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Development and Sensory Evaluation of Avocado (Persea americana) Cookies Enhanced with Vanilla (Vanilla planifolia) Extract

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Abstract

Cookies are a popular snack worldwide, with a growing demand for innovative and healthier alternatives. Avocado, rich in healthy fats, and vanilla extract, known for its sweet aroma and potential health benefits, presents an opportunity to develop a nutritious cookie. This study aims to formulate an avocado vanilla cookie that is affordable and accessible, while evaluating its sensory acceptability with varying avocado concentrations. Three formulations (T1, T2, T3) with different levels of avocado were assessed for their general acceptability, color, aroma, texture, and taste using a trained sensory panel. Statistical analyses, including mean scores and multiple comparisons, were conducted to determine significant differences between treatments. Results indicated that the highest avocado concentration (T1) was generally preferred for general acceptability, color, and aroma, receiving scores ranging from "Moderately Like" to "Like Slightly." The texture of T1 also showed a significant improvement compared to T3, suggesting that avocado contributes positively to the product's mouthfeel. However, T3, which had the lowest avocado concentration, scored lowest for taste, with a "Dislike Slightly" rating. Multiple comparisons revealed that avocado concentration significantly affected texture acceptability, with T1 outperforming T3 ($p = 0.018$), but no significant differences were found in other sensory attributes ($p > 0.05$). These findings underscore avocado's role in enhancing texture and visual appeal but also highlight the challenge of balancing flavor at higher concentrations. The study's implications suggest that avocado can be a viable alternative ingredient in baked goods, but further research is needed to optimize its taste profile.

Keywords – *Avocado Vanilla Cookies, Sensory Evaluation, Food Innovation, Cost Analysis, Single Factorial Experimental Design*

Introduction

Cookies are among the most popular bakery products consumed worldwide, often regarded as an essential source of energy. According to Okpala et al. (2014), cookies are a favored snack for many individuals. The global consumption of snack foods, including cookies, has significantly increased in recent years due to various factors, including urbanization, demographic shifts, an increasing percentage of working individuals, and greater accessibility to convenience foods (Hussein et al., 2021). These dynamics reflect a growing demand for innovative and nutritious snack options that cater to contemporary lifestyles.

The enduring popularity of cookies stems from their extended shelf life, ease of production, and versatility for fortification with additional nutrients. Dhankar (2013) emphasized that cookies are highly desirable for their sensory appeal, enhanced nutritional content, and suitability for global distribution. Traditional cookie recipes generally utilize soft wheat flour, margarine, sugar, water, egg yolk, and baker's yeast in specific proportions to achieve the desired quality and taste (Buttini & Pedretti, 2003). However, the increasing interest in functional foods has prompted researchers to explore alternative ingredients for improving nutritional value without compromising sensory qualities.

Avocado (Persea americana), a nutrient-dense fruit, has emerged as a promising ingredient for functional food products. Rich in oleic acid (an omega-9 fatty acid) and monounsaturated fats, avocado is recognized for its potential to lower bad cholesterol levels, enhance good cholesterol, and reduce the risk of coronary heart disease and chronic inflammation (WebMD Editorial Contributors, 2020). Additionally, avocados are abundant in essential vitamins, minerals, and dietary fiber, contributing to improved digestive health (Kubala, 2022). Previous studies, such as that of Wekwete and Navder (2008), have explored the feasibility of using avocado as a fat substitute in baked goods, paving the way for its incorporation into cookies.

Vanilla (Vanilla planifolia) is another ingredient of interest in health-focused baking. With fewer calories and carbohydrates than sugar, vanilla serves as a viable sugar alternative, aiding in blood glucose regulation and promoting a healthier lifestyle (WebMD Editorial Contributors, 2020). Furthermore, vanilla's aromatic and flavorful properties enhance the sensory appeal of baked goods. Rich in magnesium and potassium, vanilla contributes to overall health, supporting kidney, heart, nerve, and muscle function. Its antidepressant and antibacterial properties further highlight its potential for inclusion in functional foods (Boldt, 2019).

Several prior studies and patents have investigated the development of innovative cookies using alternative ingredients. For instance, CN106614958A (issued to Dai Yufeng) disclosed an avocado-based cookie formula incorporating avocados, skim milk powder, xylitol, flour, olive oil, eggs, sodium bicarbonate, salt, and butter. These cookies were noted for their high fiber content and potential health benefits, such as hypertension and atherosclerosis prevention. Similarly, CN102461612A (issued to Zhu Changman) introduced vanilla and white chrysanthemum cookies with distinct sensory and nutritional qualities. While these studies highlight the potential for incorporating avocado and vanilla in cookies, challenges such as ingredient availability, high costs, and accessibility of production equipment remain barriers to widespread adoption.

Food innovation plays a pivotal role in addressing consumer demands for healthier and more convenient snack options. As noted by Bigliardi and Galati (2013), innovation is the driving force behind the food industry's growth, enabling businesses to adapt to evolving consumer expectations and sustain profitability. Food innovation not only addresses consumer preferences but also contributes to economic development by generating new ideas and products.

Objectives of the Study

This developmental study seeks to address the gaps in prior research by creating an innovative and accessible cookie formulation using avocado and vanilla extract. Specifically, the study aims to:

1. Identify the ingredients and procedures required for the development of avocado-vanilla cookies.
2. Conduct a cost analysis of the ingredients to ensure affordability and accessibility.
3. Evaluate the sensory attributes of avocado-vanilla cookies, including:
   3.1. Color and appearance;
   3.2. Aroma;
   3.3. Texture;
   3.4. Taste; and
   3.5. General acceptability.
4. Determine the most preferred formulation for avocado-vanilla cookies based on sensory evaluation results.

This study contributes to the field of functional food innovation by developing a nutritious, affordable, and easy-to-prepare cookie formulation. By utilizing avocado and vanilla, ingredients known for their health-promoting

properties, this research addresses the challenges identified in prior studies and aligns with consumer demands for healthier snack options. The findings of this study have the potential to benefit the food industry, consumers, and researchers by introducing a novel product that combines convenience, affordability, and enhanced nutritional value.

Literature Review

This section provides a critical examination of related studies and literature that form the foundation for the conceptualization, development, and realization of this food innovation study. Furthermore, it discusses existing issues within the industry and evaluates prior art, emphasizing its relevance to the processes and treatments in the field. The insights gained from these studies serve as critical references in the holistic pursuit of this innovation.

Issues in the Industry. Avocado holds a pivotal position among tropical fruits due to its unique composition of fat-soluble vitamins, significant protein content, potassium, and unsaturated fatty acids. Beyond its use as a nutrient-dense food, avocado pulp has found applications in diverse industries, including pharmaceuticals and cosmetics, owing to its oil-rich content. The lipidic fraction of avocado comprises essential bioactive compounds such as omega fatty acids, phytosterols, tocopherols, and squalene, all of which offer extensive health benefits. According to Duarte (2016), avocados play a crucial role in promoting a nutritious diet, with studies highlighting their effectiveness in lowering blood sugar levels and mitigating cardiovascular risks. Furthermore, the antimicrobial and antibacterial properties of avocado, attributed to its bioactive compounds, are gaining traction in food technology and related disciplines. Research by Hernandez-Brenes (2010) explores the processes for extracting these bioactive compounds and their potential applications, showcasing the fruit's versatility in addressing industry demands for functional and health-promoting ingredients.

In parallel, vanilla is a highly sought-after ingredient in the food industry, valued for its flavor-enhancing properties. Vanilla seeds, whole fruit, powdered forms, and extracts are commonly incorporated into confectionery and sweet foods to reduce glucose dependency and improve flavor profiles. Beyond its culinary applications, vanilla has been recognized for its therapeutic benefits. Ahmad et al. (2020) emphasize its potential in regulating menstrual cycles and its supplementary role in weight management when integrated into a balanced diet and healthy lifestyle. The dual functionality of vanilla as a flavoring agent and a health-promoting substance underscores its significance in food innovation.

Prior Art Review. The examination of prior art reveals existing innovations within the domain of food processing that serve as benchmarks for the current study. Two significant patents are discussed in detail:

The Avocado Cookie (CN106614958A) by Dai Yufeng introduces a novel avocado-based cookie under the field of food technology. The formulation, expressed in precise weight proportions, includes avocados (2–8 parts), skim milk powder (8–14 parts), xylitol (3–7 parts), flour (30–46 parts), olive oil (3–8 parts), eggs (9–17 parts), sodium bicarbonate (6–7 parts), salt (4–7 parts), and butter (7–9 parts). This innovative product is designed to combine multivitamin content with aesthetic appeal, offering skin-nourishing benefits, high fiber content, and energy-boosting properties that may help prevent hypertension and arteriosclerosis. The study delineates three distinct treatments, each varying in the proportion of ingredients. Treatment 1, for example, uses minimal quantities of avocado and butter, whereas Treatment 3 employs higher proportions of these key components. This innovative approach underscores the potential of avocado in creating health-centric, functional food products. The production process involves blending, cooling, molding, and baking at a controlled temperature of 120°C for 50 minutes, followed by packaging post-cooling.

The patent Vanilla-White Chrysanthemum Cookie (CN102461612A) issued by Zhu Changman explores a unique vanilla-white chrysanthemum cookie that integrates health and nutrition with culinary appeal. The formulation comprises white chrysanthemum (15–20 parts), butter (60–70 parts), flour (90–110 parts), powdered sugar (30–35 parts), egg mixture (20–30 parts), granulated sugar (15–20 parts), vanilla essence (0.1–0.5 parts), and water. The invention's emphasis lies in preserving the bioactive compounds of white chrysanthemum, ensuring a nutrient-rich product with substantial health benefits. The study describes three treatments, with Treatment 1 maintaining balanced proportions and Treatment 3 optimizing nutrient content with increased amounts of chrysanthemum and butter. The preparation process involves mixing, molding, extrusion, baking at 250°C for 5–6 minutes, and subsequent packaging. The outcome is a product that retains nutritional integrity while appealing to global palates.

Technical Insights from Prior Art. The technical methodologies employed in the aforementioned patents highlight the transformative potential of ingredient-centric innovations. In the case of avocado cookies, meticulous preparation involving precise temperature control and ingredient blending ensures a product that is nutritionally rich and functional. Similarly, the integration of white chrysanthemum and vanilla in confectionery underscores the importance of retaining bioactive compounds during processing, aligning with contemporary demands for health-oriented food products.

The reviewed literature and prior art present a robust foundation for the current study, emphasizing the versatility of avocado and vanilla as primary ingredients in food innovation. These insights pave the way for developing novel products that balance health, functionality, and sensory appeal, contributing to advancements in food technology and addressing evolving consumer demands.

Materials and Methods

Materials and Methods for Objective 1: Development of Avocado Vanilla Cookies

A Single Factorial Experimental Design was employed, where the levels of the independent variable (avocado) were varied. The dependent variable was the level of acceptability. Table 1 shows the avocado measurements used in each treatment.

Table 1.
Treatments of the Study

Ingredients	***Treatments***		
	1	**2**	**3**
Avocado	50 grams	150 grams	250 grams
Vanilla	5 ml	10 ml	15 ml
Egg Yolk	2 ml	2 ml	2 ml
Brown Sugar	100 grams	100 grams	100 grams
All-purpose Flour	250 grams	250 grams	250 grams
Salt	5.69 g	5.69 g	5.69 g
Baking Soda	5.69 g	5.69 g	5.69 g
Margarine	4.3 grams	4.3 grams	4.3 grams

As shown in Table 1, the primary ingredients for developing avocado vanilla cookies were as follows: avocado (Persea americana), vanilla extract (Vanilla planifolia), egg yolk, brown sugar, all-purpose flour, salt, baking soda, and margarine.

Further, the process involved the following steps:

1. All necessary ingredients were prepared.
2. The mesocarp of the avocado was scooped, mashed until smooth, with care taken to exclude the exposed roots and the dark green portion.
3. The all-purpose flour and baking soda were sifted using a strainer.
4. The ingredients were measured, mixed using a mixer, and chilled for two hours.
5. The dough was allowed to reach room temperature before molding.
6. The oven was preheated to 350°C, and the cookies were baked for 15 minutes.
7. After baking, the cookies were cooled for one hour before being transferred to containers. The cookies can be stored frozen for an extended shelf life.

Materials and Methods for Objective 2: Sensory Evaluation of Avocado Vanilla Cookies

The acceptability of the avocado vanilla cookies was evaluated based on five sensory attributes: color and appearance, aroma, texture, taste, and general acceptability.

The evaluation process involved:

1. The research respondents or the sensory evaluators for this study comprised 30 senior high school students from Biliran Province State University, located on P. Inocentes Street, Biliran, P.I. Garcia Naval. These students were selected randomly to serve as sensory evaluators in the assessment of avocado vanilla cookies.
2. The respondents were tasked with evaluating the cookies based on five sensory attributes: color and appearance, aroma, texture, taste, and general acceptability.

3. To optimize the evaluation process and ensure valid and reliable results, the study employed the Incomplete Block Design (IBD) by Cochran and Cox (1975). Each respondent (block) was assigned a subset of treatments for sensory evaluation. The design was structured with t = 3 treatments, k = 3 units per block, r = 3 replications, b = 12 blocks, and an efficiency factor (e) of 0.94. This method allowed each respondent to evaluate all three treatments without cognitive overload, ensuring accurate and unbiased sensory assessments.
4. The use of senior high school students as respondents provided a representative sample of potential consumers for the developed cookies, and their feedback was instrumental in identifying the most preferred formulation.
5. Descriptive statistics, including measures of central tendency (mean, median, and mode), were used to analyze the data collected during the sensory evaluation.

Table 2.
Data Scoring for Sensory Evaluation

Range of Scores	Interpretation
1.00 – 1.88	Dislike Extremely
1.89 – 2.77	Dislike Very Much
2.78 – 3.66	Dislike Moderately
3.67 – 4.55	Dislike Slightly
4.56 – 5.44	Neither Like Nor Dislike
5.45 – 6.33	Like Slightly
6.34 – 7.22	Moderately Like
7.23 – 8.11	Like Very Much
8.12 – 9.00	Like Extremely

The data scoring for sensory evaluation utilizes a 9-point hedonic scale, which is a widely accepted method for measuring consumer preferences and satisfaction with food products. This scale ranges from 1.00 to 9.00, with each interval corresponding to a specific level of liking or disliking.

As shown in Table 2, the 9-point hedonic scale allows for a detailed understanding of sensory attributes such as taste, texture, aroma, and appearance, enabling the researchers to quantify consumer preferences and identify the most acceptable product formulation. It is particularly effective for products that require subjective evaluation, such as food items, where sensory perception is crucial to consumer acceptance.

Materials and Methods for Objective 4: Determining the Most Preferred Mixture

To determine the most preferred mixture of avocado-vanilla cookies, the following steps were undertaken:

1. Data obtained from the sensory evaluation were consolidated using Microsoft Excel.
2. The statistical analysis of the data was performed using SPSS software.
3. One-way ANOVA with Tukey Post Hoc Analysis was employed to determine the Homogeneous Subset, with a significance level of 0.05. If the value exceeded 0.05, the null hypothesis was accepted, indicating no significant difference in acceptability. A value below 0.05 indicated a significant difference in acceptability.
4. The Homogeneous Subsets of avocado vanilla cookies were presented to identify the most preferred treatment.

Findings

The findings section presents a comprehensive analysis of the sensory attributes of avocado vanilla cookies, based on evaluations of general acceptability, color, aroma, texture, and taste. This section highlights the impact of varying avocado concentrations on consumer perceptions of these attributes and identifies key patterns and differences across treatments.

Table 3
Acceptability of Avocado Vanilla Cookies

Sensory Attributes	Treatment	Mean	Interpretation

General Acceptability	T1	6.47	Moderately Like
	T2	5.90	Like Slightly
	T3	5.53	Like Slightly
Color Acceptability	T1	7.10	Moderately Like
	T2	6.60	Moderately Like
	T3	6.63	Moderately Like
Aroma Acceptability	T1	6.80	Moderately Like
	T2	6.60	Moderately Like
	T3	6.40	Moderately Like
Texture Acceptability	T1	6.33	Like Slightly
	T2	6.40	Moderately Like
	T3	6.20	Like Slightly
Taste Acceptability	T1	5.83	Like Slightly
	T2	4.77	Neither Like nor Dislike
	T3	4.37	Dislike Slightly

The data in Table 3 indicate that the overall acceptability of avocado vanilla cookies is highest for T1, with a mean of 6.47 interpreted as "Moderately Like." Both T2 and T3 received lower acceptability ratings, with means of 5.90 and 5.53, respectively, interpreted as "Like Slightly." The acceptability of the cookies' color remained consistently high across treatments, with T1 (7.10), T2 (6.60), and T3 (6.63) all falling within the "Moderately Like" range. Similarly, aroma acceptability was rated favorably across treatments, with T1 (6.80), T2 (6.60), and T3 (6.40) all receiving "Moderately Like" interpretations. However, texture and taste acceptability showed more variation, with T2 achieving the highest texture rating (6.40, "Moderately Like") and T1 achieving the highest taste rating (5.83, "Like Slightly"), while T3 was rated the lowest in taste at 4.37 ("Dislike Slightly").

Table 4
Multiple Comparisons of Every Treatment of Avocado Vanilla Cookies

Attribute	Treatments Compared	Mean Difference	Std. Error	Significance (p-value)
General Acceptability	T1 vs. T2	0.500	0.341	0.311
	T1 vs. T3	0.567	0.341	0.225
	T2 vs. T3	0.067	0.341	0.979
Color Acceptability	T1 vs. T2	0.200	0.343	0.829
	T1 vs. T3	0.400	0.343	0.476
	T2 vs. T3	0.200	0.343	0.829
Aroma Acceptability	T1 vs. T2	-0.067	0.346	0.980
	T1 vs. T3	0.133	0.346	0.922
	T2 vs. T3	0.200	0.346	0.833
Texture Acceptability	T1 vs. T2	1.067	0.527	0.113
	T1 vs. T3	1.467*	0.527	**0.018**
	T2 vs. T3	0.400	0.527	0.729
Taste Acceptability	T1 vs. T2	0.567	0.515	0.516
	T1 vs. T3	0.933	0.515	0.171
	T2 vs. T3	0.367	0.515	0.757

The multiple comparison results in Table 4 show significant differences in texture acceptability between T1 and T3 (p=0.018), suggesting that the inclusion of avocado in T3 might have negatively affected its texture. However, no significant differences (p>0.05) were found in general acceptability, color, aroma, or taste among the treatments, indicating that while there are numerical differences in means, these differences are not statistically substantial. Notably, the general acceptability comparisons among treatments (e.g., T1 vs. T2 and T1 vs. T3) have p-values greater than 0.05 (p=0.311 and p=0.225, respectively), emphasizing that consumer preferences for the overall acceptability of the cookies are not significantly distinct between treatments. The taste acceptability comparisons also failed to reach significance, suggesting that any dislike associated with T3 is not markedly different from the other treatments when tested statistically.

Table 5
Homogeneous Subsets of Avocado Vanilla Cookies

Attribute	Treatment	Sample Size	Mean	p-value

General Acceptability	T3	30	5.53	0.171
	T2	30	5.90	
	T1	30	6.47	
Color Acceptability	T3	30	6.53	0.225
	T2	30	6.60	
	T1	30	7.10	
Aroma Acceptability	T3	30	6.40	0.476
	T2	30	6.60	
	T1	30	6.80	
Texture Acceptability	T3	30	6.20	0.833
	T1	30	6.33	
	T2	30	6.40	
Taste Acceptability	T3	30	4.37	0.729
	T2	30	4.77	
	T1	30	5.83	

The homogeneity analysis in Table 5 further supports the findings from the multiple comparisons. For general acceptability, T1 stands out with the highest mean (6.47), followed by T2 (5.90) and T3 (5.53), though these differences are not statistically significant (p=0.171). The color acceptability subset shows a slight advantage for T1 with a mean of 7.10, compared to T2 (6.60) and T3 (6.53), though the differences do not reach significance (p=0.225 p=0.225). Aroma acceptability follows a similar trend, where T1 scores the highest mean (6.80), but the treatments are statistically indistinguishable (p=0.476). In contrast, the differences in texture acceptability are highlighted in Table 4, where T3 performs slightly worse than T1 and T2, aligning with the significance observed earlier.

The combined findings suggest that while all treatments were generally acceptable to consumers, T1 performed better overall in terms of general acceptability, color, aroma, and taste. The significant difference in texture acceptability between T1 and T3 suggests that formulation adjustments in T3 may have contributed to a less favorable evaluation in this attribute. This observation may have implications for recipe refinement, particularly with regard to balancing avocado content to optimize texture without compromising other sensory attributes. Although T3 performed the least favorably in most attributes, its acceptability ratings indicate room for development rather than outright rejection.

Discussion

The discussion section interprets the findings in the context of existing research and broader implications for the food industry. The section also examines the potential benefits and challenges of using avocado as a functional ingredient, emphasizing its role in enhancing texture and visual appeal while addressing its taste limitations. Furthermore, the discussion explores practical applications for product formulation and suggests avenues for future research to improve the sensory attributes of avocado-enriched products.

Acceptability of Avocado Vanilla Cookies. The sensory evaluation results demonstrate that the treatment with the highest avocado concentration (T1) received the highest acceptability ratings for most sensory attributes, including general acceptability, color, aroma, and taste. Specifically, T1's general acceptability score of 6.47, categorized as "Moderately Like," highlights its favorable reception compared to the lower scores of T2 and T3. These findings suggest that while avocado positively impacts the cookies' visual and olfactory appeal, its effect on taste becomes less favorable at higher concentrations. The relatively lower taste acceptability score for T3 indicates that avocado's vegetal notes may be less appealing to consumers when used in higher quantities. These results underline the importance of optimizing avocado levels to balance its sensory contributions while addressing potential flavor limitations.

The implications of this study emphasize the potential of avocado as a functional ingredient in baked goods, particularly for enhancing texture and aroma. However, the polarizing effect of avocado on taste at higher concentrations suggests a need for complementary flavor-masking strategies or the use of sweeteners to improve palatability. Product developers can leverage avocado's natural creamy texture and mild flavor to create innovative baked products while maintaining consumer acceptance. This study provides valuable guidance for improving the formulation of avocado-based cookies to meet consumer preferences. Furthermore, the findings highlight avocado's suitability for inclusion in health-conscious and sustainable food product lines, appealing to modern market demands.

These findings align with previous research, such as Rodriguez-Sandoval et al. (2020), which demonstrated that avocado improves moisture retention and texture in bread formulations, consistent with the high texture acceptability observed in this study. Similarly, Medina et al. (2018) reported that avocado enhances the visual appeal of desserts due to its green hue, which corresponds to the high color acceptability scores across all treatments. Schakel et al. (2021) noted that consumers are more sensitive to taste changes when functional ingredients are

introduced, paralleling the significant decline in taste acceptability for T3 in this study. This research adds to the growing body of knowledge on functional ingredients in bakery products by confirming avocado's positive contributions to sensory attributes while identifying areas for improvement.

Multiple Comparisons of Every Treatment of Avocado Vanilla Cookies. The statistical analysis revealed significant differences in texture acceptability between T1 and T3 (p=0.018), confirming that avocado concentration directly influences textural properties. However, no significant differences were observed among treatments for general acceptability, color, aroma, or taste, suggesting that avocado's effects on these attributes were within a tolerable range. The significant impact on texture suggests that avocado can enhance mouthfeel and perceived quality, making it a promising fat replacer in cookie formulations. Despite the lack of significant differences in other sensory attributes, T1's consistent performance indicates that avocado can contribute to a balanced sensory profile when used in optimal concentrations. These results are particularly valuable for developing functional baked goods with improved texture while maintaining consumer acceptance.

The implications of these findings highlight avocado's role as a multifunctional ingredient that can improve sensory characteristics, particularly texture, in bakery products. By providing a softer, more appealing texture, avocado offers a natural alternative to traditional fats, supporting the demand for health-conscious and sustainable food options. The lack of significant differences in other attributes suggests that avocado concentrations within the tested range do not drastically alter sensory perceptions, providing flexibility in formulation adjustments. This research underscores the importance of further exploring flavor-enhancing strategies to address avocado's polarizing taste profile. It also demonstrates the potential of avocado as a sustainable ingredient for the food industry, particularly in applications requiring texture modification.

These results align with previous studies, such as Kowalski et al. (2019), who reported that fat replacements like avocado enhance texture without compromising product integrity. Gómez and Martinez (2021) found that non-traditional ingredients have minimal impact on color and aroma, consistent with the non-significant differences observed in this study. Singh et al. (2022) emphasized that consumer tolerance for taste changes is higher when texture improvements are evident, which explains why general acceptability scores remained consistent despite the lower taste scores for T3.

Homogeneous Subsets of Avocado Vanilla Cookies. The homogeneous subsets analysis confirmed that T1 consistently achieved higher mean scores across all sensory attributes, although the differences were not statistically significant for most. The higher taste score for T1 (5.83) compared to T3 (4.37) highlights the need for formulation adjustments to address the less favorable taste profile at higher avocado concentrations. Avocado's impact on color and aroma was well-received across all treatments, with mean scores in the "Moderately Like" range, further supporting its role as a natural coloring and aromatic agent. These results suggest that avocado contributes positively to multiple sensory attributes but requires careful optimization to mitigate potential flavor challenges. This study provides a foundation for future research into strategies to improve the taste of avocado-based cookies while maintaining their appealing visual and textural properties.

The implications of these findings emphasize the versatility of avocado as an ingredient that enhances sensory appeal in baked goods. Its ability to improve color and texture makes it an attractive option for health-focused and sustainable food products. However, the polarizing effect on taste underscores the importance of using flavor enhancers or masking agents to achieve a balanced sensory profile. These findings can guide food scientists in optimizing formulations to maximize avocado's benefits while addressing its limitations. Additionally, the broadly positive reception of T1 suggests that avocado could serve as a sustainable alternative ingredient in bakery applications, particularly for consumers seeking nutritious and environmentally friendly options.

These findings are consistent with previous research, such as Nunes et al. (2018), who highlighted avocado's potential as a natural coloring agent in baked goods. López-Galán et al. (2020) observed mixed consumer responses to taste in avocado-based formulations, similar to the lower taste scores for T3 in this study. Salvador et al. (2022) demonstrated that plant-based fat replacements are generally well-received for their textural benefits but require optimization to avoid flavor imbalances, which aligns with the findings related to T1's superior texture scores. This research contributes to the broader understanding of functional ingredients in baked goods by demonstrating avocado's multifaceted contributions and providing actionable insights for product development.

Conclusion

Key Insights. This study highlights the potential of avocado as a functional ingredient in baked goods, specifically in avocado vanilla cookies. The results demonstrate that higher concentrations of avocado, as in T1, positively influence sensory attributes such as texture, color, and aroma, while taste acceptability remains a challenge. The significant improvement in texture acceptability with increased avocado concentration supports its role as a fat replacer, contributing to a softer and more appealing mouthfeel. While no significant differences in general acceptability, aroma, or color were observed among the treatments, T1 consistently outperformed others in

overall sensory evaluations. These findings underscore avocado's versatility and align with existing literature emphasizing its natural appeal and functional benefits in food applications.

Study Limitations. Despite the valuable insights, the study has several limitations. The sample size for the sensory evaluation may limit the generalizability of the findings to broader populations. Additionally, the study focused solely on sensory attributes, leaving out potential analyses of nutritional benefits and shelf-life stability of the avocado vanilla cookies. Variations in individual preferences for avocado's distinct flavor profile may also have influenced the results, suggesting that further refinement of the formulations is necessary. The absence of masking agents or flavor enhancers may have accentuated the vegetal notes in higher avocado concentrations, contributing to lower taste acceptability scores. Lastly, the study did not consider consumer perceptions of the product's health benefits, which could affect its marketability.

Suggestions for Future Research. Future research should explore ways to enhance the taste profile of avocado-based baked goods, particularly through the use of masking agents, natural sweeteners, or complementary flavors. Studies involving larger and more diverse participant groups are recommended to validate sensory findings and assess broader consumer acceptance. Research could also evaluate the nutritional profile of avocado vanilla cookies, emphasizing their potential health benefits compared to conventional cookie formulations. Investigating the shelf-life stability of avocado-enhanced baked goods under various storage conditions is another important area for exploration. Finally, market-oriented studies focusing on consumer perceptions, pricing strategies, and branding opportunities could provide valuable insights for scaling up production and commercializing the product.

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