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Effect of Fluted Pumpkin (*Telfairia occidentalis*) Seed Flour Supplementation on the Nutritional and Chemical Properties of Broken Rice Flour

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Abstract

The aim of this study was to evaluate the effect of defatted fluted pumpkin seed flour supplementation on the nutritional and chemical composition of broken rice flour. The fluted pumpkin seeds were processed as raw, fermented and germinated and then milled into flour. The broken rice flour was substituted with defatted fluted pumpkin seed flour from each of the processed methods at 0 to 50% substitution levels. Standard analytical methods were used to determine the proximate, mineral, vitamin A and vitamin B6 composition of the flour blends. Moisture, protein, fat, ash, fiber and carbohydrate contents ranged from 6.17 – 9.45%, 6.35 – 20.61%, 2.06 – 24.06%, 0.62 – 4.02%, 0.07 – 1.76% and 45.10 – 81.43% respectively. Calcium, magnesium, iron, manganese, sodium, potassium and copper contents ranged from 39.73 – 160.00mg/100g, 24.26 – 216.70mg/100g, 0.88 – 2.49mg/100g, 1.04 – 3.35mg/100g, 0.017 – 0.066mg/100g, 30.00 - 53.25mg/100g and 0.017 – 0.038mg/100g respectively. Vitamin A and B6 contents increased significantly ($P<0.05$) with increased supplementation with defatted fluted pumpkin seed flour. In general, supplementation of broken rice flour with defatted fluted pumpkin seed flour improved the nutritional and chemical composition of the flour blends and food products made from these flour blends could help to reduce protein-energy malnutrition prevalent in some regions.

Keywords: Broken Rice, Fluted Pumpkin Seeds, Supplementation, Nutritional and Chemical Properties.

Introduction

Most parts of the world, including Nigeria and the West Africa sub-region is faced with the health problem of protein-energy malnutrition. This is because starchy foods such as tubers and cereals are the major diets in these regions (Udoh *et al*., 2023). Most people in Africa and Asia rely on cereals and legumes as their major sources of protein, carbohydrate, vitamins and minerals (Bello *et al*., 2017).

Broken rice is a by-product produced during the milling and polishing of rice (Bodie *et al*., 2019). Grading of rice takes place after polishing, and rice that is not up to the mandatory size is called broken rice (it is usually less than three quarter of the whole kernel length)

(Bodie *et al*., 2019). The flour derived from broken rice is used in the production of various food products as it is cheap and readily available. The white color, easily digestible starches and little or no likelihood of causing an allergic response are characteristics that make rice flour ideal for making gluten-free products.

Fluted pumpkin (*Telfairia occidentalis*) seed is a locally available but underutilized seed. It is reported to contain between 27-32% protein (Udoh, 2017) making it a good source of plant protein. Fluted pumpkin seeds also contain large amounts of minerals and essential amino acids (except lysine) comparable to soybean meal with a biological value of 95%. Despite its high nutritional composition and availability, fluted pumpkin seed is mostly cooked and eaten or used as a thickener in local dishes (Udoh, 2017). Hence, its potential in food formulations has not been fully explored.

The incorporation of legumes (which are very rich sources of proteins) into cereal formulations is useful in elevating the nutritional quality of such food products (Schmidt and Oliveira, 2023). This will help reduce protein energy malnutrition as most cereals do not contain some essential amino acids (Tomicic *et al*., 2022).

This study aims to alleviate the problem of protein-energy malnutrition present in most societies by improving the nutritional quality of broken rice flour by fortification using flour from fluted pumpkin seeds. It also aims to enhance the utilization of broken rice (a byproduct of rice milling) and fluted pumpkin seeds (an underutilized but locally available plant-based protein source) and at the same time filling a significant knowledge gap.

Materials and Methods

Procurement of raw materials

Broken rice was purchased from a rice mill in Ini L.G.A while matured fluted pumpkin (*Telfairia occidentalis*) seeds were bought from Itam market, Itu L.G.A both in Akwa Ibom State.

Preparation of flour from broken rice

The method described by Okpala and Egwu (2015) was used in the preparation of broken rice flour. Broken rice was cleaned to remove all contaminants, washed in clean water, drained and oven (model pp22 US, Genlab, England) dried at 50°C for 6 hours. This was followed by milling in a laboratory miller (Cu-600 Glufex, Scientific, UK), sieving through 500mm sieves, packaging in polyethylene bags, labeling and storing in a cool, dry place.

Preparation of flours from raw, fermented and germinated fluted pumpkin seeds

The matured fluted pumpkin seeds were processed into flour using the method described by Udoh (2017) with modifications. The matured fluted pumpkin seeds were extracted from the pod and processed in three (3) different ways. Part of the extracted seeds were dehulled, made free of contaminants and extraneous matter and sliced into pieces. Another part of the seeds were dehulled, cleaned and soaked in distilled water for 48 h with occasional changing of water at 6 h intervals for fermentation to occur. The seeds were drained and sliced into pieces after the fermentation period. Part of the seeds was germinated by arranging them in layers of sawdust and watering daily for seven (7) days. Sprouted seeds were selected, dehulled, cleaned and sliced into pieces. The differently processed seeds were oven (model pp22 US, Genlab, England) dried at 50°C, milled in a laboratory miller (Cu-600 Glufex, Scientific, UK) and sieved through 500mm sieves. This was followed by defatting the flours in a Soxhlet apparatus using n-hexane at room temperature for eight (8) hours. The defatted flours were dried in an oven at 50°C to remove all traces of n-hexane, milled, packaged in polyethylene bags, labeled and stored in a cool, dry place.

Formulation of composite flours

The flour samples were blended in the ratio of 100:0, 90:10, 80:20, 70:30, 60:40, 50:50 broken rice flour and each of the raw, fermented and germinated defatted fluted pumpkin seed flour respectively as shown in Table 1 below.

Table 1: Formulation of composite flours from broken rice and defatted fluted pumpkin Seeds (%)

Sample code	Broken rice flour	Raw fluted pumpkin seed flour	Germinated fluted pumpkin seed flour	Fermented fluted pumpkin seed flour
B100	100	0	0	0
B90R10	90	10	0	0
B80R20	80	20	0	0
B70R30	70	30	0	0
B60R40	60	40	0	0
B50R50	50	50	0	0
B90G10	90	0	10	0
B80G20	80	0	20	0
B70G30	70	0	30	0
B60G40	60	0	40	0
B50G50	50	0	50	0
B90F10	90	0	0	10
B80F20	80	0	0	20
B70F30	70	0	0	30
B60F40	60	0	0	40
B50F50	50	0	0	50

Methods of Analysis

Determination of proximate composition of flour blends

Moisture, ash, fiber, protein, fat and carbohydrate composition were determined by the methods described by Onwuka (2018).

Determination of mineral composition of flour blends

Calcium, magnesium, iron, manganese, sodium, potassium and copper composition were determined using the atomic absorption spectrophotometric method described by Onwuka (2018).

Determination of vitamin A and B6 composition of flour blends

Vitamin A was determined using the spectrophotometric method described by Onwuka (2018) while vitamin B6 was determined as described by AOAC (2010).

Statistical Analysis

Statistical analysis was carried out using Analysis of Variance (ANOVA) using SPSS version 23.0 and the means separated by Duncan method. Significant differences will be taken at 5% confidence limit.

Results and Discussion

Proximate composition of composite flours from broken rice and fluted pumpkin seed

Proximate composition of any food product is of great importance as it gives a description of the percentage of nutrient content present in the food product. It enquires on the qualitative and quantitative chemical changes taking place in food products. It also gives an idea of the qualitative and quantitative chemical changes taking place in the product on storage and its effect on the overall quality and shelf life of the product (Suriya *et al.*, 2017). The proximate composition of composite flours from broken rice and fluted pumpkin seed flours are presented in Table 2.

The moisture content of the composite flour blends ranged from 6.17 to 9.45% with sample BRF(50%)/FDFPSF(50%) (50% broken rice flour and 50% fermented defatted fluted pumpkin seed flour) having the lowest, while sample BRF(100%) (100% broken rice flour) had the highest value. Samples BRF(100%) (100% broken rice flour), BRF(90%)/RDFPSF(10%) (90% broken rice flour and 10% raw defatted fluted pumpkin seed flour), BRF(90%)/FDFPSF(10%) (90% broken rice flour and 10% fermented defatted fluted pumpkin seed flour), BRF(80%)FDFPSF(20%) (80% broken rice flour and 20% fermented defatted fluted pumpkin seed flour), BRF(70%)/FDFPSF(30%) (70% broken rice flour and 30% fermented defatted fluted pumpkin seed flour), BRF(90%)/GDFPSF(10%) (90% broken rice flour and 10% germinated defatted fluted pumpkin seed flour), BRF(70%)/GDFPSF(30%) (70% broken rice flour and 30% germinated defatted fluted pumpkin seed flour and BRF(50%)/GDFPSF(50%) (50% broken rice flour and 50% germinated defatted fluted pumpkin seed flour) were significantly different ($P<0.05$). These relatively low values for moisture content indicate that the composite flour blends could be shelf stable with a long storage life. Flours with moisture content of 14% and above have a short shelf life as it is a conducive environment for the growth and multiplication of spoilage organisms (Akinsami *et al*., 2015). This range of values for moisture content are lower than the range of values (8 – 14%) for moisture content reported by Iwe *et al*. (2016) for proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. It was however, within the range of values (6.50 – 9.06%) reported by Bello *et al*. (2017) for proximate composition and functional properties of sprouted sorghum (sorghum bicolor) and defatted fluted pumpkin seed (*Telfairia occidentalis*) flour blends.

Table 2: Proximate Composition of Composite Flours from Broken Rice and Fluted Pumpkin Seeds

Sample Code	Moisture (%)	Ash (%)	Fiber (%)	Protein (%)	Fat (%)	Carbohydrate (%)
BRF(100%)	9.45^{a}±0.08	0.62^{h}±0.03	0.07^{i}±0.00	6.35^{j}±0.00	2.06^{k}±0.00	81.43^{a}±0.04
BRF(90%)/ RDFPSF(10%)	8.63^{b}±0.07	1.42^{g}±0.03	0.08^{i}±0.00	7.50^{i}±0.00	3.89^{j}±0.24	78.47^{b}±0.14
BRF(80%)/ RDFPSF(20%)	8.40^{c}±0.02	2.10^{f}±0.06	0.31^{h}±0.02	12.87^{e}±0.00	5.81^{i}±0.65	70.50^{e}±0.54
BRF(70%)/ RDFPSF(30%)	8.38^{c}±0.03	2.71^{e}±0.15	0.43^{g}±0.01	15.45^{d}±0.14	8.47^{g}±0.00	64.64^{h}±0.35
BRF(60%)/ RDFPSF(40%)	8.11^{ef}±0.05	3.55^{b}±0.05	1.37^{c}±0.01	17.90^{b}±0.29	11.29^{f}±0.17	57.77^{j}±0.35
BRF(50%)/ RDFPSF(50%)	7.68^{g}±0.11	4.02^{a}±0.06	1.76^{a}±0.01	20.61^{a}±0.13	14.44^{d}±0.35	51.48^{l}±0.04
BRF(90%)/ FDFPSF(10%)	8.19^{de}±0.01	1.33^{g}±0.04	0.08^{i}±0.00	7.04^{ij}±0.28	5.58^{i}±0.11	77.77^{b}±0.20
BRF(80%)/ FDFPSF(20%)	7.58^{gh}±0.09	1.42^{g}±0.03	0.12^{i}±0.00	10.15^{g}±0.14	8.46^{g}±0.08	72.25^{d}±0.12
BRF(70%)/ FDFPSF(30%)	6.99^{i}±0.0.5	2.76^{e}±0.10	0.32^{h}±0.02	12.68^{e}±0.16	11.39^{f}±0.03	65.85^{g}±0.15
BRF(60%)/ FDFPSF(40%)	6.23^{j}±0.04	3.32^{c}±0.05	0.38^{g}±0.01	15.35^{d}±0.21	12.39^{e}±0.09	62.30^{i}±0.19
BRF(50%)/ FDFPSF(50%)	6.17^{j}±0.03	3.86^{a}±0.06	0.77^{e}±0.04	16.53^{c}±0.42	16.47^{c}±0.01	56.18^{k}±0.29
BRF(90%)/ GDFPSF(10%)	8.30^{cd}±0.06	1.23^{g}±0.01	0.27^{h}±0.01	9.09^{h}±0.14	6.77^{h}±0.18	74.35^{c}±0.03
BRF(80%)/ GDFPSF(20%)	8.11^{ef}±0.01	2.07^{f}±0.02	0.56^{f}±0.01	11.39^{f}±0.28	11.11^{f}±0.02	66.74^{f}±0.24
BRF(70%)/ GDFPSF(30%)	7.98^{f}±0.09	2.61^{e}±0.06	1.14^{d}±0.01	13.13^{e}±0.00	16.83^{c}±0.49	58.27^{j}±0.32
BRF(60%)/ GDFPSF(40%)	7.64^{g}±0.03	3.07^{d}±0.02	1.33^{c}±0.01	15.08^{d}±0.42	21.84^{b}±0.04	51.02^{l}±0.31
BRF(50%)/ GDFPSF(50%)	7.41^{h}±0.05	3.85^{a}±0.07	1.57^{b}±0.00	17.98^{a}±0.28	24.06^{a}±0.51	45.10^{m}±0.09

Values are means ±SD of duplicate determinations, means in the same column with the different superscripts are significantly different at $p<0.05$

KEY:
BRF: Broken rice flour; RDFPSF; Raw defatted fluted pumpkin seed flour; FDFPSF: Fermented defatted fluted pumpkin seed flour; GDFPSF; Germinated defatted fluted pumpkin seed flour

The protein content of the composite flour blends from broken rice and defatted fluted pumpkin seeds ranged from 6.35 to 20.61% with sample BRF(100%) having the lowest value while sample BRF(50%)/RDFPSF(50%) (50% broken rice flour and 50% raw defatted fluted pumpkin seed flour) had the highest value. Samples BRF(100%), BRF(90%)/RDFPSF(10%), BRF(60%)/RDFPSF(40%), BRF(90%)/FDFPSF(10%) and BRF(80%)/FDFPSF(20%) were significantly different ($P<0.05$). The protein content increased as the level of substitution with defatted fluted pumpkin seed flour increased. This is because fluted pumpkin seed has high protein content (Udoh, 2017). Legumes contain more protein than cereals. Hence, complementing cereals with legumes in composite flours increases the protein content of such flours (Yetunde *et al.*, 2009). This significant increase in protein content with supplementation of broken rice flour with defatted fluted pumpkin seed flour can greatly help to reduce the problem of protein-energy malnutrition especially in regions where rice is a staple.
The fat content of the flour blends ranged from 2.06% in sample BRF(100%) to 24.06% in sample BRF(50%)/GDFPSF(50%). Samples BRF(100%), BRF(90%)/RDFPSF(10%), BRF(50%)/RDFPSF(50%), BRF(60%)/FDFPSF(40%) (60% broken rice flour and 40% fermented defatted fluted pumpkin seed flour), BRF(50%)/FDFPSF(50%), BRF(90%)/GDFPSF(10%), BRF(60%)/GDFPSF(40%) (60% broken rice flour and 40% germinated defatted fluted pumpkin seed flour) and BRF(50%)/GDFPSF(50%) were significantly different ($P<0.05$). This could be attributed to the fact that fluted pumpkin seeds also have high oil content (Udoh, 2017). The fat content increased with an increase in the percentage of defatted germinated fluted pumpkin seed flour. Fats weigh more than twice the calories per gram of protein and carbohydrate, and of all the food components, they contain the highest amount of calories. They are also useful in the transportation of fat soluble vitamins (A, D, E and K) in the body. Fat also improves the sensory characteristics of food.
The ash content of the flour blends ranged from 0.62 to 4.02% with sample BRF(100%) having the lowest value while sample BRF(50%)/RDFPSF(50%) had the highest value. There was no significant difference ($P<0.05$) between samples BRF(90%)/RDFPSF(10%), BRF(90%)/FDFPSF(10%), BRF(80%)/FDFPSF(20%) and BRF(90%)/GDFPSF(10%). The ash content increased with an increase in the level of fluted pumpkin seed flour substitution. Ash content helps to indicate the mineral density in a food sample (Camire, 2000). This shows that fluted pumpkin seeds are a good source of minerals (Udoh, 2017). These values are higher than the range reported by Bello *et al*. (2017) for proximate composition and functional properties of sprouted sorghum and defatted fluted pumpkin seed flour blends

and that reported by Iwe *et al*. (2016) for proximate, functional and pasting properties of FARO44 rice, African yam bean and brown cowpea seeds composite flour.

The crude fiber content of sample BRF(100%) was the least with a value of 0.07% while sample BRF(50%)/RDFPSF(50%) had the highest value of 1.76%. There was no significant difference (P<0.05) between samples BRF(100%), BRF(90%)/RDFPSF(10%), BRF(90%)/FDFPSF(10%) and BRF(80%)/FDFPSF(20%). Crude fiber content also increased with an increase in the percentage of fluted pumpkin seed flour. This may be due to the high crude fiber content of fluted pumpkin seed (Udoh, 2017). Fiber helps to slow down glucose absorption and emptying of the stomach (Chukwuma *et al*., 2010). Food products with high fiber content give a sense of fullness when eaten because fiber absorbs large quantities of water (Srivastava *et al*., 2012).

The carbohydrate content of the composite flour blends ranged from 45.10% in sample BRF(50%)/GDFPSF(50%) to 81.43% in sample BRF(100%). Samples BRF(100%), BRF(80%)/RDFPSF(20%), BRF(70%)/RDFPSF(30%), BRF(80%)/FDFPSF(20%), BRF(70%)/FDFPSF(30%), BRF(60%)/FDFPSF(40%), BRF(50%)/FDFPSF(50%), BRF(90%)/GDFPSF(10%) and BRF(50%)/GDFPSF(50%) were significantly different (P<0.05). This high carbohydrate content in the control sample may be due to the high carbohydrate content of rice as carbohydrate is the main chemical component of broken rice flour. The carbohydrate content reduced with an increase in the percentage of fluted pumpkin seed flour.

Mineral Composition of Composite Flours from Broken Rice and Fluted Pumpkin Seed

Minerals are important for growth, robust immune system, maintenance of cells and averting cell damage (Kassa and Hailay, 2014). They are important for maintaining the overall mental and physical wellbeing and are also important for developing and maintaining bones, teeth, tissues, muscles, blood, and nerve cells. In addition, they assist in acid base balance, response of the nerves to physiological stimulation and blood clotting (Wardlaw and Kessel, 2002). The mineral composition of broken rice and fluted pumpkin seed flours is presented in Table 3 below. Magnesium, iron, manganese, sodium and potassium content of the flour blends increased with increased substitution with defatted fluted pumpkin seed flours (Table 3).

Calcium aids the development of strong bones and teeth, formation of blood, intracellular and extracellular fluids within and outside the cells of the tissue (Mahan and Escott-Stump, 2004). The calcium content ranged from 39.73mg/100g in sample BRF(50%)/FDFPSF(50%) to 160mg/100g in sample BRF(100%). Samples BRF(100%), BRF(70%)/RDFPSF(30%), BRF(90%)/FDFPSF(10%), BRF(80%)/FDFPSF(20%), BRF(60%)/FDFPSF(40%), BRF(50%)/FDFPSF(50%), BRF(90%)/GDFPSF(10%), BRF(70%)/GDFPSF(30%), BRF(60%)/GDFPSF(40%) and BRF(50%)/GDFPSF(50%) were significantly different (P<0.05). The calcium content was seen to increase with an increase in the proportion of broken rice.

Table 3: Mineral Composition of Composite Flours from Broken Rice and Fluted Pumpkin Seeds (mg/100g)

Sample Code	Calcium	Magnesium	Iron	Manganese	Sodium	Potassium	Copper
BRF(100%)	160.00^{a}±0.00	24.26^{m}±0.00	1.69^{de}±0.09	1.04^{g}±0.00	0.031^{e}±0.01	30.00^{i}±0.00	0.017^{g}±0.00
BRF(90%)/ RDFPSF(10%)	120.09^{c}±0.01	72.83^{j}±0.00	1.85^{d}±0.08	2.34^{bcd}±0.26	0.023^{f}±0.00	31.45^{h}±0.05	0.018^{fg}±0.00
BRF(80%)/ RDFPSF(20%)	79.95^{h}±0.00	97.06^{h}±0.07	2.01^{bc}±0.08	2.34^{bcd}±0.26	0.031^{e}±0.00	32.00^{f}±0.00	0.018^{fg}±0.00
BRF(70%)/ RDFPSF(30%)	78.78^{i}±0.03	96.66^{i}±0.14	2.09^{b}±0.00	2.59^{bc}±0.00	0.036^{e}±0.00	32.35^{e}±0.05	0.033^{b}±0.00
BRF(60%)/ RDFPSF(40%)	79.96^{h}±0.01	121.40^{g}±0.17	2.17^{b}±0.08	2.60^{bc}±0.00	0.035^{e}±0.01	32.65^{d}±0.05	0.021^{cde}±0.00
BRF(50%)/ RDFPSF(50%)	39.93^{j}±0.01	169.59^{c}±0.00	2.49^{a}±0.08	2.86^{ab}±0.26	0.066^{a}±0.00	33.15^{a}±0.05	0.021^{cd}±0.00
BRF(90%)/ FDFPSF(10%)	119.78^{d}±0.02	48.58^{l}±0.14	1.04^{ij}±0.08	1.82^{def}±0.26	0.052^{c}±0.00	31.50^{h}±0.00	0.020^{defg}±0.00
BRF(80%)/ FDFPSF(20%)	119.71^{e}±0.04	96.61^{i}±0.18	1.12^{hi}±0.00	1.82^{def}±0.26	0.053^{c}±0.00	31.85^{g}±0.05	0.020^{defg}±0.00
BRF(70%)/ FDFPSF(30%)	39.91^{j}±0.00	145.36^{f}±0.10	1.21^{ghi}±0.08	2.08^{cde}±0.00	0.017^{g}±0.01	32.05^{f}±0.05	0.033^{b}±0.00
BRF(60%)/ FDFPSF(40%)	39.83^{k}±0.01	169.23^{d}±0.15	1.36^{fg}±0.08	2.33^{bcd}±0.26	0.061^{ab}±0.00	42.65^{d}±0.05	0.019^{defg}±0.00
BRF(50%)/ FDFPSF(50%)	39.73^{m}±0.03	216.70^{a}±0.18	1.36^{fg}±0.08	3.35^{a}±0.25	0.023^{f}±0.00	43.00^{b}±0.00	0.038^{a}±0.00
BRF(90%)/ GDFPSF(10%)	158.96^{b}±0.01	72.18^{k}±0.04	0.88^{j}±0.08	1.29^{fg}±0.26	0.061^{ab}±0.00	31.45^{h}±0.05	0.021^{cd}±0.00
BRF(80%)/ GDFPSF(20%)	120.05^{c}±0.03	97.15^{h}±0.08	0.89^{j}±0.08	1.56^{efg}±0.00	0.031^{e}±0.00	32.00^{f}±0.00	0.020^{cdef}±0.00
BRF(70%)/ GDFPSF(30%)	80.09^{f}±0.00	121.45^{g}±0.00	1.05^{ij}±0.08	1.56^{efg}±0.00	0.051^{c}±0.00	32.85^{c}±0.05	0.020^{defg}±0.00
BRF(60%)/ GDFPSF(40%)	80.01^{g}±0.01	145.69^{e}±0.06	1.29^{gh}±0.00	2.08^{cde}±0.00	0.044^{d}±0.00	52.60^{d}±0.00	0.018^{efg}±0.00
BRF(50%)/ GDFPSF(50%)	39.78^{l}±0.00	192.90^{b}±0.12	1.52^{ef}±0.08	2.84^{ab}±0.25	0.056^{ab}±0.00	53.25^{a}±0.05	0.023^{c}±0.00

Values are means ±SD of duplicate determinations, means in the same column with the different superscripts are significantly different at $p<0.05$

KEY:
BRF: Broken rice flour; RDFPSF; Raw defatted fluted pumpkin seed flour; FDFPSF: Fermented defatted fluted pumpkin seed flour; GDFPSF; Germinated defatted fluted pumpkin seed flour

The magnesium content ranged from 24.26mg/100g in sample BRF(100%) to 216.70mg/100g in sample BRF(50%)/FDFPSF(50%). Magnesium content increased with an increase in the percentage incorporation of defatted fermented fluted pumpkin seed flour.

Samples BRF(100%), BRF(90%)/RDFPSF(10%), BRF(50%)/RDFPSF(50%), BRF(90%)/FDFPSF(10%), BRF(70%)/FDFPSF(30%), BRF(60%)/FDFPSF(40%), BRF(50%)/FDFPSF(50%), BRF(90%)/GDFPSF(10%), BRF(60%)/GDFPSF(40%) and BRF(50%)/GDFPSF(50%) varied significantly (P<0.05) while there was no significant difference (P<0.05) between samples BRF(80%)/RDFPSF(20%) and BRF(80%)/GDFPSF(20%). Magnesium is necessary for strong bones and also acts as a cofactor for many reactions in the human body as well as being important for nerve and muscle conductivity (Grosvenor and Somolin, 2002). Fermentation helps degrade anti-nutrients such as phytate and oxalate, freeing complex minerals and thus, making them readily bioavailable (Pranato *et al.,* 2013). This could account for why sample BRF(50%)/FDFPSF(50%) had the highest magnesium content. Magnesium is a catalyst of many enzyme systems and maintains the electrical potential in the nerves (Odimegwu *et al.*, 2019). Working with calcium, it helps in muscle contraction, blood clotting, regulation of blood pressure, and lung function (Odimegwu *et al.*, 2019).

Iron is a vital component of the red blood cells (Oyegoke *et al.*, 2020). It is said to be the most common micronutrient deficiency globally, with about 20–50% of the world population affected, especially women and children in developing nations (Odimegwu *et al.*, 2019; Oyegoke *et al.*, 2020). Fatigue, weakness, and shortness of breath are some symptoms of iron deficiency (Odimegwu *et al.*, 2019). Samples BRF(100%), BRF(90%)/RDFPSF(10%), BRF(80%)/RDFPSF(20%), BRF(50%)/RDFPSF(50%), BRF(80%)/FDFPSF(20%) and BRF(70%)/FDFPSF(30%) varied significantly (P<0.05) while there was no significant difference (P<0.05) between samples BRF(70%)/RDFPSF(30%) and BRF(60%)/RDFPSF(40%). The iron content was lowest in sample BRF(90%)/GDFPSF(10%) with a value of 0.88mg/100g and highest in sample BRF(50%)/RDFPSF(50%) with a value of 2.49mg/100g. Udoh (2017) reported an iron content of 80.91mg/100g for full fat raw fluted pumpkin seed flours.

The manganese content ranged from 1.04mg/100g in sample BRF(100%) to 3.35mg/100g in sample BRF(50%)/FDFPSF(50%). Samples BRF(100%), BRF(50%)/FDFPSF(50%) and BRF(90%)/GDFPSF(10%) varied significantly (P<0.05) while there was no significant difference (P<0.05) between samples BRF(70%)/RDFPSF(30%) and BRF(60%)/RDFPSF(40%). The manganese content of the flour samples increased with increased incorporation of defatted fermented fluted pumpkin seed flour. Processing by fermentation increased the manganese content of the flour samples. This aligns with the findings of Pranoto *et al*. (2013).

The sodium content was lowest in sample BRF(70%)/FDFPSF(30%) (70% broken rice and 30% fermented defatted fluted pumpkin seed flour) with a value of 0.017mg/100g and highest in sample BRF(50%)/RDFPSF(50%) (50% broken rice and 50% raw defatted fluted pumpkin seed flour) with a value of 0.066mg/100g. There was no significant difference (P<0.05) between samples BRF(70%)/FDFPSF(30%) and BRF(60%)/GDFPSF(40%) while samples BRF(100%), BRF(80%)/RDFPSF(20%), BRF(70%)/RDFPSF(30%), BRF(60%)/RDFPSF(40%) and BRF(80%)/GDFPSF(20%) varied significantly (P<0.05).

Sodium is gotten from food and drink and lost through sweat and urine. The kidneys are important for regulating sodium levels in the body. RDA of sodium is 1,500mg. Less concentrations of the sodium in food source may not have any health problem, because the addition of sodium in form of table salt is a common practice in human food preparation for sake of taste (Satheesh and Workneh, 2019).

The potassium content ranged from 30.00mg/100g in sample BRF(100%) to 53.25mg/100g in sample BRF(50%)/GDFPSF(50%). There was no significant difference (P<0.05) between samples BRF(90%)/RDFPSF(10%), BRF(90%)/FDFPSF(10%) and BRF(90%)/GDFPSF(10%) while samples BRF(100%), BRF(70%)/RDFPSF(30%), BRF(60%)RDFPSF(40%), BRF(80%)/FDFPSF(20%), BRF(50%)/FDFPSF(50%) and BRF(70%)/GDFPSF(30%) varied significantly (P<0.05). The potassium content was observed to increase with an increase in the substitution level of defatted germinated fluted pumpkin seed flour. Potassium is an important electrolyte in the nervous system, hence, large amounts of potassium intake is needed by the body. Severe malnutrition, increased disease conditions and mental impairment are associated with insufficient intake of micronutrients such as potassium (Wardlaw, 2004).

Copper plays a vital part in absorbing and utilizing iron during hemoglobin and myoglobin synthesis and is a component of several enzyme. The copper content of the flours ranged from 0.017mg/100g in samples BRF(100%), BRF(90%)/RDFPSF(10%) and BRF(80%)/RDFPSF(20%) to 0.038mg/100g in sample BRF(50%)/FDFPSF(50%). Processing increased the copper content of the flour blends. There was no significant difference (P<0.05) between samples BRF(90%)/FDFPSF(10%), BRF(80%)/FDFPSF(20%), BRF(60%)/FDFPSF(40%) and BRF(70%)/GDFPSF(30%) while samples BRF(100%), BRF(60%)/RDFPSF(40%), BRF(50%)/FDFPSF(50%), BRF(80%)/GDFPSF(20%), BRF(60%)/GDFPSF(40%) and BRF(50%)/GDFPSF(50%) varied significantly (P<0.05).

Vitamin A and B6 Composition of Composite Flours from Broken Rice and Fluted Pumpkin Seed

The vitamin A and B6 composition of composite flours from broken rice and fluted pumpkin seeds are presented in Table 4.

The vitamin A content of samples BRF(100%) and BRF(90%)/RDFPSF(10%) were the least with a value of 0.01mg/100g while sample BRF(50%)/GDFPSF(50%) had the highest value of 0.13mg/100g. Samples BRF(80%)/GDFPSF(20%), BRF(70%)/GDFPSF(30%), BRF(60%)/GDFPSF(40%) and BRF(50%)/GDFPSF(50%) were significantly different (P<0.05) while there was no significant difference (P<0.05) between samples BRF(70%)/RDFPSF(30%), BRF(60%)/RDFPSF(40%), BRF(70%)/FDFPSF(30%), BRF(60%)/FDFPSF(40%) and BRF(50%)/FDFPSF(50%). Vitamin A content increased with an increase in the percentage of fluted pumpkin seed flour. Germination of legume and oil seeds is known to increase their vitamin composition (Malleshi and Klopfenstein, 1998). Vitamin A is vital in the human body as it enhances growth, reproduction, good vision, healthy skin, hair and nail as well as to balance energy level in the human body (Edima-Nyah *et al.*, 2019). Deficiency of vitamin A in the body results in a condition known as keratomalacia (night blindness) (Ojimelukwe *et al.*, 2005).

Pyridoxine plays a beneficial role in nerve functioning and in the formation of blood (Joint FAO, 2004; Fasuan *et al.*, 2021). It also has anticancer properties and strong antioxidant activity (Theodoratou *et al.*, 2008; Denslow *et al.*, 2005). There was no significant difference (P<0.05) between samples BRF(60%)/FDFPSF(40%), BRF(90%)/GDFPSF(10%) and BRF(80%)/GDFPSF(20%) while samples BRF(70%)/RDFPSF(30%), BRF(50%)/FDFPSF(50%), BRF(70%)/GDFPSF(30%), BRF(60%)/GDFPSF(40%) and BRF(50%)/GDFPSF(50%) varied significantly (P<0.05). The vitamin B6 content of the flour samples ranged from 0.24mg/100g in sample BRF(60%)/RDFPSF(40%) to 2.86mg/100g in sample BRF(50%)/GDFPSF(50%). This higher value for sample BRF(50%)/GDFPSF(50%) could be as a result of a high inclusion of germinated fluted pumpkin seed flours as germination is known to increase the vitamin content of legumes and oil seeds (Malleshi and Klopfenstein, 1998).

Table 4: Vitamin A and B6 Composition of Composite Flours from Broken Rice and Fluted Pumpkin Seeds

Sample Code	Vitamin A (mg/100g)	Vitamin B6 (mg/100g)
BRF(100%)	$0.01^{h}\pm0.00$	$0.46^{fg}\pm0.03$
BRF(90%)/RDFPSF(10%)	$0.01^{h}\pm0.00$	$0.50^{efg}\pm0.03$
BRF(80%)/RDFPSF(20%)	$0.02^{g}\pm0.00$	$0.55^{de}\pm0.02$
BRF(70%)/RDFPSF(30%)	$0.03^{f}\pm0.00$	$0.29^{h}\pm0.00$
BRF(60%)/RDFPSF(40%)	$0.03^{f}\pm0.00$	$0.24^{h}\pm0.02$
BRF(50%)/RDFPSF(50%)	$0.05^{e}\pm0.00$	$0.57^{de}\pm0.00$
BRF(90%)/FDFPSF(10%)	$0.02^{g}\pm0.00$	$0.50^{efg}\pm0.01$
BRF(80%)/FDFPSF(20%)	$0.02^{g}\pm0.00$	$0.46^{fg}\pm0.05$
BRF(70%)/FDFPSF(30%)	$0.03^{f}\pm0.00$	$0.54^{def}\pm0.03$
BRF(60%)/FDFPSF(40%)	$0.03^{f}\pm0.00$	$0.80^{c}\pm0.03$
BRF(50%)/FDFPSF(50%)	$0.03^{f}\pm0.00$	$0.60^{d}\pm0.00$
BRF(90%)/GDFPSF(10%)	$0.05^{e}\pm0.00$	$0.74^{c}\pm0.01$
BRF(80%)/GDFPSF(20%)	$0.09^{d}\pm0.00$	$0.79^{c}\pm0.00$
BRF(70%)/GDFPSF(30%)	$0.10^{c}\pm0.00$	$1.68^{b}\pm0.03$
BRF(60%)/GDFPSF(40%)	$0.11^{b}\pm0.00$	$0.44^{g}\pm0.03$
BRF(50%)/GDFPSF(50%)	$0.13^{a}\pm0.00$	$2.86^{a}\pm0.00$

Values are means ±SD of duplicate determinations, means in the same column with the different superscripts are significantly different at p<0.05

KEY:

BRF: Broken rice flour; RDFPSF; Raw defatted fluted pumpkin seed flour; FDFPSF: Fermented defatted fluted pumpkin seed flour; GDFPSF; Germinated defatted fluted pumpkin seed flour

Conclusion

The study revealed that supplementing broken rice flour with fluted pumpkin seed flour improved the nutritional and chemical composition of the flour blends. This also implies that food products formulated from these flour blends will possess improved nutritional quality, therefore, helping to reduce protein-energy malnutrition prevalent in some regions. The utilization of broken rice (which is often regarded as waste from the rice milling process) and fluted pumpkin seed (an underutilized, yet protein rich oilseed) for the production of composite will enhance their utilization, reduce wastage and also enhance value addition and food security. This study recommends to policymakers and food manufacturers the promotion and utilization of broken rice-defatted fluted pumpkin seeds composite flour especially at 50% supplementation level of defatted fluted pumpkin seed flour in food formulations.

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