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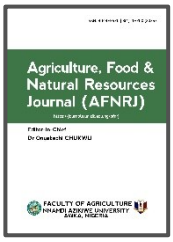

Original Article

Functional and sensory evaluation of cashew nut spread complemented with date palm and ripe banana

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ABSTRACT

This study investigated the functional properties and sensory characteristics of cashew nut-based spread, supplemented with date palm and ripe banana, aiming to develop a nutritious and palatable spread. Mixture design was employed to formulate seven blend ratios of cashew nut: date: banana; 63.33:18.33:18.33, 70:10:20, 70:20:10, 60:20:20, 66.67:16.67:16.67, 68.33:18.33:13.33, and 68.33:13.33:18.33. Roasted cashew nut paste, date palm paste, and ripe banana slurry were homogenized according to the ratios from the design and pasteurized at 60 °C for 3 minutes. Functional properties, including spreadability and viscosity, were measured, and sensory evaluation was conducted using a 9-point hedonic scale. Spreadability values ranged from 15.57 N/m to 26.16 N/m, with the highest spreadability recorded in the 70:20:10 formulations. Viscosity ranged from 20.15 to 35.70 N·s/m², with significantly higher ($p < 0.05$) values observed in blends with higher cashew nut content. Sensory attributes; appearance, taste, texture, mouthfeel, and flavor, significantly varied among samples, with overall acceptability scores ranging from 6.80 to 8.60. The formulations 63.33:18.33:18.33 and 66.67:16.67:16.67 achieved the highest acceptability scores of 8.60, indicating an optimal balance of sensory appeal and functional performance. The formulation ratio significantly influenced the functional and sensory qualities of cashew nut-based spreads. Blends with approximately 63 - 67% cashew nut and equal proportions of date palm and ripe banana (16 - 18%) are recommended for producing highly acceptable spreads with desirable viscosity and spreadability.

KEYWORDS: *Banana, Cashew, Spreadability, Viscosity*

INTRODUCTION

A nut spread is a paste-like product containing at least 40% nuts, available in various forms like whole nuts, nut paste, or nut slurry (Tonetto *et al*., 2025). Nut butters and spreads are made by grinding nuts into a smooth paste, similar to commercial butter. They can be produced from various nuts like almonds, cashews, or peanuts. Nut spreads are versatile and commonly used in sandwich preparation, as toppings for crackers, or as dips for vegetables. Consumers love nut spreads for their flavour, nutritional benefits, and versatility. The US market for nut-based spreads grew by 6.2% annually from 2004 to 2009 (Tonetto *et al*., 2025). For a nut spread to be enjoyable, it must be spreadable and have a soft texture to avoid damaging bread or crackers. Since kids are the primary users, a creamy and smooth texture makes it easy for them to use without help. This is achieved through processing techniques like grinding and emulsification, which create a uniform and stable paste (de Jonge *et al*., 2023). Many commercial spreads often contain added sugars, hydrogenated oils, and preservatives which are ingredients associated with increased risks of obesity, diabetes, and cardiovascular disease (Dietitian tips, 2025). Meanwhile, nuts such as cashews have been less explored in spread formulations, despite being rich in unsaturated fats, protein, vitamins, and minerals, and thus represent an underutilized opportunity for healthier alternatives (Tonetto *et al*., 2025).

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The cashew (*Anacardium occidentale*) nut, a drupe fruit with a heart-like shape, is widely cultivated in tropical regions. Globally, it is the third-largest edible nut, with production reaching 3,971,046 tonnes in 2017 (Orisa *et al*., 2023). West Africa leads production, contributing about 49%, followed by South East Asia and East Africa; Nigeria alone produced 98,253 tonnes in 2017. The cashew kernel, which forms 20–25% of the nut's weight, is highly valued for its nutritional richness. It contains about 47.1% lipids, 19.8% proteins, 4.7% ash, 1.2% fiber, and 48% oil (Semporé *et al*., 2021). Its oil is notable for a favorable fatty acid profile: oleic (73.73%), linoleic (13.60%), and stearic (10.20%) acids, which support cholesterol reduction (Liu *et al*., 2023). Cashew kernels are widely used in baking and confectionery and are also a rich source of essential minerals such as copper, phosphorus, magnesium, manganese, and zinc, alongside vitamins like pantothenic acid, pyridoxine, riboflavin, and thiamin (Wahauwouele *et al*., 2022). With 82% unsaturated fatty acids, cashews are considered a heart-healthy snack.

The date palm (*Phoenix dactylifera L*.) is a valuable crop from the *Arecaceae* family, producing nutrient-rich fruits which are affordable (Sejpal *et al*., 2025). Dates are primarily composed of carbohydrates, including natural sugars and dietary fiber, with minimal amounts of fats and proteins (Akhte *et al*., 2025). Moreover, dates contain a range of beneficial compounds with diverse health benefits, including anti-mutagenic, antioxidant, anti-microbial, anti-inflammatory, and anti-cancer properties, as well as protecting the liver, gut, and immune system (Fernández-López *et al*., 2022). Beyond fresh consumption, dates are also used as a natural flavour enhancer in dairy products, desserts, and other foods (Muhammad *et al*., 2020).

Bananas, a staple from the Musaceae family, are renowned for their exceptional nutritional value, particularly their abundance of bioactive compounds (Kumari, 2023). Native to tropical and subtropical regions, bananas are widely cultivated and readily available for various food applications. Consuming bananas offers numerous therapeutic advantages, primarily due to their high dietary fiber and phenolic content. Additionally, bananas and their derivatives have been discovered to exhibit antimicrobial, anticancer, and antioxidant properties, further solidifying their potential health benefits (Payal *et al.*, 2023).

Leveraging locally on abundant fruits like date palm (*Phoenix dactylifera*), rich in natural sugars, dietary fiber, and bioactive antioxidants, in combination with bananas, offers potential for creating nutrient-dense, clean-label spreads that avoid ultra-processed ingredients (Fernández-López *et al*., 2022; Payal *et al*., 2023). The current study bridges this gap by formulating a cashew nut–based spread complemented with date palm and ripe banana. This research aims to development innovative, plant-based spreads that meet growing consumer demand for healthier, minimally processed foods, while also advancing local agribusiness through value addition and diversification.

MATERIALS AND METHODS

Sources of Raw Materials

Roasted Cashew nuts, Dates, and ripe Bananas were from Eke-Awka Market in Awka South Local Government Area, Anambra State. All the chemicals and equipment used in this study were of analytical grade and were all made available at the Food Science and Technology Laboratory, Nnamdi Azikiwe University, Awka.

Cashew Nut Processing

The procedure outlined by Orisa *et al.* (2023) was adopted with little modifications. The roasted cashew nuts were sorted and milled into a smooth paste using a silver crest multi-function blender with the model number: Sc-1589. The cashew nut paste was allowed to cool and packed in a container.

Dates Palm Processing

The procedure outlined by Mondol (2025) was adopted with little modifications. Dried Date palms were sorted and washed and the seeds were removed manually. The date palm flesh was ground into a paste using a silver crest multi-function blender of the model number: Sc-1589. The date palm paste was packed in a plastic air-tight container.

Banana Processing

Ripe banana fruits were washed and peeled manually to remove the banana peel. The banana fruits were ground into slurry using a silver crest multi-function blender of the model number: Sc-1589. The ripe banana fruit slurry was also packed in a container and used immediately.

Experimental Design

Extreme Vertices mixture design was adopted for this research (Table 1).

Table 1: Extreme Vertices Mixture Design

Sample code	Std order	Run Order	Pt Type	Cashew nut	Date palm	Ripe Banana
CADB1	6	1	-1	63.3333	18.3333	18.3333
CADB2	1	2	1	70.0000	10.0000	20.0000
CADB3	3	3	1	70.0000	20.0000	10.0000
CADB4	2	4	1	60.0000	20.0000	20.0000
CADB5	4	5	0	66.6667	16.6667	16.6667
CADB6	7	6	-1	68.3333	18.3333	13.3333
CADB7	5	7	-1	68.3333	13.3333	18.3333

Formulation of Cashew Nut Spread Complemented with Date Palm and Ripe Banana

The procedure outlined by Mujidat *et al.* (2021) was adopted for the production of the spread with little modifications. The roasted cashew nut paste, date palm paste, and ripe banana slurry were weighed and mixed at different ratios as indicated in the experimental design (Table 1.) The spread was then pasteurized at 60°C for 3 minutes. It was allowed to cool, filled into airtight small plastic jars, and stored at room temperature.

Determination of Spreadability

The tests were performed with a TA.HD. Plus Texture Analyzer (Stable Micro Systems, Torun´, Poland). This was measured using penetration analysis with a "spreadability ring" spreadability test unit. During the analysis, the upper cone was inserted into the lower container (in the form of an inverted cone) at a speed of 3 mm/s until a gap of one millimeter was obtained between the two elements of this fixture. All samples were analyzed in triplicate. Samples at 20 ºC were placed in the bottom reservoir of the attachment without bubbles (Ziarno *et al.,* 2023).

Determination of Viscosity

The flow curve of spread samples was measured with an MCR302 modular compact rheometer (Anton Paar, Austria) in parallel plate geometry (PP50) by Rheo Compass software at room temperature (25 ± 0.2 °C) with three replicates by sample type. During the rotational test with controlled shear rate, the measurement consisted of two stages: first of all, increasing the shear rate from 0.0 1/s to 20 1/s. The data recording was reduced with a linear scale from 5 to 1 s, and 60 data were recorded during 180 s. In the second stage, the shear rate was constant at 20 1/s for 60 s, and 60 points were recorded. The apparent viscosity at 10 1/s on the flow curve and the viscosity were determined at a 20 1/s shear rate in the constant stage. The apparent viscosity and dynamic viscosity values of the samples were determined by Rheo Compass software (Anton Paar, Austria) (Nora *et al.,* 2023).

Sensory Analysis

Sensory evaluation was done for the produced cashew nut spread samples using randomly selected 20 semi-trained panelists from the Department of Food Science and Technology, Nnamdi Azikiwe University. A 9-point hedonic scale was used with the rating 9 as like extremely and 1 as dislike extremely. The Cashew nut spread produced was evaluated based on their quality characteristics of colour, flavour, taste, aroma, texture, and overall acceptability.

Statistical analysis

The data obtained were subjected to a one-way analysis of variance (ANOVA) using the SPSS statistics package version 25. While means separation was done with Duncan's Multiple range Test at $p<0.05$ levels.

RESULTS AND DISCUSSION

Functional Properties of Spread

The functional properties of the spread are presented in Table 2. Spreadability, which reflects the ease with which a product can be spread, ranged from 15.57 N/m in CADB4 (60 % Cashew: 20 % Date: 20 % Banana) to 26.16 N/m in CADB3 (70 % Cashew: 20 % Date: 10 % Banana). This variation can be attributed to the differences in ingredient composition and their respective textural properties. Higher spreadability values, such as that of CADB3 (70 % Cashew: 20 % Date: 10 % Banana), which contained a significant proportion of cashew nuts; suggest that the nut's oil content contributes to a smoother, creamier texture. The oil in cashew nuts is primarily composed of mono-unsaturated fatty acids, which have been shown to enhance the mouthfeel and spreadability of spreads (Meneguelli *et al.*, 2024). Conversely, lower spreadability observed in CADB4 (60 Cashew: 20 Date: 20 Banana) could be linked to the higher proportion of dates and bananas, which contain more fiber and sugar, resulting in a thicker, less spreadable consistency. According to John and Gurumurthy (2023), the fiber content in fruits can increase viscosity, thereby reducing spreadability. This aligns with the findings of Wu *et al.* (2023), who reported that spreads with higher fiber content from legumes had significantly lower spreadability due to the gel-like texture created by soluble fibers.

Viscosity measurements have a similar trend observed in spreadability, with values ranging from 20.15 N-s/m^2 in CADB4 (60 % Cashew: 20 % Date: 20 % Banana) to 35.70 N-s/m^2 in CADB3 (70 % Cashew: 20 % Date: 10 % Banana). There was significant ($p<0.05$) variations in the viscosity of the samples. Viscosity is a critical factor affecting the stability and shelf life of spreads, as higher viscosity can prevent phase separation and improve overall texture (Han *et al.*, 2025). The increased viscosity in CADB3 (70 % Cashew: 20 % Date: 10 % Banana) can also be explained by the emulsifying properties of cashew nuts which was in high proportion, which help to stabilize the mixture and create a thicker, and creamier product. This finding is consistent with previous research, which noted that emulsified products often exhibit higher viscosity due to the uniform distribution of fat and water phases (Kupikowska-Stobba *et al*., 2024).

Table 2: Functional Properties of Cashew Nut Spread Supplemented with Date Palm and Ripe Banana

Sample	Spreadability (N/m)	Viscosity (N-s/m^2)
CADB1	$16.49^{f}\pm0.10$	$22.10^{f}\pm0.10$
CADB2	$22.07^{b}\pm0.08$	$28.73^{b}\pm0.05$
CADB3	$26.16^{a}\pm0.11$	$35.70^{a}\pm0.25$
CADB4	$15.57^{g}\pm0.11$	$20.15^{g}\pm0.04$
CADB5	$18.19^{e}\pm0.11$	$25.78^{e}\pm0.05$
CADB6	$20.82^{c}\pm0.12$	$28.11^{c}\pm0.02$
CADB7	$19.51^{d}\pm0.16$	$26.28^{d}\pm0.04$

Means with different superscripts along the same column are significantly different ($p<0.05$). ***Key:*** *CADB1 = 63.3 % Cashew: 18.3 % Date: 18.3 % Banana, CADB2 = 70 % Cashew: 10 % Date: 20 % Banana, CADB3 = 70 % Cashew: 20 % Date: 10 % Banana, CADB4 = 60 % Cashew: 20 % Date: 20 % Banana, CADB5 = 66.6 % Cashew: 16.6 % Date: 16.6 % Banana, CADB6 = 68.3 % Cashew: 18.3 % Date: 13.3 % Banana, CADB7 = 68.3 % Cashew: 13.3 % Date: 18.3 % Banana*

Sensory Evaluation of the Spread

The sensory evaluation of cashew nut spread supplemented with date and ripe banana revealed significant ($p<0.05$) variations in sensory attributes across different samples (Table 3). Sensory quality refers to the characteristics of a food product that can be perceived by the senses; sight, taste, smell, touch, and hearing.

The appearance scores ranged from 6.30 in sample CADB7 (68.3 % Cashew: 13.3 % Date: 18.3 % Banana) to 8.80 in sample CADB1 (63.3 % Cashew: 18.3 % Date: 18.3 % Banana), indicating that formulations with higher cashew content tend to enhance visual appeal. This observation aligns with the findings by Hegazy *et al.* (2020), which suggests that the rich colour and texture of nuts can significantly improve a product's attractiveness.

Table 3: Sensory Evaluation of Cashew Nut Spread Supplemented with Date Palm and Ripe Banana

Sample	Appearance	Taste	Texture	Mouthfeel	Flavour	Overall Acceptability
CADB1	$8.80^{a}\pm0.11$	$8.00^{a}\pm0.08$	$8.80^{a}\pm0.03$	$8.20^{a}\pm0.11$	$8.90^{a}\pm0.11$	$8.60^{a}\pm0.12$
CADB2	$8.70^{a}\pm0.02$	$8.30^{a}\pm0.10$	$8.70^{a}\pm0.22$	$8.00^{a}\pm0.01$	$8.50^{a}\pm0.06$	$8.30^{ab}\pm0.08$
CADB3	$8.30^{a}\pm0.10$	$8.70^{a}\pm0.04$	$8.30^{a}\pm0.16$	$8.20^{a}\pm0.13$	$8.80^{a}\pm0.12$	$8.50^{a}\pm0.02$
CADB4	$7.30^{ab}\pm0.08$	$7.00^{ab}\pm0.02$	$7.30^{ab}\pm0.12$	$8.00^{a}\pm0.03$	$7.20^{b}\pm0.10$	$7.20^{b}\pm0.11$
CADB5	$8.80^{a}\pm0.06$	$7.10^{ab}\pm0.10$	$8.80^{a}\pm0.06$	$8.80^{a}\pm0.04$	$8.20^{a}\pm0.02$	$8.60^{a}\pm0.03$
CADB6	$7.30^{ab}\pm0.11$	$8.30^{a}\pm0.01$	$7.30^{ab}\pm0.18$	$7.30^{b}\pm0.07$	$8.30^{a}\pm0.05$	$8.30^{ab}\pm0.10$
CADB7	$6.30^{c}\pm0.06$	$7.60^{b}\pm0.05$	$6.70^{b}\pm0.06$	$7.80^{b}\pm0.11$	$6.06^{c}\pm0.02$	$6.80^{c}\pm0.05$

Values are means ± standard deviations. Means with different superscripts along the same column are significantly ($p<0.05$) different. ***Key****: CADB1 = 63.3 % Cashew: 18.3 % Date: 18.3 % Banana, CADB2 = 70 % Cashew: 10 % Date: 20 % Banana, CADB3 = 70 % Cashew: 20 % Date: 10 % Banana, CADB4 = 60 % Cashew: 20 % Date: 20 % Banana, CADB5 = 66.6 % Cashew: 16.6 % Date: 16.6 % Banana, CADB6 = 68.3 % Cashew: 18.3 % Date: 13.3 % Banana, CADB7 = 68.3 % Cashew: 13.3 % Date: 18.3 % Banana.*

In terms of taste, scores significantly ($p < 0.05$) varied from 7.10 in CADB5 (66.6% cashew: 16.6% date: 16.6% banana) to 8.70 in CADB3 (70% cashew: 20% date: 10% banana), indicating that specific cashew–fruit ratios can enhance sweetness, nutty intensity, and overall palatability. Notably, the higher cashew proportion in CADB3 likely amplified nut-derived volatiles and roasted notes, consistent with the report of Stéphane *et al.* (2020), who reported that greater nut content often elevates perceived taste intensity. However, the fact that CADB3, despite its highest taste score, did not achieve the highest overall acceptability suggests that taste alone is not the principal purchase driver in nut-fruit spreads; instead, consumers appear to integrate texture, mouthfeel, and flavour complexity when forming global judgments.

Texture scores ranged from 6.70 in CADB7 (68.3% cashew: 13.3% date: 18.3% banana) to 8.80 in CADB1 (63.3% cashew: 18.3% date: 18.3% banana), with differences significant at $p < 0.05$. The superior texture of CADB1 implies that a slightly lower cashew fraction, when balanced with equal proportions of date and banana, improves particle lubrication and spreadability attributes widely preferred by consumers as noted by Stéphane *et al.* (2025). In contrast, CADB7's lower texture score may reflect a fibre driven pastiness and/or increased particulates from a higher banana-to-date ratio, underscoring the importance of the fruit matrix in modulating viscosity and creaminess at constant or near-constant fat levels.

Mouthfeel scores also differed significantly ($p < 0.05$), ranging from 7.30 in CADB6 (68.3% cashew: 18.3% date: 13.3% banana) to 8.80 in CADB5 (66.6% cashew: 16.6% date: 16.6% banana). While CADB5 provided the smoothest mouthfeel, the combined performance of CADB1—pairing top-tier texture (8.80) with the highest flavour score (8.90)—suggests that consumers value harmonised sensory cues over optimisation of any single cue. This aligns with Khan *et al*. (2021), who emphasised mouthfeel as a key contributor to satisfaction but not necessarily a standalone predictor of overall liking in complex, fat-containing matrices.

Flavour scores ranged from 6.06 in CADB7 to 8.90 in CADB1, highlighting the critical role of ingredient balance in delivering nut-forward notes complemented by fruit aroma and natural sweetness. The equal fruit split in CADB1 (CADB1 = 63.3 % Cashew: 18.3 % Date: 18.3 % Banana) appears to have mitigated the green/pectic notes sometimes associated with banana-dominant systems while leveraging date's caramel-like undertones, yielding a more rounded flavour profile (Muhammad *et al.,* 2020) on flavour diversity driving acceptability.

Overall acceptability ranged from 6.80 in CADB7 to 8.60 in CADB1, establishing CADB1 (63.3% cashew: 18.3% date: 18.3% banana) as the preferred formulation. Putting into consideration, the cost of materials, CADB1 stands as the best as it is strategically advantageous because it uses less cashew than a 70% cashew benchmark in respect to CADB3 while achieving higher flavour and overall acceptability. Relative to 70% cashew, CADB1 reduces cashew usage by 6.7%. Given that cashew kernels are typically the most expensive input and subject to price volatility, this shift can improve margins and supply resilience without sacrificing consumer preference. Moreover, the equal date - banana split supports a fruit-sweetened positioning that resonates with clean-label trends and can command a premium price point. The poorer-scoring CADB7 highlights a formulation space to avoid, as unappealing

sensory parameters can translate directly into customer complaints.

CONCLUSION AND RECOMMENDATIONS

This study has demonstrated that spread could be produced from cashew nut complemented with date palm and ripe banana. Formulation ratios significantly influenced the spread's characteristics, with higher cashew nut proportions contributing to improved spreadability and viscosity. Formulations containing approximately 63 - 67% cashew nut, complemented with 16 - 18% date palm and ripe banana, can be used to achieve highly acceptable spreads. These results highlight the potential of cashew nut-based spreads as nutritious, plant-based alternatives to conventional nut butters. Shelf-life study of the spreads is recommended.

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Authors' Contributions

CCE conceptualized the study. CCE & JG designed the experiment, collected data, performed data analysis, and wrote the first draft of the manuscript. JG & FO performed literature searches and reviewed the first draft of the manuscript. FO & MCE reviewed, edited and formatted the second draft. All authors read and approved the final draft of the manuscript.

Ethical Statement

Not applicable

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