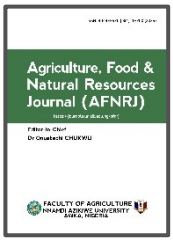
Agr. Foo. Nat. Res. J. Volume 4, Issue 2, Page 272-277

e-ISSN: 1597-7153 | p-ISSN: 3043-5420

Agriculture, Food and Natural Resources Journal

The Official Journal of the Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Nigeria

Journal homepage: https://journals.unizik.edu.ng/afnrj



Original Article

Textural and quality characteristics of doughnuts produced from wheat and date flours as sugar substitute

OPEN ACCESS

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DOI: https://www.doi.org/10.5281/zenodo.17570197

Editor: *Dr Onyekachi Chukwu, Nnamdi Azikiwe University, NIGERIA*

Received: *June 27, 2025*
Accepted: *September 5, 2025*
Available online: *September 30, 2025*

Peer-review: *Externally peer-reviewed*

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Conflict of Interest: *The authors have no conflicts of interest to declare*

Financial Disclosure: *The authors declared that this study has received no financial support.*

ABSTRACT

Snacks are important short meals, and sugar is a key component in most snack and food products. However, many health challenges have been linked to the consumption of sugar. This study aimed to evaluate the effect of date fruit flour as a sugar substitute at varying proportions on the textural and quality characteristics of doughnuts made from wheat flour. Doughnuts were produced from blends of wheat and date fruit flour in the following proportions: 95:5 ($W_{95}D_5$), 90:10 ($W_{90}D_{10}$), 85:15 ($W_{85}D_{15}$), 80:20 ($W_{80}D_{20}$), and 100% wheat flour (W_{100}) as the control. The flour blends were kneaded, shaped, and deep-fried in hot vegetable oil at a constant temperature of 130°C for 10 min. Textural and colour parameters of the doughnuts were determined using a Model CT310K Texture Analyzer and a Chroma Meter CR-410, respectively. The functional properties of the wheat-date flour blends (WDF) were evaluated using standard procedures. The results showed a significant difference ($p < 0.05$) in the textural properties of the doughnuts. The color values L (33.93 - 46.63), a* (2.51 - 6.45), and b* (3.11 - 11.59) revealed noticeable changes with increasing substitution levels of date fruit flour. There was no significant difference ($p > 0.05$) in the overall acceptability of the control sample (W_{100}) compared to the $W_{95}:D_5$ and $W_{90}:D_{10}$ doughnut samples. These findings revealed that date fruit, as a natural sweetener, can sustainably replace refined sugar and enhance the nutritional profile of snack products.*

KEYWORDS: *Date Fruit, Deep frying, Snack, Snacking Doughnut, Sugar, Wheat Flour*

INTRODUCTION

Snacks exist globally in various forms and are usually consumed as in-between meals (Njike *et al*., 2016). Snack foods are processed from a variety of ingredients, either domestically or industrially. They are usually smaller when compared with regular meals and in most cases, consumed between meals (Njike *et al*., 2016; Bolaji *et al*., 2024). Snacking is influenced by many factors, including personal, social, cultural, organizational, environmental, and policy-level elements, therefore researchers and health professionals have been advocating for healthy snacking (National Heart, Lung, and Blood Institute (NHLBI), 2004; Marangoni *et al.,* 2019). The nutritional content, processing methods, and conditions (including personnel, equipment, and environment) are usually the major parameters that determine the health quality of snacks (Hatae *et al.,* 2003; Marangoni *et al.,* 2019).

Doughnuts, common in many countries, are produced by deep-frying of prepared dough made from the mixture of relevant

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ingredients such as; wheat flour, water, egg, oil, sugar and milk in their required proportions (Hatae *et al.,* 2003). These comes in various shapes, sizes, and flavors, including glazed doughnuts (with glossy, sugary coatings), Jelly-filled doughnuts (jam doughnuts), and Chocolate-frosted doughnuts. Doughnuts are one of the most common fried confectioneries and are typically ring-shaped. They can be either yeast-raised or cake-type (Miskelly, 2017).

However, poor quality ingredients or components, inappropriate processing conditions, fat absorption, and dough moisture content can significantly influence doughnut quality (Miskelly, 2017; Adebayo-Oyetoro *et al.,* 2017). The fact that wheat is not locally grown in many developing countries and must be imported contributes to the high production costs of wheat-based snacks and food products. This has led to the development of policies promoting composite flour production, which encourages the incorporation of locally sourced or underutilized useful agricultural products into wheat flour for food production (Tan & Mittal, 2006).

Dada & Fagbohun (2018) reported that date palm fruits consist of about seventy percent (70%) natural sugars, largely composed of glucose and fructose. These natural sugars can effectively substitute refined sugar, which some researchers have linked to adverse health effects (Dada & Fagbohun, 2018; Bolaji *et al*., 2024). Beyond serving as a sugar replacer, dates also offer nutritional benefits, including antioxidants and flavonoids such as beta-carotene, lutenin, and zeaxanthin (Dada & Fagbohun, 2018; Bolaji *et . al.,* 2024). Replacing refined sugar with date fruithelp reduce the risks of many health-related diseases attributed to sugar intake in both adults and children (Dada & Fagbohun, 2018).

The textural characteristics of food products have a significant impact on customer acceptance, perception, market value, quality assurance, and food safety (Rafiq & Ghosh, 2016; Khan et al., 2024; Bolaji *et al*., 2024). According to some studies, texture can also influence how flavors are released and perceived (Rafiq & Ghosh, 2016; Khan et al., 2024). This study was carried out to investigate the effect of date fruit flour as a sugar substitute on the textural and quality characteristics of doughnuts.

MATERIALS AND METHODS

A commercial wheat flour was obtained from "Honeywell" Flour Mills, while matured date palm fruits (*phoenix dactylifera*) were purchased from Sabo Market, located along the Ikorodu-Ijebu ode road in Lagos, Nigeria. Date palm fruit flour was prepared following the method described by Ujong *et al.* (2024) Foreign materials were first removed from the date fruits and were thoroughly washed with clean water. The seeds were manually extracted from the fruits, and the fleshy parts of the date fruits sliced into small pieces and dried at 75°C for 6 h, as described by Peter-Ikechukwu *et al.* (2020). The dried pieces were milled and sieved using a 0.35mm mesh sieve to obtain a fine, homogenous flour. The resulting date palm fruit flour was then packaged for further analysis.

Preparation of doughnut

Date palm flour was blended with wheat flour following the method described by Adebayo-Oyetoro *et al.* (2017), with slight modifications. Composite flours were formulated at different wheat-to-date flour ratios of 95:5 ($W_{95}D_5$); 90:10 ($W_{90}D_{10,}$); 85:15 ($W_{85}D_{15}$); 80:20($W_{80}D_{20}$), and 100% wheat flour (W_{100}) as the control. Equal amounts: 50 g of butter, 58 g of egg, 10 % sugar based on the weight of 100 % wheat flour, and 5% yeast were incorporated into each formulation (Adebayo-Oyetoro *et al.* 2017). The ingredients were gradually combined and thoroughly mixed. Dissolved yeast in diluted milk, along with salt, was added and mixed evenly into the flour blend. The resulting dough was kneaded, shaped into ring forms, and proofed at 35°C for 15 min., following the procedure by Adebayo-Oyetoro *et al.* (2017). Deep-frying was carried out in hot vegetable oil using a 3.5 L deep fryer, maintained at a constant temperature of 130°C for 10 minutes, to produce doughnuts of varying compositions.

Pasting Properties of wheat-date fruit flour

The pasting characteristics of the flour samples were evaluated using a Rapid Visco Analyzer (RVA), Model 3D RVA (Newport Scientific Pvt. Ltd.), as reported by Adebayo-Oyetoro *et al.* (2017).

Determination of textural properties of doughnut

The texture profile of the doughnut samples was determined using a Texture Analyzer (Model CT310K, USA). Texture profile Analysis (TPA) was conducted using a 3 mm cylindrical stainless-steel probe (TA 44). Texture profile Parameters recorded include Peak Force, Weight, Adhesiveness, Chewiness, Cohesiveness, Gradient, and Stringiness was recorded.

Proximate composition doughnuts

Moisture content of the wheat-date flour blends and doughnut samples was determined using standard methods described by the AOAC (2005). While the bulk densities, Water absorption capacity, oil absorption capacity, swelling power, and solubility index were evaluated using the methods of Horsfall *et al.* (2007).

Determination of mineral content and color deep fried doughnut

Calcium, phosphorus, potassium, magnesium, and iron contents were determined according to the method described by Shahid (2000). The color intensity in L*, a* and b* was measured using a Chroma Meter CR-410 (Minolta LTD, Japan).

Sensory evaluation

The sensory attributes of the doughnut samples, cooled to room temperature, were evaluated by a panel of thirty (30) untrained; all panelists were above 18 years of age and familiar with doughnuts.

Data analysis

The data obtained in triplicates for the parameters measured were subjected to statistical analysis using SPSS version 17. Analysis of variance (ANOVA) was conducted, and were significant differences were separated using Duncan's Multiple Range Test at $p < 0.05$.

RESULTS AND DISCUSSION

Textural profile analysis of doughnut produced from wheat-date fruit flour blends

The results for the textural properties of doughnuts produced from blends of wheat and date fruit flour are presented in Table 1. There were significant differences ($p < 0.05$) in the values reported for Texture Profile Analysis (TPA), including gumminess, peak force, weight, adhesiveness, chewiness, cohesiveness, gradient, and stringiness except for height, which showed no significant variation. The peak force values were lower compared with values reported by Nasir *et al.,* (2020). It is well established that textural properties are crucial for characterizing processed food products (Rafiq & Ghosh, 2016; Khan *et al.,* 2024; Bolaji *et al*., 2024). In this study, the addition of date fruit flour significantly influenced key texture parameters such as peak force, cohesiveness, gumminess, and chewiness of the doughnut. These findings were in line with the observation of Nasir *et al*. (2020) and were attributed to the moisture loss during processing and the retrogradation behavior of wheat flour (Nasir *et al.,* 2020).

In snack production, these properties play a vital role in consumer preferences and acceptance (Rafiq & Ghosh, 2016; Khan *et al.*, 2024). Textural attributes are closely related to the physical structure of food and are typically measured by their response to deformation, disintegration, and flow, quantified as a function of mass, time, and distance (Ujong *et al.,* 2024). Processing conditions and compositional differences have been widely recognized to influence product texture and structural performance (Kumar *et al.,* 2021). According to Liu *et al.* (*2009)*, elastic recovery is influenced by the network formed during gelatinization, which is dependent on amino acid content, molecular weight distribution, and extraction procedures (Liu *et al. 2009; Bolaji et al*., 2024).

Table 1: Texture profile of doughnut produced from wheat and date flour

Sample	Peak Force A (g)	Height (mm)	Weight (g)	Adhesiveness	Chewiness	Cohesiveness	Gradient (g/mm)	Gumminess	Stringiness
W_{100}	761.00 ^{a}	24.90 ^{a}	48.00 ^{d}	252.87 ^{e}	290.00 ^{ab}	0.59 ^{c}	40.00 ^{a}	448.00 ^{a}	7.18 ^{b}
$W_{95}D_5$	1910.00 ^{e}	24.91 ^{a}	34.20 ^{c}	2278.90 ^{d}	444.00 ^{de}	0.48 ^{ab}	110.00 ^{e}	920.00 ^{e}	8.26 ^{c}
$W_{90}D_{10}$	1346.00 ^{c}	22.22 ^{b}	16.00 ^{a}	130.52 ^{b}	264.00 ^{a}	0.49 ^{ab}	71.00 ^{b}	665.00 ^{c}	7.30 ^{b}
$W_{85}D_{15}$	1712.00 ^{d}	24.92 ^{a}	23.60 ^{b}	1843.93 ^{c}	422.00 ^{d}	0.50 ^{ab}	92.00 ^{d}	854.00 ^{d}	8.46 ^{c}
$W_{80}D_{20}$	1265.00 ^{b}	24.91 ^{a}	34.00 ^{c}	119.86 ^{a}	322.00 ^{c}	0.44 ^{a}	86.00 ^{c}	558.00 ^{b}	6.79 ^{a}

The Mean with same superscripts within same column is not significantly different at ($p< 0.05$). KEY: W_{100} (100% Wheat Flour), $W_{95}D_5$ (95% Wheat Flour, 5% Date Flour), $W_{90}D_{10}$ (90% Wheat Flour, 10% Date Flour), $W_{85}D_{15}$ (85%WheatFlour,15%DateFlour)

Pasting properties of flour

The pasting properties of the wheat-date fruit flour are presented in Table 2. Significant differences ($p < 0.05$) were observed in all measured pasting parameters except for peak temperature. Pasting parameters such as peak viscosity, breakdown viscosity, final viscosity, set back viscosity, and pasting time decreased with increasing levels of date fruit flour inclusion. In contrast, the pasting temperature increased with the addition of date flour across all samples. Breakdown viscosity, which measures the degree of starch granule disintegration and reflects the stability of the formed paste (Zaidul *et al.,* 2007), decreased with increasing levels of date flour substitution. This showed that both the inclusion ratio and the processing conditions significantly affected the breakdown viscosity values. Increased breakdown viscosity implies a lower capacity of the composite flour to withstand heat and shear stress during cooking (Ubbor *et al.,* 2022; Bolaji *et al.,* 2024). Final viscosity, which indicates the resistance of the paste to shear stress, also showed a decreasing trend. Setback viscosity, an indicator of starch retrogradation and the state of molecular reassociation in the paste, is a critical measure of the textural quality of the cooked product (Ubbor *et al.,* 2022). Pasting temperature increased with the addition of date flour. This variation suggests a potential change in the functional behavior of the wheat-date flour blends.

Proximate composition of wheat and date flour blend

The proximate composition of wheat and date flour blends is as presented in Table 3. There was a significant difference ($p<0.05$) in the values obtained for Moisture content, Protein, Ash, Fat, Crude fiber, and Carbohydrate for both the wheat-date flour and doughnut samples. The values obtained for the moisture content of doughnuts were significantly higher approximately twice those recorded for the wheat-date flour blends. This was primarily due to reconstitution, the addition of other ingredients, and the frying process using vegetable oil. The high protein content observed in W_{100} could be attributed to its high gluten content. Although, the inclusion date fruit

flour appeared to impact the mineral content of the blends, no consistent pattern was observed. This inconsistency may be linked to the varying mineral composition of date fruits, which nonetheless show a strong tendency to increase ash content (Bolaji *et al*., 2024). The fat content of the blends increased with the addition of more date palm fruit flour. According to previous studies, the crude fiber values may be influenced by the specific species of date used and the processing techniques applied (Okafor & Usman, 2013; Bolaji *et al*., 2024).

Table 2: Pasting properties of composite flour of wheat and date

Sample	Peak viscosity (cP)	Trough viscosity (cP)	Breakdown viscosity (cP)	Final viscosity (cP)	Set back viscosity (cP)	Peak Time (min)	Peak Temperature (°C)
W_{100}	2394.00±16.97^{d}	1385.00±22.62^{e}	1009.00±5.65^{d}	2669.00±52.32^{e}	1284.00±29.69^{e}	6.26±.00^{e}	79.02±11.49^{a}
$W_{95}D_5$	1202.00±82.02^{e}	621.50±24.74^{d}	580.50±57.27^{c}	1343.50±79.90^{d}	722.00±55.15^{d}	5.50±.04^{d}	88.87±.035^{a}
$W_{90}D_{10}$	870.00±8.48^{c}	512.00±11.31^{c}	358.00±19.79^{b}	1032.50±13.43^{c}	520.50±24.74^{c}	5.40±.00^{c}	89.60±.00^{a}
$W_{85}D_{15}$	608.50±34.64^{b}	406.00±33.94^{b}	202.50±.70^{a}	832.50±4.94^{b}	426.50±38.89^{b}	5.26±.00^{b}	90.40±1.13^{a}
$W_{80}D_{20}$	367.50±58.68^{a}	219.50±34.64^{a}	148.00±24.04^{a}	428.50±17.67^{a}	209.00±16.97^{a}	5.13±.00^{a}	92.82±.03^{a}

The Mean with same superscripts within same column is not significantly different (p >0.05)

Table 3: Proximate composition doughnut

Sample	Moisture content (%)	Protein (%)	Ash (%)	Fat (%)	Crude fiber (%)	Carbohydrate (%)
DOUGHNUT						
W_{100}	20.83± 0.29^{a}	11.69±0.57^{e}	1.17±0.29^{a}	23.00±3.0^{a}	0.32±0.016^{e}	43±3.06^{b}
$W_{95}D_5$	21.5±0.5^{abc}	10.06±0.03^{d}	1.90±0.53^{bc}	24.33±3.06^{ab}	0.28±0.00^{d}	41.93±3.91^{b}
$W_{90}D_{10}$	21.33.00±1.53^{ab}	8.56±0.02^{c}	1.57±0.12^{ab}	28.67±1.15^{b}	0.24±0.00^{c}	39.64±0.89^{b}
$W_{85}D_{15}$	22.83±0.29^{bc}	7.44±0.00^{b}	2.43±0.12^{c}	34.00±1.0^{c}	0.21±0.00^{b}	33.08±1.25^{a}
$W_{80}D_{20}$	23.00±0.87^{c}	4.09±0.02^{a}	2.33±0.02^{ab}	26.67±2.52^{ab}	0.11±0.00^{a}	43.8±1.32^{b}

The Mean with same superscripts within same column is not significantly different at (p< 0.05)

Colour of doughnut produced from wheat-date fruit flour blends

The color characteristics of doughnuts produced from wheat-date fruit flour blend at varying proportion are presented in Table 4. The results showed that the substitution of wheat flour with date fruit flour significantly affected the colour attributes of the doughnuts. The lightness value (L*) ranged from 33.93 to 46.63 and was observed to decrease with increasing levels of date fruit flour inclusion. A similar decreasing trend was recorded for redness (a*), while the yellowness (b*) values exhibited a contrary pattern, increasing with higher substitution levels. These trends differ from the findings reported by Okafor & Usman (2013). Color is a crucial quality attribute in evaluating raw materials and finished products, providing insights into the suitability and quality of the final food product (Adebayo-Oyetoro *et al*., 2017; Bolaji *et al.,* 2024). The darker appearance of the doughnuts in this study could be attributed to the natural color of date fruits, which intensified as their proportion increased, coupled with browning reactions induced by heat during frying. The lower sensory color scores for sample $W_{80}D_{20}$ may be due to the higher percentage of date flour used as a sweetener substitute. Panelist preferences were influenced by the dark appearance of doughnuts with higher date fruit content. Based on sensory responses, doughnuts with 5% to 15% date fruit flour substitution were more favorably accepted. This suggests that a substitution level within this range offers a good balance between nutritional enhancement and consumer appeal.

Table 4: Color properties of the doughnut produced from wheat flour and date flour

Sample	L*	a*	b*
W_{100}	46.63±0.25^{a}	6.45±0.28^{a}	11.59±0.47^{a}
$W_{95}D_5$	42.84±0.15^{b}	4.89±0.02^{b}	10.24±0.11^{b}
$W_{90}D_{10}$	39.04±0.12^{c}	3.51±0.02^{d}	4.36±0.13^{c}
$W_{85}D_{15}$	34.48±0.40^{d}	4.28±0.08^{c}	4.64±0.07^{c}
$W_{80}D_{20}$	33.93±0.42^{d}	2.51±0.11^{e}	3.11±0.13^{d}

Means with different superscripts in the same column are significantly different at (p < 0.05). KEY: W100 (100% Wheat Flour), W95D5 (95% Wheat Flour, 5% Date Flour), W90D10 (90% Wheat Flour, 10% Date Flour), W85D15 (85%WheatFlour,15%DateFlour. L - lightness value, a- redness, b*- yellowness*

Sensory evaluation of doughnut samples

The sensory evaluation scores for five doughnut samples, as assessed by a 30-member panel showed that there were no significant differences (p > 0.05) observed in sensory attributes such as color, aroma, taste, texture, and over all acceptability among samples W_{100}, $W_{95}D_5$, and $W_{90}D_{10}$. However, significant differences (p <0.05) were reported in panelist ratings for samples $W_{85}D_{15}$ and $W_{80}D_{20}$.

CONCLUSION AND RECOMMENDATION

This study demonstrated the potential of date fruit flour as a viable sugar replacer in doughnut production. The results indicated that date palm fruit flour can effectively substitute sugar in doughnut formulations, producing a healthier alternative with desirable textural and organoleptic qualities.

The inclusion of date flour contributed to improved nutritional attributes and acceptable quality characteristics. However, based on the findings from sensory and colour analysis, optimal substitution levels of date fruit flour should be maintained between 5% and 15% to ensure consumer acceptability, particularly in terms of colour. Considering the outcome of this study, it is recommended that further research be conducted to assess the bioavailability and digestive uptake of the nutrients enhanced by date fruit flour in doughnut products. Additionally, exploration of its application in other baked goods could broaden its functional food potential.

Acknowledgement

The researchers would like to appreciate the efforts and support provided by the technologist and laboratory assistants in the Department of Food Science and Technology, Lagos State University of Science and Technology, Ikorodu, Lagos.

Authors' Contributions

OTB coordinated the entire research work. He managed the Conceptualization, Data curation, Formal Analysis, Funding, Methodology, project administration, Resources, Supervision, Validation, Visualization, Writing original draft. OIA. And EOB. Contributed to Funding, Methodology, Visualization, Project Administration, Resources, Supervision. TIO engaged in Supervision, Validation, Visualization. Writing original draft and RTO Participated actively in the Validation, Visualization, Writing original draft.

Ethical Statement

Not applicable.

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