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Chemical and functional properties of soy and ginger enriched brown rice (*Oryza sativa)* based flaked breakfast cereal

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Abstract

Breakfast meal, the first meal taken in the day is very important to start off the day well both physically and mentally. This study sought to create quality breakfast cereal using locally available crops namely brown rice (*Oryza sativa*), defatted soybean (*Glycine max*), and ginger (*Zingiber officinale*) flours. To get rid of dirt and superfluous objects, brown rice, soybeans, and ginger were each cleansed separately. After being cleaned, drained, and dried for eight hours at 70 °C in a cabinet dryer, the brown rice was milled. After being finely sliced, the ginger was ground after being dried for 20 hours in a hot air oven at 60 °C. The brown rice, defatted soybean, and ginger flours were optimized to get the quantities required for each blend. To every 100g of the blends, 0.1g sweetener, 1g salt, 6 ml vegetable oil, 4g xanthan gum, and before extrusion and flaking, 100 ml of water were added, mixed, and precooked for 30 minutes. Functional and chemical properties were assessed. The outcome revealed that the moisture content of the breakfast cereal ranged from 8.70 – 9.47%, the protein content (11.72 – 16.11%), the carbohydrate content 67.88 – 72.88%, and the energy content (370.98 – 375.28 kcal). The flour blends exhibited higher mineral concentrations with increased supplementation of the blends. The bulk density and water absorption show that the value improves with an increase in the brown–rice flour quantity, while the swelling capacity improves with an increase in ginger flour. The results show that the formulation of these flour blends is suitable for the production of a breakfast cereal with high nutritional value and functional properties that is energy dense and has the potential for the diabetic.

Keywords: Breakfast cereals; Brown rice flour; Defatted soybean flour; Ginger flour; Diabetic

Introduction

Breakfast is the first and most crucial meal of the day. After an 8–12-hour fast, the brain and muscles will lack the energy necessary to function properly. Eating breakfast is crucial for the body and mind. Hence, breakfast helps to start the day off well both physically and mentally. Consuming a healthy breakfast is of utmost importance and it should be given priority. The body gets its energy from glucose. When the body is filled with nutrient-dense whole foods, it will function very efficiently. Overnight during sleep, glycogen is broken down by the liver and released into the bloodstream as glucose to keep the bloodstream level normal. For the brain, which almost exclusively depends on glucose for energy, this is crucial (Betts *et al.,* 2016).

A healthy nutritious breakfast meal can be chosen from whole, unprocessed foods from fruits, vegetables, whole grains, nuts, seeds, and dairy foods when consumed provide the fibre that makes one full for a long period, When compared to persons who don't have breakfast, eating breakfast frequently helps to control weight, improves brainpower, and lowers the risk of being sick. Additionally, it lowers the risk of type 2 diabetes and obesity (Otaki *et al.*, 2017).

Brown rice (*Oryza sativa)* is unmilled rice that contains the pericarp, the seed coat, the germ and the endosperm. The bran layer, which is high in vitamins, minerals, and dietary fibre and low in glycemic index, is primarily responsible for brown rice's dark colour (Kim *et al*., 2011). It has hypoglycemic effects and is an energy-dense diet, which makes it the best choice for diabetes (Sun *et al*., 2010). Compared to polished rice, brown rice is chewier and has a nutty flavour. It is also rich in bioactive components but is rarely eaten as a staple diet because of its dark colour and its hard, gritty texture (Bergman, 2019).

Soybean (*Glycine max*_L.merril) is a species of legume grown widely for its edible bean which has numerous uses. It is one of the most important leguminous species because of its high nutritional value, functionality, health benefits and commercial importance (Singh *et al.,* 2019). One of the most significant protein and oil crops in the world is soybean. Soybean is known as the "protein hope of the future" because of its abundance of lecithin, protein, minerals, and vitamins (Ndife *et al*., 2011). Defatted soy flour is obtained from solvent extraction of soy flakes, a flour which contains less than 1% oil. Defatted soybean flavours vary from beany to a mild sweet taste. It is used for making bakery goods, cakes, doughnuts and in the fortification of cereals. Defatted soy flour contains low saturated fats which can help in maintaining ideal body weight and promoting good health. Defatted soy flour provides less total fat, the process changes the nutrient composition of the product (Anon, 2017).

Ginger (*Zingiber officinale*) is cultivated for its succulent edible rhizome (Iwanaegbe *et al*., 2019). It is one of the most common spices that is used for flavouring meals, it also has hypoglycemic properties (Iroaganachi *et al.,* 2015). Ginger is rich in dietary fibre, minerals and vitamins. Apart from being used as an agent in food flavouring such as soft drinks, spices in bakery products, confectionary items, pickles, and sauces, Kala *et al*. (2016) submits that it is also employed as a preservative. Due to its direct anti-microbial properties, ginger is utilised in traditional Chinese medicine as an antibiotic, colic treatment, and stimulant. It is also used to treat headaches, nausea, colds, gastrointestinal disorders, respiratory disorders, migraine, gastric ulcers, and cholesterol, aids weight loss,

and controls blood sugar and atherosclerosis (Sharma, 2017).
Globally, there has been a rise in the number of people suffering from non-communicable diseases especially diabetes, cardiovascular diseases, hypertension cancer, and the risk factors associated with it like overweight, obesity, and other related illnesses due to poor lifestyle and poor feeding habits (UNO, 2020). Recently there has been an increase in the advocacy for the consumption of food with a low glycemic index because of the numerous health benefits it gives. Sweet potatoes, carrots, whole-wheat pasta, legumes, whole grains, like whole-wheat bread, brown or wild rice, oat bran, steel-cut oatmeal and most fruits are examples of low glycemic foods. In addition to foods low in glycemic index, foods that are rich in protein, dietary fibre, and antioxidants which help to maintain a healthy lifestyle are also encouraged to be consumed. To produce low glycemic index breakfast cereal, this investigation used brown rice that had been enhanced with soybean and ginger. It also determined the chemical and functional properties of the product.

Materials and Methods

The brown rice was purchased from the Ogbese rice farm, Ogbese, Akure, Ondo State, and Soybean and Ginger rhizome were bought from the Orisunmibare market, Osogbo, Osun State. The samples were authenticated in the Department of Botany, Obafemi Awolowo University, Ile-Ife, Nigeria.

Production of Brown rice, Defatted soyabean and Ginger flour Blends

Brown rice, defatted soyabean and ginger flour were first produced and blended into composite flour

Production of brown rice flour

Brown rice flour is produced according to the method described by Awolu, *et al*. (2019). The grains were weighed, and sorted to remove stones and extraneous materials. It was then washed using water, strained to remove excess water, dried in the cabinet drier, milled into a fine powder, allowed to cool, and then packaged in airtight containers.

Production of defatted soybean flour

Defatted soybean flour was produced using the method described by Oluwajuyitan and Ijarotimi, (2019). The soybean was weighed, sorted, and soaked overnight in water, the water was decanted off, the soybean is boiled for 10 minutes, washed to remove the seed coat, and the dehulled soybean was tempered to make a flake. After flaking, the oil was extracted using n-Hexane solvent. The Soybean cake was toasted, dried, cooled, and milled into flour, sieved to get a fine and smooth consistent particle size and then packaged.

Production of ginger flour

The method of Sekwati-Monang and Ganzle (2011) was employed for production of ginger flour. The ginger roots were cleaned with water to remove soil, debris and field damage, then they were drained, peeled and then cut into 2 - 3 mm slices. They were then dried at 75 °C until completely dry, milled and sieved through a fine mesh before being packaged as fine ginger flour in a clean, airtight container until needed.

Production of Breakfast Cereal

Blends of brown rice, defatted soyabean and ginger flour were first optimized and the blends were subsequently made into breakfast cereal

Formulation of blends of flours

The flaked breakfast cereal was made from a mixture of brown rice, defatted soybeans, and ginger. Samples were produced using composite flour that had been optimized using a simple lattice design method of mixture. The Simple lattice design with three independent variables was used for the process optimization. The dependent variables (responses) were the average of experimental values obtained from replicate determinations. Version 13.0.5.0 of the Design Expert programme from Stat Ease Inc. in Minnesota, USA, was utilized.

Table 1: Individual Flour Blend Composition Limits Using the Model

Individual flour samples	Maximum	Minimum
Brown rice flour	89	75
Defatted Soy flour	20	10
Ginger	5	1

Table 2: Blends for the Optimization of the Flour Blend (g)

Sample	Brown rice flour	Defatted Soy flour	Ginger flour
AVF	83.16	15.84	1.00
BYF	81.10	13.93	4.97

CXF	85.97	11.40	2.63
DWF	78.13	16.87	5.00
EVF	76.46	19.78	3.76

Production of breakfast cereal from brown rice, defatted soybean, and ginger

A homogenous thick paste was made by mixing 100 mL of water, 0.1 g of sweetener, 1 g of salt, 6 mL of vegetable oil, 2 g of Xanthan gum, and 100 g of the blended flour sample. The starch in this paste was then gelatinized by pre-cooking it for 30 minutes. After being allowed to cool to room temperature, the dough was divided. After chilling, the dough was rolled and flaked with a manual pasta cutter before being dried for one hour and thirty minutes at 75 °C. The finished goods were chilled before being put into an airtight, spotless container for packaging (Fig. 1). The process followed is the one reported by Usman (2012).

Determination of the Proximate Composition of the Breakfast Cereal

The moisture content, crude protein, crude fat, total ash, crude fibre, and total carbohydrate of the flour samples were determined using the AOAC (2010) technique while the energy value was calculated using the Atwater factor formula as published by Iyang, 2018. The mineral content of the breakfast food was determined using an atomic absorption spectrophotometer. The mineral content of the breakfast food was determined using atomic absorption spectrophotometer. Sodium and potassium content were assessed using flame photometer (AOAC, 2010).

Functional Properties of Breakfast Cereal Determination

The bulk density, water absorption, oil absorption, and swelling capacity of the mixes were all evaluated as functional characteristics. The bulk density was calculated using the method described by Okezie and Bello (1988). The water absorption capacity and oil absorption capacity were determined using the methods reported by Ocheme *et al.* (2015). The swelling capacity was determined using the modified method of Okaka and Potter (1977). From each sample, 10 ml was poured into a 100 ml graduated cylinder. Thereafter it was filled with water up to the 50 ml mark on the cylinder. The mouth of the graduated cylinder was tightly sealed, and the mixture was produced by inverting the cylinder. After two minutes, the suspension was turned around once more, and it was left to stand for 30 minutes. Thereafter, a measurement of the sample's volume was made.

Statistical analysis

The data collected were analyzed with One-way analysis of Variance (ANOVA) test at the 0.05 level. The significant level test was computed using Duncan's multiple range test and Tukey's test in the SPSS 20.0 programme.

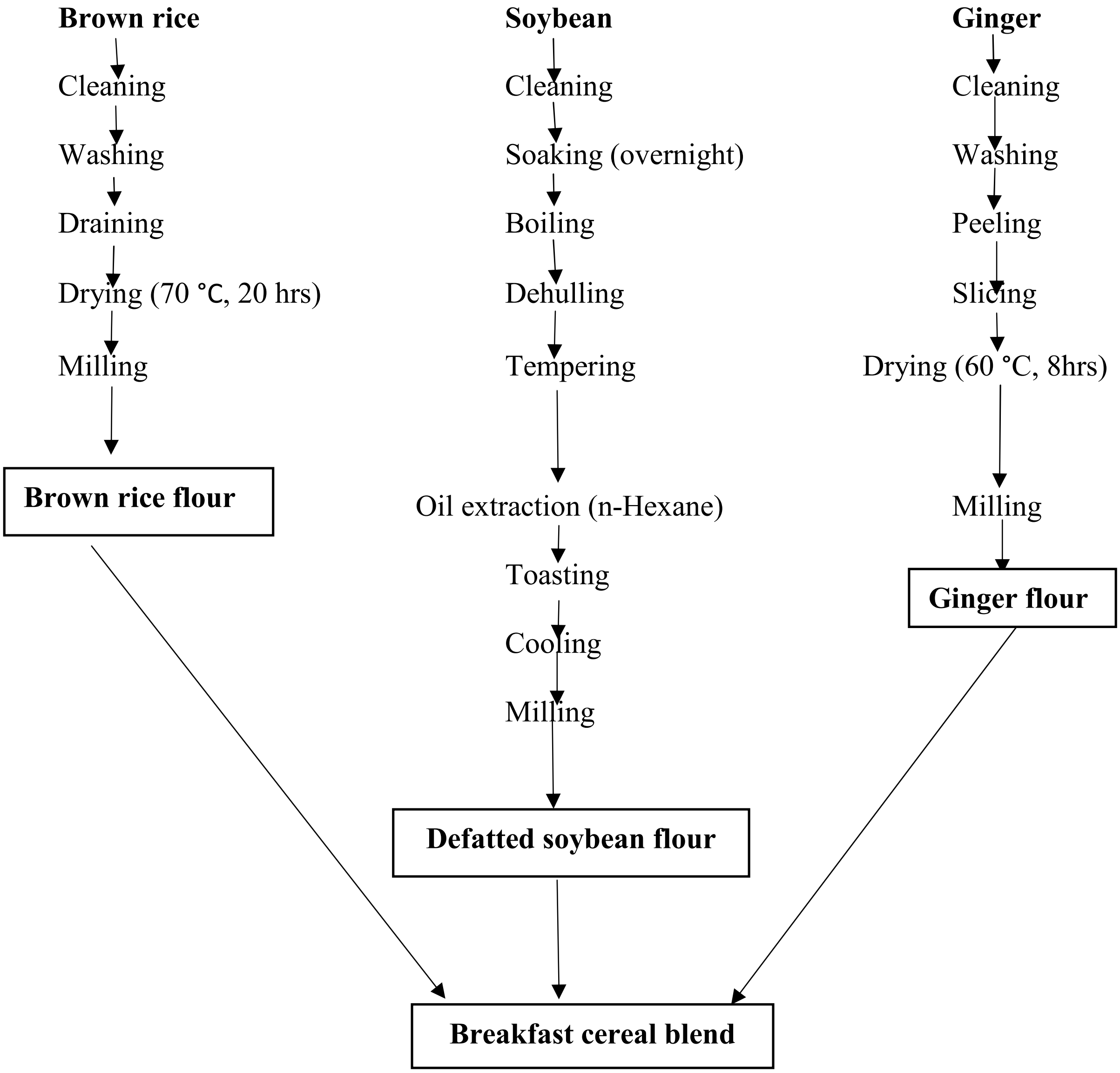

Figure 1: Flowchart for the production of breakfast blends from brown rice, defatted soybean and ginger flour.

Results and Discussion

Proximate Composition of Breakfast Cereal Samples

Proximate composition of the produced breakfast cereals are presented in Table 3. The moisture content of the flakes ranged between 8.70- 9.47%. The moisture content values of the flakes are within the recommended value for flour samples (<10%). The lower moisture content observed is an indication that the shelf life of the flakes would be longer, since the moisture content of the samples was very low for the activity of microorganisms, thereby increasing the shelf life of the product. It is well-established that these findings are in agreement with the reports for flour blend samples by Awolu *et al*. (2017) and Akinjayeju *et al*. (2019).

The protein content of the products ranged between 11.72 and 16.11%. There is an increase in the amount of protein in the breakfast flakes as the proportion of soybean content in the formulations increases. The daily allowance of protein recommended for diabetics is between 15-20% of the total calories (Vansunder, 2009). These values are similar to the reports of Olawale, (2009) and Tenagashaw *et al*., (2015). Usman *et al*., (2015), reported higher crude protein values of 22.38-30.30% for breakfast cereals made from blends of local rice soybean and coconut flour.

Table 3: Proximate Composition of Breakfast Cereal (%)

Sample	AZF	BYF	CXF	DWF	EVF
Moisture (%)	9.30 ± 0.07^{c}	9.23 ± 0.08^{cd}	9.47 ± 0.05^{b}	9.14 ± 0.09^{d}	8.70 ± 0.03^{a}
Ash (%)	1.86 ± 0.01^{d}	2.07 ± 0.03^{b}	1.99 ± 0.01^{c}	2.03 ± 0.01^{bc}	2.36 ± 0.05^{a}
Protein (%)	12.72 ± 0.02^{c}	11.72 ± 0.03^{e}	11.97 ± 0.02^{d}	14.25 ± 0.04^{b}	16.11 ± 0.03^{a}
Fat (%)	3.84 ± 0.03^{c}	4.05 ± 0.03^{b}	4.02 ± 0.01^{b}	4.00 ± 0.04^{b}	4.32 ± 0.03^{a}
Crude Fiber (%)	0.89 ± 0.03^{a}	0.11 ± 0.02^{d}	0.89 ± 0.01^{a}	0.11 ± 0.01^{d}	0.73 ± 0.03^{b}
Carbohydrate (%)	71.47 ± 0.01^{c}	72.88 ± 0.45^{a}	71.72 ± 0.06^{b}	70.57 ± 0.02^{e}	67.88 ± 0.09^{d}
Energy (kcal)	371.36 ± 0.37^{b}	374.89 ± 0.23^{a}	$370.\ 98 \pm 0.33^{b}$	375.28 ± 0.58^{a}	374.79 ± 0.38^{a}

Mean values having different superscripts in the same column are statistically different from each other ($P \leq 0.05$). AZF = 83.16 g brown rice flour, 15.84 g defatted soy flour and 1.00 g ginger flour, BYF = 81.10 g brown rice flour, 13.93 g defatted soy flour and 4.97 g ginger flour, CXF = 85.97 g brown rice flour, 11.40 g defatted soy flour and 2.62 g ginger flour, DWF = 78.13 g brown rice flour, 16.87 g of defatted soy flour and 5.00 g of ginger flour, EVF = 76.46 g of brown rice flour, 19.78 g of defatted soy flour and 3.76 g of ginger flour.

The fat content of the breakfast cereal ranged from 3.84-4.32%. The low-fat content benefits the products by extending their stability and shelf life. The fat content as reported by Iwanegbe *et al*. (2019) ranged from 2.41-3.94%. The fat content of the flakes was low because of the soybean used in the formulation was defatted, while Usman *et al*. (2015) recorded a higher value; Edima-Nyah *et al*. (2019a) likewise reported a low-fat content (2.15-4.82%) for breakfast cereal meals made from yellow maize, soybean, and unripe banana flour blends.

The crude fibre content of the breakfast cereal samples ranged from 0.11 to 0.89%; these values varied significantly ($p > 0.05$). Ijarotimi and Keshinro (2013) had reported 0.85% for the samples of complementary foods formulated from the combination of fermented popcorn, African locust and Bambara Groundnut seed flour. This range is similar to the values of 0.09-1.01% reported by Twinomuhwezi *et al*. (2020). Usman *et al.* (2015) also reported that during the milling process of rice, fibre is was lost resulting into low crude fibre content of their samples. Consumption of fibre has been linked to improved digestive health as well as lower risk of diabetes, colon cancer, and other disorders, according to studies. Crude fibre also helps in the reduction in the rate at which glucose is released into the bloodstream and also reduces intracolonic as a result, the risk of colon cancer is decreased.

The ash content of the breakfast cereal samples ranged between 1.86-2.36%. Food ash content gives an idea of how many different mineral components are present overall. After moisture and organic elements have been eliminated, ash content provides an idea of the overall inorganic compositions (Iwe *et al*., 2016).

The reported values are comparable to (1.5–2.5%) provided by Mbaeyi (2005) and (1.05–2.40%) reported by Usman *et al*. (2015). The amount of ash in the breakfast flakes was discovered to increase in direct proportion to the volume of rice flour added to the mixture. A high ash level could also be attributable to soy flour mixed with rice flour.

Carbohydrate content of the samples varied from 67.88 to 72.88%. The high percentage of brown rice, which is the main ingredient in the recipe, can be attributed to the breakfast cereal's high carbohydrate content. The majority of daily calories and nutritional energy come from rice, which is a particularly rich source of carbohydrates. Edema-Nyah *et al.* (2019) reported a carbohydrate content of (67.28-76.58%) of carbohydrate from blends of yellow maize, soybean and unripe banana, while Twinomuhwezi *et al*. (2020), reported a carbohydrate content value of (64.64-81.53%) from composite flours of amaranth, rice, millet and soybean while Chima, *et al.* (2022), reported a range of 68.23-74.10% of carbohydrate content from a blend of soybean and orange-fleshed sweet potato. The presence of a lot of carbohydrates in breakfast cereal indicates that it is an energy-dense food, which is ideal for breakfast meals that will provide people with energy.

The total energy of the breakfast flakes ranged between 370.98-375.28 kcal. This is close to 363.95-413.94 kcal reported by Twinomuhwezi *et al*. (2020), and Edema-Nyah *et al*. (2020) reported (362.59-371.50 kcal). Foods contain a significant amount of energy. Our body needs energy for a variety of tasks like walking, talking, working, relaxing, and breathing, all of which are supported by the food we eat. Carbohydrates, lipids, and frequent protein are used to determine the amount of energy in the diet.

Mineral Content of the Breakfast flake

Results of the mineral content of the breakfast flake samples are presented in Table 4. The results show that the analysed mineral elements (Ca, Na, Zn, Fe, K, Mg, and Mn) varied significantly ($P > 0.05$) among the breakfast flakes produced. The result shows the mineral elements determined in the study (Ca, Na, Zn, Fe, K, Mg, Mn) varying significantly ($P > 0.05$) among the produced breakfast flake samples (Inyang, 2018).

Sodium was the most abundant mineral in the formulation. The amount of sodium ranged between 2160-2514 mg/100 g. Life is dependent on sodium. It helps regulate the fluid balance in the body. It also plays a crucial role in transmission of nerve signals and has an impact on muscular activity. Iwanegbe *et al.* (2019) reported sodium ranging between 47.81 and 75.66 ppm for a composite flour blend.

Potassium content of the breakfast cereal were between 495 and 834 mg/100 g. These values were within the values (228.20 – 245.08 mg/100 g) reported by Inyang *et al*. (2018) for rice, unripe banana, and sprouted soybean blends while Okache *et al*. (2020) reported a range (566.60-1400 mg/100g) for breakfast cereals produced from finger millet, wheat, soybean and peanut flour blends. In human body, potassium plays a vital role in maintaining fluid equilibrium, controlling muscular contraction, and regulating nerve messages. A high potassium intake also lowers blood pressure and water retention, guards against stroke, and avoids kidney stones and osteoporosis. Potassium is needed in relatively large amounts in the body because it functions as an important electrolyte in the nervous system (McLean and Wang, 2021).

Calcium content of the breakfast cereal ranged between 66.10 – 78.4 mg/100 g. Calcium is essential for the contraction of muscles, the transmission of nerve signals, and the release of hormones. It is an essential part of intracellular processes that take place in tissues that respond to insulin, such as muscle and adipose tissues. Inyang *et al*. (2018) reported 46.28 – 62.30 mg/100 g in cookies production from rice, unripe banana and sprouted soybean

Table 4: Mineral Content of Breakfast Cereal

SAMPLE	AZF	BYF	CXF	DWF	EVF
Calcium (mg/100 g)	69.8 ± 0.10^{c}	70.6 ± 0.10^{b}	66.1 ± 0.10^{e}	78.4 ± 0.10^{a}	67.1 ± 0.10^{d}
Iron (mg/100 g)	15.4 ± 0.10^{c}	13.6 ± 0.10^{d}	17.6 ± 0.10^{a}	15.8 ± 0.10^{b}	10.8 ± 0.10^{e}
Potassium (mg/100 g)	834 ± 1.00^{a}	495 ± 1.00^{e}	612 ± 1.00^{c}	750 ± 1.00^{b}	549 ± 1.00^{d}
Sodium (mg/100 g)	2418 ± 1.00^{c}	2262 ± 1.00^{d}	2508 ± 1.00^{b}	2514 ± 1.00^{a}	2160 ± 1.00^{e}
Manganese (mg/100 g)	1.5 ± 0.01^{e}	2.8 ± 0.01^{b}	2.0 ± 0.01^{d}	3.2 ± 0.01^{a}	2.3 ± 0.01^{c}
Zinc (mg/100g)	2.2 ± 0.01^{b}	2.3 ± 0.01^{a}	2.3 ± 0.01^{a}	2.1 ± 0.01^{c}	1.9 ± 0.01^{d}
Magnesium (mg/100 g)	21.4 ± 0.01^{c}	20.6 ± 0.01^{d}	20.07 ± 0.01^{e}	24.5 ± 0.01^{b}	25.11 ± 0.01^{a}

Mean values having different superscripts in the same column are statistically different from each other (P ≤ 0.05). AZF = 83.16 g brown rice flour, 15.84 g defatted soy flour and 1.00 g ginger flour, BYF = 81.10 g brown rice flour, 13.93 g defatted soy flour and 4.97 g ginger flour, CXF = 85.97 g brown rice flour, 11.40 g defatted soy flour and 2.62 g ginger flour, DWF = 78.13 g brown rice flour, 16.87 g of defatted soy flour and 5.00 g of ginger flour, EVF = 76.46 g of brown rice flour, 19.78 g of defatted soy flour and 3.76 g of ginger flour.

while Iwanegbe *et al*. (2019) reported 236.11 -804.04 ppm from blends of unripe plantain, soybean and ginger.

The breakfast cereal samples were found to have iron levels of between 10.80 and 17.60 mg/100g. Iron affects insulin activity and glucose metabolism. It also prevents insulin from inhibiting glucose generated in the liver from being used as fuel (Chatterjir *et al.,* 2012). Iwanegbe *et al.* (2019) reported iron content that ranged between 28.65- 141.49 ppm for the composite blend from unripe plantain, soybean and ginger, while Inyang (2018) reported 2.75 – 3.72 mg /100 g in cookies production from rice, unripe banana and sprouted soybean flour blends.

Functional Properties of the breakfast flake

Findings on the functional properties of the flaked breakfast cereal samples are presented in Table 5. The bulk density of the samples ranged between (0.795-0.826 g/mL). The bulk density which is also called volumetric density is the mass of several particles of flour material about the total volume they occupy. Okafor and Usman (2014) reported a bulk density of 0.29 - 0.71 g/mL for breakfast cereals produced from blends of maize, African Yam Beans, coconut cake and sorghum extract while values ranging from 0.93 – 1.71 g/mL were reported for yellow maize, soybeans and banana flour blends (Edima-Nyah *et al*., 2020). The bulk density of flour is significantly influenced by its density and particle size, which is crucial for defining the type of packaging and material handling required (Malomo *et al*., 2012).

The water Absorption Capacity (WAC) of the breakfast flakes ranged between 278.67 and 338.00%. WAC of any food product refers to its capacity to associate with water in situations where water availability is constrained. Edima-Nyah *et al*. (2019), reported a range of 1.90 - 2.60% for maize, soybean and banana flour blends while Twinomuhwezi *et al*. (2020), reported WAC ranging from 5.79-7.17% for blends of amaranth, rice, millet, and soybean. Ability of food product to absorb water is crucial since it affects other functional qualities including emulsification, solubility, gelation, and viscosity (Obiegbuna *et al*., 2019).

The Oil Absorption Capacity of the breakfast cereal samples were between 63.67and 71.33%. The capacity of foods to absorb oil is determined by how well fats bind to the proteins in those foods (Awuchi *et al.,* 2019). Chandra and Samsher, (2013), reported that the ability of proteins in flour to bind with oil is a useful key in the food system to achieve the optimal oil absorption desired. It also enhances the mouth feel and flavour in food preparations. Okafor and Usman (2014) recorded values that ranged from 0.87 to 1.32% for breakfast cereals made with maize, sorghum extract and coconut flour blends while higher values that ranged from 1.70 to 2.50% were reported by Edima-nyah *et al*., (2020) for breakfast cereal from local rice, African yam bean and coconut flour blends.

Table 5: Functional Properties of Breakfast Cereal

SAMPLE	AZF	BYF	CXF	DWF	EVF
Bulk density (g/mL)	48.67 ± 0.02^{a}	47.63 ± 0.01^{c}	51.27 ± 0.01^{c}	49.70 ± 0.02^{c}	48.80 ± 0.16^{b}
Water absorption (g/mL)	334.67 ± 21.55^{a}	275.00 ± 20.30^{c}	328.67 ± 21.20^{ab}	323.00 ± 6.00^{bc}	333.33 ± 6.66^{ab}
Oil absorption (g/mL)	104.00 ± 11.79^{a}	110.67 ± 14.01^{a}	118.00 ± 10.15^{a}	107.66 ± 17.62^{a}	106.33 ± 17.79^{a}
Swelling capacity (g/mL)	31.66 ± 1.53^{ab}	33.00 ± 2.00^{a}	27.67 ± 1.53^{bc}	34.00 ± 1.00^{a}	32.00 ± 1.00^{a}
Dispersibility (g/mL)	47.67 ± 0.58^{c}	53.67 ± 0.58^{b}	39.00 ± 0.00^{a}	40.00 ± 1.00^{d}	37.33 ± 0.58^{b}

Mean values having different superscripts in the same column are statistically different from each other ($P \leq 0.05$). AZF = 83.16 g brown rice flour, 15.84 g defatted soy flour and 1.00 g ginger flour, BYF = 81.10 g brown rice flour, 13.93 g defatted soy flour and 4.97 g ginger flour, CXF = 85.97 g brown rice flour, 11.40 g defatted soy flour and 2.62 g ginger flour, DWF = 78.13 g brown rice flour, 16.87 g of defatted soy flour and 5.00 g of ginger flour, EVF = 76.46 g of brown rice flour, 19.78 g of defatted soy flour and 3.76 g of ginger flour.

The swelling capacity is a measurement of the starch's capacity to absorb water molecules and swell; it is a sign of the associative forces present in the flour granules and is influenced by the flour's particle size, variety, and processing technique (Mbaeyi and Uchedu, 2016). The swelling capacity of the breakfast cereal in this study ranged between 29 and 33 mL. The amount of amylose and amylopectin in the mixture is influenced by amylase, which is shown by the swelling power (Malomo, 2012). Mbaeyi and Uchendu (2016), reported higher values (131.32-399.51) for breakfast cereal samples from *Acha* flour and fermented soybean paste. Twinomuhwezi *et al.* (2020) reported values ranged between (5-23.5 mL) for composite flour of amaranth, rice, millet and soybean. Swelling capacity of flour depends on the particle size, the various type and the unit operation employed in the processing (Iwanegbe *et al.,* 2019). The swelling capacity of the blends under investigation

were slightly higher that the values reported by Twinomuhwezi *et al.* (2020).
The dispersibility index of the breakfast cereal samples ranged between 53.3 – 69.67%. Dispersibility is the measure of how individual molecules of flour disperses and homogenize with a medium of dispersion (Asaam, *et al.,* 2018). Olapade *et al.* (2014) reported values from 68.0-70.67% for the blends *fufu* flour and Bambara groundnut flour. Asaam *et al.* (2018) reported values ranging from 56-65% for breakfast cereal from maize-soya bean-pumpkin composite flours.

Conclusion

The study produced successfully a breakfast cereal with good chemical and functional characteristics from brown rice, defatted soybean and ginger flour. Different quantities of each flour are blended to give a breakfast cereal with high nutritional content. The findings showed that the breakfast cereal contained an appreciable amount of protein and carbohydrate content which is within the recommended value for a diabetic. The study also showed that mixtures of brown rice, defatted soybeans, and ginger flour have good functional qualities such as a high water absorption capacity and swelling capacity which are factors useful in pastry making and in the production of flaked breakfast cereals.

Conflicts of Interest

The authors declare no conflict of interest.

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