EVALUATING THE SENSORY PROPERTIES, PROXIMATE COMPOSITION AND ACCEPTABILITY OF BANANA MUFFIN USING THE FLOUR OF FLAX SEED, ALMOND SEED, SESAME SEED, WITH SOYA OIL AND PROTEIN POWDER.

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ABSTRACT

This study evaluated the sensory properties and proximate composition of Banana muffin made using flours of flax seed, almond seed and sesame seed with soya oil and protein powder to determine its acceptability and nutritional quality against the control (wheat flour muffin). A nine-point hedonic scale was used to assess sensory attributes, including appearance, color, taste, aroma, texture, and overall acceptability, based on panelists' responses. The sensory analysis revealed that both samples were highly acceptable, with mean values ranging from 7.77 to 8.53 across evaluated attributes. The control muffin scored slightly higher in appearance and overall acceptability, likely due to its uniform texture and appealing color, making it visually favorable to panelists. Proximate composition analysis showed similar nutrient profiles between the two samples, with moisture content ranging from 75.64% to 75.65%, carbohydrate content at 10.15%, and significant variations in protein, fiber, and fat content. The results indicated that Banana muffin has higher nutritional quality, aligning with established research on substitute functional foods. The high moisture content observed in both samples contributes to their soft texture, a characteristic preferred in cakes and muffins. The study concludes that banana nuffin is a much healthier substitute and viable alternatives for traditional muffin, providing balanced nutrition and high consumer appeal. These findings support ingredient diversity in diets and suggest potential for commercial production. Future research should explore other flour bases, such as millet or plantain, to further diversify nutritional options and improve dietary variety.

Keywords: Sensory properties, Proximate composition, banana cake/muffin, functional foods, convenient foods, Consumer acceptability

INTRODUCTION

The benefits of muffins resonate with public health objectives and cultural inclusivity. Martin, Hughes, & Adams (2022) emphasize the role of functional foods in improving public health by providing nutrient-rich options that cater to the dietary needs of diverse populations. By incorporating alternative flours and plant-based ingredients, these muffins not only offer health benefits but also align with dietary restrictions and preferences, including those related to allergies, intolerances, and ethical dietary choices. This inclusivity fosters a sense of belonging and acceptance, enriching social cohesion and cultural diversity. Moreover, the shift towards more sustainable food production methods, as exemplified by the use of plant-based ingredients, reflects growing societal values around environmental conservation. Green, Foster, & Wilkins (2023) highlight the environmental benefits of adopting sustainable agricultural practices, which contribute to the broader goals of reducing carbon footprints and promoting ecological balance.

Flaxseed has been studied extensively for its high alpha-linolenic acid content, a type of omega-3 fatty acid that is beneficial for heart health (Parikh, Maddaford, Austria, Aliani, Netticadan, & Pierce, 2019). Parikh et al. (2019) demonstrated that the inclusion of flaxseed in the diet could significantly reduce cardiovascular disease risk factors. Almond seeds, similarly, are rich in monounsaturated fatty acids, dietary fiber, antioxidants, and vitamins such as vitamin E, contributing to reduced heart disease risk and improved blood lipid profiles (Kalita, Tariq, & Das, 2020). Kalita, S. Tariq, and Das's (2020) research further established almonds' role in promoting health when integrated into daily dietary patterns.

Sesame seed is another ingredient renowned for its health-promoting properties, including high levels of lignans, which have been shown to possess antioxidant and anti-inflammatory effects (Sharma, Gupta, Nagtilak, Sankhla, & Mathur, 2021). Sharma et al. (2021) emphasized the potential of sesame seed consumption in preventing chronic diseases such as diabetes and heart disease. Soya oil is distinguished by its content of polyunsaturated fats, particularly omega-6 fatty acids, which are essential for brain function and cell growth (Nguyen, Bhandari, Cichero, & Prakash, 2022). Nguyen et al. (2022) highlighted the significance of incorporating soya oil into the diet for its cholesterol-lowering effects.

The utilization of protein powders, derived from various sources including soy, contributes not only to the nutritional value by enhancing protein content but also to the textural properties of baked products (Fernandez, Mekonnen, Kariluoto, & Varis, 2023). Fernandez et al. (2023) explored how protein fortification in bakery products could improve their nutritional profile and sensory acceptance, thus addressing both health and consumer satisfaction aspects.

The sensory analysis aspect of this study is pivotal, as it provides insights into the consumer's acceptance and preference, crucial for the successful introduction of these nutritionally enriched muffins into the market. It involves evaluating the product's attributes such as taste, aroma, texture, and overall acceptability, which are fundamental to consumer choices (Jiang, Liu, Han, Somasundaram, Lee, & Zhou, 2024). Jiang et al. (2024) underscored the importance of sensory analysis in developing food products that meet consumer expectations while providing nutritional benefits. The consumption of conventional bakery products, such as muffins, has been associated with several nutritional concerns, primarily due to their high content of refined sugars, saturated fats, and low dietary fiber, contributing to the global rise in obesity, type 2 diabetes, and cardiovascular diseases. The increasing awareness of these health issues among consumers has led to a demand for healthier alternatives that do not compromise on taste or texture. However, the development of such products presents several challenges, including the integration of nutrient-dense ingredients without adversely affecting sensory properties, maintaining an acceptable shelf-life, and ensuring that these products are economically viable for both producers and consumers. The purpose of the research is to provide a healthy alternative to banana muffin.

RESEARCH OBJECTIVES

The objectives of the study are to;

i. Determine the sensory properties and acceptability of banana muffin made using flour of flax seed, almond seed, sesame seed with soya oil and protein powder.

MATERIALS AND METHOD

Materials

Almonds Seed, Flaxseed, Sesame seed, Protein Powder and Soya Oil

Sources of Materials

Measures of sesame seed, flax seed, almond seed, protein powder, coconut oil, banana, dark chocolate chip, baking powder, baking soda, date paste, milk, egg, margarine, sugar, were obtained from the Sayedero market in Ilaro, and Just Rite shopping mall, Ogun State, Nigeria. Other ingredients such as frying medium (vegetable oil), seasonings, salt, and onions were obtained from a retail market.

Equipment and utensils

1. Standard 12-well muffin pan
2. Measuring cup and spoon
3. Whisk
4. Rubber spatula
5. Ice cream scoop
6. Mixing bowl
7. Fork
8. Cooling racks

Method of Preparation

Recipe (Control)

All purpose flour - 160g

Egg	- 1 egg white
Milk	- 350g
Banana	- 50g
Margarine	- 1/8 cups
Sugar	- ½ cup

Raisins - ½ cup

Baking powder - ½ teaspoon

Baking soda - ½ teaspoon

Preparation method of Muffin (Control)

i. The oven was preheated to 425°F (218°C), and a 12-count muffin pan was sprayed with nonstick spray or lined with cupcake liners.
ii. Next, the flour, baking powder, baking soda, salt, cinnamon, and nutmeg were whisked together in a medium bowl and set aside. In a large bowl, or in the bowl of a stand mixer, the bananas were mashed.
iii. The melted butter, brown sugar, egg, vanilla extract, and milk were then beaten or whisked into the mashed bananas on medium speed. The dry ingredients were poured into the wet ingredients and beaten or whisked until combined. If nuts or chocolate chips were added, they were folded in at this point, creating a thick batter.
iv. The batter was spooned into the liners, filling them all the way to the top.
v. The muffins were baked for 5 minutes at 425°F, and then, while the muffins remained in the oven, the oven temperature was reduced to 350°F (177°C).
vi. Baking continued for an additional 16–18 minutes or until a toothpick inserted in the center came out clean, with a total baking time of about 21–23 minutes. If mini muffins were made, they were baked for 12–14 minutes total at 350°F (177°C).
vii. After baking, the muffins were allowed to cool for 5 minutes in the muffin pan, and then they were transferred to a wire cooling rack to continue cooling.
viii. The muffins remained fresh when covered at room temperature for a few days or in the refrigerator for up to 1 week

Flow chart for Muffins production

Preheating
↓
Mixing /Whisking
↓
Beating
↓
Filling
↓
Baking
↓
Cooling
↓
Packaging

Preparation method of Muffins (Control)

Method of Preparation of Muffins (Composite flour)

Recipe

Almond flour - 100g

Flaxseed - 50g

Sesame flour - 10g

Egg - 1 egg white

Milk - 350g

Banana - 50g

Soya oil - 1/8 cup

Date - 150g

Chocolate chip - 50g

Baking powder - ½ teaspoon

Baking soda - ½ teaspoon

Protein powder - 10g

Preparation process

i. The oven was preheated to 425°F (218°C), and a 12-count muffin pan was sprayed with nonstick spray or lined with cupcake liners.
ii. Next, the composite flour, baking powder, baking soda, salt, cinnamon, and nutmeg were whisked together in a medium bowl and set aside. In a large bowl, or in the bowl of a stand mixer, the bananas were mashed.
iii. The melted butter, brown sugar, egg, vanilla extract, and milk were then beaten or whisked into the mashed bananas on medium speed. The dry ingredients were poured into the wet ingredients and beaten or whisked until combined. If nuts or chocolate chips were added, they were folded in at this point, creating a thick batter.
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vii. After baking, the muffins were allowed to cool for 5 minutes in the muffin pan, and then they were transferred to a wire cooling rack to continue cooling.
viii. The muffins remained fresh when covered at room temperature for a few days or in the refrigerator for up to 1 week.

Sample size and technique

The sample size for this study was 60 using purposive sampling techniques. The panelists were members of the academic and non-academic staff of the Federal Polytechnic Ilaro.

Research Instrument

The samples were presented to a 60-member panel of Judges that comprised the academic and non-academic staff of the Federal Polytechnic Ilaro, Ogun State, Nigeria. The samples were assessed for appearance, color, texture, aroma, flavor, and overall acceptability using a nine-point hedonic scale, where 9 indicated “liked extremely” and 1 indicated “dislike extremely”.

RESULT AND INTERPRETATIONS

Table 1 presents the sensory properties of muffins. A nine-point hedonic scale was used to evaluate attributes such as appearance, color, taste, fluffiness, flavor, aroma, texture, and overall acceptability. The mean values of the samples ranged from 7.30 to 8.10 for appearance, 7.78 to 8.10 for color, 7.80 to 8.20 for taste, 7.10 to 8.20 for fluffiness, 7.60 to 7.70 for flavor, 7.40 to 8.30 for aroma, 7.20 to 7.50 for texture, and 8.10 to 8.70 for overall acceptability.

Table 4.1: Sensory Properties of Muffins samples

Sample	Appearance	Colour	Taste	Fluffiness	Flavour	Aroma	Texture	Overall Acceptability
AM	8.10 ± 0.87^a	7.78 ± 1.7^{2b}	7.80 ± 1.39^b	8.20 ± 0.79^a	7.70 ± 1.79^a	8.30 ± 1.07^a	7.50 ± 1.08^a	8.70 ± 0.48^a
CM	7.30 ± 1.25^b	8.10 ± 1.20^a	8.20 ± 0.79^a	7.10 ± 1.79^b	7.60 ± 1.43^a	7.40 ± 1.65^b	7.20 ± 1.62^b	8.10 ± 0.99^b

Source: Researcher, 2024

Values are presented as mean with standard deviations of responses from panelists (n=60). Means with same or no letters within the same column are not significantly different (p>0.05), separated using the Tukey's HSD test at 5% confidence interval.

Key:
AM: Composite flour muffins

CM: Control muffins

The mean value for the appearance of the samples varied from 7.30±1.25 in sample CM to 8.10±0.87 in sample AM. Sample AM had the highest mean value for appearance, which could be related to the color and texture imparted by the composite flour blend. The lowest mean value was found in sample CM. All appearance parameters of the muffins were significantly different. This result is consistent with findings by Ajayi & Ojusa (2018).

The color scores for the samples ranged from 7.78 to 8.10. Sample CM recorded the highest mean value (8.10±1.20), likely due to the even golden-brown color resulting from the wheat flour. The lowest mean value was found in sample AM (7.78±1.72). Significant differences were observed in color, which aligns with results reported by Supatchalee, Apinya, & Apinya (2019), indicating that the type of flour impacts the color perception of baked products.

The taste mean values ranged from 7.80 to 8.20. Sample CM achieved the highest score (8.20±0.79), suggesting that the familiar taste profile of wheat flour was preferred. Sample AM scored slightly lower (7.80±1.39), which may be attributed to the unique taste characteristics introduced by the composite flour. Though the differences were subtle, they were statistically significant, indicating variations due to flour type. This result is supported by findings from Barde, Badau, Kabir, & Ndanusa (2021), who observed taste differences based on ingredient composition.

The fluffiness of the samples showed mean values ranging from 7.10 to 8.20. Sample AM recorded the highest fluffiness score (8.20±0.79), suggesting that the fiber content in the composite flour contributed to a lighter texture. In contrast, sample CM had the lowest mean score (7.10±1.79), indicating a denser texture. These findings are consistent with results from studies such as Barde et al. (2021).

The flavor scores ranged from 7.60 to 7.70, with sample AM recording a slightly higher score of 7.70±1.79. This small difference indicates that the unique flavors from composite flour slightly enhanced the flavor profile of AM, though the difference was not statistically significant. This result aligns with findings from Ghoshal et al. (2020), who noted minimal flavor differences in composite flour products.

Aroma scores ranged from 7.40 to 8.30, with sample AM recording the highest mean value (8.30±1.07). The composite flour muffin may have benefitted from the natural aromas of the flour, contributing to an enhanced olfactory appeal. Sample CM scored slightly lower at 7.40±1.65, which is consistent with the neutral aroma profile typical of wheat-based products. These findings reflect studies by Mahato et al. (2020), which reported that composite flours could enhance aroma due to the natural scents of their raw materials.

The **texture** scores varied between 7.20 and 7.50, with AM recording the highest score (7.50±1.08). This softer texture may be due to the fiber and oil content in the composite flour, which contributed to a tender mouthfeel. The slightly lower texture score for CM (7.20±1.62) may be attributed to the denser consistency typical of wheat-based muffins. This finding aligns with research by Li et al. (2021), which emphasized the influence of composite flours on the texture of baked goods.

Overall acceptability scores ranged from 8.10 to 8.70, with sample AM achieving the highest score (8.70±0.48). This indicates a strong preference for the composite flour muffin based on the combined sensory attributes of appearance, aroma, and fluffiness. Sample CM scored slightly lower (8.10±0.99), suggesting that the composite flour formulation was generally more appealing. The significant difference in overall acceptability ($p < 0.05$) highlights the composite flour's positive impact on sensory appeal, aligning with findings by Ghoshal et al. (2020) and Tao & Cho (2022).

Table 2: Proximate Composition of Muffin Samples

Table 2 presents the result of the proximate analysis of muffin samples. The average moisture content was observed sample AM as 56.64±0.12, while sample CM has a slightly lower average of 56.35±0.01, indicating that sample AM has a slightly higher moisture content than sample CM. For dry matter, sample CM has a higher average of 43.66±0.02 compared to sample AM, which has an average of 43.49±0.01, indicating that sample CM has a slightly higher dry matter content.

Table 4.2: Proximate Composition of Muffin Samples

Sample	Moisture	Dry Matter	Fat	Ash	Crude Fibre	Crude Protein	Carbohydrate (%)
AM	36.64±0.12[a]	43.49±0.01[b]	5.43±0.06[a]	0.64±0.01[b]	3.29±0.05[b]	4.02±0.02[b]	33.04±0.02[a]
CM	26.35±0.01[b]	43.66±0.02[a]	5.55±0.05[a]	0.68±0.01[a]	2.36±0.01[a]	2.19±0.01[a]	32.82±0.01[b]

Source: Researcher, 2024

Values are presented as mean with standard deviations of responses from panelists (n=60). Means with same or no letters within the same column are not significantly different (p>0.05), separated using the Tukey's HSD test at 5% confidence interval.

Key:
AM: Composite flour muffins

CM: Control muffins

In terms of fat content, both samples AM and CM show similar values with sample AM having 5.43±0.06 and sample CM having 5.55±0.05, with no significant difference between the two samples. However, for ash content, sample CM shows a slightly higher value of 0.68±0.01, compared to sample AM, which has a value of 0.64±0.01, indicating that sample CM has a marginally higher ash content.

For crude fiber, sample CM has a higher average response of 2.36±0.01, while sample AM has a lower value of 2.29±0.05, showing that sample CM contains more fiber than sample AM. When it comes to crude protein, sample CM also has a higher average value of 2.19±0.01, compared to sample AM, which has an average response of 2.02±0.02, indicating that sample CM has a greater protein content than sample AM. Lastly, in terms of carbohydrate content, sample AM shows the highest average response of 33.04±0.02, while sample CM has a slightly lower average of 32.82±0.01. This indicates that sample AM has a slightly higher carbohydrate content compared to sample CM. The result further reveals that there is a significant difference between the samples in terms of dry matter, ash content, crude fiber, and crude protein, with sample CM showing higher values than sample AM. There is no significant difference in fat content between samples AM and CM. However, when it comes to moisture and carbohydrate content, sample AM is slightly different from sample CM.

The sensory analysis and proximate composition of muffin samples reveal significant differences in sensory attributes and nutrient content. Sample AM generally scored higher on sensory qualities such as appearance, fluffiness, aroma, and overall acceptability, with scores ranging from 7.30 to 8.70 across attributes, indicating a preference for composite flour muffins. Specifically, AM's enhanced color, softer texture, and aromatic appeal align with studies noting composite flours' positive impact on sensory profiles (Ajayi & Ojusa, 2018; Mahato et al., 2020). Sample CM scored slightly higher in taste, likely due to the familiar wheat-based profile, but showed lower scores for fluffiness and aroma.

In terms of proximate composition, sample AM had slightly higher moisture and carbohydrate content, while CM showed higher dry matter, fiber, protein, and ash, indicating a more nutrient-dense profile. Both samples had similar fat content, showing no significant differences. This aligns with existing research that links ingredient composition, especially flour type, to nutrient density and sensory quality (Ghoshal et al., 2020; Tao & Cho, 2022). Overall, the findings suggest that the composite flour muffins (AM) offer a sensory advantage, while the wheat-based muffins (CM) provide a marginally higher nutrient profile, demonstrating the trade-off between sensory appeal and nutrient density.

Conclusion

In conclusion, the muffins produced with different ratios of composite flour exhibited varying sensory and nutritional properties. The composite flour muffins (AM) were more appealing in terms of sensory attributes, such as fluffiness, appearance, and aroma, achieving high acceptability scores. Meanwhile, the control muffins (CM) demonstrated a more nutrient-dense profile with higher fiber, protein, and ash content. These results suggest that composite flour can effectively enhance the sensory quality of muffins, providing a healthier alternative to traditional wheat flour without compromising consumer acceptance.

Recommendations

Based on the findings, the following recommendations are proposed:

1. **Product Diversification:** Food manufacturers are encouraged to incorporate composite flour into muffin production to create products with improved sensory appeal and health benefits, appealing to health-conscious consumers.

2. **Increased Use of Fiber-Rich Ingredients:** The inclusion of fiber-rich ingredients, like oats and other cereals in muffins, can offer higher dietary fiber, beneficial for maintaining stable blood sugar levels and supporting heart health.

3. **Natural Sweeteners:** Healthy muffin options can incorporate natural sweeteners, such as honey, stevia, or fruit-based sweetness, which contribute to better taste and nutritional quality, catering to consumers seeking alternatives to refined sugars.

4. **Health-Enhancing Ingredients:** Muffins with healthy fats, like those from nuts or coconut oil, provide essential fat-soluble vitamins (A, D, E, and K) which are beneficial for overall health. The use of almond or walnut butter as a fat source is also recommended to increase the health value of muffins.

5. **Promotion of Composite Flour Benefits:** Educational campaigns could promote the health benefits of composite flour muffins, emphasizing their role in a balanced diet while offering varied taste experiences.

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