervous and digestive systems in good health [43].

The vitamin B_6 content obtained from the sample ranged between 7.12 and 7.23 mg/100 g. The highest vitamin B_6 content was observed in sample 80:20:0 (wheat, mushroom and plantain). Vitamin B_6 are important in several metabolic activities in the body especially those reaction involving nitrogen containing compounds [44].

Vitamin C (ascorbic acid) helps in the health of lungs and bronchia, teeth and gums, bones and joints, and purifies the blood. The result of the vitamin C content obtained in this study was less than the value (3.18 and 5.30 mg/100 g) as reported by Adegunwa *et al*. [45].

Table 2: Proximate composition (g/100 g) and energy value of the composite flour comprising wheat, mushroom and unripe plantain

Sample			Moisture	Protein	Fat	Fibre	Ash	CHO	Energy
WF (%)	MF (%)	UF (%)	(%)	(%)	(%)	(%)	(%)	(%)	(kcal)
86.67	6.67	6.67	10.44^{c}	11.40^{e}	1.95^{e}	0.50^{c}	1.14^{e}	74.55^{c}	361.35^{f}
80	0	20	9.91^{e}	9.03^{g}	1.13^{f}	0.42^{e}	0.85^{g}	78.64^{a}	360.85^{g}
83.33	13.33	3.33	10.84^{b}	13.18^{b}	3.08^{b}	0.59^{b}	1.83^{b}	70.47^{e}	362.32^{e}
90	10	0	10.05^{d}	11.43^{e}	2.75^{c}	0.52^{c}	1.28^{d}	73.96^{c}	366.31^{c}
90	0	10	9.95^{e}	8.65^{h}	0.95^{g}	0.39^{f}	0.80^{h}	79.24^{a}	360.11^{g}
93.33	3.33	3.33	9.92^{e}	11.31^{f}	1.96^{e}	0.43e	0.90^{g}	75.47^{b}	364.76^{d}
83.33	3.33	13.33	11.82^{a}	11.37^{e}	2.07^{d}	0.45^{d}	1.00^{f}	73.28^{d}	357.23^{h}
80	10	10	9.86^{e}	11.48^{d}	3.08^{b}	0.58^{b}	1.38^{c}	73.60^{c}	368.04^{b}
80	20	0	8.46^{f}	14.01^{a}	4.98^{a}	0.62^{a}	1.87^{a}	70.04^{f}	381.02^{a}
100	0	0	11.79^{a}	11.62^{c}	0.96^{g}	0.35^{g}	0.54^{i}	74.73^{b}	354.04^{i}

Values with different superscript along the same column are significantly different at $p<0.05$.
WF: wheat flour, MF: mushroom flour, UPF: unripe plantain flour; CHO: Carbohydrate

Sample			Calcium	Phosphorus	Potassium	Magnesium	Iron	Sodium
WF (%)	MF (%)	UF (%)	(mg/100 g)	(mg/100 g)	(mg/100g)	(mg/100 g)	(mg/100 g)	(mg/100 g)
86.67	6.67	6.67	28.18^{e}	1.95^{a}	1.74^{f}	3.34^{g}	0.95^{d}	83.35^{c}
80	0	20	25.60^{h}	1.93^{b}	1.86^{b}	4.02^{b}	1.02^{b}	93.50^{b}
83.33	13.33	3.33	29.06^{b}	1.90^{c}	1.84^{c}	3.74^{f}	0.96^{d}	81.80^{f}
90	10	0	27.13^{g}	1.82^{f}	1.72^{g}	3.14^{i}	0.91^{f}	108.14^{a}
90	0	10	26.22^{h}	1.93^{b}	1.78^{e}	4.05^{a}	0.88^{g}	80.50^{g}
93.33	3.33	3.33	28.07^{f}	1.94^{a}	2.01^{a}	3.96^{c}	0.93^{e}	83.34^{c}
83.33	3.33	13.33	29.95^{a}	1.86^{e}	1.86^{b}	4.01^{b}	1.16^{a}	82.04^{f}
80	10	10	26.15^{h}	1.89^{d}	1.62^{h}	3.91^{d}	0.98^{c}	82.28^{e}

80	20	0	28.45^{d}	1.91^{c}	1.82^{d}	3.86^{e}	0.93^{e}	82.43^{e}
100	0	0	28.53^{c}	1.88^{d}	1.66^{g}	3.24^{h}	0.93^{e}	82.56^{d}

Table 3: Mineral composition of wheat, mushroom and unripe plantain composite

Values with different superscript along the same column are significantly different at $p<0.05$.

WF: wheat flour, MF: mushroom flour, UPF: unripe plantain flour

Table 4: Vitamin composition of wheat, mushroom and unripe plantain composite flour

Sample			Vitamin B_1 (mg/100 g)	Vitamin B_2 (mg/100 g)	Vitamin B_3 (mg/100 g)	Vitamin B_6 (mg/100 g)	Vitamin C (mg/100 g)
WF (%)	MF (%)	UF (%)					
86.67	6.67	6.67	18.35^{b}	15.51^{d}	23.92^{a}	7.18^{abcd}	2.02^{f}
80	0	20	20.25^{a}	9.68^{g}	12.61e	7.22^{ab}	2.39^{d}
83.33	13.33	3.33	10.95^{d}	8.00^{h}	10.71^{f}	7.17^{bcd}	3.05^{a}
90	10	0	9.15^{e}	14.00^{e}	14.18^{d}	7.12^{d}	2.34^{d}
90	0	10	20.25^{a}	9.68^{g}	12.61^{e}	7.22^{ab}	2.39^{d}
93.33	3.33	3.33	18.65^{b}	11.08^{f}	16.78^{c}	7.22^{ab}	2.65^{b}
83.33	3.33	13.33	9.55^{e}	30.52^{a}	6.04^{h}	7.17^{bcd}	2.39^{d}
80	10	10	7.10^{f}	22.23^{b}	8.44^{g}	7.16^{cd}	2.34^{d}
80	20	0	14.93^{c}	19.80^{c}	17.28^{c}	7.23^{a}	2.53^{c}
100	0	0	15.65^{c}	13.60^{e}	19.66^{b}	7.17^{bcd}	2.22^{e}

Values with different superscript along the same column are significantly different at $p<0.05$.

WF: wheat flour, MF: mushroom flour, UPF: unripe plantain flour

4. CONCLUSION

This study concluded that wheat based composite flour comprising of mushroom and unripe plantain flour was developed. The result of the proximate content showed that the composite flour of wheat, mushroom and unripe plantain flour is a good source of ash, protein, fat, dietary fibre and carbohydrate.

Minerals (calcium, magnesium, potassium, phosphorus, sodium and iron) and vitamins (B_1, B_2, B_3, B_6 and C) detected in the flour samples revealed nutritional benefits of the flours for human consumption and also promote their potential for use in other food application. The use of optimum mixture model of response surface methodology helped in obtaining optimum flour combination in terms of quality characteristics. The best blends based on the optimization of nutritional compositions of the flour blends were 80:12.68:7.32 and 80:13.21:6.79 (wheat mushroom and unripe plantain). These are therefore recommended for the productions of snacks. Nutritional educational programmes should be planned and implemented to convince the populace that flour can be nutritionally improved by substituting wheat with mushroom and matured unripe plantain flour and further research on amino acid composition of the flour should be carried out.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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