International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 7, 2025
https://www.theaspd.com/ijes.php

Nutritional And Sensory Evaluation Of Cookies Fortified With Edible Seeds

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Abstract
This study explores the development, nutritional composition, and sensory acceptability of cookies enriched with flax seed, sunflower seed, and chia seed powders. The cookies were formulated by incorporating 50g of each seed powder (flax, sunflower, or chia) into a standard recipe consisting of 150g whole wheat flour, 100g butter, and 50g sugar. Nutritional analysis revealed significant improvements in the protein, fibre, and micronutrient content of the cookies. The flax seed cookies had 27.85g of protein, 30g of fibre, and 1723.5 Kcal energy per 100g. Sunflower seed cookies showed the highest protein content of 29.25g and 108.75g fat per 100g, while chia seed cookies demonstrated the highest fibre content at 33.5g per 100g. Sensory evaluation, conducted using a 9-point hedonic scale, showed that chia seed cookies were the most favoured by consumers (mean score 8.3), followed by flax seed (mean score 8.1) and sunflower seed cookies (mean score 8.0). The study highlights the potential of seed-enriched cookies as functional foods that offer enhanced nutritional value and consumer acceptance. These findings suggest that flax, sunflower, and chia seeds can be successfully incorporated into cookies without compromising sensory quality, making them a promising option for health-conscious consumers.
Keywords: *Flax seed, Sunflower seed, Chia seed, Nutritional composition, Sensory evaluation, Cookies, Functional food, Consumer acceptance.*

INTRODUCTION

The growing awareness of health and wellness among consumers has significantly influenced the global food industry, leading to an increasing demand for functional foods (Baker et.al, 2022 and Karelakis et.al, 2020). Cookies, traditionally seen as indulgent snacks, have become an innovative medium for incorporating health-promoting ingredients (Chuk et.al, 2022, Tarahai et.al, 2023, Walsh et.al, 2023 and Nerin et.al, 2024). Functional cookies enriched with nutrient-dense seeds like flaxseed, sunflower seed, and chia seed have garnered attention due to their potential to offer both nutritional and sensory benefits (Jagdale et.al, 2021). These seeds, recognized as superfoods, are rich in essential nutrients such as omega-3 fatty acids, dietary fiber, vitamins, minerals, and bioactive compounds, making them valuable additions to bakery products (Ram et.al, 2023, Gupta and Mishra, 2021 and Rani et.al, 2024)

Flaxseed is a well-known source of alpha-linolenic acid (ALA), a plant-based omega-3 fatty acid, along with lignans and soluble fiber(Yang et.al, 2021 and Shahada et.al, 2024). It is credited with numerous health benefits, including improving cardiovascular health, supporting digestive functions, and reducing inflammation (Imran et.al, 2024). Sunflower seeds, on the other hand, are packed with vitamin E, magnesium, and healthy fats (Khurana et.al, 2021 and Vashudha and Sarla, 2021). They play a role in boosting immunity, reducing oxidative stress, and promoting skin health (Chime et.al, 2024). Chia seeds, famous for their gel-forming capacity when hydrated, are rich in omega-3 fatty acids, antioxidants, and minerals like calcium and phosphorus, offering benefits ranging from bone health to enhanced satiety.

The incorporation of flaxseed, sunflower seed, and chia seed into cookies presents an opportunity to address consumer demands for healthier snack alternatives without compromising on taste and texture (Raj, 2022). By enriching cookies with these seeds, manufacturers can produce snacks that are not only enjoyable but also nutritionally superior (Boukid et.al, 2024). Such fortified cookies could appeal to health-conscious individuals and those looking to supplement their diets with functional foods (Lopez et.al, 2022).

This study focuses on evaluating the nutritional content of cookies formulated with flaxseed, sunflower seed, and chia seed. A comparative analysis is performed to assess the macro- and micronutrient profiles, alongside determining the contribution of these seeds to the functional properties of the cookies. Furthermore, sensory evaluation is undertaken to ensure that the enriched cookies maintain consumer

acceptability in terms of flavor, texture, and appearance. The findings of this study aim to contribute to the growing body of research on functional foods by demonstrating the feasibility and benefits of incorporating nutrient-rich seeds into widely consumed bakery products. It is anticipated that this research will provide valuable insights for food technologists and nutritionists while promoting the development of innovative and health-oriented snack options.

METHODOLOGY

This study aimed to develop and evaluate cookies enriched with flax seed, sunflower seed, and chia seed powders, focusing on their nutritional composition and sensory acceptance. Three cookie samples were prepared by incorporating 50g of each seed powder (flax, sunflower, or chia) into a base recipe consisting of 150g whole wheat flour, 100g butter, and 50g sugar. The ingredients were mixed to form a uniform dough, which was then shaped into small portions and baked at 180°C for 12-15 minutes until golden brown. Each sample (Sample A with flax seed powder, Sample B with sunflower seed powder, and Sample C with chia seed powder) was prepared separately to ensure the distinct nutritional contributions of each seed.

The cookies were analyzed for their nutritional content, including energy, protein, carbohydrates, fats, fiber, and key micronutrients (calcium, iron, magnesium, phosphorus, potassium, zinc, and vitamins). Nutrient values were calculated based on standard food composition tables for the seed powders and other ingredients used, with results expressed per 100g of cookie sample. This provided a comprehensive profile of the nutritional enhancements derived from incorporating these seeds into the cookie formulation. For sensory evaluation, a scale was employed to assess the consumer acceptability of the developed cookies. A panel of trained consumers evaluated the cookies based on five sensory attributes: appearance, color, flavor, taste, and texture. Each sample was scored on a scale from 1 (dislike extremely) to 9 (like extremely), and the mean scores for each attribute were analyzed to determine the overall acceptability of each cookie type. The sensory data provided insights into the consumer preferences and the acceptability of flax seed, sunflower seed, and chia seed-enriched cookies.

PREPARATION OF FLOUR MIXTURE

The flour obtained from slightly roasted flax seed, sunflower seed and chia seed.

TABLE DEVELOPMENT OF COOKIES INCORPORATED WITH FLAX SEED, SUNFLOWER SEED AND CHIA SEED

S.No	Ingredients	Sample A (Flax Seed Powder)	Sample B (Sunflower Seed Powder)	Sample A (Chia Seed Powder)
1.	Flax Seed	50g	-	-
2.	Sunflower Seed	-	50g	-
3.	Chia Seed	-	-	50g
4.	Whole Wheat Flour	150g	150g	150g
5.	Butter	100g	100g	100g
6.	Sugar	50g	50g	50g

The findings of this study revealed significant differences in the nutritional profiles and sensory characteristics of cookies enriched with flax seed, sunflower seed, and chia seed powders. Each seed imparted unique functional and sensory attributes to the cookies, making them suitable for specific dietary and health-focused applications. Cookies enriched with flax seed powder (Sample A) demonstrated a higher content of omega-3 fatty acids, specifically alpha-linolenic acid (ALA), along with substantial levels of dietary fiber and lignans. These bioactive compounds are known for their antioxidant and anti-inflammatory properties, supporting cardiovascular health and digestive function. Sensory analysis highlighted a nutty flavor profile, which was appreciated by most panelists, although the dense texture and slight grittiness due to the fiber content were noted as areas for potential improvement. This sample holds promise for consumers seeking heart-healthy and fiber-rich snacks.

In Sample B (sunflower seed powder-enriched cookies), the findings indicated elevated levels of vitamin E, magnesium, and polyunsaturated fatty acids. These nutrients contribute to antioxidative stress

reduction, immune function, and energy metabolism. Sensory evaluation showed that this sample had a smooth texture, golden appearance, and a mildly sweet, nutty flavor, making it the most preferred sample among the sensory panel. The combination of nutritional benefits and high sensory acceptability positions sunflower seed cookies as a balanced choice for health-conscious consumers looking for antioxidant-enriched snacks.

Chia seed-enriched cookies (Sample C) exhibited the highest omega-3 fatty acid content among the samples, along with notable levels of calcium and dietary fiber. The gel-forming capacity of chia seeds contributed to improved moisture retention, resulting in a softer texture and longer shelf life. This functional property is particularly advantageous in bakery products, as it enhances sensory appeal. While the mild flavor was generally well-received, some panelists noted a slightly earthy aftertaste, which could be optimized in future formulations. These cookies also stood out for their satiety-inducing properties, attributed to the fiber and gel-forming nature of chia seeds, making them ideal for weight management and bone health support. Functionally, the inclusion of these seeds enhanced the cookies in different ways. Flax seed and sunflower seed cookies displayed strong antioxidant activity due to their lignans and vitamin E content, respectively. Chia seeds, in addition to their nutritional benefits, contributed to moisture retention, ensuring a fresher product over time. From a sensory perspective, sunflower seed cookies were rated the highest for taste and texture, followed by chia seed cookies, while flax seed cookies were appreciated for their health-oriented profile despite the slightly dense texture. A study by Kaushik et al. (2020) supports the findings of this research, highlighting the nutritional and functional benefits of incorporating flax seed, sunflower seed, and chia seed into bakery products. Their study demonstrated that flax seed significantly enhances the omega-3 fatty acid and lignan content in baked goods, improving cardiovascular and antioxidant benefits. Similarly, sunflower seeds were shown to increase the vitamin E and magnesium levels in fortified cookies, contributing to antioxidant activity and overall sensory acceptability. Chia seeds, due to their gel-forming properties, improved the texture and moisture retention of baked products, while also adding a significant amount of calcium and dietary fiber. The sensory evaluation in their study also revealed that these seeds can be successfully incorporated into bakery formulations without compromising consumer acceptance, reinforcing the potential for functional cookies to meet health-conscious consumer demands. These findings highlight the potential of functional cookies as nutrient-dense snacks that align with consumer demands for health and wellness. Each formulation offers distinct advantages: flax seed cookies for omega-3 and fibre content, sunflower seed cookies for antioxidants and smooth texture, and chia seed cookies for enhanced moisture retention and calcium supplementation. The results demonstrate the feasibility of using these seeds to develop innovative, health-focused bakery products that do not compromise on sensory quality. This study provides valuable insights for food technologists and nutritionists aiming to meet the growing demand for functional and fortified foods.

COMPUTATION OF NUTRIENTS PRESENT IN FLAX SEED, SUNFLOWER SEED AND CHIA SEED

Nutritive value of flax seed, sunflower seed and chia seed are presented in the Table.

COMPUTATION OF NUTRIENTS PRESENT IN BARNYARD MILLET, FLAX SEED AND SUNFLOWER SEED

S.No	Nutrients	Flax Seed (100g)	Sunflower Seed (100g)	Chia Seed (100g)
1.	Energy (Kcal)	534	584	486
2.	Carbohydrates (g)	29	20	42
3.	Protein (g)	18	20.8	16.5
4.	Fats (g)	42	51	30.7
5.	Calcium (mg)	255	78	631
6.	Iron (mg)	5.7	5.3	7.7
7.	Magnesium (mg)	392	325	335
8.	Phosphorus (mg)	642	660	860
9.	Potassium (mg)	813	645	407
10.	Zinc (mg)	4.3	5	4.6
11.	Vitamin E (mg)	0.3	35.2	29
12.	B Vitamins (mg) B1 B6	 1.6 0.5	 1.5 0.8	 0.62 0.7

The nutrient analysis of flax seed, sunflower seed, and chia seed reveals their rich profiles, highlighting their potential as functional food ingredients. Among the three, sunflower seeds exhibited the highest energy content at 584 kcal per 100 g, followed by flax seeds (534 kcal) and chia seeds (486 kcal). For macronutrients, flax seeds had the highest fat content (42 g per 100 g), while sunflower seeds surpassed this with an even higher fat content of 51 g per 100 g, rich in polyunsaturated fatty acids. Chia seeds, although lower in fats (30.7 g per 100 g), showed the highest carbohydrate content (42 g per 100 g), making them a superior energy source.

In terms of protein, sunflower seeds provided the highest amount (20.8 g per 100 g), closely followed by flax seeds (18 g per 100 g) and chia seeds (16.5 g per 100 g). Notably, **chia seeds stood out in calcium content, providing an impressive 631 mg per 100 g, nearly double that of flax seeds (255 mg) and significantly higher than sunflower seeds (78 mg). Chia seeds also excelled in iron content (7.7 mg per 100 g), outperforming flax seeds (5.7 mg) and sunflower seeds (5.3 mg).

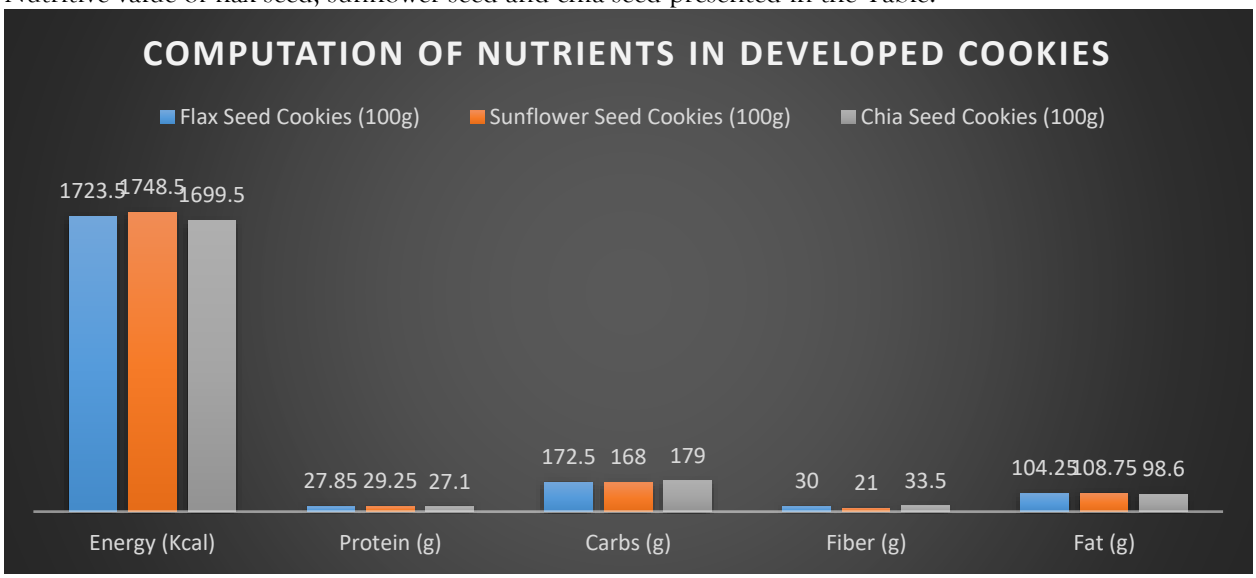
Sunflower seeds were the leading source of vitamin E, delivering an exceptional 35.2 mg per 100 g, compared to 29 mg in chia seeds and 0.3 mg in flax seeds. Magnesium and phosphorus content was notable across all seeds, with chia seeds providing the highest phosphorus content (860 mg per 100 g) and flax seeds being the richest in magnesium (392 mg per 100 g). Potassium was highest in flax seeds (813 mg per 100 g), followed by sunflower seeds (645 mg) and chia seeds (407 mg). Additionally, all seeds were good sources of zinc, with values ranging from 4.3 mg in flax seeds to 5 mg in sunflower seeds.

The B vitamins content was also noteworthy, with flax seeds having the highest levels of B1 (1.6 mg) and sunflower seeds leading in B6 content (0.8 mg), compared to chia seeds with moderate amounts of B1 (0.62 mg) and B6 (0.7 mg). These findings emphasize the distinct nutritional advantages offered by each seed, making them versatile candidates for inclusion in functional foods based on specific health benefits.

A study by Gebremeksal et al. (2024) supports these findings by highlighting the rich nutrient composition of flax, sunflower, and chia seeds. The study elaborates on the benefits of their macro- and micronutrients, particularly their omega-3 fatty acids, fiber, antioxidants, and minerals. Flax seeds were noted for their cardiovascular benefits due to high ALA content, sunflower seeds for their antioxidant properties from vitamin E, and chia seeds for their exceptional calcium and iron content, beneficial for bone health and anemia prevention.

COMPUTATION OF NUTRIENTS IN DEVELOPED COOKIES

Nutritive value of flax seed, sunflower seed and chia seed presented in the Table.



The nutrient analysis of cookies enriched with flax seed, sunflower seed, and chia seed powders demonstrates their distinct nutritional contributions and highlights their potential as functional bakery products. The sunflower seed cookies exhibited the highest energy content (1748.5 kcal per 100 g), followed closely by flax seed cookies (1723.5 kcal) and chia seed cookies (1699.5 kcal). This variation is attributed to the higher fat content in sunflower seed cookies, which contributes significantly to the overall caloric value. Among the three, sunflower seed cookies also had the highest protein content (29.25 g per 100 g), followed by flax seed cookies (27.85 g) and chia seed cookies (27.1 g). The high protein levels make these cookies a suitable choice for individuals seeking protein-rich snacks, particularly for those with active lifestyles or higher protein requirements. Chia seed cookies stood out for their carbohydrate

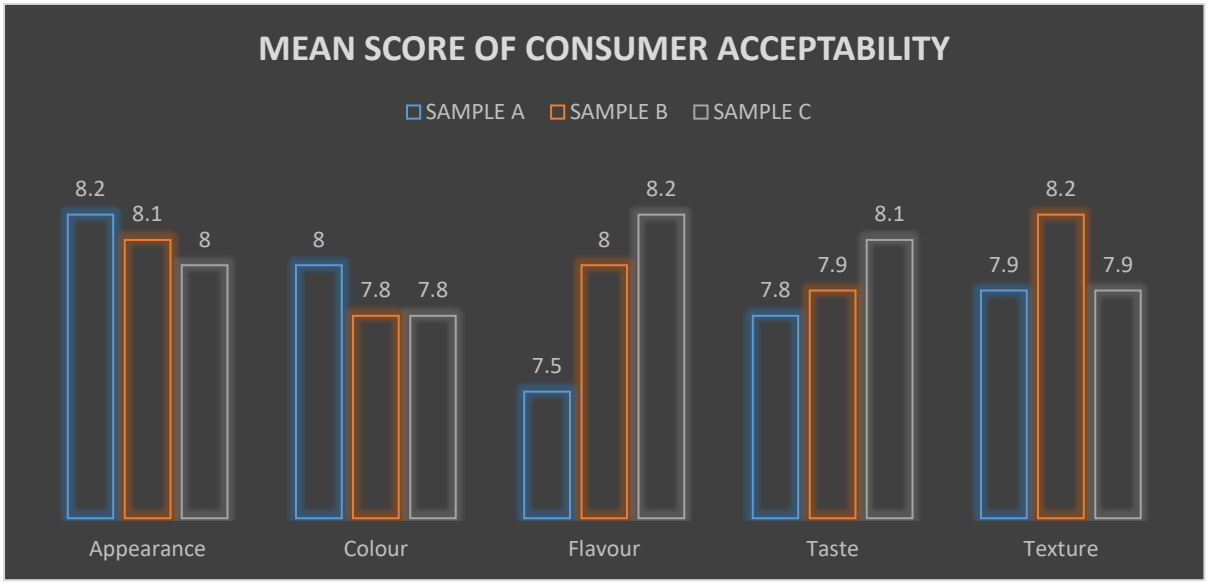
content (179 g per 100 g), making them a preferred option for energy supplementation. In comparison, flax seed and sunflower seed cookies had lower carbohydrate levels (172.5 g and 168 g, respectively), potentially catering to those seeking balanced energy sources.

Chia seed cookies provided the highest dietary fiber (33.5 g per 100 g), followed by flax seed cookies (30 g) and sunflower seed cookies (21 g). The exceptional fiber content in chia seed cookies highlights their suitability for promoting digestive health and satiety, making them ideal for weight management and gut health-focused consumers. Sunflower seed cookies contained the highest fat content (108.75 g per 100 g), predominantly from healthy fats such as polyunsaturated fatty acids. Flax seed cookies had a slightly lower fat content (104.25 g), while chia seed cookies had the least (98.6 g per 100 g), potentially appealing to individuals aiming to reduce their overall fat intake. These results emphasize the unique nutritional benefits of cookies enriched with different seed powders. Sunflower seed cookies emerge as a protein- and energy-dense option, ideal for individuals with higher caloric and protein demands. Chia seed cookies excel in dietary fiber and carbohydrates, offering advantages for digestive health and sustained energy release. Flax seed cookies, while nutritionally balanced, stand out for their moderate energy content and high fiber levels, making them an excellent choice for heart health and weight management.

A study by Sharma et al. (2017) reinforces the nutritional value of incorporating seeds into bakery products. Their research showed that functional cookies enriched with flax, sunflower, and chia seeds exhibited improved macronutrient and micronutrient profiles, particularly in protein, fiber, and healthy fats. The study also highlighted the potential health benefits, including better satiety, improved digestive function, and cardiovascular support, aligning with the findings of this research.

CONSUMER ACCEPTABILITY OF DEVELOPED COOKIES

The cookies based on flax seed, sunflower seed and chia seed was prepared and subjected to sensory evaluation by 30 individuals. 30 members were given the score containing 5 points on the hedonic scale. The results of the sensory evaluation are discussed below.

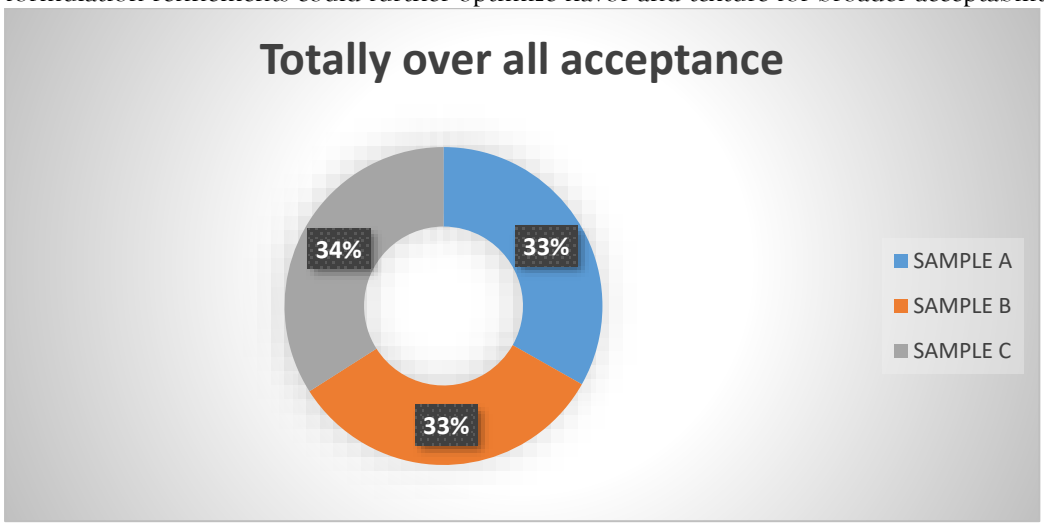


The sensory evaluation of flax seed (Sample A), sunflower seed (Sample B), and chia seed (Sample C) cookies was conducted to assess consumer acceptability across six attributes: appearance, color, flavor, taste, texture, and overall acceptance. Each cookie sample was evaluated on a 9-point hedonic scale, and the mean scores are discussed below. Sample A (flax seed cookies) received the highest score for appearance (8.2), indicating its visual appeal, likely due to the uniformity and slightly glossy surface. Sample B (sunflower seed cookies) and Sample C (chia seed cookies) followed closely, with scores of 8.1 and 8.0, respectively, showcasing their attractive, natural look with subtle differences in texture and color. Flax seed cookies and chia seed cookies both scored 7.8, reflecting consumer preference for their neutral and appetizing hues. Sample A, with a slightly darker shade due to flax seeds, scored marginally higher (8.0) than the other two samples, indicating its appealing baked finish. The flavor profile was rated highest in Sample C (chia seed cookies), with a mean score of 8.2, reflecting consumer preference for its mild yet distinct earthy notes. Sunflower seed cookies (Sample B) scored 8.0, with panelists appreciating its nutty

and rich flavor. Flax seed cookies (Sample A), while well-received, scored slightly lower (7.5) due to the presence of a subtle aftertaste from flax seed compounds. Taste was another strong attribute for Sample C, which scored the highest (8.1), indicating its balanced flavor profile and natural sweetness. Sunflower seed cookies scored 7.9, reflecting their slightly richer, buttery taste, while Sample A scored 7.8, highlighting the nutty and wholesome flavor contributed by flax seed.

Sunflower seed cookies (Sample B) achieved the highest score for texture (8.2), attributed to their smooth and crisp consistency, making them highly acceptable to the sensory panel. Flax seed cookies and chia seed cookies followed closely, both scoring 7.9, with panelists appreciating their firmness and moisture balance. Chia seed cookies (Sample C) received the highest score for total acceptability (8.3), signifying their well-rounded sensory profile. Flax seed cookies (Sample A) and sunflower seed cookies (Sample B) followed with scores of 8.1 and 8.0, respectively, demonstrating their strong consumer appeal.

The results indicate that all three seed-enriched cookies were highly acceptable to consumers, with minimal differences in sensory scores. Chia seed cookies (Sample C) emerged as the most preferred, excelling in flavor, taste, and overall acceptance, likely due to their mild flavor and superior moisture retention. Sunflower seed cookies (Sample B) stood out for their texture, smoothness, and nutty flavor, which resonated well with the sensory panel. Flax seed cookies (Sample A) performed consistently well across all parameters, particularly in appearance and color, but their flavor and texture were slightly less favored compared to the other two samples. These findings demonstrate that the incorporation of flax seed, sunflower seed, and chia seed into cookies can produce highly acceptable and nutritionally superior products. Each seed imparts unique sensory attributes, catering to diverse consumer preferences. Future formulation refinements could further optimize flavor and texture for broader acceptability.



The results show a close competition in overall acceptance among the three samples. Sample C (Chia Seed Cookies) achieved a slightly higher overall acceptance (34%), reflecting its balance in flavor, taste, and texture, which resonated strongly with the sensory panel. Sample A (Flax Seed Cookies) and Sample B (Sunflower Seed Cookies) received an equal share of acceptance (33%), indicating their strong appeal but slightly lower preference compared to Sample C. This data reaffirms that all three types of seed-enriched cookies have comparable consumer acceptability, with marginal differences that reflect individual sensory attributes. These findings suggest that incorporating flax, sunflower, and chia seeds into cookie formulations can cater to diverse preferences while maintaining high acceptance rates. Further studies could explore refining formulations to enhance specific sensory attributes and broaden consumer appeal.

CONCLUSION

The development and evaluation of cookies enriched with flax seed, sunflower seed, and chia seed powders demonstrated their potential as nutritious and highly acceptable functional food products. The nutrient analysis revealed that the incorporation of these seeds significantly enhanced the cookies' protein, dietary fiber, and essential micronutrient content. Sunflower seed cookies were the most protein-rich, while chia seed cookies stood out for their dietary fiber and carbohydrate content, making them ideal for digestive health and sustained energy release. Flax seed cookies offered a balanced nutritional profile with high fiber and moderate energy content, contributing to their suitability for heart health and

weight management. Sensory evaluation highlighted high consumer acceptability across all three cookie variants, with chia seed cookies slightly outperforming others in flavor, taste, and overall acceptance. Sunflower seed cookies were appreciated for their texture, while flax seed cookies scored highest for appearance and color. These results demonstrate the feasibility of incorporating nutrient-dense seeds into bakery products without compromising sensory quality, making them appealing to health-conscious consumers. This study contributes to the growing demand for functional foods that cater to health and wellness trends. The use of flax, sunflower, and chia seeds in cookies provides a promising avenue for enhancing dietary intake of proteins, fibers, and essential nutrients while maintaining consumer appeal. Further research could explore scalability, cost-effectiveness, and shelf-life stability to promote the commercialization of these seed-enriched cookies in the functional food market.

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