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NUTRITIONAL AND MICROBIAL QUALITY OF HOME-MADE COMPOSITE BREAKFAST CEREALS PRODUCED IN ILARO OGUN STATE, NIGERIA

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ABSTRACT

Breakfast cereals (BFCs) consumption is spreading and steadily replacing traditional diets due to its compositions and convenience for various consumers. This study assessed vitamins, minerals, anti-nutrients and microbial quality of home-made composite BFCs produced in Ilaro Ogun State, Nigeria. Yellow maize, unripe plantain, soybeans and dates were processed into flours and formulated into blends of five samples at different percentages: sample A-100% maize; sample B-60:5:20:15; sample C-55:10:20:15; sample D-50:15:20:15 and sample E-45:20:20:15. Flour blends were mixed, moist, lightly kneaded, oven dried at 80°C for 2 hours, crushed and lightly toasted. Vitamins, minerals, anti-nutrients and microbial contents of BFCs were determined using standard methods. Data were analyzed using SPSS version 20.0, with significance tested at a 5% probability level. Results revealed that Vitamins A (98.13- 121.64 µg/100g), B_1 (0.17 – 0.21 mg/100), C (6.19 – 7.88 mg/100); iron (3.11 – 3.82 mg/100), zinc (0.62 – 0.79 mg/100) and potassium (701.08 - 781.44 mg/100) contents of BFCs significantly increased ($P<0.05$) with increasing addition of unripe plantain flour. The oxalate (0.61 – 0.67 mg/100), phytate (0.39 – 0.41 mg/100), tannin (0.12 – 0.13 mg/100), total bacterial count (0.25×10^4 - 1.75×10^4 CFU/g) total fungi count (0.00 – 0.50×10^4 CFU/g) and total coliform count (0.10 to 0.30×10^4 CFU/g) contents of BFCs were within recommended safe limits. This study demonstrates that supplementing yellow maize with unripe plantain flour in soybean-date-based BFCs can enhance the vitamins and minerals, yield low anti-nutrient and safe food products. Commercial breakfast cereal producers could incorporate unripe plantain flour, in maize-soybean-date blend for consumer healthier choice.

Keywords: Breakfast Cereals, Date, Micronutrients, Microbial Quality

INTRODUCTION

Breakfast cereals (BFCs) are ready-to-eat cereals, typically in flake form, which can be consumed plain or with milk (Nkiru *et al*., 2019). BFCs are commonly referred to as cereals, morning cereals, or breakfast cereals (Abogunrin & Ujiroghene, 2022). Félix-Medina *et al*. (2020) reported that breakfast cereals have become important component of diverse consumers food intake and Sumczynski *et al*. (2023) asserted that breakfast cereals are sources of nutrients, including vitamins and minerals. Due to increasing awareness of nutrition, convenience, and economic factors, breakfast cereals, along with bread, are progressively replacing many traditional breakfast staples that were previously consumed (Nkiru *et al*., 2019).

Breakfast cereals products are ready-to-eat food items primarily derived from grains such as oats, maize, wheat, rice, and barley predominantly consumed in the morning (Nkiru *et al*., 2019; Fasuan *et al*., 2021; Ariviani & Nastiti, 2024). Maize (*Zea mays*) serves as the primary raw material in the production of breakfast cereals (Abogunrin & Ujiroghene, 2022). Yellow maize is a pro-vitamin A rich cereal that has the potential of addressing vitamin A deficiency which is a major public health concern in Nigeria and Africa at large (Pillay *et al*., 2011). However, maize has a relatively low nutritional profile, particularly in micronutrients such as certain trace minerals (Dragana *et al.*, 2015; Barber *et al*., 2017). Therefore, enhancing the nutritional value of breakfast cereals by combining maize with other nutrient-rich food sources is advisable (Mbaeyi-Nwaoha & Uchendu, 2016).

Plantain (*Musa paradisiaca*) is a large, perennial herb cultivated in tropical and subtropical regions, including Nigeria. Both ripe and unripe plantains are consumed in various forms, such as boiling, frying, roasting, or processing into flour for making 'amala' (Famakin *et al.*, 2016). Amala is a widely consumed Yoruba staple food prepared by gradually adding yam flour (elubo) to boiling water and stirring continuously until a smooth, lump-free paste is formed. Continuous stirring is essential for achieving the characteristic soft and elastic texture of the food. Amala is commonly shaped into small portions and served with a variety of traditional soups and stews containing meat or fish. It is popularly eaten across southwestern Nigeria and in several West African communities as a meal that can be consumed at any time of the day. Traditionally, amala is produced mainly from yam flour derived from white yam (*Dioscorea rotundata*), although cassava flour (lafun) and unripe plantain flour (elubo ogede) are also frequently used in its preparation (Ukpabi *et al*., 2008; Ojo *et al*., 2022).

Previous studies have shown that unripe plantain is rich in dietary fibre and essential micronutrients, emphasizing its nutritional importance (Lamptey *et al*., 2019; Oluwajuyitan & Ijarotimi, 2019; Honfo *et al*., 2020). According to Taak & Awasthi (2025) plantain is a rich source of vitamins (A, B, C and K) potassium and magnesium. However, they are naturally low in protein (Lamptey *et al.*, 2019; Oluwajuyitan & Ijarotimi, 2019; Honfo *et al*., 2020).

Soybeans are widely utilized because they have a higher nutritional content than other legume crops (Qin *et al*., 2022). Products derived from soybean protein have been employed as functional food components in nearly every food group available to consumers (Qin *et al.*, 2022). Dates are high in carbohydrates and consist of more than 70% sugar, of which are glucose, fructose, and a small amount of sucrose (Sayas-Barberá *et al*., 2023).

Dates are also rich in fibers, vitamins and minerals such as magnesium, iron, zinc, potassium (Abo-El-Saad & Shawir, 2024). The incorporation of unripe plantain, soybeans, and dates into flake production offers a promising solution to the nutritional limitations of maize-based breakfast cereals. This study aimed to determine the vitamins, minerals, anti-

nutrients and microbial quality of BFCs produced from yellow maize, unripe plantain, soybeans and dates.

MATERIALS AND METHODS

Yellow maize, unripe plantain, soybeans and dates were purchased at Sayedero market, Ilaro, Ogun State, Nigeria. Other materials and equipment used were gotten from the Nutrition and Dietetics Kitchen, Federal Polytechnic Ilaro, Ogun State.

Sample Preparation

Processing of Maize into Maize Flour

Maize was processed into maize flour using the method described by Anne *et al*. (2019). About 3kg of yellow maize was sorted to remove spoilt grains, stones and other extraneous materials. The grains were winnowed, washed with distilled water to remove dirt, steeped in water for 12 hours, drained and oven-dried at 60℃ for 10 hours. It was milled into flour using attrition milling machine, sieved using 0.4mm aperture to fine flour. The flour was kept at ambient room temperature in plastic container with airtight lids and labelled for further use.

Processing of Soybean into Soybean Flour

Two kilograms of soybean was processed according to the methods described by Akpara and Ogbogo (2015). Soybean was sorted, washed and steeped in water at a 1:2 weight-to-volume ratio for 12 hours, dehulled, oven dried at 60℃ for 1 hour, milled using an attrition mill, flour was sifted through a 0.15mm mesh screen. Soybean flour was packaged in airtight container, labelled and stored at room temperature for further use.

Processing of Unripe Plantain into Unripe Plantain

According to methods described by Ndayambaje *et al. (*2019), one and the half kilogram of unripe plantain flour was rinsed in clean water, peeled with a knife, sliced into thin uniform sizes and blanched for 5 minutes. It was oven dried at 60℃ for 14 hours, milled into powdered form and it was sieved using 0.4mm aperture into flour. The flour was kept at room temperature in plastic container with airtight lids and labelled for further use.

Processing of Dates into Date Meal

The method described by Obiegbuna *et al*. (2017) was used with slight modification to process dates into date meal. Two kilograms of date fruit was sorted, washed, deseeded and cut into 2mm sizes. The pulp was oven dried at 46°C for 8hours and subsequently milled into fine powder in an attrition mill. The powder was sieved through 2mm mesh screen, packaged in air tight container and stored at 25ºC temperature for further use.

Formulation of Samples

Breakfast cereal was formulated from the blends of yellow maize flour, unripe plantain flour, soybean flour and date powder. Five samples of breakfast cereals were produced by using the graded levels presented on Table 1 and 100% yellow maize flour served as the control. Table 1 shows the formulation ratio of breakfast cereals.

Table 1: Formulation of Breakfast Cereals

Samples	Maize	Unripe plantain	Soybean	Date
A	100	0	0	0
B	60	5	20	15
C	55	10	20	15
D	50	15	20	15
E	45	20	20	15

Sample A (maize 100% control), sample B (maize 60%, unripe plantain 5%, soybean 20%, date15%), sample C (maize 55%, unripe plantain10%, soybean 20%, date 15%), sample D (maize 50%, unripe plantain15%, soybean 20%, date 15%) sample E (maize 45%, unripe plantain20%, soybean 20%, date 15%)

Breakfast Cereal Production

The method described by Nkiru *et al.* (2019) was used for the production of breakfast cereals with slight modification. The breakfast cereal was made by mixing the composite flour of yellow maize, unripe plantain, soybean and date meal. Water was added to the mixture to form a batter which was poured thinly on cleaned flat greased stainless tray. The batter was oven dried at 80°C for 2hours until semi dried samples were obtained, crushed into small sizes with sharp knife, placed back into the oven for further drying. The breakfast cereal samples were left to cool at room temperature, packaged in air-tight containers, labelled and used for laboratory analysis. Figure 1 shows the flowchart for production of breakfast cereals made from flour blends of yellow maize, unripe plantain, soybean and date meal.

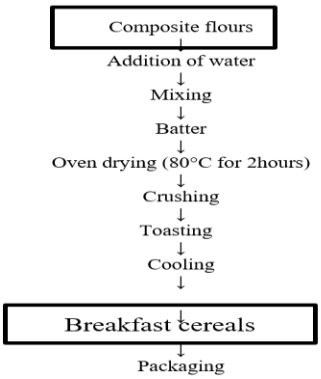

Figure 1: Flowchart for the Production of Breakfast Cereals

Chemical and Microbial Analysis of Breakfast Cereals

Vitamin A was determined using the method described by Achinkann *et al*. (2013). Vitamins B_1 and C were determined according to the method described by Baraket *et al*. (1973) and modified by Okwu and Josiah (2006). Iron, zinc and potassium elements were measured with Atomic Absorption Spectrophotometer (Thermo scientific S Series Model GE 712354) after digesting with a perchloric – nitric acid mixture (AOAC, 2000). Phytate was determined using the method described by Maga (1982). The method of Swain (1979) was used for the determination of tannin contents of samples of breakfast cereal. Oxalate was determined using methods described by Day and Underwood (1986).

Microbial Determination

Total plate count, total fungi count and total coliform count of samples of breakfast cereal were determined following the method described by Ochei and Kolhaktar (2008).

Statistical Analysis

Data collected were subjected to statistical analysis using Analysis of Variance (ANOVA) to identify significant difference among sample means. The means were separated with the use of Duncan New Multiple Range Test (DMRT) with Statistical Package for Social Sciences (SPSS) version 23.0.

RESULTS AND DISCUSSION

Vitamin Contents of Breakfast Cereals

Table 1 shows the Vitamin A, B_1 and C contents of breakfast cereal samples. Vitamin A Content was highest (121.64 µg/100g) in the sample E and lowest (98.13 µg/100g) in sample A. Vitamin B_1 ranged from 0.17 µg/100g in sample A to 0.21 µg/100g in sample E. Vitamin C ranged from 6.19 – 7.88 µg/100g with the lowest in sample A and highest in sample E.

Table 2: Vitamin Contents of Breakfast Cereals

Samples	Vitamin A (µg/100g)	Vitamin B_1(µg/100g)	Vitamin C (µg/100g)
A	98.13 ±0.00^a	0.17 ±0.00^a	6.19 ±0.00^a
B	98.86 ±0.01^a	0.18 ±0.01^a	6.82 ±0.00^a
C	100.82 ±0.01^b	0.19 ±0.01^b	7.00 ±0.00^b
D	110.73 ±0.00^c	0.19±0.00^b	7.36 ±0.00^c
E	121.64 ±0.01^d	0.21 ±0.01^c	7.88 ±0.00^d

Values are means of duplicate determination ± SD (Standard deviation). Means in the same column with different superscript are significantly different (p>0.05). Sample A (maize 100% control), sample B (maize 60%, unripe plantain 5%, soybean 20%, date15%), sample C (maize 55%, unripe plantain10%, soybean 20%, date 15%), sample D (maize 50%, unripe plantain15%, soybean 20%, date 15%) sample E (maize 45%, unripe plantain20%, soybean 20%, date 15%)

Mineral Contents of Breakfast Cereals

Result of mineral compositions of breakfast cereal is shown in Table 3. Iron, zinc and potassium were determined in samples of breakfast cereal. Iron contents ranged from 3.11 mg/100g to 3.82 mg/100g in samples of breakfast cereal where the highest iron (3.82 mg/100g) content was determined in sample E and was different from the lower iron (3.11 mg/100g) value in sample A. The zinc content ranged from 0.62 mg/100g to 0.79 mg/100g. The potassium contents ranged from 701.93mg/100g to 781.44µg/100g where the higher potassium (781.44µg/100g) value was found in sample E and was different from the lower potassium (701.93 µg/100g) content found in sample A.

Table 3: Mineral Content of Breakfast Cereals

Samples	Iron (mg/100g)	Zinc (mg/100g)	Potassium (mg/100g)
A	3.11±0.00^a	0.62±0.00^a	701.93±0.01^a
B	3.41±0.00^b	0.68±0.00^b	712.08±0.01^b
C	3.68±0.00^c	0.73±0.00^c	726.11±0.00^c
D	3.72±0.01^d	0.75±0.01^c	744.05±0.01^d
E	3.82±0.00^e	0.79±0.00^d	781.44±0.01^e

Values are means of duplicate determination ± SD (Standard deviation). Means in the same column with different superscript are significantly different (p>0.05). Sample A (maize 100% control), sample B (maize 60%, unripe plantain 5%, soybean 20%, date15%), sample C (maize 55%, unripe plantain10%, soybean 20%, date 15%), sample D (maize 50%, unripe plantain15%, soybean 20%, date 15%) sample E (maize 45%, unripe plantain20%, soybean 20%, date 15%)

Anti-nutrient Contents of Breakfast Cereal

The anti-nutrient contents of samples of breakfast cereals are presented in Table 4. Oxalate, phytate, and tannin contents were highest in sample E. Oxalate ranged from 0.61 to 0.67 mg/g, phytate from 0.39 to 0.41 mg/g and tannin from 0.12 to 0.13 mg/g.

Table 4: Anti-nutrient Contents of Breakfast Cereal

Samples	Oxalate (mg\g)	Phytate (mg\g)	Tannin (mg\g)
A	0.61±0.00^a	0.39±0.00^a	0.12±0.00^a
B	0.63±0.00^{ab}	0.39±0.00^a	0.12±0.00^a
C	0.65±0.00^b	0.40±0.00^{ab}	0.12±0.00^a
D	0.67±0.00^b	0.40±0.00^{bc}	0.13±0.00^{ab}
E	0.67±0.00^b	0.41±0.00^c	0.13±0.00^b

Values are means of duplicate determination ± SD (Standard deviation). Means in the same column with different superscript are significantly different (p>0.05). Sample A (maize 100% control), sample B (maize 60%, unripe plantain 5%, soybean 20%, date15%), sample C (maize 55%, unripe plantain10%, soybean 20%, date 15%), sample D (maize 50%, unripe plantain15%, soybean 20%, date 15%) sample E (maize 45%, unripe plantain20%, soybean 20%, date 15%)

Microbial Quality of Breakfast Cereals

The microbial count of samples of breakfast cereal is presented in Table 5. It was found that the bacterial count, fungi count and coliform count for breakfast cereals ranged from 0.25 X 10^4 to 1.75 X 10^4 Cfu/g, 0.00 X 10^4 to 0.50 X 10^4 Cfu/g and 0.10 X 10^4 to 0.30 X 10^4 Cfu/g, respectively.

Table 5: Microbial Quality of Breakfast Cereals

Samples	TBC (X10^4 Cfu/g)	TFC (X10^4 Cfu/g)	TCC (X10^4 Cfu/g)
A	0.25±1.41^{a}	0.00±1.41^{a}	0.10±0.71^{a}
B	0.70±0.00^{a}	0.10±1.41^{ab}	0.15±1.41^{a}
C	1.15±0.00^{ab}	0.20±1.41^{ab}	0.20±1.41^{a}
D	1.20±0.71^{b}	0.40±0.00^{bc}	0.25±0.71^{a}
E	1.75±2.12^{c}	0.50±2.82^{d}	0.30±1.41^{a}

Values are means of duplicate determination ± SD (Standard deviation). Means in the same column with different superscript are significantly different (p>0.05). Sample A (maize 100% control), sample B (maize 60%, unripe plantain 5%, soybean 20%, date15%), sample C (maize 55%, unripe plantain10%, soybean 20%, date 15%), sample D (maize 50%, unripe plantain15%, soybean 20%, date 15%) sample E (maize 45%, unripe plantain20%, soybean 20%, date 15%)

Discussion

Vitamin Contents of Breakfast Cereals

The vitamin A contents were increasing with increase in the percentage composition of unripe plantain. This could be attributed to beta-carotene present in yellow maize. Edima-Nyah *et al*. (2019) recorded a much higher values ranging from 11.30 to 21.15 mg/100g in breakfast cereals from blends of local rice, African yam beans and coconut flour. Vitamin A is an essential vitamin and its deficiency in the body cause night blindness (Ojimelukwe *et al*., 2005). The US Recommended daily allowance (USRDA) for vitamin A is 5000 I.U. The vitamin A values obtained in this study exceeded the findings (70.07 to 74.01µg) reported by Ujong *et al*. (2023) in breakfast cereals made from the blend of yellow maize enriched with soybean and groundnut.

Vitamin A is essential for young children to maintain healthy vision and immunological function. According to Ujong *et al*. (2023) yellow maize can supply 40– 50% of the adult Recommended Dietary Intake for vitamin A, making it an efficient source of vitamin A. Nevertheless, maize typically lacks other vital nutrients, sample B (60% maize, 5% unripe plantain, 20% soybean, and 5% date) showed a marginal increase in vitamin A, this is similar to the report by Ahmadu *et al*. (2023) that realized an increase in vitamin A content in their study by the substitution with soybean and date, this increase in this study may be as a result of the addition of the unripe plantain. However, sample E had a higher Vitamin B_1 content compared to sample A. Ahmadu *et al*. (2023) reported the vitamin B_1 (1.36 to 2.57mg) of breakfast cereals made from the blend of millet flour supplemented with soybean and date fruit flour.

The vitamin B_1 content indicated the possible effect of the extra substances on the micronutrient profile. The body uses thiamine as a co-enzyme in the metabolism of energy. Additionally, it helps young children and adolescents maintain a healthy mental attitude and treat beriberi, a serious nutritional disorder caused by a severe deficiency of thiamine. Thiamine is equally important for nerve signal transmission and muscle contraction. Vitamin C content was notably higher in sample E, which included more unripe plantain, soybean and date, ingredients known for their ascorbic acid content. The increase in ascorbic acid content observed in all the substituted samples could be attributed to the addition of different levels of unripe plantain in the products. Ahmadu *et al*. (2023) reported a vitamin C content of 1.55 mg to 2.22 mg which is lower when compare to the report from this study. Vitamin C is important in the prevention of scurvy and development of strong immune system in newborns, young children, and adults (Ahmadu *et al*., 2023).

Mineral Composition of Breakfast Cereals

Mineral analysis revealed that sample E, which contained the highest proportion of unripe plantain and soybean, provided the most substantial amounts of iron, zinc and potassium. Iron content of the samples varied significantly from each other. The sample E had the highest value, while sample A had the least iron content. The values obtained in this study were high. However, the values of iron was consistent with the values reported by Mbaeyi-Nwaoha & Uchendu, 2016 that realized an increase in iron content from 3.22 – 5.64mg/100g in their breakfast cereals made from fermented soybean paste and acha mixes. This suggests that plantain, dates and soybean may be important for increasing mineral content, which is especially important for addressing iron and zinc deficiency that are common in malnourished children (Ijarotimi & Oluwalana, 2013).

In contrast sample A, with a lower proportion of these ingredients, had the lowest mineral levels, underscoring the need for diversified ingredients to improve micronutrient density in breakfast cereals. The zinc contents in samples of the breakfast cereals varied. Sample E substituted with 20% unripe plantain, 20% soybean 15% date fruit flour had the highest zinc content while sample A had the least zinc value. Higher values of zinc were reported by (Usman *et al.,* 2015) for breakfast cereals made from blends of African yam bean, maize, and defatted coconut flour. Zinc plays an important role in immune function and wound healing (Abdullahi *et al.,* 2025).

Zinc is essential for every living cell which also aids in blood coagulation. Zinc is also necessary for hormone regulation, cell growth and protein synthesis and reproduction (Abdullahi *et al.,* 2025).

The potassium contents of samples of breakfast cereals increased significantly as the levels of unripe plantain, soybean, date fruit flour increased in the products. The findings showed that potassium content increased with increasing substitution of maize flour with unripe plantain flour in the samples. This may be attributed to the potassium naturally present in plantain.

The values of potassium in the samples of breakfast cereals were higher compared to that reported by (Ahmadu *et al*., 2023) in their study of breakfast cereals produced from millet flour, soybeans and date flour. Potassium is a crucial mineral that aids in fluid equilibrium and enables muscles to contract and nerves to react to stimuli.

Anti-nutrient Contents of Breakfast Cereals

The anti-nutrient composition of the samples of breakfast cereals were generally low and within acceptable limits for plant-based foods. Oxalates and phytate are known to reduce the bioavailability of essential minerals such as iron (Gibson,

2021). Oxalate contents of breakfast cereals of sample A was the lowest. High anti-nutrient content suggests that further processing and /or ingredient modifications might be required to reduce these compounds and improve overall nutrient absorption. A moderate proportion of plant-based ingredients can balance nutrient content and anti-nutrient effects (Oluwafemi *et al.,* 2020). Oxalates are important in diet in reducing mineral absorption. Phytate and tannin contents of the samples of breakfast cereals varied. Sample A and Sample E has the lowest and highest values of phytate and tannin, respectively.

The tannin contents of the current study were lower than the values reported by Usman *et al.* (2021) that made breakfast cereals from blends of local rice, soybeans and defatted coconuts flour. Tannin is important in the diet as it helps improve blood pressure and reduce the risk of heart disease.

Microbial Quality of Breakfast Cereals

The total bacterial count in the breakfast cereals varied with noticeable differences across the samples. According to Anon (2001), a bacterial count of 10^4 CFU/g is deemed satisfactory, while counts surpassing 10^5 CFU/g indicate substandard quality. Based on this benchmark, the total bacterial counts recorded in the breakfast cereals fall within acceptable safety limits. The total fungal count varied with significant variations observed among the samples. The total coliform counts obtained showed significant differences. The microbial counts observed in this study conform to the safety standards set by the International Commission on Microbiological Specifications for Foods, which recommends microbial limits between 10^2 and 10^5 CFU/g for ready-to-eat products (ICMSF, 1996) and the Microbiological Guidelines for Foods (MGF, 2014).

CONCLUSION

This study showed that ready-to-eat breakfast cereals could be produced from blends of yellow maize, unripe plantain, soybean, date flour and as sources of vitamins A, B_1 and especially vitamin C which are absent in some commercial products. Samples of breakfast cereal in the current study were sources of iron, zinc and potassium. Blends of flour and processing procedures employed in this study yielded samples of breakfast cereals with safe levels of anti-nutrients and high microbial quality. The incorporation of locally available ingredients such as unripe plantain, soybean, and dates into breakfast cereal formulations is recommended to enhance nutritional quality, reduce dependence on wheat importation, and strengthen food security.

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