

REGULAR ARTICLE

DEVELOPMENT OF NATA DE MOLASSES FROM SUGARCANE MOLASSES AS A VALUE-ADDED PRODUCT OF THE SUGAR INDUSTRYAmanda Tyareka Puandari^{*1}, Dianita Kumalasari²**Address:**¹Department of Food Technology, Faculty of Engineering and Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, East Java, Indonesia; Tel: +62 88210675715²Department of Food Technology, Faculty of Engineering and Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, East Java, Indonesia*Corresponding author: amandatvareka@gmail.com**ABSTRACT**

Sugarcane molasses is one of the major by-products generated during sugar manufacturing and contains high concentrations of fermentable sugars, making it a promising raw material for developing value-added food products. Despite its nutritional potential, the utilization of molasses in Indonesia remains limited and is predominantly directed toward ethanol production, animal feed, and fertilizer. One alternative approach to increasing its economic value is the production of nata de molasses through microbial fermentation using *Acetobacter xylinum*. This study aimed to develop nata de molasses from sugarcane molasses and evaluate its consumer acceptance through sensory analysis. Molasses was diluted, supplemented with nutrients, adjusted to the optimum pH, sterilized, inoculated with *Acetobacter xylinum*, and fermented under controlled conditions. The resulting nata was harvested, washed, boiled, flavored with cinnamon powder, and subjected to sensory evaluation involving 25 untrained panelists. Consumer acceptance was assessed for color, aroma, taste, texture, and overall preference using a five-point hedonic scale. Market research and production cost analyses were also conducted to evaluate the commercial potential of the developed product. The sensory evaluation indicated that the formulation containing 25% molasses achieved the highest overall acceptability, particularly in terms of taste and texture. The addition of cinnamon successfully reduced the characteristic odor of molasses while improving flavor acceptability. Furthermore, the product demonstrated promising commercial potential due to the low cost and high availability of sugarcane molasses as a raw material. These findings suggest that nata de molasses represents an innovative strategy for increasing the value of sugar industry by-products while providing an alternative functional food product with favorable consumer acceptance.

Keywords: sugarcane molasses; nata de molasses; *Acetobacter xylinum*; fermentation; sensory evaluation.

INTRODUCTION

The sugar industry plays a strategic role in supporting food security and the agro-industrial sector by producing crystalline sugar and various by-products, including bagasse, filter cake, and molasses. Among these by-products, sugarcane molasses is generated in substantial quantities during the final stage of sugar crystallization and still contains high concentrations of fermentable sugars, mainly sucrose, glucose, and fructose, together with amino acids, organic acids, vitamins, and essential minerals. Owing to its rich nutritional composition, molasses has attracted considerable attention as an inexpensive carbon source for microbial fermentation. Previous studies have demonstrated that sugarcane molasses can be successfully utilized for the production of ethanol, organic acids, probiotics, enzymes, and other value-added bioproducts, providing an effective approach to improve the economic value of this sugar industry by-product while reducing environmental burdens associated with industrial waste disposal (Acosta-Piantini *et al.*, 2023). At present, however, the utilization of molasses in Indonesia is still predominantly limited to animal feed, alcohol production, and fertilizer, indicating that its potential for the development of innovative food products has not yet been fully explored.

The conversion of sugarcane molasses into fermented food products represents one of the most promising strategies to enhance its commercial value. Among various fermentation products, nata de molasses has considerable potential because it is produced through the biosynthesis of bacterial cellulose by *Acetobacter xylinum*. During fermentation, this bacterium converts soluble sugars into extracellular cellulose that accumulates as a gelatinous layer on the surface of the culture medium. Compared with plant-derived cellulose, bacterial cellulose possesses higher purity because it is naturally free from lignin and hemicellulose, exhibits excellent water-holding capacity, forms a three-dimensional nanofibrillar network, and demonstrates desirable mechanical properties that make it highly suitable for food applications. In addition, bacterial cellulose

is recognized as a low-calorie dietary fiber with potential applications in functional foods, biomedical materials, and biodegradable packaging. These characteristics have stimulated increasing interest in developing alternative fermentation substrates capable of supporting efficient bacterial cellulose production while utilizing agro-industrial by-products more sustainably (Isnaeni & Putri, 2025).

Sugarcane molasses possesses favorable characteristics as a fermentation substrate because of its abundant fermentable sugars and the presence of nutrients that support microbial metabolism. In addition to sucrose, glucose, and fructose, molasses contains nitrogenous compounds, minerals, and vitamins that contribute to microbial growth during fermentation. These components reduce the need for expensive nutrient supplementation and make molasses an economically attractive substrate for industrial fermentation. Recent studies have reported that molasses can be successfully utilized as a low-cost fermentation medium for the production of various microbial metabolites, indicating its considerable potential for the development of value-added food products. Nevertheless, variations in molasses composition resulting from differences in sugarcane variety, processing conditions, and storage may influence fermentation performance and product quality. Therefore, optimization of fermentation media and product formulation remains essential to obtain bacterial cellulose with desirable physical and sensory characteristics (Seshadrinathan & Chakraborty, 2022).

The formation of bacterial cellulose is strongly influenced by the physiological characteristics of *Acetobacter xylinum* and fermentation conditions. During fermentation, the bacterium utilizes soluble sugars as carbon sources and polymerizes glucose into extracellular cellulose microfibrils that accumulate on the medium surface. The efficiency of cellulose biosynthesis is affected by carbon source availability, nitrogen concentration, pH, temperature, oxygen availability, and fermentation duration. An adequate supply of nutrients promotes bacterial growth and cellulose production, whereas excessive substrate concentration may inhibit bacterial metabolism because of osmotic stress. Consequently, the selection of appropriate substrate concentration is important not only for maximizing bacterial cellulose production but also for improving the physical quality of nata, including its texture, elasticity, and water-holding capacity. Recent studies have demonstrated that bacterial cellulose produced through controlled fermentation exhibits excellent structural properties and has broad applications in food, pharmaceutical, and biomedical industries (Nuryanti & Rini Pratiwi, 2021).

Although sugarcane molasses has considerable potential as a fermentation substrate, studies concerning the development of nata de molasses as a consumer-oriented food product remain limited, particularly in Indonesia. Most previous studies have focused on bacterial cellulose production from coconut water, tofu whey, or other agricultural by-products, whereas information regarding the utilization of sugarcane molasses combined with consumer acceptance and preliminary commercialization analysis is still scarce. In addition, the characteristic dark color and caramel-like aroma of molasses may reduce consumer preference, making formulation improvement and sensory evaluation important aspects of product development. Therefore, this study aimed to develop nata de molasses from sugarcane molasses using *Acetobacter xylinum*, evaluate consumer acceptance based on color, aroma, taste, texture, and overall acceptability, and assess its commercial feasibility through preliminary market research and production cost analysis. The findings are expected to provide an alternative strategy for increasing the added value of sugar industry by-products while supporting sustainable agro-industrial development.

MATERIAL AND METHODS

Materials

Sugarcane molasses used as the primary fermentation substrate was obtained from PT. RPN—Pusat Penelitian Perkebunan Gula Indonesia (P3GI), Pasuruan, East Java, Indonesia. The starter culture of *Acetobacter xylinum* was provided by the Postharvest Research Laboratory of PT. RPN—Pusat Penelitian Perkebunan Gula Indonesia. Additional ingredients included granulated sugar, urea as a nitrogen source, glacial acetic acid for pH adjustment, distilled water, and food-grade cinnamon powder for flavor enhancement. All chemicals used for media preparation were of analytical grade.

Preparation of Molasses Medium

Fresh sugarcane molasses was filtered through a fine cloth to remove suspended impurities before being diluted with distilled water. Four different molasses concentrations, namely 25%, 50%, 75%, and 100%, were prepared to determine the most acceptable formulation based on consumer preference. The media were supplemented with granulated sugar and ammonium sulfate to provide additional carbon and nitrogen required for bacterial cellulose production. The pH of each medium was adjusted to approximately 4.0 using glacial acetic acid because *Acetobacter xylinum* grows optimally under acidic conditions.

Production of Nata de Molasses

The prepared fermentation media were heated to boiling for approximately 15 min to dissolve all ingredients and reduce microbial contamination. After heating, the media were poured into sterile plastic trays and allowed to cool to room temperature. Subsequently, *Acetobacter xylinum* starter culture (approximately

10% v/v) was inoculated aseptically into each fermentation medium. Fermentation was conducted under static conditions at ambient temperature (28–30°C) for 10–14 days. During fermentation, the bacteria converted soluble sugars into bacterial cellulose, forming a thick gelatinous layer on the surface of the medium. After fermentation, the nata sheets were harvested and washed repeatedly under running water to remove residual fermentation broth and acetic acid. The nata was then boiled several times until the acidic odor disappeared completely. The cleaned nata was cut into cubes of approximately 1 × 1 cm before being immersed in sugar syrup containing cinnamon powder as a natural flavoring agent to improve aroma and overall sensory quality.

Product Development

The final product was packaged in polypropylene (PP) plastic cups equipped with attractive labels developed specifically for the product. Product branding, packaging design, and market positioning were developed based on preliminary market research conducted among potential consumers. A product logo and promotional materials were also designed to enhance product attractiveness and commercialization potential.

Sensory Evaluation

Consumer acceptance was evaluated using a hedonic test involving 25 untrained panelists, consisting of laboratory staff, university students, internship participants, and members of the general public. Four nata de molasses formulations (25%, 50%, 75%, and 100% molasses concentration) were evaluated.

Panelists assessed five sensory attributes:

- Color
- Aroma
- Taste
- Texture
- Overall acceptance

A five-point hedonic scale was employed:

- 1 = Dislike very much
- 2 = Dislike
- 3 = Neither like nor dislike
- 4 = Like
- 5 = Like very much

The average score for each sensory attribute was calculated to determine the most preferred formulation.

Market Research

A preliminary market survey was conducted before product development to evaluate consumer interest in nata de molasses. The questionnaire included consumer preferences regarding flavor, packaging, product appearance, purchasing intention, and acceptable selling price. Information obtained from the survey was used to formulate product characteristics and marketing strategies.

Production Cost Analysis

The economic feasibility of nata de molasses production was evaluated through calculation of production costs, including raw materials, packaging, labor, utilities, and marketing expenses. Cost analysis comprised variable costs, fixed costs, total production cost, cost of goods manufactured (COGM), selling price estimation, break-even point (BEP), and projected profit. This analysis was performed to determine the commercial viability of nata de molasses as a value-added sugar industry product.

Statistical Analysis

Sensory evaluation data were analyzed descriptively using mean hedonic scores for each sensory attribute. The formulation receiving the highest overall acceptance score was considered the optimum product formulation. Spider charts were prepared to visualize consumer preferences among the four molasses concentrations. Economic analysis was performed descriptively using standard production cost calculations.

RESULTS AND DISCUSSION

Market Research for Nata de Molasses Development

Prior to product development, a preliminary market survey was conducted to evaluate consumer awareness, preferences, and purchasing intentions regarding nata de molasses as a novel fermented food product. The survey revealed that most respondents had never encountered nata produced from sugarcane molasses, indicating that this product remains relatively unfamiliar to Indonesian consumers. Nevertheless, after respondents were informed about the nutritional benefits of bacterial cellulose and the utilization of sugarcane molasses as a value-added raw material, most expressed positive interest in trying the product. This finding suggests that consumer knowledge plays an important role in determining the acceptance of newly developed functional foods. Innovative products derived from agro-industrial by-products generally require adequate information regarding their nutritional value and environmental benefits to improve consumer confidence and purchasing intention.

The survey also indicated that sensory attributes were considered the most important factors influencing purchasing decisions. Respondents preferred products with an attractive appearance, mild aroma, balanced sweetness, soft texture, and practical packaging. These findings were used as the basis for

developing the nata de molasses formulation. In particular, cinnamon powder was selected as a natural flavoring because it effectively reduced the characteristic caramel-like odor of sugarcane molasses while contributing a pleasant aroma that was more acceptable to consumers. The use of natural spices as flavor enhancers has been reported to improve sensory quality and increase consumer preference for fermented food products by masking undesirable odors without reducing product functionality.

Another important finding from the market survey was that respondents preferred products with affordable prices and attractive packaging. Since sugarcane molasses is a low-cost by-product that is abundantly available throughout the sugar industry, the production cost of nata de molasses can be maintained at a relatively low level compared with products manufactured from refined sugar. This economic advantage provides opportunities for commercialization, particularly among small- and medium-scale food enterprises seeking innovative products with high added value. Moreover, the utilization of molasses contributes to waste valorization by converting industrial by-products into functional food products with greater economic potential, thereby supporting the implementation of sustainable agro-industrial practices (Acosta-Piantini *et al.*, 2023; Seshadrinathan & Chakraborty, 2022).

Development of Nata de Molasses

Nata de molasses was successfully produced through static fermentation of sugarcane molasses using *Acetobacter xylinum* as the cellulose-producing microorganism. Prior to fermentation, sugarcane molasses was filtered to remove suspended impurities and diluted into four different concentrations (25%, 50%, 75%, and 100%). The fermentation medium was supplemented with granulated sugar and urea as additional carbon and nitrogen sources, respectively, while glacial acetic acid was added to adjust the medium to approximately pH 4.0, which is considered favorable for the growth and metabolic activity of *A. xylinum*. The prepared medium was then heated to dissolve all ingredients and reduce microbial contamination before inoculation with the bacterial starter culture under aseptic conditions.

Sugarcane molasses served as the principal carbon source for bacterial cellulose synthesis because it contains considerable amounts of fermentable sugars, mainly sucrose, glucose, and fructose. During fermentation, *A. xylinum* metabolizes these sugars and polymerizes glucose into extracellular cellulose microfibrils that gradually accumulate at the air–liquid interface, forming a compact gelatinous layer known as nata. The formation of this cellulose pellicle is closely related to the aerobic nature of the bacterium, which requires oxygen availability at the medium surface to support efficient cellulose biosynthesis. Consequently, static fermentation was employed to facilitate continuous oxygen diffusion and promote uniform bacterial cellulose formation throughout the fermentation period.

Besides providing fermentable sugars, the addition of urea supplied an accessible nitrogen source required for bacterial cell growth and enzyme synthesis during fermentation. Adequate nitrogen availability supports biomass development and enhances bacterial metabolic activity, thereby contributing to cellulose production. Likewise, maintaining the fermentation medium under acidic conditions using glacial acetic acid helps suppress the growth of undesirable microorganisms while creating an environment favorable for *A. xylinum*. Appropriate control of carbon source, nitrogen availability, and medium acidity is therefore essential to achieve efficient bacterial cellulose formation and obtain nata with desirable physical characteristics.

After fermentation for 10–14 days, the cellulose pellicle formed on the surface of the medium was harvested and repeatedly washed under running water to eliminate residual molasses, bacterial cells, and acetic acid remaining from the fermentation process. The nata was subsequently boiled several times until the acidic odor disappeared before being cut into uniform cubes. This post-fermentation treatment is important because residual acids and fermentation metabolites may negatively influence sensory quality, particularly aroma and taste. Repeated washing and boiling improve product cleanliness and contribute to a more neutral flavor profile, thereby enhancing consumer acceptance.

To further improve product acceptability, cinnamon powder was incorporated into the sugar syrup used during the final soaking process. Cinnamon contains volatile aromatic compounds, including cinnamaldehyde and eugenol, which provide a pleasant sweet-spicy aroma capable of masking the characteristic caramel-like odor of sugarcane molasses. In addition to improving aroma, cinnamon also contributes phenolic compounds with antioxidant activity, making it an attractive natural flavoring ingredient for fermented food products. The incorporation of cinnamon therefore not only enhanced sensory quality but also increased the overall attractiveness of nata de molasses as a potential value-added functional food derived from sugar industry by-products.

Sensory Evaluation

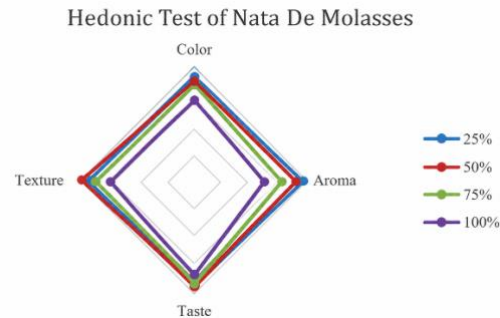


Figure 1 Radar chart of hedonic scores for nata de molasses at different molasses concentrations.

Table 1. Hedonic scores of nata de molasses produced from different molasses concentrations.

Attribute	25% (297)	50% (359)	75% (645)	100% (932)	p-value
Color	3.68 ± 0.48 ^a	3.60 ± 0.50 ^a	3.48 ± 0.65 ^a	3.00 ± 0.58 ^b	<0.001
Aroma	3.80 ± 0.50 ^a	3.60 ± 0.58 ^b	3.12 ± 0.53 ^c	2.48 ± 0.65 ^d	<0.001
Taste	3.68 ± 0.48	3.72 ± 0.46	3.60 ± 0.50	3.36 ± 0.57	0.062 ns
Texture	3.80 ± 0.65 ^{ab}	4.00 ± 0.00 ^a	3.52 ± 0.59 ^b	3.16 ± 0.55 ^c	<0.001

Note. Values are expressed as mean ± standard deviation (SD) from 25 untrained panelists. Means within the same row followed by different superscript letters are significantly different according to Duncan's Multiple Range Test (DMRT) at $p < 0.05$. ns = not significant.

Color

Color is one of the most influential sensory attributes because it forms the consumers' first impression and significantly affects purchasing decisions. The hedonic evaluation demonstrated that the formulation containing 25% molasses (Sample 297) obtained the highest color acceptance score (3.7), followed by 50% molasses (3.5), 75% molasses (3.3), and 100% molasses (3.0). These results indicate that consumer preference decreased as the concentration of sugarcane molasses increased.

The reduction in color acceptance can be attributed to the naturally dark brown appearance of sugarcane molasses, which originates from caramelized sugars, melanoidins, and other colored compounds formed during sugar manufacturing. Increasing the proportion of molasses in the fermentation medium consequently intensified the brown color of nata de molasses. Although the darker appearance reflects the original characteristics of molasses, many panelists associated lighter-colored nata with better freshness and quality, resulting in higher preference for the 25% formulation. Similar observations have been reported in fermented products developed from sugarcane molasses, where increasing molasses concentration produced progressively darker products and reduced consumer acceptance because appearance strongly influenced purchasing decisions(Acosta-Piantini *et al.*, 2023).

In addition to the intrinsic pigments present in molasses, thermal processing during medium preparation may also contribute to color development. Heating promotes non-enzymatic browning reactions, including caramelization and the Maillard reaction, leading to the formation of high-molecular-weight brown pigments. Consequently, formulations containing higher concentrations of molasses possess greater amounts of browning precursors, resulting in a darker final product. Similar findings have been reported for molasses-based fermentation media, where increased substrate concentration enhanced color intensity because of the accumulation of caramelized compounds during processing.

Despite the darker appearance observed at higher molasses concentrations, the 25% formulation maintained a light brown color that remained acceptable to consumers while still providing sufficient fermentable sugars for bacterial cellulose production. This finding suggests that reducing molasses concentration is beneficial not only for improving sensory appearance but also for increasing market acceptance of nata de molasses as a novel functional food product.

Aroma

Aroma is another important sensory attribute that strongly influences overall consumer acceptance because it determines the first perception immediately before tasting the product. The hedonic evaluation indicated that formulations prepared with lower molasses concentrations received higher aroma preference scores than those containing 75% and 100% molasses. The decrease in aroma acceptance at higher molasses

concentrations was primarily associated with the persistence of the characteristic caramel-like odor originating from sugarcane molasses.

Sugarcane molasses contains various volatile compounds formed during sugar processing that contribute to its distinctive aroma. As the concentration of molasses increased, these volatile compounds became more dominant and were perceived by several panelists as excessively strong. Therefore, cinnamon powder was incorporated during post-processing to improve aroma quality. Cinnamon is rich in volatile compounds, particularly trans-cinnamaldehyde, which is the major aroma constituent, together with eugenol and other phenolic compounds that impart a pleasant sweet-spicy aroma while helping to mask undesirable odors. Recent reviews have highlighted that cinnamaldehyde is the principal bioactive compound responsible for cinnamon's characteristic aroma and its usefulness in food applications.

The incorporation of cinnamon successfully reduced the perception of the characteristic molasses odor and generated a more balanced aroma profile, particularly in formulations containing 25% and 50% molasses. Besides improving aroma, cinnamon contributes antioxidant and antimicrobial compounds that may provide additional benefits in fermented food products. Consequently, the use of cinnamon not only enhanced sensory quality but also increased the attractiveness of nata de molasses as a value-added product derived from sugarcane molasses.

Taste

Taste is one of the most decisive attributes influencing consumer acceptance because it directly determines the overall eating experience. The sensory evaluation revealed that the formulation containing 25% sugarcane molasses received the highest taste preference score, whereas formulations prepared with higher molasses concentrations exhibited progressively lower acceptance. This result indicates that increasing the proportion of molasses affected flavor perception and reduced consumer preference.

Although sugarcane molasses contains high concentrations of fermentable sugars, it also contains considerable amounts of minerals, organic acids, and phenolic compounds that contribute to its characteristic flavor. At higher concentrations, these components become more pronounced and may produce a slightly bitter, metallic, or burnt aftertaste that reduces overall palatability. Consequently, formulations prepared with 75% and 100% molasses were perceived as having a stronger molasses flavor that was less preferred by the panelists. Similar observations have been reported in fermentation studies utilizing sugarcane molasses, where high substrate concentrations altered the sensory profile because of the accumulation of non-sugar components present in molasses (**Acosta-Piantini et al., 2023**).

Another factor contributing to improved taste acceptance was the incorporation of cinnamon powder during the final soaking process. Besides imparting a pleasant aroma, cinnamon provided a mild sweet-spicy flavor that complemented the sweetness of the sugar syrup and helped reduce the perception of undesirable molasses aftertaste. The combination of balanced sweetness and cinnamon flavor produced a more acceptable sensory profile, particularly in the 25% molasses formulation. This finding indicates that flavor optimization through natural additives is an effective strategy for improving consumer acceptance of fermented products developed from agro-industrial by-products.

Overall, the results suggest that moderate molasses concentrations provide a more balanced flavor profile while still supplying sufficient fermentable sugars for bacterial cellulose production. Therefore, the 25% formulation offered the best compromise between maintaining the nutritional advantages of molasses and achieving favorable taste acceptance among consumers.

Texture

Texture is considered one of the most important quality attributes of nata because it reflects the structure and quality of bacterial cellulose produced during fermentation. In the present study, the formulation containing 25% molasses obtained the highest texture preference score, whereas consumer acceptance gradually declined with increasing molasses concentration. Panelists described the nata produced from lower molasses concentrations as softer, more elastic, and easier to chew than those produced from concentrated molasses media.

The texture of nata is closely associated with the synthesis of bacterial cellulose by *Acetobacter xylinum*. During fermentation, the bacterium converts soluble sugars into cellulose microfibrils that assemble into a three-dimensional network capable of retaining large amounts of water. This highly hydrated network gives nata its characteristic chewy and elastic texture while maintaining structural integrity. Previous studies have reported that bacterial cellulose possesses high purity, remarkable water-holding capacity, and a dense nanofibrillar structure, making it highly suitable for food applications requiring desirable textural properties (**Isnaeni & Putri, 2025**).

The lower texture acceptance observed in formulations containing 75% and 100% molasses may be associated with the high concentration of dissolved solids in the fermentation medium. Excessive sugar concentrations increase osmotic pressure, which may reduce bacterial metabolic activity and interfere with cellulose biosynthesis. As a consequence, the resulting bacterial cellulose network may become less uniform, leading to nata with a firmer and less desirable texture. Similar relationships between substrate concentration and cellulose production have been reported in previous studies, indicating that balanced nutrient availability

promotes more homogeneous cellulose formation and improves the physical quality of nata (Isnaeni & Putri, 2025).

Furthermore, post-fermentation processing, including repeated washing and boiling, also contributed to the final texture by removing residual molasses and organic acids that could affect the firmness and mouthfeel of the product. The combination of an appropriate fermentation medium and adequate post-processing therefore produced nata with a clean appearance, pleasant chewiness, and improved consumer acceptance.

The superior texture of the 25% molasses formulation indicates that this concentration provided a more favorable environment for bacterial cellulose synthesis while simultaneously producing a product with desirable sensory characteristics. These findings support the potential application of diluted sugarcane molasses as an effective fermentation substrate for producing high-quality nata with acceptable texture and consumer preference.

Packaging and Product Branding



Figure 2 Final packaging design of nata de molasses developed from sugarcane molasses.

Packaging plays an essential role in maintaining product quality while simultaneously influencing consumer purchasing decisions. In the present study, nata de molasses was packaged in transparent polypropylene (PP) cups equipped with specially designed labels representing the identity of the developed product. Transparent packaging enables consumers to directly observe the appearance, color, and cleanliness of the product, which are important factors affecting confidence in newly introduced food products. In addition, polypropylene is widely used for food packaging because of its good mechanical strength, moisture resistance, chemical stability, and suitability for direct food contact.

Besides providing physical protection, packaging also functions as an effective communication medium between producers and consumers. The product label was designed to emphasize the utilization of sugarcane molasses as a value-added by-product of the sugar industry while highlighting the innovative concept of bacterial cellulose-based functional food. Such branding strategies are important because many consumers remain unfamiliar with nata produced from sugarcane molasses. Clear product information and attractive visual design may therefore improve consumer awareness, increase product credibility, and encourage purchasing intention.

The preliminary market survey indicated that respondents preferred products with practical packaging, attractive labels, and affordable prices. These findings support the importance of integrating packaging design with product development to improve market competitiveness. Attractive packaging has been reported to positively influence consumer perception of product quality, particularly for innovative food products introduced to the market for the first time. Therefore, the combination of appropriate packaging, appealing branding, and favorable sensory quality is expected to enhance the commercial potential of nata de molasses.

CONCLUSION

The development of nata de molasses demonstrated that sugarcane molasses can be successfully utilized as a value-added raw material for producing bacterial cellulose-based food products. The fermentation process using *Acetobacter xylinum* produced nata with acceptable physical characteristics and consumer acceptance, indicating the feasibility of converting sugar industry by-products into innovative functional foods.

Sensory evaluation revealed that the formulation containing 25% sugarcane molasses achieved the highest overall acceptability in terms of color, aroma, taste, and texture. The incorporation of cinnamon powder effectively improved the sensory quality by reducing the characteristic odor of molasses and enhancing product flavor.

Overall, the results suggest that nata de molasses can serve as an alternative functional food while simultaneously increasing the economic value of sugar industry by-products and supporting sustainable agro-industrial development. Future studies are recommended to investigate the physicochemical properties, nutritional composition, shelf life, microbial safety, and large-scale production of nata de molasses to further support its commercialization.

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