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Nutrient Composition and Sensory Properties of Breakfast Cereals Produced from Millet Flour Supplemented with Soybean and Date Fruit Flours

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was designed to evaluate the nutrient composition and sensory properties of breakfast cereals produced from blends of millet, soybean and date fruit flour. Soybean and date fruit flours were used at varying replacement levels (5-30% soybean and 5-20% date fruit) for malted millet flour in the production of breakfast cereals with breakfast cereal produced from 100% malted millet flour as control. The nutrient composition and sensory properties of the breakfast cereals were evaluated using standard methods. The moisture, crude protein, fat, crude fibre and ash contents of the breakfast cereals increased significantly ($p<0.05$) with increase in substitution of soybean and date fruit flours from 7.19-7.63%, 7.69-18.32%, 3.09-4.03%, 2.47-3.86% and 1.21-2.07, respectively, while the carbohydrate and energy contents decreased from 78.37-64.13% and

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371.99-365.10KJ/100g, respectively. The mineral composition of the breakfast cereals also increased significantly ($p<0.05$) with increase in substitution of soybean and date fruit flours from 17.86-96.52mg/100g (calcium), 58.47-132.72mg/100g (potassium), 79.01-120.76mg/100g (phosphorus), 16.54-86.54mg/100g (magnesium), 1.55-2.14mg/100g (iron) and 1.32-1.72mg/100g (zinc), respectively. The thiamine, riboflavin, niacin, ascorbic acid, vitamin A and folic acid contents of the samples equally increased significantly ($p<0.05$) with increase in substitution of soybean and date fruit flours from 1.36-2.57mg/100g, 2.36-3.51mg/100g, 2.14-3.56mg/100g, 1.55-2.22mg/100g, 2.23-4.26mg/100g and 1.02-1.81mg/100g, respectively. The sensory properties of the samples showed that the porridge made from the control sample (Breakfast cereal made with 100% malted millet flour) was the most acceptable to the panelists and also differed significantly ($p<0.05$) from those prepared from the substituted samples in colour, texture, taste and flavour. The study, however, showed that the nutrient contents and sensory properties of millet based breakfast cereals could be improved by supplementing millet flour with different proportions of soybean and date fruit flours in the preparation of nutrient-dense and acceptable breakfast cereal products.

Keywords: Breakfast cereals; enrichment; quality attributes; millet flour; soybean flour; date fruit flour.

1. INTRODUCTION

"In developing countries, particularly Nigeria and other sub-Saharan African countries, breakfast meal for both adult and infants are based on local staple diets made from cereals, legumes, roots and tubers" [1]. "However, the findings from the previous studies showed that most cereals are limiting in essential amino acids such as lysine, threonine and tryptophan even though they are rich in cystine" [2-4], "whereas most oilseeds and legumes are rich in essential amino acids particularly the sulphur amino acids" [5,6]. "Thus, a combination of such food stuffs will improve the nutritional value of the resulting blends compared to the individual components alone" [1].

"The search for better quality and nutrient dense meals has led to an extensive work in an effort to formulate various breakfast and infant cereal meals by combining the available local cereals and legumes" [7]. "These meals are usually prepared as flakes for adults or as pap for infants" [7]. The suitability of cereal, oilseed and legume blend meals for human consumption has been extensively reviewed [5] and many countries have reported success in those formulations [8,6].

Breakfast literally means 'breaking the fast' from the last meal or snack from the previous day. Breakfast is the nutritional foundation or the first meal of the day [9]. "Nutritional experts have referred to breakfast as the most important meal of the day. A lot of studies have shown that people who skip breakfast are disproportionately likely to have problems with concentration, metabolism and weight" [10]. "Breakfast meals vary widely in different cultures around the world. It often includes a carbohydrate source such as cereals, fruits or vegetables, protein, sometimes dairy, and beverages. However, the most widely eaten breakfast foods are cereals" [9].

"Breakfast cereals are legally defined as foods obtained by swelling, grinding, rolling or flaking of any cereal" [11]. "They can be categorized into traditional (hot) cereals that require further cooking or heating before consumption and ready-to-eat (cold) cereals that can be consumed ordinarily or with the addition of milk" [12]. Ready-to-eat breakfast cereals are increasingly gaining acceptance in most developing countries and gradually displacing most traditional diets that serve as breakfast due to convenience, nutritional values, improved income, status symbol and job demands especially among urban dwellers. According to Jones [13], "instantized and ready-to-eat cereals facilitate independence because of their ease of preparation which means that children and adolescents can be responsible for their own breakfast meals or snacks". "Such foods may need to be reconstituted, pre-heated in a vessel or allowed to thaw if frozen before consumption, or they may be eaten directly without further treatment" [14].

"Millet is the fourth most important and readily available cereal crop in the world. It refers to a number of different species of cereal crop, all of which are small grained, annual cereal grasses. Millet is dependent upon around the world to provide basic nutrition for many developing nations. Millet is a tropical cereal crop that produces good yields of grains under unfavourable conditions. It is a good source of

some very important mineral elements such as calcium, iron, potassium, zinc, phosphorus, copper, manganese and magnesium. It is equally regarded as a healthy source of essential fat in the body" [15,16]. "It is also a rich source of B-group vitamins particularly thiamine. Millet contains significant levels of protein and dietary fibre which contribute to the health benefits of this important grain" [17]. "Millets are rich sources of phytochemicals and other micronutrients" [16].

"Soybean (*Glycine max)* is one of the most important legumes of the tropics with high lysine content compared to other plant proteins" [18]. "Soybean has gained popularity in its utilization as a staple crop due to its high nutritional and excellent functional properties" [19]. It is rich in protein (39.4%), carbohydrate (27.1%) and oil (20.6%) [20]. Soybean also contains vitamin B-complex such as thiamine (B_1), riboflavin (B_2), niacin (B_3), pyridoxine (B_6) and folate and minerals such as calcium, phosphorus, magnesium, potassium and trace elements including iron and zinc in minute quantities. The fibre content of soybean helps to control cholesterol [21]. Varieties of products are produced from soybean [22] and these products are called soy products. Soybean contains antioxidants and phytochemicals such as phytosterols, isoflavones, phytic acid and saponins and many of them have anti-inflammatory and anti-carcinogenic effects when consumed [18].

Date fruit (*Phoenix dactylifera L.*) is a tree belonging to the family *Palmaceae.* Date fruitss are also known as *Dabino* in Nigeria and are commonly used by the Muslims to break their fast. The fruit is naturally sweet among all fruits containing 60-80% sugar. Date fruits are rich sources of dietary fibre, essential vitamins and minerals. Date fruits also contain phytochemicals such as anthocynins, phenolics, sterols, carotenoids, procyanidins and flavonoids and these compounds are known to possess multiple beneficial effects [23]. Date fruits equally possess free radical scavenging antioxidants, gastroprotective, hepatoprotectie, nephroprotective, anti-cancer and immune stimulant. However, the supplementation of breakfast-cereals with soybean and date fruit flours will improve both the macro and micro- nutrient contents of the products. The objective of this work was to evaluate the quality characteristics of breakfast cereals produced from millet flour supplemented with soybean and date fruit flours.

2. MATERIALS AND METHODS

The pearl millet (*Pennisetum typhoides*), soybean *(Glycine max)* and date fruits (*Phoenix dactylifera L.*) used for the study were purchased from Ogbete Main Market, Enugu, Enugu State, Nigeria.

2.1 Preparation of Millet Flour

The malted millet flour was prepared according to the method described by Inyang and Zakari [24]. One kilogramme (1kg) of millet grains were manually sorted to remove the dirt and other extraneous materials. The sorted grains were thoroughly cleaned and steeped in 2.5 litres of potable water in a plastic bowl at room temperature (30 ± 2^oC) for 24 h with a change of water at intervals of 6 h to prevent fermentation. After steeping, the grains were drained, rinsed and immersed in 2% Sodium hypochlorite solution for 10 min to sterilize the grains. The grains were rinsed repeatedly for five consecutive times with excess water and cast on a moistened jute bag, covered with a polyethylene bag and left for 24 h to hasten sprouting. The sprouted grains were spread carefully on the jute bag and allowed to germinate in the germinating chamber at room temperature ($30\underline{+}2^oC$) and relative humidity of 95% for 96 h. During this period, the grains were sprinkled with water at intervals of 6 h to facilitate germination. Non-germinated grains were handpicked and discarded. The germinated grains were collected, spread on the trays and dried in a tray dryer (Model HR 6200, UK) at 60^oC for 24 h with occasional stirring of the grains at intervals of 30 min to ensure uniform drying. After drying, the roots and shoots of the malted millet grains were removed by rubbing them in-between palms. The dried millet malts were milled in a hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in a covered plastic container, labelled and stored in a refrigerator until needed for further use.

2.2 Preparation of Soybean Flour

The boiled soybean flour was prepared according to the method described by Okoye et al. [25]. One kilogramme (1kg) of soybean seeds were manually sorted to remove the dirt and other extraneous materials. The sorted seeds were thoroughly cleaned and soaked in 2.5 litres of potable water in a plastic bowl at room temperature (30 ± 2^oC) for 12 h with a change of

water at intervals of 4 h to prevent fermentation. The soaked seeds were drained, rinsed and dehulled manually by rubbing them in-between palms to remove the hulls. The dehulled seeds were rinsed, put into a stainless pot and boiled with 2.5 litres of potable water at 100^{o}C for 30 min on a hot plate. The boiled seeds were drained, spread on the trays and dried in a tray dryer (Model HR 6200, UK) at 60^{o}C for 16 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried soybean seeds were milled in a hammer mill and sieved through a 500 micron mesh sieve. The flour produced was packaged in a covered plastic container, labelled and stored in a refrigerator until needed for further use.

2.3 Preparation of Date Fruit Flour

The date fruit flour was prepared according to the method described by Al-Farsi and Lee [23] with slight modifications. One kilogramme (1kg) of date fruits were manually sorted to remove the dirt and other contaminants. The sorted date fruits were thoroughly cleaned and steeped in 2 litres of potable water in a plastic bowl at room temperature (30±2^{o}C) for 24 h with a change of water at intervals of 6 h to prevent fermentation. The steeped fruits were manually cut into two equal parts with a kitchen knife to remove the seeds from the pulps. The pulps of the fruits were rinsed with water, spread on the trays and dried in a tray dryer (Model EU 850D, UK) at 60^{o}C for 18 h with occasional stirring of the pulps at intervals of 30 min to ensure uniform drying. The dried pulps were milled in a hammer mill and sieved through a 500 micron mesh-sieve. The flour produced was packaged in a covered plastic container, labelled and kept in a refrigerator until needed for further use.

2.4 Formulation of Flour Blends

Millet flour was mixed thoroughly with soybean and date fruit flours in the ratios of 100:0:0, 90:5:5, 80:15:5, 70:20:10, 60: 25:15 and 50:30:20, in a rotary mixer (Philips, type HR, 1500A Holland) to obtain homogenous samples of composite blends. The composite blends produced were separately packaged in airtight plastic containers, labelled and preserved in a refrigerator until needed for further use. The substitution levels of 5-20% for date fruit and 5-30% for soybean flours were adopted based on the fact that soybeans are relatively high in protein, while date fruits are rich in micronutrients such as minerals and vitamins.

2.5 Preparation of Breakfast Cereals

The flaked breakfast cereals were prepared according to the method described by Agunbiade and Ojezele [26] with slight modifications. The breakfast cereals were prepared by mixing the composite flours with small quantity of water, sugar and salt so as to have binding effect and improve their taste. The mixture was heat treated by steaming for 10 min and then allowed to age at a temperature of about 4^{o}C for 6 h. The resultant dough was cut into very small sizes and shapes with a sharp knife, placed into flat greased baking trays and flaked or toasted in an electric oven (Salva, USA) at a temperature of 130^{o}C for 1 h. Thereafter, the products were allowed to cool at room temperature (30±2^{o}C) and after that, they were packaged separately in covered plastic containers, labelled and kept in a refrigerator until needed for analysis.

2.6 Proximate Analysis

The moisture, crude protein, ash, fat and crude fibre contents of the samples were determined on dry weight basis according to the standard analytical methods of AOAC [27]. The carbohydrate was calculated by difference. % Carbohydrate = 100 - % (Moisture + Crude Protein + Fat + Ash + Crude Fibre). The energy content was calculated by multiplying the percentage values of protein, fat and carbohydrate by the Atwater factors of 4, 9 and 4, respectively [27]. All determinations were carried out in triplicate samples.

2.7 Mineral Analysis

The minerals were extracted by dry-ashing of the samples in a muffle furnace at 550^{o}C to constant weight followed by the dissolution of the ash obtained from each sample in a volumetric flask by the addition of 50mL of de-ionized water and a few drops of concentrated hydrochloric acid. The calcium, magnesium and zinc contents of the samples were determined using the Techcomp AA600 atomic absorption spectrophotometer. The potassium and iron contents were also determined using the atomic absorption spectrophotometer and further confirmed using a digital flame photometer. The phosphorus content was determined by the use of colourimetric method. The colour was developed using ammonium molybdate reagent and read on a spectronic 20 Colourimeter. All determinations followed the methods of AOAC [27] and were carried out in triplicate samples on dry weight basis.

2.8 Vitamin Analysis

The ascorbic acid, thiamine and niacin contents of the samples were determined on dry weight basis using the atomic absorption spectrophotometer (Perkin-Elmer Model 300, Norwalk, CT) after extraction. The riboflavin and folic acid contents were determined using a digital flourimeter. The vitamin A content was determined using the ultraviolet absorption spectrophotometer after extraction with chloroform. All determinations followed the AOAC [27] procedures and were carried out in triplicate samples.

2.9 Sensory Evaluation

The breakfast cereals prepared from both the control and the substituted samples were evaluated by a panel of twenty (20) semi-trained judges comprising of staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The selection was based on their previous participation in similar sensory tests. The samples were evaluated for the attributes of colour, taste, texture, flavour and overall acceptability using a nine point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively [28]. The sensory evaluation was carried out in the Food Processing and Preservation Laboratory of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria at 11.00a.m in the morning. The laboratory was adequately lighted and free from distraction. The judges were sitted in such a way that they could not see the rating of each other. The breakfast cereals were separately prepared into porridges by dispersing one hundred and fourty grammes (140g) of each sample in one hundred millilitres (100mL) of hot potable water with continuous stirring until it develops into gel. Two teaspoonfuls of powdered milk were added to each of the sample and stirred repeatedly until the milk was well distributed. The samples were randomly coded and presented in plain coloured plastic cups to the panelists with plastic teaspoons. Also, clean potable water was provided to the judges to rinse their mouth after testing each sample to avoid residual effect. The panelists were instructed to taste, assess and score each sample of the breakfast cereals based on their degree of preference and acceptance of each sample. Expectoration cups with lids were provided for the panelists who would not like to swallow the samples after testing each of them.

2.10 Statistical Analysis

The data generated were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, Version 20) software. Significant means were separated using Turkey's least significant difference (LSD) test at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Breakfast Cereal Samples

The proximate composition of the breakfast cereals are presented in Table 1. The moisture content of the samples varied significantly ($p<0.05$) from each other. The moisture content ranged from 7.19 to 7.63% with the control sample (Breakfast cereal made with 100% malted millet flour) having the least moisture content (7.19%), while the sample substituted with 30% soybean and 20% date fruit flours had the highest value (7.63%). There was significant ($p<0.05$) difference in moisture content between the samples. The low moisture content obtained in this study is in agreement with the report of Mbaeyi-Nwaoha and Uchendu [29] for breakfast cereals made from blends of acha and fermented soybean paste (okara). The values (7.19-7.63%) obtained in the study were within the range of moisture content (6.38-10.28%) recommended for proper storage of breakfast cereal products [30]. The low moisture contents observed in the formulated breakfast cereal samples may be beneficial in extending the shelf-life of the products with proper packaging and storage.

The protein content of the samples which ranged from 7.69 to 18.32% was observed to increase with increase in substitution of soybean and date fruit flours in the products. The protein contents of all the substituted breakfast cereals were superior to that of the control (Breakfast cereal made with 100% malted millet flour) and this is a clear demonstration of the effect of supplementation of millet flour with soybean flour in the production of breakfast cereal products [31]. The values (7.69-18.32%) obtained in this study were lower than the protein content (17.16-21.30%) reported by Mbeayi-Nwaoha and Uchendu [29] for breakfast cereals produced from blends of acha and fermented soybean

paste. Protein is important for growth and tissue replacement [32].

The fat content of the breakfast cereals ranged from 3.09 to 4.03%. The fat content of the control sample (Breakfast cereal made with 100% malted millet flour) was significantly ($p<0.05$) lower than the fat contents of all the formulated samples. The sample substituted with 30% soybean and 20% date fruit flours had the highest fat content (4.03%). The variation in the fat content could be due to the differences in the raw materials used in the formulation of the breakfast cereals. The level of soybean flour added to the formulation might be responsible for the slight increase in the fat content of the resultant breakfast cereal products because there was an increase in the fat content with the addition of soybean flour in the formulation even though that the products were generally low in fat. The result showed that the increase in the fat content of the breakfast cereals with increase in addition of soybean flour is an indication that soybean is a good source of fat [25]. High fat content (8.70-14.32%) has been reported by Agunbiade and Ojezele [26] for breakfast cereal products made from maize, sorghum and African yam bean composite flours. The low fat content observed in the formulated breakfast cereals make them suitable for weight watchers. Fat increases the energy density and also supplies the body with fat soluble vitamins and essential fatty acids needed for proper development of neurons in the body [32].

The ash content of the samples ranged from 1.21 to 2.07% with the control (Breakfast cereal made with 100% malted millet flour)and the sample substituted with 30% soybean and 20% date fruit flours having the least (1.21%) and highest (2.07%) values, respectively. The values (1.21-2.07%) obtained in this study were lower than the ash content (2.43-4.18%) reported by Agunbiade and Ojezele [26] for instant breakfast meals produced from maize, sorghum, soybean and African yam bean composite flours. The increase in the ash content observed in substituted samples could be attributed to high mineral contents of soybean and date fruit flours used in the preparation of the breakfast cereals.

The crude fibre content of the samples ranged from 2.47% in the control sample to 3.86% for the sample substituted with 30% soybean and 20% date fruit flours, respectively. The crude fibre content of the samples was observed to increase as the levels of substitution with soybean and date fruit flours increased and this is in agreement with the report that soybean and date fruits are rich sources of dietary fibre [33,23]. Fibre helps to increase the utilization of nitrogen and absorption of some other micronutrients in the body [32]. Fibre is also needed to assist in digestion and in keeping the gastrointestinal tract healthy. It also slows down the release of glucose during digestion. The faecal bulking action of insoluble fibre makes it useful in the treatment of constipation and diverticular disease [34].

The carbohydrate content of the samples varied from 78.37 to 64.13% with the control and the sample substituted with 30% soybean and 20% date fruit flours having the highest (78.37%) and the least (64.13%) values, respectively. The result showed that an increase in the levels of substitution of soybean and date fruit flours for millet flour led to a corresponding decrease in the carbohydrate content of the formulated breakfast cereal products. Similar decrease in carbohydrate content has been reported by Onweluzo and Nnamuchi [4] for porridge-type breakfast cereals produced from *Treculia africana* and *Sorghum bicolor* flours.

The energy content of the breakfast cereals which varied from 371.99 to 365.10KJ/100g decreased significantly ($p<0.05$) with increased substitution of soybean and date fruit flours in the products. The control sample (Breakfast cereal made with 100% malted millet flour) had the highest energy value (371.99KJ/100g), while the sample substituted with 30% soybean and 20% date fruit flours had the least energy value (365.10KJ/100g). The energy value of the samples decreased steadily with increased substitution of soybean and date fruit flours. Similar decrease in energy content has been reported by Usman et al. [35] for breakfast cereals produced from blends of African yam bean, maize and defatted coconut flour. Energy value represents the amount of energy in the food that can be supplied to the body for the maintenance of basic body functions. The substitution of millet flour with soybean and date fruit flours in the preparation of breakfast cereals greatly increased the protein, fat, ash and crude fibre contents of the products.

Table 1. Proximate composition (%) of breakfast cereal samples

Samples	% Substitution MF:SF:DFF	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate	Energy (KJ/100g)
A	100: 0 : 0	7.19^{e}±0.01	7.69^{f}±0.01	1.21^{f}±0.01	3.09^{e}±0.01	2.47^{f}±0.01	78.37^{a}±0.01	377.99^{a}±0.02
B	90 : 5 : 5	7.22^{e}±0.01	8.44^{e}±0.01	1.37^{e}±0.03	3.13^{e}±0.06	2.65^{e}±0.03	77.22^{b}±0.01	370.73^{b}±0.01
C	80 :15: 5	7.27^{d}±0.02	10.18^{d}±0.02	1.43^{d}±0.05	3.19^{d}±0.04	2.85^{d}±0.01	75.10^{c}±0.02	369.75^{c}±0.01
D	70 :20: 10	7.36^{c}±0.01	12.25^{c}±0.06	1.68^{c}±0.07	3.34^{c}±0.02	3.08^{c}±0.02	72.32^{d}±0.01	368.26^{d}±0.06
E	60 :25: 15	7.48^{b}±0.01	15.14^{b}±0.03	1.77^{b}±0.01	3.67^{b}±0.01	3.79^{b}±0.01	68.18^{e}±0.01	366.26^{e}±0.04
F	50 :30: 20	7.63^{a}±0.01	18.32^{a}±0.04	2.07^{a}±0.04	4.03^{a}±0.04	3.86^{a}±0.05	64.13^{f}±0.02	365.10^{f}±0.01

Values are mean± standard deviation of triplicate determinations. Means in the same row with different superscripts are significantly different ($p<0.05$).

A - Breakfast cereals prepared from 100% millet flour. B - Breakfast cereals prepared from 90% millet flour, 5% soybean flour and 5% date fruits flour. C - Breakfast cereals prepared from 80% milletflour, 15% soybean flour and 5% date fruits flour. D - Breakfast cereals prepared from 70% millet flour, 20% soybean flour and 10% date fruits flour. E - Breakfast cereals prepared from 60% millet flour, 25% soybean flour and 15% date fruits flour. F - Breakfast cereals prepared from 50% millet flour, 30% soybean flour and 20% date fruits flour.

MF- Malted millet flour, SF- Boiled soybean flour, DFF- Date fruits flour

3.2 Mineral Composition of Breakfast Cereal Samples

The mineral composition of the breakfast cereals are presented in Table 2. The calcium, magnesium, iron, zinc, potassium and phosphorus contents of the samples increased with increased substitution of soybean and date fruit flours in the substituted samples compared to the control sample (Breakfast cereal made with 100% malted millet flour).

The calcium content of the breakfast cereals ranged from 17.86 to 96.52mg/100g. The control sample (Breakfast cereal made with 100% malted millet flour) had the least value (17.86mg/100g), while the sample substituted with 30% soybean and 20% date fruit flours had the highest calcium content (96.52mg/100g). The increase in calcium content observed in all the substituted samples could be attributed to the substitution effect caused by high levels of calcium in soybean and date fruit flours used in the formulation of the breakfast cereal products [36,29]. The values (17.86-96.52mg/100g) obtained in this study were lower than the calcium content (169-213mg/100g) reported by Usman et al. [35] for breakfast cereals made from African yam bean, maize and defatted coconut flour blends. The calcium content observed in the formulated breakfast cereal samples was lower than the value (1000mg/100g) recommended by US recommended dietary allowance (RDA) for calcium. Since the formulated breakfast cereal products contained reasonable amounts of calcium, they could be used as ideal breakfast meals for both adolescents and adults. Calcium in conjunction with magnesium, phosphorus and protein are important for proper bone development in infants and young children.

The magnesium content of the samples varied from 16.54 to 86.54mg/100g with the control and the sample substituted with 30% soybean and 20% date fruit flours having the least (16.54mg/100g) and highest (86.54mg/100g) values, respectively. The increase in the magnesium content of the samples is an indication that soybean and date fruits are good sources of magnesium [23,26]. The magnesium content (16.54-86.54mg/100g) obtained in this study was lower than the values (45.61-126.2mg/100g) reported by Agunbiade and Ojezele [26] for instant breakfast cereals made from maize, sorghum, soybean and African yam bean composite flours. The magnesium content obtained in this study was lower than the values recommended by US RDA for magnesium (280mg/100g) and 350mg/100g for women and men, respectively. Magnesium is an activator of many enzyme systems and it helps in the maintenance of the electrical potential in the nerves [37]. “Magnesium works with calcium to assist in muscle contraction, blood clotting and regulation of blood pressure and lung function” [38]. The formulated breakfast cereal products could be used as ideal breakfast meals for both women and men since they contained significant amount of magnesium.

The phosphorus content of the samples varied from 79.01 to 120.76mg/100g with the control and the sample substituted with 30% soybean and 20% date fruit flours having the least (79.01mg/100g) and highest (120.76mg/100g) values, respectively. The result revealed that the phosphorus content of the breakfast cereal products increased with increase in the addition of soybean and date fruit flours. The values (79.01-120.76mg/100g) obtained in this study were lower than the phosphorus content (188-289mg/100g) reported by Mbaeyi-Nwaoha and Uchendu [29] for breakfast cereals made from blends of acha and fermented soybean paste (okara). The phosphorus content obtained in the formulated breakfast cereals was less than the recommended US RDA (350-450mg/100g) for adults per day. Phosphorus is an essential mineral that is primarily used for growth and repair of body cells and tissues. Phosphorus together with calcium provides structure and strength. Phosphorus is also required for a variety of biochemical processes including energy production and regulation.

The potassium content of the samples which ranged from 58.47 to 132.72mg/100g increased significantly ($p<0.05$) as the levels of soybean and date fruit flours increased in the products. There was significant ($p<0.05$) difference between the samples in the potassium content. The result showed that there was subsequent increase in the potassium content with increase in the levels of soybean and date fruit flours substituted for millet flour in the samples. The values (58.47-132.72mg/100g) obtained in this study were lower than the potassium content (88.00-191mg/100g) reported by Usman et al. [35] for breakfast cereals made from African yam bean, maize and defatted coconut. “Potassium is primarily an intercellular cation that is mostly bound to protein and with sodium, it influences

the osmotic pressure and contributes to normal pH equilibrium" [37].

The iron content of the samples varied significantly ($p<0.05$) from each other. The sample substituted with 30% soybean and 20% date fruit flours had the highest value (2.14mg/100g), while the control sample had the least iron content (1.55mg/100g). The values (1.55-2.14mg/100g) obtained in this study were lower than the iron content (3.22-5.64mg/100g) of breakfast cereals produced from blends of acha and fermented soybean paste (okara) reported by Mbaeyi-Nwaoha and Uchendu [29]. The iron content of the breakfast cereal products produced in this study was lower than the recommended US RDA of 10-15mg/100g. The sample substituted with 30% soybean and 20% date fruit flours was relatively high in iron content compared to the control and other formulated samples. This could be due to the fact that soybean and date fruit are rich sources of iron [39,40]. "Inadequate intake of iron causes iron deficiency anemia (IDA) and it is very common around the world especially for women and children in developing countries. The symptoms of iron deficiency include fatigue, weakness and shortness of breath" [41].

The zinc content of the breakfast cereals varied from 1.32 to 1.72 mg/100g. The sample substituted with 30% soybean and 20% date fruit flours had the highest zinc content (1.72mg/100g), while the control sample had the least zinc value (1.32mg/100g). The result showed an increase in zinc content with subsequent increase in the amount of soybean and date fruit flours added to the products. Higher values were reported by Usman et al. [35] for breakfast cereals made from blends of African yam bean, maize and defatted coconut flour. The values (1.32-1.72mg/100g) obtained in this study were lower than the recommended values (15mg/100g) for men and (12mg/100g) for women. Zinc is a component of every living cell and it helps in assisting blood clotting. It is also essential for taste, vision and wound healing. The substitution of millet-based breakfast cereals with soybean and date fruit flours generally increased the mineral contents of the products.

3.3 Vitamin Composition of Breakfast Cereal Samples

The vitamin composition of the breakfast cereals are presented in Table 3. The ascorbic acid, niacin, thiamine, vitamin A, folic acid and riboflavin contents of the samples increased with increased substitution of soybean and date fruit flours in the products. The increase could be attributed to the high levels of vitamins in soybean and date fruit flours [42,26].

The ascorbic acid content of the samples varied from 1.55 to 2.22 mg/100g with the control and the sample substituted with 30% soybean and 20% date fruit flours having the least (1.55mg/100g) and highest (2.22mg/100g) values, respectively. The increase in ascorbic acid content observed in all the substituted samples could be attributed to the addition of different levels of soybean and date fruit flours in the products. Soybeans and date fruits have been reported to be good sources of ascorbic acid [42,18]. The values (1.55-2.22mg/100g) obtained in the study were lower than the ascorbic acid content (4.22-6.42mg/100g) reported by Kanu et al. [30] for breakfast cereal-porridge mixed with sesame and pigeon pea for adults. "Ascorbic acid is important in the prevention of scurvy and development of healthy immune system in infants, young children and adults" [43].

The niacin content of the breakfast cereals varied significantly ($p<0.05$) from each other. The sample substituted with 30% soybean and 20% date fruit flours had the highest (3.56mg/100g) niacin content, while the control sample had the least (2.14mg/100g) value. The niacin content of the breakfast cereals produced in this study (2.14-3.56mg/100g) was higher than the niacin content (0.04 – 2.85mg/100g) reported by Mbaeyi-Nwaoha and Uchendu (2016) for breakfast cereals produced from blends of acha and fermented soybean paste (okara). "Niacin plays an important role in energy transfer reactions in the metabolism of glucose, fat and alcohol" [44].

The thiamine content of the breakfast cereals varied from 1.36 to 2.57mg/100g with the control (Breakfast cereal made with 100% malted millet flour) and the sample substituted with 30% soybean and 20% date fruit flours having the least (1.36mg/100g) and highest (2.57mg/100g) values, respectively. The observed increase in the thiamine contents of the substituted samples could be due to substitution effect which is an indication that soybeans and date fruits are rich sources of thiamine [20,23]. The result also revealed an increase in thiamine content with subsequent increase in the amount of soybean and date fruit flours added to the products.

Table 2. Mineral composition (mg/100g) of breakfast cereal samples

Samples	% Substitution MF:SF:DFF	Calcium	Magnesium	Phosphorus	Potassium	Iron	Zinc
A	100: 0 : 0	17.86^{f}±0.07	16.54^{f}±0.02	79.01^{f}±0.06	58.47^{f}±0.06	1.55^{f}±0.01	1.32^{f}±0.01
B	90 : 5 : 5	24.54^{e}±0.01	22.47^{e}±0.01	83.71^{e}±0.07	79.52^{e}±0.04	1.63^{e}±0.01	1.41^{e}±0.04
C	80 :15: 5	36.41^{d}±1.31	37.45^{d}±0.01	89.24^{d}±0.09	103.36^{d}±0.02	1.77^{d}±0.04	1.48^{d}±0.00
D	70 :20: 10	54.97^{c}±0.06	51.73^{c}±1.26	95.88^{c}±1.35	120.83^{c}±1.26	1.85^{c}±0.02	1.56c±0.06
E	60 :25: 15	78.77^{b}±0.06	73.67^{b}±1.40	107.87^{b}±1.28	125.79^{b}±0.07	2.08^{b}±0.03	1.67^{b}±0.01
F	50 :30: 20	96.52^{a}±0.09	86.54^{a}±1.40	120.76^{a}±1.27	132.72^{a}±0.06	2.14^{a}±0.05	1.72^{a}±0.08

Values are mean± standard deviation of triplicate determinations. Means in the same row with different superscripts are significantly different (p<0.05).

A - Breakfast cereals prepared from 100% millet flour. B - Breakfast cereals prepared from 90% millet flour, 5% soybean flour and 5% date fruits flour. C - Breakfast cereals prepared from80% millet flour, 15% soybean flour and 5% date fruits flour. D - Breakfast cereals prepared from 70% millet flour, 20% soybean flour and 10% date fruits flour. E - Breakfast cereals prepared from 60% millet flour, 25% soybean flour and 15% date fruits flour. F - Breakfast cereals prepared from 50% millet flour, 30% soybean flour and 20% date fruits flour.

MF- Malted millet flour, SF- Boiled soybean flour, DFF- Date fruits flour

Table 3. Vitamin composition (mg/100g) of breakfast cereal samples

Samples	% Substitution MF:SF:DFF	Ascorbic Acid	Niacin	Thiamine	Riboflavin	Vitamin A	Folic acid
A	100: 0 : 0	1.55^{f}±0.01	2.14^{f}±0.02	1.36^{f}±0.03	2.36^{f}±0.01	2.23^{f}±0.01	1.02^{f}±0.06
B	90 : 5 : 5	1.63^{e}±0.05	2.20^{e}±0.01	1.54^{e}±0.01	2.67^{e}±0.04	2.54^{e}±0.04	1.13^{e}±0.07
C	80 :15: 5	1.80^{d}±0.12	2.45^{d}±0.04	1.79^{d}±0.00	2.83^{d}±0.01	2.85^{d}±0.01	1.24^{d}±0.03
D	70 :20: 10	1.89^{c}±0.16	2.83^{c}±0.02	1.97^{c}±0.01	3.04^{c}±0.02	3.43^{c}±0.06	1.36^{c}±0.00
E	60 :25: 15	2.09^{b}±0.03	3.27^{b}±0.02	2.27^{b}±0.03	3.21^{b}±0.04	3.87^{b}±0.07	1.67^{b}±0.08
F	50 :30: 20	2.22^{a}±0.09	3.56^{a}±0.01	2.57^{a}±0.06	3.51^{a}±0.16	4.26^{a}±0.02	1.81^{a}±0.02

Values are mean± standard deviation of triplicate determinations. Means in the same row with different superscripts are significantly different (p<0.05).

A - Breakfast cereals prepared from 100% millet flour. B - Breakfast cereals prepared from 90% millet flour, 5% soybean flour and 5% date fruits flour. C - Breakfast cereals prepared from80% millet flour, 15% soybean flour and 5% date fruits flour. D - Breakfast cereals prepared from 70% millet flour, 20% soybean flour and 10% date fruits flour. E - Breakfast cereals prepared from 60% millet flour, 25% soybean flour and 15% date fruits flour. F - Breakfast cereals prepared from 50% millet flour, 30% soybean flour and 20% date fruits flour.

MF- Malted millet flour, SF- Boiled soybean flour, DFF- Date fruits flour

Table 4. Sensory properties of breakfast cereal samples

Samples	% Substitution MF:SF:DFF	Colour	Flavour	Taste	Texture	Overall acceptability
A	100: 0 : 0	7.90^{a}±0.10	7.45^{a}±1.32	7.60^{a}±1.39	7.30^{a}±1.13	7.35^{a}±1.39
BC	90 : 5 : 5	6.75^{b}±1.25	6.85^{b}±1.19	6.80^{b}±1.47	6.45^{b}±1.19	7.05^{b}±1.32
	80 :15: 5	6.40^{c}±1.28	6.75^{c}±1.33	6.80^{c}±1.24	6.45^{c}±1.45	6.75^{c}±1.07
D	70 :20: 10	6.40^{d}±1.27	6.65^{d}±1.23	6.60^{d}±1.43	6.30^{d}±1.45	6.40^{d}±1.31
E	60 :25: 15	6.20^{e}±1.07	6.10^{e}±1.33	6.45^{e}±1.23	5.90^{e}±1.46	6.40^{e}±1.14
F	50 :30: 20	6.05^{f}±1.05	5.90^{f}±1.41	6.40^{f}±1.28	5.85^{f}±1.44	5.95^{f}±1.28

Values are mean± standard deviation of twenty (20) semi trained judges. Means in the same row with different superscripts are significantly different ($p<0.05$).
A - Breakfast cereals prepared from 100% millet flour. B - Breakfast cereals prepared from 90% millet flour, 5% soybean flour and 5% date fruits flour. C - Breakfast cereals prepared from 80% milletflour, 15% soybean flour and 5% date fruits flour. D - Breakfast cereals prepared from 70% millet flour, 20% soybean flour and 10% date fruits flour. E - Breakfast cereals prepared from 60% millet flour, 25% soybean flour and 15% date fruits flour. F - Breakfast cereals prepared from 50% millet flour, 30% soybean flour and 20% date fruits flour.
MF- Malted millet flour, SF- Boiled soybean flour, DFF- Date fruits flour

Thiamine functions as a co-enzyme in energy metabolism in the body. It also helps in the treatment of beriberi and in the maintenance of healthy mental attitude in young children and adolescents. Thiamine equally plays a role in muscle contraction and conduction of nerve signals [32].

The riboflavin content of the samples was found to increase gradually with increased substitution of soybean and date fruit flours in the products. The control sample had the least riboflavin content (2.36mg/100g), while the sample substituted with 30% soybean and 20% date fruit flours had the highest riboflavin content (3.51mg/100g). The observed increase in riboflavin content certainly demonstrates the effect of substitution of millet flour with soybean and date fruit flours in the formulation of breakfast cereal products. The result is in agreement with the report of Mbaeyi-Nwaoha and Uchendu [29] for breakfast cereals made from blends of acha and fermented soybean paste (okara). Riboflavin is involved in energy production for the electron transport chain in the citric acid cycle as well as in the catabolism of fatty acids. Riboflavin, which is commonly known as vitamin B_2 is also necessary for growth and development in infants and young children [45].

The Vitamin A content of the samples which ranged from 2.23 to 4.26mg/100g increased significantly ($p<0.05$) with increased substitution of soybean and date fruit flours. The sample substituted with 30% soybean and 20% date fruit flours had the highest vitamin A content (4.26mg/100g), while the control sample had the least value (2.23mg/100g). The levels of soybean and date fruit flours in the samples might be responsible for the slight increase in the vitamin A content of the formulated breakfast cereal products. This is because it was observed that the vitamin A content increased gradually with the addition of soybean and date fruit flours to the millet flour in the formulation of the products. Vitamin A which is a fat soluble vitamin plays a vital role in the maintenance of good sight. Vitamin A also serves as natural defence to the body against illnesses and infections such as skin irritation, stunted growth, bitot sport, keratomalacia and keratinization etc.

The folic acid content of the samples increased significantly ($p<0.05$) from 1.02mg/100g in the control sample to 1.81mg/100g for the sample substituted with 30% soybean and 20% date fruit flours. The observed increase in the folic acid could be attributed to substitution effect which showed that the folic acid content increased with subsequent increase in the addition of soybean and date fruit flours to the products. The folic acid content (1.02-1.81mg/100g) obtained in the study was lower than the folic acid content (1.92-3.05mg/100g) reported by Agunbiade and Ojezele [26] for instant breakfast cereals made from maize, sorghum, soybean and African yam bean composite flours. Folic acid plays a significant role as a co-enzyme in the body. The substitution of millet-based breakfast cereals with soybean and date fruit flours generally enhanced the vitamin contents of the samples.

3.4 Sensory Properties of Breakfast Cereal Samples

The sensory properties of the breakfast cereals are presented in Table 4. The sensory scores of the breakfast cereals prepared from both the control and the substituted samples showed significant ($p<0.05$) differences in colour, taste, flavour, texture and overall acceptability.

The colour of the breakfast cereal samples ranged from 6.05 to 7.90. The result showed that the colour of the sample substituted with 30% soybean and 20% date fruit flours had the lowest value (6.05), while the control sample (Breakfast cereal made with 100% malted millet flour) had the highest value for colour (7.90). The result is in agreement with the findings of Santos et al. [46] for extruded corn-based breakfast cereals enriched with whole peach fruit powder. The change in colour observed could be due to increased substitution of the soybean and date fruit flours coupled with the high sugar content of date fruit flour which gave the formulated breakfast cereals a slightly dark colouration. Colour darkening of the breakfast cereals could be due to Maillard browning which is a reaction between reducing sugars and amino acids of the proteins. Colour appeared to be a very important criterion for the initial acceptability of the food product by the consumers.

The flavour of the breakfast cereal samples ranged from 5.90 to 7.45. The result showed the sample substituted with 30% soybean and 20% date fruit flours had the lowest value for flavour (5.90), while the control sample (Breakfast cereal made with 100% malted millet flour) had the highest value (7.45). The observation is in agreement with the findings of Mbaeyi-Nwaoha and Uchendu [29] for breakfast cereals made from blends of acha and fermented soybean paste (okara). Flavour is an important attribute of food which contributes to its palatability and acceptability.

The taste of the breakfast cereal samples ranged from 6.40 to 7.60. The sample substituted with 30% soybean and 20% date fruit flours had the least value (6.40), while the control sample (Breakfast cereal made with 100% malted millet flour) had the highest value for taste (7.60). This showed that the taste of the samples decreased significantly ($p<0.05$) with increased substitution of soybean and date fruit flours in the products. The observation is in agreement with the findings of Kanu et al. [30] for breakfast cereal-based porridge mixed with sesame and pigeon pea for adults. Taste plays an important role in the evaluation of food for toxicity and nutrients. It also helps the human body to decide what to ingest and equally prepares the body to metabolize the foods once they have been ingested.

The texture of the breakfast cereal samples ranged from 5.85 to 7.30. The sample substituted with 30% soybean and 20% date fruit flours had the least value (5.85), while the control sample had the highest value (7.30). The texture ranges in foods are very important and a deviation from an expected texture is regarded as a quality defect. Processing also affects the texture of foods. This is because there are correlations between the colour and texture in some food products, hence colour may be used as an indicator of acceptable texture in such products [47].

The overall acceptability of the breakfast cereal samples ranged from 5.95 to 7.35, with the control sample and the sample substituted with 30% soybean and 20% date fruit flours having the highest (7.35) and least (5.95) values, respectively. The decrease in the acceptability of the sample with highest amounts of soybean and date fruit flours could be due to beany flavour associated with soybean flour as well as the change in the colour of the product due to Millard browning reaction which occur in the presence of amino acids and reducing sugars. The overall acceptability is an indication of acceptable colour, taste, flavour, texture and other sensory attributes in a given food. The consumer's acceptance of a food is referred to as the overall or general acceptability of such a food product [28]. Although, the control sample (Breakfast cereal made with 100% malted millet flour) was generally the most acceptable by the panelists compared to the substituted samples, the formulated breakfast cereal samples were equally acceptable organoleptically because they were also rated high by the judges.

Therefore, the substitution of millet flour with soybean and date fruit flours at different graded levels could be used to produce nutrient dense and organoleptically acceptable flaked bre akfast cereal products.

4. CONCLUSION

The incorporation of different proportions of soybean and date fruit flours into millet flour in the formulation of breakfast cereals drastically influenced the proximate, mineral and vitamin contents of the formulated breakfast cereal products. The study showed that the increase in addition of soybean and date fruit flours resulted to subsequent increase in protein, ash, fat, crude fibre, calcium, magnesium, potassium, phosphorus, iron, zinc, ascorbic acid, niacin, folic acid, riboflavin, thiamine and vitamin A contents of the breakfast cereals with remarkable decrease in their carbohydrate and energy contents. The sensory properties revealed that the control (Breakfast cereal made with 100% malted millet flour) was the most acceptable to the panelists and also showed significant ($p<0.05$) differences in colour, taste, texture and flavour compared to the substituted breakfast cereal samples. The result also showed that the formulated breakfast cereals were equally acceptable because they were generally rated high by the judges. In effect, the use of these nutrient dense food materials would help to extend their utilization in formulation of a wide range of ready-to-eat breakfast cereals that could serve as cheap sources of nutrients in Nigeria and other developing nations of the world.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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