Development of Lansium Domesticum Chia Candy Sweetened with Stevia

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ABSTRACT

This study aimed to develop and evaluate the acceptability of Lansium domesticum chia candy sweetened with stevia as an alternative confectionery product. An experimental research design was used to develop three formulations combining stevia with isomalt, maltitol, and corn syrup. Trial-and-error optimization was conducted to obtain the desired hard-candy characteristics. The eighth trial produced the desired product, and Treatment 1, composed of isomalt and stevia, was selected as the final formulation because it reached the hard-crack stage, produced a hard and brittle texture, retained its shape after demolding and packaging, and remained stable during the storage observation. The final formulation consisted of isomalt, water, concentrated lansones paste, powdered chia seeds, stevia powder, and white food coloring. The cooking target was 140-150 °C and 95-99 °Brix. Microbiological analysis reported an aerobic plate count (APC) of <1.0 CFU/g, a total coliform count (TCC) of <1.0 CFU/g, and a combined yeast and mold count (YMC) of 10 CFU/g. These results describe the microbiological quality of the tested samples at the time of analysis and do not establish long-term microbiological stability. A preliminary 9-point hedonic evaluation by 10 respondents yielded scores from 5.2 to 7.6, with appearance receiving the highest score. Final acceptability testing used a five-point scale with 50 consumers and five expert evaluators. The developed candy obtained grand means of 4.49 among consumers and 4.37 among experts, both interpreted as highly acceptable. In a separate questionnaire section, respondents rated their perceptions of traditional commercial hard candy, yielding grand means of 4.36 among consumers and 4.60 among experts. Because no physical commercial sample was evaluated, these results reflect perceived acceptability rather than a direct product comparison. Within the study's scope and limitations, the results indicate that isomalt with stevia provided a feasible basis for producing an acceptable Lansium domesticum chia hard candy. Further nutritional and shelf-life studies are recommended.

Keywords: Lansium domesticum; chia seeds; stevia; isomalt; hard candy

INTRODUCTION

Lansium domesticum, commonly known as lanzones or lansones, is a tropical fruit that has been studied for its nutritional, phytochemical, and potential food applications. The related literature identifies the fruit as a locally available agricultural resource with potential for value-added processing (Abdallah et al., 2022; Mayanti et al., 2022). Developing confectionery products from locally available fruit can provide a route for product diversification while incorporating familiar fruit characteristics into processed foods.

Chia seeds (Salvia hispanica L.) have also received attention as a food ingredient because of their nutritional composition and functional properties. Chia mucilage can influence rheological and textural properties, supporting its application in food formulations (Garcia e Silva et al., 2022; Khalid et al., 2023; Mensah et al., 2024). Stevia has been investigated as a high-intensity sweetener and as a sugar substitute in different food matrices, although sensory responses can depend on formulation and concentration (Naik & Poyil, 2022;

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Schiatti-Sisó et al., 2023). Isomalt and maltitol are sugar alcohols used in confectionery, where their functional properties can contribute to bulk, texture, and stability (Bhattacharya, 2023).

The research identified a gap in the combined use of lansones, chia seeds, and stevia in a hard-candy formulation, particularly with respect to sensory acceptability and microbiological assessment. Accordingly, this study developed Lansium domesticum chia candy sweetened with stevia using three sweetener systems isomalt with stevia, maltitol with stevia, and corn syrup with stevia then selected the formulation that achieved the desired physical characteristics for further evaluation.

The study specifically evaluated the selected product through microbiological testing, preliminary hedonic assessment, and final sensory acceptability testing by consumers and expert evaluators. The study also documented respondents' perceptions of traditional commercial hard candy; no physical commercial sample was used for direct comparison.

MATERIALS AND METHODS

Research Design and Locale

An experimental research design was employed. Product development and evaluation were conducted, with respondent activities conducted in the City of San Jose del Monte, Bulacan. The sensory evaluation was carried out in a controlled environment. The study involved 50 consumer respondents and five expert evaluators selected through convenience sampling.

Formulation and Product Development

Three treatments were developed: T1, isomalt with stevia; T2, maltitol with stevia; and T3, corn syrup with stevia. Trial-and-error formulation was used to determine the combination that produced a hard-candy product with adequate hardness, shape retention, texture, and storage stability. The eighth trial produced the desired hard-candy characteristics, and T1 was selected for final testing. The formal treatment labels describe the intended sweetener systems; Trials 4 and 7, which contained both corn syrup and isomalt, were intermediate optimization attempts and do not redefine T3 or the final T1 formulation.

Trial	Recorded formulation	Processing summary	Observed outcome / reason for modification
Trial 1	1 cup fresh lansones pulp; 2 tbsp chia seeds; 1 tsp stevia powder; 1/2 cup water; 2 tsp agar-agar powder	Pulp and water cooked over low heat; chia, stevia, and agar-agar added; cooled in a flat tray without a candy mold.	Soft, jelly-like, and high in moisture; difficult to cut. Discontinued for the intended hard-candy product.
Trial 2	74 g isomalt; 15 g water; 10 g concentrated lansones pulp; 1 g powdered chia; 0.1 g stevia; 0.3 g lansones juice; 2 drops white food colorant	Isomalt and water heated; remaining ingredients stirred in; molded and cooled at room temperature.	Hardened and retained shape, but crystals/dots caused graininess. Cooking temperature and duration were not adequately controlled.
Trial 3	74 g maltitol; 5 g water; 10 g concentrated lansones pulp; 10 g lansones juice; 1 g powdered chia; 0.1 g stevia; 2 drops white food coloring	Maltitol and water heated; fruit components, chia, stevia, and color incorporated; molded and cooled overnight.	Did not harden completely; sticky and difficult to demold; lacked firm, brittle texture.
Trial 4	60 g corn syrup; 14 g isomalt; 10 g concentrated lansones pulp; 20 g lansones juice; 1 g powdered chia; 0.1 g stevia; 2 drops white	Corn syrup and isomalt heated until dissolved; remaining ingredients added; molded and cooled.	Watery/soft and difficult to demold. High liquid proportion, particularly 20 g juice, was associated with failure to reach

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	food coloring		hard-crack stage.
Trial 5	74 g isomalt; 5 g water; 10 g concentrated lansones pulp; 10 g concentrated lansones juice; 1 g powdered chia; 0.1 g stevia; 2 drops white food coloring	Isomalt and water heated; remaining ingredients incorporated; molded and cooled overnight.	Soft and sticky; deformed during demolding. Added lansones juice increased moisture.
Trial 6	74 g maltitol; 10 g water; 8 g highly concentrated lansones paste; 1 g powdered chia; 0.1 g stevia; 2 drops white food coloring	Maltitol and water heated; paste, chia, stevia, and color added; molded, cooled, and packaged.	Hardened enough to demold but lost form and deformed slightly after packaging.
Trial 7	50 g corn syrup; 15 g isomalt; 5 g concentrated lansones paste; 1 g powdered chia; 0.1 g stevia; 2 drops white food coloring	Corn syrup and isomalt heated; paste, chia, stevia, and color incorporated; molded, cooled, packaged, and observed.	Hardened sufficiently for demolding but became sticky, deformed, and adhered to packaging.
Trial 8 (final/T1)	74 g isomalt; 15 g water; 5 g highly concentrated lansones paste; 0.5 g powdered chia; 0.05 g stevia; 2 drops white food coloring	Isomalt and water heated to 140-150 °C and 95-99 °Brix; paste, chia, stevia, and color added; molded and cooled.	Hardened in approximately one hour, retained shape after demolding and packaging, and showed no observed softening, deformation, or stickiness during the reported one-week observation. Selected as T1.

Table 1. Formulation and development of the Lansium domesticum chia candy.

Note. These eight trials were sequential formulation-development iterations, not independent replicate batches. The trial outcomes document the optimization pathway and do not support statistical comparisons among treatments. Batch-to-batch reproducibility was not established.

For the selected formulation, lansones were washed, peeled, and deseeded. The pulp was extracted and cooked until concentrated. Chia seeds were powdered. Isomalt was heated with water until the mixture reached 140-150 °C and 95-99 °Brix. The concentrated lansones paste, powdered chia seeds, stevia, and food-grade white coloring were then incorporated. The mixture was placed into molds and allowed to cool and harden at room temperature before being transferred to food-grade glass containers.

Ingredient	**Quantity**
Isomalt	74 g
Water	15 g
Concentrated lansones paste	5 g
Powdered chia seeds	0.5 g
Stevia powder	0.05 g
White food coloring	2 drops

Table 2. Final formulation of the selected Lansium domesticum chia candy.

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Microbiological Analysis

Samples of the developed lansones chia candy were submitted to two laboratory facilities for microbiological analysis. The Bulacan State University Analytical Testing Laboratory conducted the Aerobic Plate Count (APC) and Total Coliform Count (TCC) analyses. Yeast and Mold Count (YMC) analysis was conducted by Precision Analytical Research and Diagnostic Laboratory, Inc., using the US FDA Bacteriological Analytical Manual, Chapter 18. The researchers submitted the samples, while laboratory personnel performed the analyses. The corresponding laboratory certificates are included in the research appendices.

Microbial Parameter	**Test Result**	**FDA Reference Criterion for Sugar Confectioneries***		**Testing Laboratory**
		m= acceptable level	**M= maximum level**	
Aerobic Plate Count (APC)	<1.0 CFU/g	m= 10^3 CFU/g	M= 10^4 CFU/g	Bulacan State University Analytical Testing Laboratory
Total Coliform Count (TCC)	<1.0 CFU/g	m= <10 CFU/g	M= <10^2 CFU/g	Bulacan State University Analytical Testing Laboratory
Yeast and Mold Count (YMC)	10 CFU/g	molds m= <10 CFU/g osmophilic yeast m= <10 CFU/g	molds M= <10^2 CFU/g osmophilic yeast M= <10^2 CFU/g	Precision Analytical Research and Diagnostic Laboratory, Inc.

Table 3. Microbiological results reported in the study.

**Source: FDA Circular No. 2022-012, Table 4, Sugar Confectioneries. The FDA table specifies a sampling plan of n = 5 and c = 2. CFU/g = colony-forming units per gram; m = acceptable level; M = maximum level.*

Note: Detailed analytical procedures and test conditions were based on the protocols of the respective testing laboratories. The study reports the results provided in the laboratory certificates; additional procedural details not documented by the researchers are not claimed.

Sensory Evaluation and Acceptability Testing

A preliminary sensory evaluation was conducted using a 9-point hedonic scale with 10 respondents in Bulacan State University Analytical Testing Laboratory. The attributes were appearance, aroma, neutral sweetness, mouthfeel, aftertaste, texture, and overall acceptability. After the selected formulation was established and microbiological testing was completed, final acceptability was evaluated by 50 consumers and five experts using a five-point Likert-type scale ranging from 5 (Highly Acceptable) to 1 (Not Acceptable). No specific commercial brand or physical commercial sample was presented; respondents rated the developed candy in relation to their familiarity with traditional commercial hard candy. Thus, this part of the questionnaire captured perceived acceptability rather than a side-by-side comparison. The original records do not document randomized sample coding or presentation order, so neither has been retrospectively assigned or claimed. The questionnaire was reviewed by the adviser, statistician, and lecturers, as documented in the study.

Data Analysis

Final acceptability results were summarized using item-level means, sample standard deviations (SDs), and approximate 95% confidence intervals (CIs) calculated from the five-point response-frequency distributions. The CIs were estimated using the t-distribution. Because the expert group comprised only five respondents, its intervals are imprecise; some upper limits exceed the scale maximum of 5.00 and should be interpreted

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cautiously. Preliminary nine-point hedonic results were reported separately and were not compared numerically with the final five-point results. The questionnaire section referring to traditional commercial hard candy was analyzed descriptively because no physical comparator was tested. No inferential hypothesis tests were performed, and no statistical significance, equivalence, or superiority is claimed. The available frequency tables support item-level calculations but do not preserve respondent-level pairing across the six questions; therefore, an overall respondent-level SD or CI for the six-item composite could not be calculated from these tables alone.

RESULTS AND DISCUSSION

Selection of the Final Treatment

Treatment 1 (isomalt with stevia) was selected as the final formulation based on the recorded product-development trials. Trial 8 achieved the desired hard-candy characteristics, including complete hardening, shape retention after demolding and packaging, and no observed stickiness or deformation during the one-week observation period. Earlier trials showed issues such as crystallization, incomplete hardening, excessive moisture, stickiness, and deformation. Because the trials were sequential formulation-development attempts rather than replicated, controlled experiments, these observations support the descriptive selection of the final formulation but do not establish statistical superiority among the intended sweetener systems.

Criterion	Selected formulation (Trial 8)	Issues observed in earlier trials
Hardening ability	Achieved the desired hard-candy structure	Some trials remained soft or failed to harden completely
Texture	Hard and brittle, with the desired consistency	Crystallization, softness, or stickiness occurred in some trials
Shape retention	Retained shape after demolding and packaging	Some trials deformed after cooling, demolding, or packaging
Stickiness	No observed stickiness during the one-week observation	Stickiness or adhesion to packaging occurred in some trials
Storage stability	Selected for final microbiological and sensory evaluation	Earlier formulations were modified because of their recorded physical outcomes

Table 4. Recorded Product Characteristics Supporting Selection of the Final Formulation.

Preliminary Sensory Evaluation

Attribute	Mean	Interpretation
Appearance	7.6	Like moderately
Aroma	5.2	Neither like nor dislike
Neutral sweetness	7.4	Like moderately
Mouthfeel	6.6	Like slightly
Aftertaste	5.6	Neither like nor dislike
Texture	6.2	Like slightly
Overall acceptability	6.2	Like slightly

Table 5. Preliminary sensory evaluation using a 9-point hedonic scale (n=10).

The preliminary evaluation produced mean scores from 5.2 to 7.6. Appearance received the highest score (7.6), followed by neutral sweetness (7.4). Aroma (5.2) and aftertaste (5.6) were comparatively lower and were

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interpreted as neither like nor dislike. Texture and overall acceptability both received 6.2, interpreted as like slightly. These results supported further refinement and selection of the formulation before final acceptability testing.

Microbiological Quality

According to FDA Circular No. 2022-012, Table 4, sugar confectioneries have specified microbiological reference criteria for aerobic plate count, coliforms, molds, and osmophilic yeast. The Bulacan State University Analytical Testing Laboratory reported an aerobic plate count (APC) of less than 1.0 CFU/g and a total coliform count (TCC) of less than 1.0 CFU/g. Precision Analytical Research and Diagnostic Laboratory, Inc. reported a combined yeast and mold count (YMC) of 10 CFU/g using the US FDA Bacteriological Analytical Manual, Chapter 18. The APC and TCC results were below the corresponding reference levels presented in Table 3. However, because molds and osmophilic yeast are listed separately in the FDA criteria, the combined YMC result alone does not independently establish compliance with each separate criterion. These results describe the tested samples at the time of analysis and do not establish long-term microbiological stability.

Final Sensory Acceptability

Sensory attribute	Consumers (n=50)	Experts (n=5)
Taste	4.58 ± 0.64 95% CI: 4.40–4.76 (Highly Acceptable)	5.00 ± 0.00 95% CI: 5.00–5.00 (Highly Acceptable)
Aroma	4.30 ± 0.74 95% CI: 4.09–4.51 (Highly Acceptable)	4.60 ± 0.89 95% CI: 3.49–5.71 (Highly Acceptable)
Texture	4.16 ± 0.93 95% CI: 3.89–4.43 (Acceptable)	3.80 ± 1.10 95% CI: 2.44–5.16 (Acceptable)
Color/Visual	4.58 ± 0.73 95% CI: 4.37–4.79 (Highly Acceptable)	4.20 ± 1.30 95% CI: 2.58–5.82 (Highly Acceptable)
Flavor	4.60 ± 0.61 95% CI: 4.43–4.77 (Highly Acceptable)	4.00 ± 1.22 95% CI: 2.48–5.52 (Acceptable)
Overall acceptability	4.70 ± 0.58 95% CI: 4.54–4.86 (Highly Acceptable)	4.60 ± 0.55 95% CI: 3.92–5.28 (Highly Acceptable)
Grand mean	4.49 – Highly Acceptable CI not calculated for composite	4.37 – Highly Acceptable CI not calculated for composite

Table 6. Final sensory acceptability of the developed candy (mean ± sample standard deviation).

Consumers gave the developed candy a grand mean of 4.49, interpreted as Highly Acceptable. Overall acceptability received the highest consumer score (4.70), followed by flavor (4.60), taste and visual quality/color (4.58 each), and aroma (4.30). Texture obtained the lowest score (4.16) and was interpreted as Acceptable. Among experts, the grand mean was 4.37, also Highly Acceptable. Taste received the highest rating (5.00), followed by aroma and overall acceptability (4.60 each). Visual quality/color received 4.20, while flavor (4.00) and texture (3.80) were interpreted as Acceptable.

The consistent overall acceptability ratings indicate favorable sensory response to the developed formulation among both respondent groups. However, texture was the lowest-rated attribute for both consumers and experts, indicating a specific area for further formulation and processing improvement.

Recent confectionery research supports interpreting texture as a key formulation concern. Özel et al. (2024) reviewed how formulation, heating, and storage conditions influence hard-candy quality, including crystallization and stickiness. This is consistent with the present development history: earlier trials showed crystallization, incomplete hardening, deformation, or stickiness, while the selected T1 formulation reached the

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targeted cooking range and retained its shape during the reported observation. Souiy et al. (2023) used mixture-design optimization for a nutraceutical hard candy, supporting the value of systematic formulation optimization; however, their formulation and design cannot be assumed to predict the behavior of the present lansones-chia product. Maringka et al. (2024) studied sugar replacers in gummy candy, a different confectionery matrix, so that study provides context for sweetener-related texture effects rather than direct evidence for hard candy. In this study, texture was the lowest-rated attribute among both consumers and experts, indicating that additional instrumental texture testing and replicated formulation trials would be useful in future work.

Attribute	Consumers (n=50)	Experts (n=5)
Taste	4.60 ± 0.61 95% CI: 4.43–4.77 (Highly Acceptable)	4.60 ± 0.55 95% CI: 3.92–5.28 (Highly Acceptable)
Aroma	4.38 ± 0.81 95% CI: 4.15–4.61 (Highly Acceptable)	4.60 ± 0.55 95% CI: 3.92–5.28 (Highly Acceptable)
Texture/hardness	4.16 ± 0.84 95% CI: 3.92–4.40 (Acceptable)	4.60 ± 0.55 95% CI: 3.92–5.28 (Highly Acceptable)
Color/visual	4.26 ± 0.85 95% CI: 4.02–4.50 (Highly Acceptable)	4.20 ± 0.84 95% CI: 3.16–5.24 (Highly Acceptable)
Flavor	4.24 ± 0.89 95% CI: 3.99–4.49 (Highly Acceptable)	4.80 ± 0.45 95% CI: 4.24–5.36 (Highly Acceptable)
Overall acceptability	4.54 ± 0.68 95% CI: 4.35–4.73 (Highly Acceptable)	4.80 ± 0.45 95% CI: 4.24–5.36 (Highly Acceptable)
Grand mean	4.36 – Highly Acceptable CI not calculated for composite	4.60 – Highly Acceptable CI not calculated for composite

Table 7. Respondents' perceptions of the developed candy in relation to familiar traditional commercial hard candy (mean ± sample standard deviation).

For the questionnaire section referring to traditional commercial hard candy, the grand means were 4.36 among consumers and 4.60 among experts. No specific brand or physical reference product was presented; respondents rated their perceptions in relation to familiar traditional hard candy. These results describe perceived acceptability only and do not represent a direct comparison, statistical equivalence, or product superiority. Texture/hardness was the lowest-rated consumer attribute (4.16, Acceptable), while experts rated visual quality/color lowest (4.20, Highly Acceptable).

Study Limitations

This study has several limitations. Convenience sampling and the participation of 50 consumers and five expert evaluators limit the generalizability of the sensory findings. The formulation trials were sequential product-development attempts rather than replicated, controlled experiments; therefore, the observed outcomes support descriptive formulation selection but not statistical comparisons among sweetener systems. The commercial candy evaluation was perception-based rather than a direct comparison with a physical control. In addition, microbiological results describe the tested samples at the time of analysis and do not establish shelf life or long-term microbiological stability. Future research should include independent production batches, larger and more diverse respondent groups, a defined physical commercial comparator, and formal shelf-life testing.

CONCLUSION

The study demonstrated the feasibility of developing Lansium domesticum chia candy sweetened with stevia through iterative formulation optimization. Of the three intended sweetener systems, the isomalt-and-stevia

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formulation was selected because it achieved the desired hard-candy characteristics during the recorded development trials, including hardness, shape retention, and resistance to observed stickiness. These findings are descriptive and do not establish statistical superiority among sweetener systems.

The microbiological analyses reported APC and TCC results below 1.0 CFU/g and a combined YMC result of 10 CFU/g. These findings describe the tested samples at the time of analysis. Further assessment of the applicable criteria for molds and osmophilic yeast, together with formal shelf-life testing, is needed before making broader claims regarding regulatory compliance or long-term microbiological stability. Final five-point sensory evaluation yielded grand means of 4.49 among consumers and 4.37 among experts, both interpreted as Highly Acceptable.

In the questionnaire section referring to traditional commercial hard candy, the developed product received grand means of 4.36 among consumers and 4.60 among experts. Because no specific commercial brand or physical reference sample was evaluated, these results represent perceived acceptability based on respondents' familiarity with traditional hard candy rather than a direct product comparison. The results support the feasibility of the developed formulation as an acceptable fruit-based hard candy within the conditions and respondent groups covered by the study. They do not establish nutritional superiority, formal shelf-life performance, or statistical equivalence with a specific commercial product.

RECOMMENDATIONS

Conduct replicated production trials and use instrumental texture measurements to optimize hardness, texture, and resistance to stickiness.

Systematically evaluate the effects of isomalt, stevia, concentrated lansones paste, and chia-seed levels on product quality and sensory acceptability.

Conduct proximate and relevant nutritional analyses before making nutritional or health-related claims.

Perform a formal shelf-life study under documented packaging, temperature, and relative-humidity conditions, monitoring physical quality and microbiological indicators at defined intervals.

Use a larger and more diverse respondent sample, randomized sample codes and presentation order, and appropriate measures of variability and statistical analysis in future sensory studies. Include a clearly identified physical commercial comparator if direct comparison is intended.

Declarations

Ethics and Data Privacy

Prior to participation, respondents were informed of the purpose and procedures of the study and were asked to sign the researchers' informed-consent and Data Privacy Act agreement. Participation was voluntary, and respondent information was treated as confidential and used solely for academic research purposes. The manuscript does not claim institutional ethics-committee approval because the documented ethical procedure reported for the study was informed consent and the Data Privacy Act agreement.

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Conflict of Interest

The authors declare no conflict of interest related to the development, evaluation, or reporting of this study.

Data Availability

The respondent-level dataset is not publicly deposited. The summarized results reported in this manuscript are derived from the completed thesis and the evaluation instruments described therein.

Author Contribution

The four student authors contributed to the development and completion of the research project, including product development, data collection, analysis and interpretation, documentation, and preparation of the final thesis manuscript. Shirley C. Espiña provided research supervision and guidance throughout the study. All authors reviewed and approved the final manuscript for submission.

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