The Quality Characteristics of Probiotic Ice Cream with The Addition of Tempoyak Durian Lai

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Abstract : Durian lai (*Durio zibethinus* × *Durio kutejensis*) is an endemic fruit of East Kalimantan resulting from a cross between local durian and lai. It has distinct characteristics such as golden-yellow flesh, a sweet taste, mild aroma, and soft texture. However, due to its seasonal availability and perishable nature, further processing is required. This study aimed to develop probiotic tempoyak from durian lai and diversify it into ice cream. A Completely Randomized Design (CRD) with a single factor was used, applying tempoyak at concentrations of 0%, 25%, 50%, and 75%, each replicated five times. Parameters tested included sensory quality (hedonic and hedonic quality), physical properties (melting time and overrun), and total lactic acid bacteria (LAB). Results indicated that tempoyak addition significantly affected hedonic quality, overrun, and total LAB, but had no significant effect on hedonic value and melting time. The 75% treatment produced the best results, with a yellow color, strong tempoyak aroma, sour-salty taste, and soft texture. Other attributes included the highest overrun (86.12%), the longest melting time (11.66 min), and the highest LAB count (8.11 log CFU/ml). Thus, durian lai tempoyak ice cream shows potential as a probiotic-based functional food.

Keywords: tempoyak, durian lai, ice cream, probiotic

1. Introduction

Durian lai (*Durio zibethinus* × *Durio kutejensis*) is the result of a natural cross between local durian (*Durio zibethinus*) and lai (*Durio kutejensis*). This fruit has the characteristics of golden yellow flesh, sweet taste, not too pungent aroma, soft texture, and a relatively longer shelf life, which is about 7–10 days. Durian lai is one of the 18 *species of Durio* that only grows naturally on the island of Kalimantan, and since 2008 has been developed as a regional flagship fruit (1,2) However, durian lai is a seasonal fruit that only bears fruit once a year, is easily damaged, and has limited shelf life, so post-harvest processing efforts are needed to increase added value and extend its shelf life.

One form of durian processing is tempoyak. Tempoyak is a traditional fermented product made from durian meat that involves the activity of natural microflora, especially lactic acid bacteria (LAB). LAB is a Gram-positive bacterium in the form of coccus or bacilli, is facultative, catalase-negative, does not form spores, and is able to produce various metabolite compounds such as organic acids (lactate, acetate, format), hydrogen peroxide, diacetyl, and bacteriocin which are antibacterial. Based on metabolic pathways, LAB can be categorized into homofermentative, which ferments sugars into lactic acid, as well as heterofermentative, which produces less ethanol, CO_2, and lactic acid(3) . The fermentation of durian lai tempoyak is dominated by lactic acid bacteria (LAB), contributing to improved

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product stability, probiotic potential, and microbiological quality and safety (Marwati et al., 2025)

Diversifying tempoyak into products that are more accepted by consumers is one of the strategies to increase its added value. One of them is processing into ice cream. Ice cream is a dairy product that is popular with various people and has a great opportunity to be developed into a probiotic food (5,6) (9). Probiotic ice cream not only offers the taste that consumers love, but it can also provide health benefits, especially in improving the balance of gut microflora and improving gastrointestinal function (7)

Based on this, this study aims to evaluate the effect of diversification of durian lai into ice cream on product quality, which includes sensory aspects, physical characteristics (overrun and melting power), and total lactic acid bacteria (LAB).

2. Research Methods

2.1 Materials and Equipments

The research materials include durian lai flesh, salt, sugar, Haan brand ice cream mixture (85 g), mineral water, and ice cubes. Total testing of lactic acid (BAL) bacteria using de Man, Rogosa, and Sharpe Agar (MRSA) media, 0.85% NaCl solution, and 70% alcohol.

The equipment used includes tempoyak and ice cream making equipment, overrun and melting power analysis tools, and microbiological equipment for total BAL testing, such as counter colonies, petri dishes, test tubes, vortexes, autoclaves, ovens, micropipettes, erlenmeyers, analytical scales, incubators, and bunsen burners

2.2 Experimental design

This study employed a completely randomized design (CRD) with a single factor consisting of four treatments and five replications. The treatments were: ice cream without the addition of durian lai tempoyak (control), ice cream with 25% durian lai tempoyak, ice cream with 50% durian lai tempoyak, and ice cream with 75% durian lai tempoyak. Formulation of durian lai tempoyak ice cream shown by Table 1.

Table 1. Formulation of Durian Lai Tempoyak Ice Cream

Ingredient	Amount
Vanilla ice cream mix	85 g
Cold water	150 mL
Durian lai tempoyak	0%, 25%, 50%, or 75%*

The data obtained were analyzed using analysis of variance (ANOVA). When significant differences among treatments were observed, the analysis was followed by Tukey's test at a significance level of $\alpha = 0.05$.

2.3 Tempoyak Durian Lai Brewing

The process of making tempoyak begins by separating the flesh of the durian lai fruit from the skin and seeds. The flesh of the fruit is then weighed as much as 100 gr, salt as much as 3% and sugar as much as 1%, then homogenized until evenly distributed. The mixture is then fermented at room temperature for 4 days.

2.4 Ice Cream Making

The ice cream preparation process with the addition of durian lai tempoyak began by mixing 85 g of vanilla ice cream mix with 150 mL of cold water, followed by stirring for 3 minutes at a speed of 120 rpm until the mixture became partially aerated. Subsequently,

durian lai tempoyak was added according to the treatment, and the mixture was further mixed at 120 rpm for 2 minutes until fully aerated and homogeneous. The ice cream was then stored in a freezer at −20 °C The resulting ice cream is then stored in the freezer until the time of testing.

2.5 Analysis Method

The parameters test in this study included sensory tests, physical characteristics consisting of overrun and melting power, and total lactic acid bacteria (LAB).

2.5.1 Sensory Tests

Organoleptic properties were analyzed through hedonic and hedonic quality tests that included color, aroma, taste, and texture parameters. The assessment was carried out using the affective test method involving 30 untrained panelists .

2.5.2 Overrun

The overrun test was carried out using a weight-based method, which was to weigh 100 grams of ice cream dough in a beaker glass, then beat until it was perfectly fluffy and weighed again. The overrun value is calculated using the formula: the difference between the weight of the dough before and after it rises is divided by the weight of the dough after it rises, then multiplied by 100% (8). The overrun equation is as follows:

$$\text{Overrun} = \frac{W1-W2}{W2} \text{ x } 100\%$$

Where:

W_1 = weight of the initial ice cream mix

W_2 = weight of the ice cream after aeration

2.5.3 Melting Power

The melting power test was carried out by weighing 5 grams of ice cream samples, then put them in tightly closed plastic cups and stored in the freezer for three days. After that, the sample is removed and placed at room temperature, then the defrosting time is measured using a stopwatch from the time the ice cream is removed from the freezer until it is completely thawed (8).

2.5.4 Total Lactic Acid Bacteria

The total test of lactic acid bacteria (BAL) was carried out by the pour plate method. A sample of 1 ml was diluted in stages in 9 mL of physiological NaCl solution (0.85%) to a dilution of 10^{-8}. From the dilution of 10^{-6}, 10^{-7}, and 10^{-8}, 1 ml of each is put into a sterile petri dish, then 15–20 ml of liquid MRSA media is added in a duplo. The cup is shaken until the sample is evenly mixed, allowed to solidify, and then incubated upside down at 37 °C for 2–3 days. The number of growing colonies was calculated using the Standard Plate Count (SPC) method and expressed in units CFU/ml

3. Results and Discussion

3.1 Sensory Tests

The results of the panelists' assessment of the organoleptic properties of tempoyak durian lai ice cream, both through hedonic and hedonic quality tests, are presented in detail in Table 2 to facilitate analysis and interpretation.

Table 2. The Effect of the Addition of Durian Tempoyak on Hedonic Value and Hedonic Quality of Tempoyak Durian Ice Cream

Sensory characteristic		Percentage of Tempoyak Durian Lai (%)			
		0	25	50	75
Hedonic	Color	3.43±0.971	3.70±1.022	3.70±0.876	3.60±1.003
	Aroma	3.80±1.349	3.96±0.850	3.36±1.066	3.26±1.229
	Taste	3.96±1.159	3.80±1.063	3.46±1.166	3.00±1.017
	Texture	3.50±1.042	3.90±0.994	3.26±1.014	3.33±0.958
Hedonic quality	Color	2.90±0.402a	2.03±0.490b	3.40±0.723c	3.26±0.639c
	Aroma	2.43±0.678a	3.40±0.621b	4.66±1.028b	4.90±0.803b
	Taste	2.53±0.899a	3.80±0.664b	3.16±0.833bc	4.93±0.9074c
	Texture	4.56±1.222a	4.96±1.188a	4.93±1.112a	3.13±0.819a

Information:

Data are presented as mean ± standard deviation (SD) obtained from five replications. Values within the same row or column followed by the same superscript letter, or values not followed by any letter, indicate no significant difference based on the least significant difference (LSD) test at $\alpha = 0.05$. Sensory evaluation was conducted using a 5-point hedonic scale, where 1 = strongly dislike, 2 = dislike, 3 = somewhat like, 4 = like, and 5 = very much like. Hedonic quality scores (1–5) were assigned for color (milky white, pale yellow, yellow, yellowish orange, and orange), aroma (very milky aroma, milky aroma, moderate tempoyak aroma, strong tempoyak aroma, and very strong tempoyak aroma), taste (no sour and salty taste, slightly sour and salty taste, moderately sour and salty taste, strong sour and salty taste, and very strong sour and salty taste), and texture (very dense, dense, soft, very soft, and extremely soft).

3.1.1 Color

Based on the results of the hedonic test on the color indicator, the average panelist assessment of durian lai time ice cream with different treatment ranged from 3.43 to 3.70 (like category). The panelists liked the color of ice cream the most in the treatment of adding 25 percent tempoyak. This suggests that panelists tend to prefer less striking yellows. The results of the hedonic quality test on color showed an average value ranging from 2.03 to 3.40, namely from pale yellow to yellow (Table 2). The yellow-orange color that appears comes from the natural pigment of the flesh of durian lai.(9) Color is a sensory attribute that plays an important role in shaping the visual appeal of a food product and influencing consumer acceptance. Carotenoid pigments in durian pulp play a role in giving a natural yellow-orange color , so that the intensity of the addition of tempoyak affects the panelists' perception of the color of the ice cream produced.

3.1.2 Aroma

Based on the hedonic evaluation of the aroma attribute, the mean panelist scores for durian lai tempoyak ice cream across different treatments ranged from 3.26 to 3.96, corresponding to the “like” category. The highest aroma preference was observed in the treatment with 25% tempoyak addition, indicating that panelists favored a balanced aroma profile. The hedonic quality assessment showed average scores ranging from 2.42 to 4.90, describing aroma characteristics from milky aroma to strong tempoyak aroma. The fermentation process of tempoyak contributes to the development of a distinctive aroma, primarily through lactic acid production by lactic acid bacteria (LAB), resulting in aroma notes ranging from mildly acidic to strongly acidic as the level of tempoyak increased. Higher concentrations of tempoyak led to a more dominant typical fermented acidic aroma, which influenced panelists’ perception and preference. These results are consistent with previous studies reporting that lactic acid fermentation of durian generates characteristic sour aromas that significantly affect consumer acceptance.(10)

3.1.3 Taste

Based on the results of the hedonic test, the average panelists' assessment of the taste of durian lai tempoyak ice cream ranged from 3.00 to 3.96 (like category), with the panelists liking the ice cream the most without the addition of tempoyak. This suggests that the addition of tempoyak produces the sour and salty flavor character formed during fermentation. The higher the tempoyak concentration, the sour taste in ice cream is more dominant. These findings are in line with research (10,11), which states that durian fermentation produces a distinctive sour taste depending on the length of fermentation and durian concentration.

The results of the hedonic quality evaluation showed that the mean scores ranged from 2.53 to 4.93, corresponding to flavor characteristics from slightly sour and salty to strongly sour and salty. The fermentation process of tempoyak contributes to the development of a distinctive flavor profile through the production of lactic acid by lactic acid bacteria (LAB). Consequently, increasing the proportion of tempoyak significantly influences the intensity of sour and salty flavors in the ice cream, as reflected in the higher hedonic quality scores at higher levels of tempoyak addition

3.1.4 Texture

Based on the results of the hedonic test on texture indicators, the average panelist assessment of durian lai tempo ice cream with different treatment ranged from 3.26 to 3.90 (like category), with the most preferred texture in the 25 percent tempyak addition treatment. The results of the hedonic quality test showed an average value ranging from 3.13 to 4.96, ranging from soft to very soft. The difference in the concentration of tempoyak in each treatment affected the panelists' preferences, because the texture of the ice cream was influenced by the source of fat used. The milk fat (cream) in the ice cream mix plays an important role in producing a soft texture, giving it shape and density (12).

Table 3. Overrun test results, melting power and total lactic acid bacteria (LAB) on Tempoyak Durian Lai Ice Cream

Parameter	Percentage of Tempoyak Durian Lai (%)			
	0	25	50	75
Overrun (%)	86.12±0.020a	85.82±0.022b	78.96±0.027c	66.09±0.032d
Melting Power (Minute)	10.80±0.41a	11.66±0.77a	10.92±0.85a	11.64±0.74a
Total LAB (log CFU/mL)	0.00±0.00a	4.56±4.17b	7.94±0.29c	8.11±0.64cd

Information:

Data on the same column or rows, followed by the same .letter, or data on the same row and column not followed by letters, show an intangible difference based on the LSD follow-up test α 5%.

3.2 Overrun

Overrun is an indicator that indicates an increase in volume due to air trapped in the ice cream during the stirring process, which affects the texture and density of the product (11). According to (13) (2019), ice cream is categorized as good quality if it has an overrun value ranging from 60%–100%. The overrun value of durian lai tempoyak ice cream in this study was in the range of 66.09%–86.12%, so it still met these quality criteria (Table 3).

The overrun value shows a decreasing tendency along with the increase in the concentration of adding durian lai, which is 86.12% in the 0% treatment, 85.82% in 25%, 78.96% in 50%, and 66.09% in 75%. This decrease in the overrun value indicates that the higher the proportion of tempoyak added, the less the ice cream dough's ability to retain air

during the stirring process. In addition, studies on probiotic ice cream generally report an overrun value ranging from 40%–70%.(14)

3.3 Melting Power

The melting power parameters of durian lai ice cream showed relatively uniform values throughout the treatment, ranging from 10.80–11.66 minutes. The results of BNT's follow-up test (α 5%) showed that the addition of durian lai tempoyak to 75% did not have a real effect on the meltability of ice cream (Table 3). This indicates that despite the decrease in overrun value as the percentage of time increases, the structure of the ice cream matrix is still able to maintain melting stability. Recent studies state that the melting behavior of ice cream is more influenced by the integrity of the microstructure, the viscosity of the serum phase, and the fat-protein network than by the overrun alone (15,16)(16) The presence of dissolved solids components, fermented organic acids, and lactic acid bacterial activity in tempoyak is suspected to contribute to increased viscosity and the formation of more stable structural tissues, so that the melting rate does not differ significantly between treatments. These findings are in line with recent research reports that an increase in the total solids and fermentation components can maintain or slow down the melting rate of ice cream despite a decrease in overruns (16,17). Thus, the addition of durian lai tempoyak to high concentration still produces ice cream with good melting power and acceptable physical quality.

3.4 Total Lactic Acid Bacteria

The total lactic acid bacteria (LAB) in durian lai tempyak ice cream showed a significant increase as the percentage of tempoyak increased (Table 3). The control ice cream (0%) showed no presence of LAB, while a tempo increase of 25–75% increased the number of LABs from 4.56 to 8.11 log CFU/mL, with a marked difference based on LSD assays (α 5%). This increase confirms that the tempoyak durian lai is a natural source of fermented LAB, so the higher the concentration added, the larger the LAB population distributed in the ice cream matrix. Several recent studies report that ice cream can act as an effective protective matrix for LAB viability because its total fat and solids content is able to protect bacterial cells from damage during the freezing and freezing storage process (18,19). In addition, the presence of fermentation components such as organic acids and exopolysaccharides has also been reported to improve the stability and survival of LAB in frozen food products (Jonatha et al., 2026). Thus, durian lai tempoyak ice cream has the potential to be developed as a fermented ice cream product with additional functional value.

4. Conclusion

The addition of durian lai tempoyak to ice cream formulations significantly affected hedonic quality, overrun, and total lactic acid bacteria (LAB), while no significant effect was observed on overall panelist acceptance or melting power. The formulation containing 75% durian lai tempoyak exhibited the most favorable characteristics, producing ice cream that was sensory acceptable with hedonic quality attributes characterized by a yellow color, a very strong tempoyak aroma, a very sour and salty taste, and a very soft texture. Furthermore, this treatment demonstrated desirable physical and microbiological properties, with an overrun of 86.12%, a melting power of 11.66 minutes, and a total LAB count of 8.11 log CFU/mL.

These findings show that durian lai tempoyak ice cream has strong potential to be developed as a fermented functional food with its probiotic properties.

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