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# Development and Acceptability of Calcium-Enriched Cookie Using Eggshell Powder

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**Abstract:***This study aimed to develop calcium-enriched cookies using eggshell powder and evaluate their sensory acceptability and nutritional quality. Specifically, it sought to assess the acceptability of three cookie formulations based on appearance, aroma, taste, texture, and overall appeal; and identify significant differences in sensory attributes across formulations. The most preferred formulation was also analyzed for its physicochemical composition, particularly fat, protein, sugar, and calcium content. Using a mixed-method approach combining experimental and descriptive designs, the cookies were prepared with varying ingredient proportions and tested at the Food Science Laboratory of Surigao del Norte State University. Statistical analyses included MANOVA, ANOVA, and post-hoc tests to assess sensory ratings. Results revealed that all formulations were acceptable, but Formulation C was significantly preferred and rated "Like Very Much" in all sensory attributes. The physicochemical analysis of Formulation C confirmed its potential as a functional food, with high calcium content and balanced nutritional components, making it a promising product for health-focused consumers.*

**Keywords:**Calcium-enriched cookies, eggshell powder, sensory evaluation, functional food, nutritional fortification

## I. INTRODUCTION

The food industry produces a significant quantity of eggshell waste due to the large consumption of eggs in most processed food products. In this regard, households play a significant role in daily egg consumption that leads to high accumulation of eggshell waste. This further worsens environmental issues because the waste will occupy more landfill space and costs for waste handling will be much higher. In line with the Sustainable Development Goal 12 (SDG 12), focusing on Responsible Consumption and Production, the sustainable exploitation and valorization of eggshells offer a new way of minimizing waste and practices related to the circular economy. Mainly comprising 97% inorganic minerals, including calcium carbonate (CaCO□) and magnesium carbonate, as well as 3% organic contents, such as proteins and lipids, the eggshells have high value for the generation of calcium-rich products (Aditya et al., 2021). More importantly, calcium materials derived from eggshells serve directly to achieve SDG 3, Good Health and Well-being, which solves the wide nutritional problem of calcium deficiency in bone health, especially in children, pregnant women, and the elderly. Bioavailability of calcium from eggshells has been established and used in functional food, supplements, and pharmaceuticals (Saleem et al., 2024).

Additionally, eggshells are considered a natural calcium source to promote healthier lives and well-being by preventing conditions such as osteoporosis, dental health, and enhancing nutrition in general.

The study aims to develop an innovative cookie product enriched with eggshell powder for the prevention of calcium deficiencies, especially in pediatric and geriatric populations. This study aims to bridge nutritional gaps by supplementing cookies-a common and widely available food-with sustainable calcium derived from eggshell powder, thus promoting the utilization of a largely underutilized by-product of the food industry. It is rich in bioavailable calcium and offers considerable nutritional benefit while allowing the environmentally friendly management of waste through the recycling of discarded eggshells. This venture aligns well with the thrust of Surigao del Norte State University towards innovations in food science and higher standards in nutritional excellence. In fact, through the

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addition of fortified cookies into local diets, the community will be reinforced toward health while encouraging economic growth because it enables and promotes functional value-added food product development and marketing.

There have been several studies indicating that food fortification is one of the promising approaches in nutrimental deficiency prevention through enrichment of staple foods. Bakery products, especially cookies, can be used to provide crucial minerals such as calcium to all segments of society using fortification (Pravst et al., 2019. Eggshell powder is made from normal eggs and is a source of strong and sustainable calcium that can be added into food products for enhancement of the nutritional level of those products. Adding powdered eggshell into cookies increases the calcium level in cookies by a margin multiple folds while being an economical, naturally available, and locally sourced mineral source for small bakeries (Cisowska et al., 2020. In tandem with the strategic direction of Ambisyon Natin 2040, this program promotes a healthier and more resilient Filipino population capable of enjoying life to its highest quality. Since the approach ensures the fortification of cookies by eggshell powder, it works to enhance better nutrition, further improve food security, and induce sustainability in handling practices, supporting the long-term well-being and economic empowerment of communities.

This study examined the development and evaluation of cookies enriched with powdered eggshells as an eco-friendly and calcium-rich source. Sensory acceptability, nutritional composition and consumer preference were determined. Cookies enriched with calcium are healthy and aesthetic diet options that are appropriate especially for vulnerable populations, such as children, pregnant women and the elderly, who are often more prone to calcium deficiency. All research objectives can help improve health in communities and promote healthy practices by bringing something of value-food ingredient-from wasted eggshells. It will also enable local bakeries to provide the opportunity but also contribute to this progress of betterment in the economic improvement through enhanced cookies expanded as a new function food product.

## II. LITERATURE REVIEW

### Role of Calcium Fortification in Public Health

Calcium is essential not only for musculoskeletal systems but also for metabolic processes. Despite its importance, inadequacies still must be improved among children and older people (Terrell, 2023). Traditional calcium supplements often need to improve absorption or be bypassed by consumers mainly on questions of taste and convenience; thus, food fortification is an attractive option. (Gavelle et al. 2019) suggested that adding calcium to regularly consumed foods would increase the daily dietary intake, especially among populations resistant to supplementation, but ensure that the required intake is adequately maintained. Fortified foods may efficiently serve as delivery agents for improving public health regarding bone diseases. The green and relatively economical alternative is eggshell powder, which has been found primarily to be constituted of calcium carbonate. Eggshells, from a once useless by-product are now considered valuable as a means of introducing into the diet some edible products, enriched with calcium. Recent studies indicate that calcium is available in eggshell powder, an efficient and natural additive to food products without changing their flavor or texture (Aditya et al. 2021). This research bases its exploration of the feasibility of using eggshell powder as a fortifying ingredient in cookies on similar findings that fall in line with sustainability and zero-waste initiatives by the food industry. Adding eggshell powder to cookies can help in reducing waste and providing calcium to overcome deficiency, which might help reduce the risk of osteoporosis and other related diseases in high-risk populations.

### Development of Novel Pastry Products

Baked foods such as cookies are among the excellent food matrices for nutrient enhancement. Notably, these items are even patronized by children, creating an excellent cluster to be considered for dietary interventions. According to the findings, nutrition enrichment in baked foods is generally provable with relatively minimal impacts on sensory properties as flavor, texture, aroma, and appearance. For example, muffins enriched with calcium have received wide acceptance from consumers with little effect upon taste and texture (Alves et al., 2021). This study investigates the fortification of cookies with eggshell powder, which presents a sustainable and bioavailable mineral source of calcium.

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This will supplement dietary calcium with minimal drastic changes in the commonly consumed diets, especially for populations with a lower calcium status. The success of fortified food items in markets with little alternative calcium sources has been attributed to consumer acceptability and sensory evaluation (Palacios et al., 2021).

**Sensory Attributes**

Generally, the sensory features of taste, texture, aroma and appearance have significantly affected consumer preference determinants. Most fundamental sensory characteristics like taste, texture, aroma and appearance have heavily influenced determinants of consumer preference. According to Manisha et al. (2023), very often, ingredients must be balanced in fortified pastries with respect to their sensory properties to ensure consumer acceptability. Employ more trained panelists and longer consumer surveys to measure the sensory effect of quail eggshell powder on products with potentially formulation-enhanced areas. Another of the other essential sensory attributes affecting consumer preference of the fortified product is appearance. A food's appearance will either draw the consumer to purchase the product or deter them from buying it. Fortified foods, especially those supplemented with additives like eggshell powder, should have that usual appearance acceptable to the consumer. If the fortification process introduces a change in color or results in visible particulates, consumers will not find it very appealing and of inferior quality. According to Manisha et al. (2023), the visual appearance of fortified pastries should be consistent with what consumers expect so that the product does not raise doubts about its flavor or texture. Using sensory panels and surveys can determine how fortification affects appearance and offer evaluations that manufacturers can address to produce attractive-to-look-at products that can lead to consumer trials and repeat purchases (Palacios et al., 2021).

The aroma of baked goods such as cookies is very important for sensory acceptance, influencing flavor and, therefore, affecting consumer choices and purchase decisions (Darwanto et al., 2021). The introduction of other ingredients such as eggshell powder may affect changes in aroma profile that become subtler in front of this consumer acceptability. Aroma substances are essentially obtained from complex reactions involved in the Maillard reaction along with lipid oxidation and such reactions can differ according to the nature of these fortifying ingredients (Liu et al., 2021) To guarantee the sensory acceptability of cookies to consumers in the market, the obscure change of aroma in cookies fortified with eggshell powder together with other nutrients should still maintain its traditional aroma. Recent studies state that, with proper formulations and processing techniques, the addition of calcium-rich eggshell powder does not alter the aroma considerably and further promises a good sensory appeal to the end consumer (Cisowska et al, 202). When optimizing through an aromatic profile to produce fortified cookies, one could create nutrient-rich products providing health benefits and still satisfying the sense of taste.

To be accepted by the consumer, the taste of fortified food items will be very significant, mainly in markets with meager alternative sources of essential nutrients, like calcium. Aura, Linda Amaya (2022) outline that taste is one of consumers' foremost sensory factors before buying fortified food items. Fortified pastries can often be complex because of the masking or complementing effect some added fortifying agents may display on potentially distinct flavor contributions, such as that which eggshell powder may introduce in the form of mineral flavors or aftertaste. Suitable formulation must, therefore, focus on an excellent balancing of ingredients toward a smooth taste profile so that the fortification does not overpower familiar flavor profiles consumers expect. If the flavor of the enriching agent is too pronounced, consumer acceptance may decrease; therefore, there is a great need to well-engineer the flavor profiles (Manisha et al., 2023

Similarly, texture is central to consumer acceptance and perception of fortified products. Consumers will reject a product if the fortifying ingredient changes the expected mouthfeel to either too grainy, complex, or sticky (Manisha et al., 2023). For example, adding eggshell powder to the fortified pastries may affect the final product texture because of the powdery grind and the possible interactions in the dough or batter. For example, it has been demonstrated that customers would be more willing to accept fortified foods if the mouthfeel was what they would expect from their counterpart products. The ideal addition, therefore, should be texturally imperceptible (Fombong et al., 2023). Full sensory assessment and more extensive consumer research with trained sensory panelists may suggest what texture the addition alters and how the food scientist might adjust their formulation to produce a consumer-friendly texture.

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A key emphasis of this study has been the assessment of nutritional enrichment for eggshell powder enrichment. Research indicates that eggshell powder generally helps increase the calcium content in baked goods, fulfilling daily dietary requirements with minimal consumption (Drysdale, Rebekah, 2022). In addition, market trends also indicate a gain in the demand for functional foods; thereby, consumers are becoming more willing to buy health-oriented products (Antoniak et al., 2022). The present study incorporates consumer preference and willingness to purchase to determine market feasibility for calcium-enriched pastries. This will help local bakeries and quail egg producers when deciding to pursue this potential demand.

## III. METHODOLOGY

This study combined elements of experimental and descriptive designs with a mixed method approach designed for the development and evaluation of the formulation of calcium-enriched cookies using eggshell powder. Therefore, the primary intention of the present research is formulating, optimizing, and evaluating cookies that are prepared by using eggshell powder as safe and bioavailable sources of calcium. The phases include adjusting portions of ingredients in use through the three formulations from the base ingredients, carrying out sensory tests, and measuring nutritional value while ensuring that all the cookies must meet any intentions of dietary enrichment. This experimental design produced calcium-rich cookies by utilizing eggshell powder as the main source of calcium. The raw eggshells were carefully cleaned, sterilized, and ground into fine powder for safe and high-quality production. Formulations of cookies varied systematically by the percentage of eggshell powder added to the formulation to find the optimal amount at which the addition of its powder increases the calcium content in the cookies with desirable sensory attributes. The study was held at Surigao del Norte State University, which uses the Food Science Laboratory, a full-fledged laboratory with updated and high technology equipment in the Main Campus. All this equipment is all important in ensuring that food formulation is taken with great accuracy to deliver valid results. There were 20 food experts and 100 consumers who evaluated the sensory acceptability of the three formulations using the 9-point Hedonic Scale. Mean and Standard Deviation were used to determine the acceptability of the Calcium-Enriched Cookie using Eggshell Powder in terms of appearance, aroma, flavor/taste, and texture. Multivariate Analysis of Variance (MANOVA) for Repeated Measures and Bonferroni's Test were used to compare the three formulations of Calcium-Enriched Cookie using Eggshell Powderin terms of the four sensory attributes: appearance, aroma, taste, and texture.

## IV. RESULTS AND DISCUSSION

Table 1 presents the sensory evaluation results on the acceptability of appearance of calcium-enriched cookies made with eggshell powder across three different formulations.

TABLE 1
ACCEPTABILITY OF APPEARANCE OF CALCIUM-ENRICHED COOKIE USING EGGSHELL POWDER

| Statement | Formulation A | | | Formulation B | | | Formulation C | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | SD | *D* | M | SD | *D* | M | SD | *D* |
| 1. The color of the product looks appealing. | 6.54 | 1.06 | ***LM*** | 6.88 | 0.62 | ***LM*** | 8.43 | 0.59 | ***LVM*** |
| 2. The color is vibrant and fresh. | 6.36 | 1.18 | ***LS*** | 6.86 | 1.62 | ***LM*** | 8.18 | 0.72 | ***LVM*** |
| 3. The product's color is consistent and uniform. | 6.90 | 1.04 | ***LM*** | 6.99 | 2.62 | ***LM*** | 8.37 | 0.63 | ***LVM*** |
| 4. The color of the product is suitable for its type. | 7.09 | 1.39 | ***LM*** | 6.97 | 3.62 | ***LM*** | 8.12 | 0.57 | ***LVM*** |
| 5. The product's color matches my expectations for this type of product. | 6.56 | 1.04 | ***LM*** | 6.89 | 4.62 | ***LM*** | 8.23 | 0.92 | ***LVM*** |
| **Average** | 6.69 | 0.84 | ***LM*** | 6.92 | 5.62 | ***LM*** | 8.27 | 0.50 | ***LVM*** |

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Formulation A received an overall average mean of 6.69, corresponding to the description "Like Moderately (LM)," indicating a generally positive perception of its appearance. Among all the statements, the color being suitable for its type scored the highest mean at 7.09 (LM), suggesting that participants found the appearance appropriate for what they expect from this type of cookie. The lowest mean was 6.36 (LS) for the statement "The color is vibrant and fresh," implying that while still positively received, this aspect was seen as less strong compared to others.

Formulation B had a slightly higher average mean of 6.92, also within the "Like Moderately (LM)" range. The highest-rated statement was "The product's color is consistent and uniform," with a mean of 6.99 (LM), highlighting consistency in appearance as the formulation's strongest visual feature. On the other hand, the lowest mean score of 6.86 (LM) was given to "The color is vibrant and fresh," indicating this formulation, like Formulation A, could improve on projecting freshness through its color.

Formulation C outperformed the other two, with a significantly higher overall mean of 8.27, falling into the "Like Very Much (LVM)" category. This suggests a high level of satisfaction with the cookie's visual appeal. The highest-rated statement was "The color of the product looks appealing," which received a mean of 8.43 (LVM), showing strong agreement among raters that the product was visually attractive. The lowest, though still highly rated, was "The color is vibrant and fresh" with a mean of 8.18 (LVM), reinforcing that even the least appreciated attribute in this formulation was still very well accepted.

Table 2 summarizes the acceptability of aroma for the calcium-enriched cookie using eggshell powder across three different formulations.

TABLE 2
ACCEPTABILITY OF AROMA OF CALCIUM-ENRICHED COOKIE USING EGGSHELL POWDER

| Statement | Formulation A | | | Formulation B | | | Formulation C | | |
|---|---|---|---|---|---|---|---|---|---|
| | **M** | **SD** | ***D*** | **M** | **SD** | ***D*** | **M** | **SD** | ***D*** |
| 1. The product has an appealing odor. | 6.48 | 1.32 | ***LS*** | 7.26 | 0.97 | ***LM*** | 8.21 | 0.48 | ***LVM*** |
| 2. The product's odor is pleasant and not overpowering. | 6.53 | 1.20 | ***LM*** | 7.15 | 1.21 | ***LM*** | 8.12 | 0.87 | ***LVM*** |
| 3. The product has a natural odor. | 6.63 | 1.25 | ***LM*** | 7.16 | 0.99 | ***LM*** | 8.14 | 0.57 | ***LVM*** |
| 4. The odor of the product is pleasant enough to encourage consumption. | 7.13 | 1.20 | ***LM*** | 7.19 | 1.10 | ***LM*** | 8.48 | 0.56 | ***LVM*** |
| 5. The product's odor is consistent with its intended flavor. | 6.81 | 1.01 | ***LM*** | 7.03 | 1.01 | ***LM*** | 8.45 | 0.70 | ***LVM*** |
| **Average** | 6.72 | 1.05 | ***LM*** | 7.16 | 0.90 | ***LM*** | 8.28 | 0.49 | ***LVM*** |

Formulation A obtained an overall mean of 6.72, falling under the "Like Moderately (LM)" category. Among all the aroma-related statements, the highest mean was 7.13 (LM) for the statement "The odor of the product is pleasant enough to encourage consumption," indicating that this formulation had a relatively inviting smell. The lowest rating was for "The product has an appealing odor," which received a mean of 6.48, described as "Like Slightly (LS)," suggesting a slight weakness in the initial aromatic appeal of this variant. Formulation B performed slightly better, with an average mean of 7.16, also within the "Like Moderately (LM)" range. The highest-rated statement was "The product has an appealing odor," scoring 7.26 (LM), showing that this formulation was more favorably received in terms of overall scent compared to Formulation A. The lowest mean was 7.03 (LM) for the statement "The product's odor is consistent with its intended flavor," which, although the lowest, still reflected a generally good impression of the

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product's aromatic alignment with its expected taste. Formulation C again achieved the highest scores, with a notably strong average mean of 8.28, classified as "Like Very Much (LVM)," signifying a high level of aroma acceptability. The strongest attribute was "The odor of the product is pleasant enough to encourage consumption," with an impressive mean of 8.48 (LVM), indicating that participants found the smell highly appetizing. The lowest, though still very favorable, was "The product's odor is pleasant and not overpowering," with a mean of 8.12 (LVM), which implies a well-balanced scent that did not overwhelm the senses.

Table 3 presents the results of the sensory evaluation on the acceptability of taste for the calcium-enriched cookie using eggshell powder in three formulations.

Formulation A received an overall average mean of 6.80, interpreted as "Like Moderately (LM)." Among the statements, the highest-rated was "The taste of the product is enjoyable," with a mean of 7.10 (LM), suggesting that participants found the flavor pleasant and satisfactory. The lowest mean was 6.62 (LM) for the statement "The taste of the product is unique and refreshing," indicating that while still moderately liked, this formulation did not stand out in terms of flavor novelty or refreshing quality.

TABLE 3
THE ACCEPTABILITY OF TASTE OF CALCIUM-ENRICHED COOKIE USING EGGSHELL POWDER

| Statement | Formulation A | | | Formulation B | | | Formulation C | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | SD | *D* | M | SD | *D* | M | SD | *D* |
| 1. The taste of the product is enjoyable. | 7.10 | 0.79 | ***LM*** | 6.77 | 1.21 | ***LM*** | 8.16 | 0.55 | ***LVM*** |
| 2. The product has a balanced taste. | 6.69 | 0.98 | ***LM*** | 6.93 | 1.17 | ***LM*** | 8.62 | 0.51 | ***LE*** |
| 3. The taste of the product is unique and refreshing. | 6.62 | 1.49 | ***LM*** | 7.19 | 0.83 | ***LM*** | 8.40 | 0.56 | ***LVM*** |
| 4. The product has the right level of sweetness or saltiness. | 6.95 | 1.05 | ***LM*** | 7.45 | 0.97 | ***LM*** | 8.27 | 0.64 | ***LVM*** |
| 5. The aftertaste of the product is pleasant. | 6.65 | 1.16 | ***LM*** | 7.57 | 0.79 | ***LVM*** | 8.20 | 0.40 | ***LVM*** |
| **Average** | 6.80 | 0.90 | ***LM*** | 7.18 | 0.90 | ***LM*** | 8.33 | 0.39 | ***LVM*** |

Formulation B had a slightly higher overall mean of 7.18, also within the "Like Moderately (LM)" range. Its strongest attribute was "The aftertaste of the product is pleasant," with a mean of 7.57, which was uniquely rated as "Like Very Much (LVM)," indicating that the formulation left a favorable impression after consumption. The lowest mean was 6.77 (LM) for "The taste of the product is enjoyable," which, although the least favored among the five, still suggests general acceptability. Formulation C stood out once again with the highest overall mean of 8.33, classified as "Like Very Much (LVM)." This formulation was especially praised for its balanced flavor, with the statement "The product has a balanced taste" earning the highest mean score of 8.62, reaching the rare and highest descriptor of "Like Extremely (LE)." The lowest mean, though still exceptionally favorable, was 8.16 (LVM) for "The taste of the product is enjoyable," reinforcing that even the least favoredflavor attribute of this formulation was still highly accepted.

Table 4 displays the sensory evaluation results for the acceptability of texture in the calcium-enriched cookie using eggshell powder, assessed across three different formulations.

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TABLE 4
ACCEPTABILITY OF TEXTURE OF CALCIUM-ENRICHED COOKIE USING EGGSHELL POWDER

| Statement | Formulation A | | | Formulation B | | | Formulation C | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | SD | D | M | SD | D | M | SD | D |
| 1. The texture of the product is smooth and pleasant. | 6.62 | 1.20 | ***LM*** | 6.67 | 1.11 | ***LM*** | 8.17 | 0.42 | ***LVM*** |
| 2. The product has the right amount of crunch or softness. | 6.55 | 1.02 | ***LM*** | 7.11 | 0.96 | ***LM*** | 8.46 | 0.61 | ***LVM*** |
| 3. The texture is consistent throughout the product. | 6.76 | 1.51 | ***LM*** | 6.87 | 1.16 | ***LM*** | 8.36 | 0.50 | ***LVM*** |
| 4. The texture makes the product enjoyable to eat. | 6.76 | 0.99 | ***LM*** | 6.53 | 1.25 | ***LM*** | 8.52 | 0.57 | ***LE*** |
| 5. The texture is suitable for the type of product. | 7.19 | 1.04 | ***LM*** | 6.44 | 1.46 | ***LS*** | 8.61 | 0.51 | ***LE*** |
| **Average** | 6.72 | 1.11 | ***LM*** | 6.67 | 1.14 | ***LM*** | 8.36 | 0.84 | ***LVM*** |

Formulation A garnered an average mean of 6.72, interpreted as "Like Moderately (LM)," indicating a generally favorable perception of its texture. Among the five attributes, “The texture is suitable for the type of product” received the highest mean score of 7.19 (LM), showing that participants found the texture appropriate for a cookie. The lowest mean score was 6.55 (LM), given to the statement “The product has the right amount of crunch or softness,” suggesting that while acceptable, improvements could be made in balancing the desired texture elements. Formulation B had a slightly lower average mean of 6.67, also falling within the "Like Moderately (LM)" category. The most favorable attribute was “The product has the right amount of crunch or softness,” with a mean of 7.11 (LM), reflecting a relatively positive response in terms of bite quality. The least accepted attribute was “The texture is suitable for the type of product,” which scored a mean of 6.44 and was rated only as "Like Slightly (LS)," indicating a mild reservation from participants about how well the texture matched their expectations for cookies. Formulation C again received the highest ratings, with a strong average mean of 8.36, categorized as "Like Very Much (LVM)." Two statements stood out with exceptionally high scores: “The texture makes the product enjoyable to eat” and “The texture is suitable for the type of product,” with mean scores of 8.52 and 8.61, respectively, both falling under the highest descriptive equivalent “Like Extremely (LE).” The lowest-rated statement, “The texture of the product is smooth and pleasant,” still earned a high mean of 8.17 (LVM), affirming the consistency and high satisfaction with texture across all aspects.

Tables 5 and 6 present the results of the statistical analysis conducted to determine significant differences in the sensory attributes of calcium-enriched cookies made with eggshell powder across three formulations.

TABLE 5
SIGNIFICANT DIFFERENCE ON THE ACCEPTABILITY OF THE SENSORY ATTRIBUTES OF THE THREE FORMULATIONS OF CALCIUM- ENRICHED COOKIE USING EGGSHELL POWDER

| Attribute | F | p | Decision on Ho | Interpretation |
|---|---|---|---|---|
| Appearance | 461.35 | <0.01 | Rejected | Significant |
| Aroma | 379.37 | <0.01 | Rejected | Significant |
| Taste | 356.25 | <0.01 | Rejected | Significant |
| Texture | 368.55 | <0.01 | Rejected | Significant |

*Wilks' Lambda $\Lambda = 0.117$, $F=113.24$, $p<0.01$*

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Based on Table 5, the Wilks' Lambda value of 0.117, F=113.24, and p<0.01 indicates a highly significant multivariate effect of the formulations on the combined sensory attributes. This suggests that the overall sensory profiles of the three formulations differ significantly. When the individual attributes were tested through univariate ANOVAs, all four—appearance, aroma, taste, and texture—showed significant differences across formulations, with p-values all less than 0.01 and corresponding F-values ranging from 356.25 to 461.35. This led to the rejection of the null hypothesis for all attributes, confirming that the differences in sensory perceptions were statistically meaningful.

TABLE 6
PAIRWISE COMPARISONS ON SENSORY ATTRIBUTES OF CALCIUM-ENRICHED COOKIE USING EGGSHELL POWDER IN THREE FORMULATIONS

| Attribute | Formulation (Mean) | | p | Decision on Ho | Interpretation |
|---|---|---|---|---|---|
| Appearance | A (M=6.69) | B (M=6.92) | <0.01 | Rejected | Significant |
| | A (M=6.69) | C (M=8.27) | <0.01 | Rejected | Significant |
| | B (M=6.92) | C (M=8.27) | <0.01 | Rejected | Significant |
| Aroma | A (M=6.72) | B (M=7.16) | <0.01 | Rejected | Significant |
| | A (M=6.72) | C (M=8.28) | <0.01 | Rejected | Significant |
| | B (M=7.16) | C (M=8.28) | <0.01 | Rejected | Significant |
| Taste | A (M=6.8) | B (M=7.18) | <0.01 | Rejected | Significant |
| | A (M=6.8) | C (M=8.33) | <0.01 | Rejected | Significant |
| | B (M=7.18) | C (M=8.33) | <0.01 | Rejected | Significant |
| Texture | A (M=6.72) | B (M=6.67) | 1.000 | Not Rejected | Not Significant |
| | A (M=6.72) | C (M=8.36) | <0.01 | Rejected | Significant |
| | B (M=6.67) | C (M=8.36) | <0.01 | Rejected | Significant |

Table 6 further clarifies the specific differences through pairwise comparisons. For appearance, Formulation C (M=8.27) was significantly preferred over both Formulation B (M=6.92) and Formulation A (M=6.69), with all p-values below 0.01. The same pattern was observed in aroma, where Formulation C (M=8.28) again outperformed Formulation B (M=7.16) and Formulation A (M=6.72), indicating its stronger appeal in terms of scent. In terms of taste, Formulation C (M=8.33) was significantly more liked compared to both B (M=7.18) and A (M=6.80), with participants clearly favoring the flavor of Formulation C. For texture, while no significant difference was found between Formulations A (M=6.72) and B (M=6.67) (p=1.000), Formulation C (M=8.36) was again significantly more acceptable than both A and B (p<0.01).

Table 7 presents the physicochemical composition of the calcium-enriched cookie using Formulation C, which was previously established as the most preferred variant based on sensory evaluation.

TABLE 7
PHYSICOCHEMICAL COMPONDENTS OF FORMULATION "C" OF CALCIUM-ENRICHED COOKIE USING EGGSHELL POWDER

| Analysis | Unit | Results |
|---|---|---|
| Total Fat | g/100g | 22.4 |
| Crude Protein (N × 6.25) | g/100g | 7.13 |
| ᵠTotal Sugar | g/100g | 6.23 |
| Calcium | mg/kg | 733 |

The results show that Formulation C contains 22.4 grams of total fat per 100 grams, indicating a relatively high fat content, which may contribute to the cookie's rich texture and flavor—attributes that were highly rated in the sensory evaluation. The crude protein content is 7.13 grams per 100 grams, a moderate level that can contribute to the cookie's nutritional value, making it more than just a carbohydrate-rich snack. The total sugar content is 6.23 grams per 100

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grams, which aligns well with the sensory feedback indicating that the cookie had a balanced and well-accepted sweetness level. The cookie contains 733 mg of calcium per kilogram, reflecting the successful enrichment using eggshell powder. This significant calcium content enhances the functional value of the product, potentially supporting bone health and making it a nutritionally superior alternative to regular cookies.

## V. CONCLUSION

The developed calcium-enriched cookies were well received overall, with Formulation C showing the highest potential for consumer satisfaction in terms of appearance, aroma, taste, and texture. Formulation C stands out as the superior product among the three variations, indicating its advantage in future production and marketability. Formulation C not only excelled in sensory quality but also offered a meaningful nutritional profile, particularly in calcium enrichment, aligning with the study's goal of developing a functional cookie product.

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