Evaluation of the Nutritional Quality and Glycaemic Index of Biscuits Enriched with Date and Banana Flours

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ABSTRACT

Background: *Nutrition transition and consumption of calorie-dense diets have increased the prevalence of non-communicable diseases especially diabetes mellitus amongst the population worldwide.*

Objective: *The aim of this study was to evaluate the nutritional composition and the glycaemic properties of biscuits made from date and banana flours.*

Methodology: *Date flour (DF) and overripe banana flour (OBF) were incorporated in the proportion 10, 20 and 30% each with wheat flour as total replacement for refined sugar in biscuits production with the control being commercially-purchased biscuits. The proximate and mineral compositions were evaluated according to standard methods. Sensory evaluation was carried out to assess the acceptability of the formulated biscuits. In vitro glycaemic characteristics were analyzed using Englyst method.*

Results: *The proximate composition of DF, OBF, and control biscuits showed variations in ash (1.97–2.05%, 2.03–2.61%, and 1.29%, respectively), crude protein (0.45–0.82%, 6.95–7.88%, and 8.69%), carbohydrate (61.09–62.29%, 52.59–59.15%, and 68.18%), and dietary fibre (4.59–13.15%, 9.12–12.18%, and 1.33%). The formulated biscuits has significantly higher ($p<0.05$) mineral compositions compared to the control especially for 20% OBF biscuits. Additionally, the vitamin content of the 10% DF biscuits has the highest values of Vitamins A, D and C compared to the control biscuits. Sensory analysis indicated the control as highest values for overall acceptability (4.90) while 20% DF biscuits had the highest values amongst the formulated samples (4.29).*

Conclusion: *Incorporation of date and overripe banana flour in biscuits as substitute to sugar, positively influenced the nutritional composition of the biscuits.*

Keywords: *Biscuits, Date flour, Over-ripe banana flour, Natural sweeteners, in vitro*

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INTRODUCTION

The availability of nutrient-dense, reasonably priced, appetizing, and rapidly consumable convenience meals, such as snacks help in addressing the dietary concerns of contemporary society, which is characterized by fast-paced lifestyles, given the noticeable shift in food consumption habits (1). These diseases, which include cardiovascular diseases (CVD), cancers, chronic respiratory diseases, and diabetes mellitus (DM) are the major cause of mortality in the world. According to WHO, non-communicable diseases (NCDs) account for the death of 41 million people each year, equivalent to 71% of all deaths globally. Each year, more than 15 million people between the ages of 30 and 69 years die from chronic diseases; 85% of these untimely deaths occur in low- and middle-income countries (2). Sub-Saharan Africa has the fastest-growing rate of diabetes, with Nigeria having a prevalence rate between 3-5%. The relevance of nutrient-dense and fibre-rich formulations, such as date- and banana-based biscuits, lies in their potential to reduce risk factors associated with non-communicable diseases, including diabetes and cardiovascular diseases, particularly in regions like Sub-Saharan Africa where prevalence is increasing (Mayor, 2019; Reynolds et al., 2022). Nutrition transition, urbanization, consumption of calorie-dense diets, and increasing consumer demand for baked products in developing countries have increased the prevalence of non-communicable diseases (3). According to experts, sugar consumption is a major cause of obesity and many chronic diseases, such as diabetes (4).

Bakery products have served as dietary staples for humans from ancient times by providing consumers with delectable choices (5). Among the wide range of different bakery products available in the market, biscuits constitute a popular cereal consumed by the young and the old (6). Biscuits may be considered a form of confectionery dried to very low moisture content (7). Some of the reasons for its popularity are low cost compared with other processed foods, availability in different forms, varied taste, and longer shelf-life (8). The key ingredients generally used in the manufacture of biscuits are flour, sugar, and fat. Biscuits are characterized by low content of protein, vitamins, dietary fibre, and minerals but a high amount of sugar and fat, making them not so healthy option for consumers. Modification of ingredients such as proteins, vitamins, minerals, and fibres into the basic formulation of biscuits can enhance the nutritional as well as sensory qualities of biscuits.

Sugars play a major role in our diets. When added to foods and drinks, they enhance the taste, texture, and color. Despite these benefits, sugars offer minimal vitamins and minerals, its overuse can lead to weight gain, altered insulin response, and potentially diabetes and obesity (9). Certain artificial sweeteners have been related to unfavorable health outcomes, including abnormal weight gain, cancer, nausea, diarrhea, and metabolic problems (10). Hence, these have led to increasing interest in the search for a more natural and nutrient-rich sweetener. Natural alternatives that have been explored in baking include Honey, maple syrup, agave nectar, molasses, corn syrup, raw cane sugar, and fruit sugars (11). Additionally, natural sweeteners derived from high-sugar tropical fruits like banana, pineapple, mango, and pomegranate are gaining traction as potentially healthier options (9).

Literature suggests that date fruit supplementation may exert maximum serum cholesterol, triglyceride, and LDL reduction potential through several mechanisms that modulate cholesterol absorption and metabolism (12). Dates are grown worldwide as it is a source of energy due to the presence of dextrose, fructose, and other dietary components such as vitamins, minerals, dietary fibre, flavonoids, and polyphenolics (13). Dates possess antioxidants, anti-inflammatory, anti-haemorrhagic, anti-infective, anticancer, hepatoprotective, neuro-protective, and antidiabetic properties, thereby facilitating good health and a fit lifestyle. (14, 15).

Banana is one of the most widely consumed fruits and the main international trade fruit in the world (16). Overripe banana reportedly provides excellent sources of vitamins (A, B_6, C, and D), minerals (potassium and magnesium), dietary fibre, and a natural sweetener (17). The sugar content, which is mainly composed of sucrose, fructose, and glucose, is increased tenfold compared to unripe banana (1.26 to 12.28%) (18). Previous studies have used sweeteners extracted from fruits as a partial substitute for refined sugar in the production of cookies, biscuits, and bread (19, 20, 21). By incorporating natural ingredients (dates and overripe bananas) into biscuits, consumers have improved options of healthy food items in their daily food choices, as these contain more of other sugars, vitamins, minerals, antioxidants, and other useful nutrients. Therefore, this study aimed to evaluate the nutritional quality and glycaemic index of biscuits enriched with date and banana flours, with the aim of developing functional bakery products that are both nutrient-dense and suitable for reducing risk factors associated with non-communicable diseases.

MATERIALS AND METHODS

Materials

The fruits (banana and dried dates) and bakery ingredients such as wheat flour, baking powder, and margarine were purchased from a local market in Ilorin, Kwara State.

Methods

Fully ripened banana (*Musa acuminata*) was purchased at Ado market, Ekiti State, and kept in room temperature at 25°C, relative humidity of 80–85% until the fruit reached the desired ripeness (overripe, stage 5) without the addition of a ripening agent. The stage of ripening was determined according to Karim *et al*. (22) using a colour chart and physical observation (many brown and big spots in peel and pulp were observed). The product obtained corresponds to an overripe banana, which has similar characteristics to that product that is commercially discarded due to its over-ripening. The study compared the control and formulated biscuits in terms of the nutritional composition, sensory acceptability, and glycaemic Index value.

The composition of the different flour formulation are shown in Table 1.

Table 1: Ingredients used in the production of date and banana biscuits

Ingredients	B11 (g)	B12 (g)	B13 (g)	C11 (g)	C12 (g)	C13 (g)
Wheat flour	180	160	140	180	160	140
Date flour	20	40	60	---	---	---
Banana flour	---	---	---	20	40	60
Margarine	100	100	100	100	100	100
Milk	10	10	10	10	10	10
Baking powder	3	3	3	3	3	3
Milk flavour	10	10	10	10	10	10
Vanilla flavour	3	3	3	3	3	3

Experimental Design

There was one control sample and six experimental samples. The control sample was a commercially purchased biscuit (Fiber Active), while the experimental samples consisted of biscuits formulated with the fruit flours. Wheat flour and the fruit flours were combined in the ratios 90:10, 80:20, and 70:30 each for the dried dates and the overripe banana flour. As shown in Table 1.

Preparation of Overripe Banana Flour

The banana flour was prepared using the method described by Abbas *et al.* (23) and Soto-Maldonado *et al.* (24) with slight modifications. The modifications included the reduction of slice thickness to approximately 2 mm, the incorporation of a citric acid pretreatment step, and the adjustment of storage conditions after processing. The fruits were peeled and cut into transverse slices of about 2 mm thickness. Fruit slices were dipped in a citric acid solution, sliced, frozen at – 20 °C, and lyophilised using a freeze dryer (model no LGJ-10). The dried samples were milled to obtain banana flour. The flour was stored in airtight Ziploc bags in cold storage (15±2°C) for further use.

Preparation of Date Fruit Flour

The dried date palm fruits were washed with clean water to remove adhering dirt. This was followed by seed removal (de-pitting). The pulp with pericarp was oven dried at 45°C for 72 hours, milled, and sieved through a 0.35 mm mesh sieve to obtain a fine homogenized flour according to the method described by Olagunju *et al.* (25).

Chemical Analysis of Samples

Proximate analysis was carried out on the samples as described by the Association of Official Analytical Chemists (26) for moisture (air-oven method), total ash (dry-ashing method), protein (Kjeldahl method), and fat (Soxhlet method). Carbohydrate was calculated by differences using the following:

$$Total\ CHO\ (\%) = 100 - [moisture + ash + crude\ protein + crude\ fat + crude\ fibre] \quad \text{Eq. 1}$$

Determination of the mineral content of the biscuits

Total calcium and magnesium ion contents were determined by the EDTA versanate complexometric titration method. Sodium and potassium ion contents were determined by flame photometry as described by Onwuka (27).

Duplicate solutions were prepared for each sample, and a minimum of three separate readings were taken to minimize error. The mean values were used to calculate the concentrations.

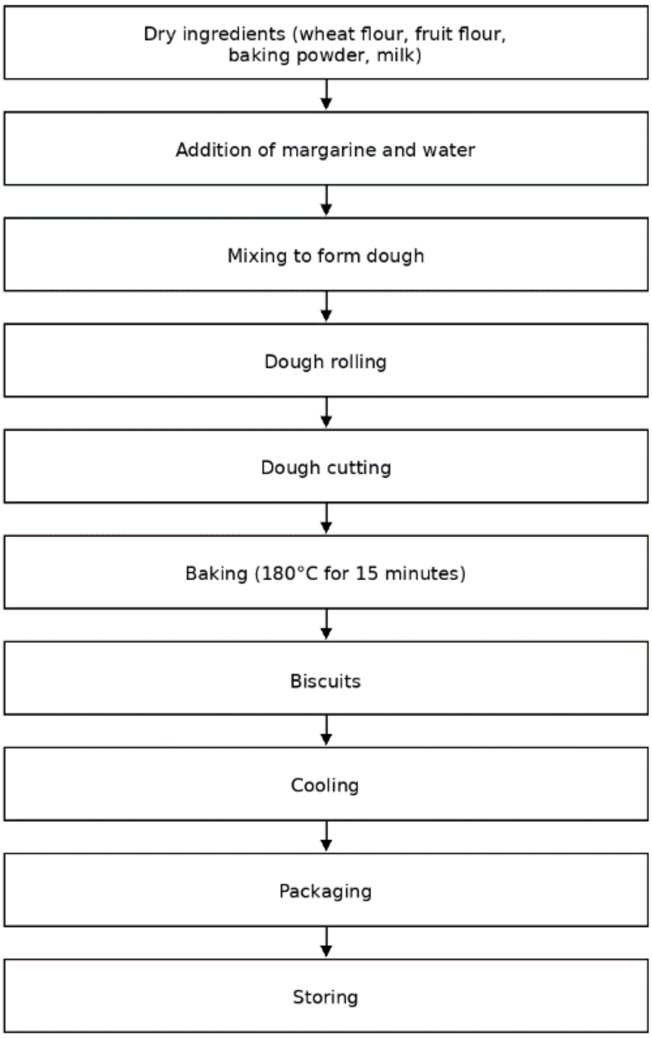

Figure 1: Flowchart of Biscuit Production

Determination of Vitamins

The vitamins were determined according to the method outlined by Okwu (28).

In vitro Glycaemic Properties

This was analysed according to the method described by Englyst *et al*. (29). The method is based on the measurement of the glucose released from a test food during timed incubation with digestive enzymes under standardised conditions. This chemically-based classification estimates the amounts of glucose (from sugar and starch digestion) that are likely to become available for rapid or slow absorption from the small intestine. The internal standard solution was 40 g/L arabinose in water with 50% saturated benzoic acid. The stock sugar mixture was 50 g/L glucose in water with 50% saturated benzoic acid. Sugars were dried to constant weight before use.

Microbiological analyses of the biscuits

The total bacteria and coliform counts of the biscuits were determined using standard microbiological plating method as described by Giwa *et al*. (30) and Adeoye at al. (31). Samples of biscuits from each treatment groups were milled to powdered and 1 g of the sample was measured and dissolved in 9 ml of sterile water and vortexed for homogenisation at 3000 rpm for 5 min. The supernatant was decanted, and 1 ml of supernatant was diluted serially in 9 ml of sterile water to an appropriate dilution factor of 10^2. About 1 ml of dilution 10^2 was plated aseptically on sterile prepared nutrient agar (NA) and Eosin methylene blue (EMB) agar plates.

Inoculated plates were incubated aerobically in a bacterial incubator (DNP-9102, China). All media were prepared according to the manufacturer's instructions and autoclaved at 121°C, 15 mmHg pressure for 30 min. Incubation was done for 24 h at 37 °C.

Sensory Evaluation

The sensory evaluation of the samples was carried out for consumer acceptance. A total of seven biscuit samples (A11, B11–B13, C11–C13) were evaluated by 20 untrained panelists who were randomly selected, comprising students and staff of the department who regularly consume biscuits. They were instructed on how to taste and score the samples before presenting the coded samples randomly with the same type of plate to them in a well-lighted room. Water was presented to each panellist to rinse their mouths before and after each test. They were to taste each coded sample presented before them, evaluate their colour, taste, flavour, mouth feel, and overall acceptability one after the other, and score them on the 5-point hedonic scale according to Iwe (32).

Statistical analysis

Data obtained were subjected to a one-way analysis of variance (ANOVA) followed by a Least Significant Difference (LSD) *post-hoc* test to compare the mean differences among the samples. Data analysis was performed using SPSS, Version 21.0. (SPSS Inc, Chicago, Illinois). Three batches of the biscuits were produced for all measurements. Results were expressed as the mean of three replicates ($n = 3$) ± standard deviation (SD) except for sensory evaluation ($n = 20$). The significance level was established at $p < 0.05$.

RESULTS

Proximate composition (g/100g) of commercial biscuit, and formulated biscuits made from date and banana flours

Table 2 presents the proximate composition (g/100 g) of the commercial biscuit and biscuits formulated from date and banana flours. Moisture content varied among samples, with C13 recording the highest value (3.40 ± 0.05%), while B11 had the lowest (2.84 ± 0.01%). Ash content was highest in C13 (2.61 ± 0.04%) and lowest in A11 (1.29 ± 0.02%). Fat and crude fibre contents were highest in C12 (27.36 ± 0.01% and 2.59 ± 0.04%, respectively), whereas A11 recorded the lowest values (18.06 ± 0.11% fat and 0.44 ± 0.01% fibre). Protein content was highest in C13 (8.73 ± 0.01%) and lowest in B11 (6.95 ± 0.01%). Carbohydrate content was highest in A11 (68.16 ± 0.09%), while C12 recorded the lowest value (52.59 ± 0.15%). Similarly, C12 exhibited the highest energy value (2084.84 ± 4.30 kJ/100 g), whereas A11 had the lowest (1964.27 ± 2.79 kJ/100 g).

Table 2: Proximate composition (g/100g) of commercial biscuit, and formulated biscuits made from date and banana flours

Sample	A11	B11	B12	B13	C11	C12	C13
Moisture	3.35 ± 0.02^e	2.84 ± 0.01^f	3.57 ± 0.07^d	4.08 ± 0.11^c	6.59 ± 0.02^b	7.44 ± 0.01^a	3.40 ± 0.05^e
Total Ash	1.29 ± 0.02^d	2.05 ± 0.01^c	1.97 ± 0.01^c	1.98 ± 0.08^c	2.03 ± 0.01^c	2.15 ± 0.11^b	2.61 ± 0.04^a
Crude Fat	18.06 ± 0.11^f	25.77 ± 0.14^b	24.58 ± 0.11^c	24.15 ± 0.01^d	27.29 ± 0.03^a	27.36 ± 0.01^a	23.82 ± 0.22^e
Crude Fibre	0.44 ± 0.01^f	0.45 ± 0.01^f	0.53 ± 0.04^e	0.82 ± 0.03^d	0.97 ± 0.04^c	2.59 ± 0.04^a	2.29 ± 0.04^b
Crude Protein	8.69 ± 0.01^c	6.95 ± 0.01^e	6.98 ± 0.02^e	7.88 ± 0.01^d	9.55 ± 0.02^a	7.87 ± 0.01^d	8.73 ± 0.01^b
Carbohydrate	68.16 ± 0.09^a	61.94 ± 0.13^c	62.39 ± 0.01^b	61.09 ± 0.08^d	53.67 ± 0.02^f	52.59 ± 0.15^g	59.15 ± 0.28^e
Energy	1964.27 ± 2.79^f	2122.12 ± 2.91^a	2084.84 ± 4.30^b	2062.15 ± 0.77^c	2083.03 ± 1.51^b	2041.08 ± 2.67^d	2031.41 ± 3.81^e

Values are means of three determinations. Means ± Standard Deviation with different alphabetical superscripts in the same row are significantly different at *P<0.05*. Where A11 the control (commercially purchased biscuits); B11 is formulated biscuits with 10% date flour; B12 is formulated biscuits with 20% date; B13 is formulated biscuits with 30% date flour; C11 is formulated biscuits with 10% banana flour; C12 is formulated biscuits with 20% banana flour; C13 is formulated biscuits with 30% banana flour

Mineral composition (mg/100g) of biscuits from Cooked Samples

Table 3 reveals the mineral composition (mg/100g) of commercial biscuits and formulated biscuits made from date and banana flours. B13 ranked highest in calcium, while C11 ranked lowest (1.12 ± 0.00^a, 1.04 ± 0.00^f). A11 ranked highest in magnesium, while B12 ranked lowest (1.41 ± 0.01^a, 1.34 ± 0.01^g), C12 ranked highest in sodium, while A11 ranked lowest (17.51 ± 0.01^a and 16.87 ± 0.01^g). All samples ranked the same for potassium, zinc, and iron, and B12 ranked highest in sodium/potassium molar ratio, while C12 ranked lowest (4.04 ± 0.00^a, 3.72 ± 0.00^g), respectively.

Sensory attributes of biscuits from cooked samples

Table 4 reveals the sensory attributes of the formulated biscuits made from date and banana flours. A11 ranked highest in aroma and appearance, while C13 ranked lowest

(4.60±0.50[a] and 2.45±1.32[c] and 4.40±0.68[a], 2.45±1.23[c]) respectively. A11 ranked highest in crispiness while C11 ranked lowest (4.65±0.49[a], 3.05±1.19[d]), A11 ranked highest in taste, texture and overall acceptability while C13 ranked lowest (4.80±0.41[a], 2.40±1.19[c]), (4.40±0.75[a] and 2.70±1.08[c]) and (4.90±0.31[a], 2.40±1.09[e]) respectively.

Microbial load of biscuits

Table 5 reveals the total coliform count and total bacteria count. It was observed in the results obtained that the biscuits were safe, as they were all free from coliforms, and the bacteria present in some of the biscuits were still within the acceptable limit.

Table 3: Mineral composition (mg/100g) of biscuits from Cooked Samples

Sample	A11	B11	B12	B13	C11	C12	C13
Ca	1.05±0.00[e]	1.06±0.00[d]	1.11±0.00[b]	1.12±0.00[a]	1.04±0.00[f]	1.09±0.00[c]	1.06±0.01[d]
Mg	1.41±0.01[a]	1.36±0.01[e]	1.34±0.01[g]	1.38±0.00[b]	1.37±0.01[c]	1.35±0.01[f]	1.37±0.01[d]
Na	16.87±0.01[g]	16.94±0.01[f]	17.21±0.01[d]	17.06±0.01[e]	17.39±0.00[c]	17.51±0.01[a]	17.46±0.01[b]
K	0.43±0.01[d]	0.42±0.00[e]	0.43±0.01[d]	0.43±0.00[d]	0.44±0.01[c]	0.47±0.00[a]	0.46±0.00[b]
Zn	0.04±0.00[e]	0.05±0.00[d]	0.09±0.00[b]	0.08±0.00[c]	0.07±0.00[c]	0.10±0.00[a]	0.06±0.00[d]
Fe	0.48±0.01[g]	0.51±0.00[e]	0.55±0.01[b]	0.60±0.00[a]	0.51±0.00[d]	0.52±0.00[c]	0.49±0.00[f]
Na/K	3.97±0.00[d]	4.02±0.01[b]	4.04±0.00[a]	4.00±0.01[c]	3.93±0.00[e]	3.72±0.00[g]	3.82±0.01[f]

Values are the mean of two determinations. Means ± Standard Deviation with different alphabetical superscripts in the same row are significantly different at *P<0.05*. Where A11 the control (commercially purchased biscuits); B11 is formulated biscuits with 10% date flour; B12 is formulated biscuits with 20% date; B13 is formulated biscuits with 30% date flour; C11 is formulated biscuits with 10% banana flour; C12 is formulated biscuits with 20% banana flour; C13 is formulated biscuits with 30% banana flour

Table 4: Sensory Attributes of Biscuits from Cooked Samples

Sample	A11	B11	B12	B13	C11	C12	C13
Aroma	4.60±0.50[a]	3.60±0.68[b]	4.00±0.89[ab]	3.79±1.32[b]	3.40±1.05[b]	3.30±1.22[b]	2.45±1.32[c]
Appearance	4.40±0.68[a]	4.30±0.66[a]	4.33±0.48[a]	3.47±1.47[b]	3.50±1.15[b]	3.50±0.83[b]	2.45±1.23[c]
Crispiness	4.65±0.49[a]	4.45±0.69[ab]	4.38±0.67[ab]	4.21±0.63[ab]	3.05±1.19[d]	3.95±0.60[bc]	3.60±1.14[c]
Taste	4.80±0.41[a]	3.85±0.81[b]	4.38±0.80[ab]	3.74±1.37[b]	2.90±1.21[c]	2.85±1.04[c]	2.40±1.19[c]
Texture	4.40±0.75[a]	4.10±0.64[ab]	4.05±0.92[ab]	4.06±0.73[ab]	3.70±1.12[b]	3.10±0.97[c]	2.70±1.08[c]
Overall	4.90±0.31[a]	3.90±0.72[bc]	4.29±0.78[b]	4.05±1.18[bc]	3.50±1.24[cd]	3.10±1.02[d]	2.40±1.09[e]

Means ± Standard Deviation with different alphabetical superscripts in the same row are significantly different at *P<0.05*. Where A11 the control (commercially purchased biscuits); B11 is formulated biscuits with 10% date flour; B12 is formulated biscuits with 20% date; B13 is formulated biscuits with 30% date flour; C11 is formulated biscuits with 10% banana flour; C12 is formulated biscuits with 20% banana flour; C13 is formulated biscuits with 30% banana flour

Table 5: Microbial Load of Biscuits

Sample	TBC	TCC
A11	2 x 10^2	Nil
B11	1 x 10^2	Nil
B12	Nil	Nil
B13	2 x 10^2	Nil
C11	Nil	Nil
C12	Nil	Nil
C13	Nil	Nil

TBC= total bacteria count; TCC= total coliform count

DISCUSSION

The biscuits formulated with banana flour at 10% and 20% had a very high moisture content, while the formulated biscuits with date flour at 10% had the least moisture content of all the samples. It was noticed that the moisture content of the biscuit samples increased from 2.84%-4.08% with an increase in the date flour substitution. The high moisture content may be due to high sugar content in date which binds water in formulated biscuits. This corresponds with the findings of (33-35), which recorded an increased moisture content in biscuits enriched with date flour. The formulated samples were higher in fat content compared to the control, suggesting that the incorporation of banana and date flours contributed additional lipids to the biscuits. This increase in fat content may enhance the energy density, mouth-feel, and overall palatability of the product, which is beneficial for developing nutrient-dense snack foods (10).

The crude fat content of the biscuits decreased with increasing levels of date flour, declining from 25.77% to 24.15%. This trend is consistent with the findings of Amin et al. (34), who reported that substitution with date flour reduced fat content due to the inherently low lipid content of dates and the dilution of fat-rich ingredients in composite flour formulations. However, this result contradicts the reports of Olagunju (25) and Peter-Ikechukwu et al. (36), who observed increased fat content with higher levels of date flour. The disparity may be attributed to differences in date variety, processing method, formulation ratios, and fat-containing ingredients used, which can significantly influence fat retention in baked products.

Biscuits formulated with 10% and 20% banana flour exhibited the highest fat contents among the formulated samples, likely due to the contribution of residual lipids in banana flour and its interaction with shortening during baking. No significant difference was observed between the fat contents of the 10% and 20% banana flour biscuits, both of which exceeded the recommended 25% fat limit for baked goods, beyond which susceptibility to rancidity increases (37). Fat contributes to biscuit palatability, energy density, and the transport of fat-soluble vitamins (34).

The control sample had the lowest value for the crude fibre, while banana biscuits at 20% had the highest crude fibre content amongst the formulated samples. The crude fibre content for the date samples increased as the amount of date flour added increased. The rising crude protein content with increasing date flour aligns with Olagunju (25), Ali et al. (35), and Ibrahim et al. (38), who all found a protein increase in biscuits made with 100% date flour compared to lower or no date flour. This protein surge is a welcome benefit, as dietary protein is important for the development and maintenance of bodily tissues, hormones, enzymes, and other critical processes (39).

The mineral composition of the biscuit samples showed significant improvements in most minerals after formulation. Magnesium was highest in the control sample compared to formulated buscuits samples. Iron content increased with the addition of date flour, with the highest levels found in the sample containing the most date flour (30%), while the control had the least. Calcium was also higher in the date flour biscuits, peaking at 30% inclusion. Biscuits with banana flour had higher sodium and potassium levels compared to both the date flour samples and the control.

The potassium content in the biscuits increased with higher levels of date flour. Biscuits made with banana flour showed higher potassium levels, aligning with findings by Pragati et al. (40), who identified banana flour as a rich potassium source. Zinc levels were lowest in the control and highest in biscuits with 20% banana flour. Overall, the formulated biscuits had higher zinc content than the control. Zinc plays a vital role in immune support and antioxidant defense, especially in type 2 diabetes, and its deficiency is linked to various metabolic disorders such as impaired glucose tolerance and reduced insulin function (41,42).

The *in vitro* measurement of rapidly available glucose and slowly available glucose is physiologically important for evaluating the health impact of dietary carbohydrates (29). Free glucose was highest in the control sample containing sucrose, consistent with Di-Cairano et al. (43), who found increased glucose levels in cookies made with sugar versus sugar alcohols. The date flour biscuits developed a greater Rapidly Available Glucose value, which indicates a possible greater glycaemic response compared to the banana flour biscuits. The biscuit with 30% date flour had the highest free glucose, followed by the 20% banana flour biscuit with the lowest. The trend of substituting date flour with flour suggests that more of it can be used to increase the proportion of rapidly digestible carbohydrates, but the introduction of banana flour can also be used to regulate the glucose supply.

Microbiological testing showed that all the samples of biscuits were microbiologically safe to eat, as no coliform bacteria were found, and the total bacterial count was within acceptable ranges. The sensory analysis indicated that the overall acceptability of the control biscuit was the greatest. But among the developed samples, the most popular sample was the biscuit with 20% date flour, and the highest acceptability was registered with the sample biscuit with 10% banana flour.

The present study has some limitations. The glycaemic response of the biscuits was based on *in vitro* carbohydrate digestibility (Rapidly

Available Glucose value) as compared to *in vivo* glycaemic index testing on human subjects. The sensory assessment was also done using a small number of panelists, and this might not be representative of overall consumer preferences. The next generation research should hence comprise human glycaemic response trials and larger consumer panels to confirm the performance of the formulated biscuits in terms of functionality and sensory issues.

CONCLUSION

The incorporation of date and overripe banana flour to biscuits positively affected the nutritional composition of the biscuits, especially dietary fibre, minerals, and vitamin content. This study demonstrated that dates and overripe bananas could be novel sources of dietary fibre for biscuits and low-GI food ingredients, which could widely be utilised in developing various functional foods. Further research can also be conducted on the effectiveness of the biscuits made with date flour in improving the haemoglobin level among anaemia patients. In addition, the use of date flour in biscuits for diabetic patients is recommended in order to discourage the intake of common table sugar.

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