

Physicochemical and Sensory Characteristics of Plant-Based Ice Cream Enriched with Lemongrass (*Cymbopogon citratus* DC. Stapf) Extract

Komang Patra Nadi Jaya¹, I Gede Arie Mahendra Putra², Gusti Ayu Komang Devina Twin Arta³, Ni Wayan Listiani Asih⁴, Anak Agung Ary Savitri⁵, Almira Juniyantri Salim⁶, Ida Ayu Puspa Anjani⁷, Ni Luh Putu Anggita Suandewi⁸

^{1,2,3,4,5,6,7,8} Department of Food Technology, Faculty of Agricultural Technology, Udayana University, Badung-Bali, Indonesia, 80361

²Center of Excellence for Food Sovereignty, Udayana University, Bali-Indonesia

ABSTRACT: Plant-based ice cream continues to gain attention as consumers increasingly reduce dairy intake due to lactose intolerance and lifestyle preferences. While soy milk and coconut cream provide a suitable non-dairy base, the resulting products often require improvements in sensory appeal and functional value. Butterfly pea flower has been used as a natural colorant and antioxidant source, yet its heat-sensitive bioactive compounds may not remain stable throughout processing. This study explored the incorporation of lemongrass extract into a soy-coconut ice cream system enriched with butterfly pea flower. Different concentrations (0-6%) were evaluated to observe changes in physical properties, sensory acceptance, and antioxidant activity. Although overrun values remained relatively consistent, melting resistance and hedonic responses varied across formulations. The 2% treatment achieved the most balanced performance, combining favorable texture, aroma, and taste with improved antioxidant capacity (17.55%), markedly higher than a commercial comparator. The findings indicate that controlled incorporation of lemongrass extract may enhance both functional and sensory attributes of plant-based frozen desserts without compromising structural stability.

KEYWORDS: plant-based ice cream, lemongrass extract (*Cymbopogon citratus*), sensory characteristics, physicochemical properties, antioxidant activity, functional food

I. INTRODUCTION

Ice cream is one of the most widely consumed frozen desserts worldwide and has increasingly attracted attention for its innovation toward healthier, more sustainable alternatives. The rise in public health awareness paired with the high prevalence of lactose intolerance and cow's milk protein allergy has spurred rapid development of plant-based ice cream products as substitutes for traditional dairy formulations. Plant-based ingredients such as soy milk and coconut cream are commonly used for their functional properties, which closely mimic the texture and mouthfeel of dairy while being naturally free of lactose and cholesterol (Azra et al., 2025).

Despite these advantages, plant-based ice cream often exhibits several drawbacks, including suboptimal color appearance and characteristic beany or vegetal off-flavors, which can limit consumer appeal. These sensory limitations underscore a critical technological challenge in plant-based dairy alternatives: the need to enhance sensory attributes without compromising health benefits. Prior research on plant-based ice cream has documented improvements in quality through ingredient modification, but solutions remain limited in their functional performance and sensory balance (Azra et al., 2025).

Natural bioactive compounds and pigments such as anthocyanins have emerged as promising alternatives to synthetic additives in food systems. Butterfly pea flower (*Clitoria ternatea* L.) is rich in acylated anthocyanins known as ternatins, which confer an intense blue color and notable antioxidant activity that can be leveraged for functional food applications (Vidana Gamage et al., 2021). However, the incorporation of anthocyanin-rich extracts in processed foods presents a significant challenge due to the instability of these compounds under heat and variable pH conditions, which can lead to degradation and loss of functional properties during common food processing steps such as pasteurization and mix cooking (Muzi Marpaung et al., 2017; Sipahli et al., 2017). Concurrent with consumer interest in functional foods, there has been growing investigation into complementary plant ingredients that can improve both sensory quality and functional value. Lemongrass (*Cymbopogon citratus*)

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contains a spectrum of bioactive compounds including flavonoids, phenolic acids, and essential oils that exhibit strong antioxidant and aromatic properties (Majewska et al., 2019; Tajidin, N. E, 2012). The fresh citrus aroma of lemongrass, primarily due to citral and other volatile constituents, offers potential sensory enhancement, particularly in masking undesirable beany notes associated with soy based products while contributing additional bioactive benefits (Tajidin, N. E, 2012).

Although studies have demonstrated the antioxidant capacity of lemongrass extracts and their potential role as natural food preservatives, optimal integration strategies in complex food matrices especially those requiring heat processing remain underexplored (Santoso et al., 2018). Furthermore, while some food systems have optimized plant extract concentrations to balance flavor and functional attributes, the specific effects and ideal proportions of lemongrass in plant-based ice cream enriched with natural colorants have not yet been clearly established.

Therefore, this study addresses a critical gap in the literature by systematically evaluating the impact of lemongrass extract on the physical properties, sensory characteristics, and antioxidant activity of soy coconut plant-based ice cream containing butterfly pea flower anthocyanins. The novelty of the research lies in its integrative approach to enhancing ice cream's sensory and functional quality under realistic processing conditions. By identifying optimal lemongrass extract concentrations that maintain desirable sensory properties while maximizing antioxidant activity, this study aims to contribute novel insights to plant based dairy alternative innovation, functional food formulation, and sustainable food product development aligned with current global trends.

II. METHOD

MATERIALS AND EXPERIMENTAL DESIGN

This experimental work was carried out in December 2025 under controlled laboratory conditions at the Faculty of Agricultural Technology, Udayana University. The materials used in this study included lemongrass (*Cymbopogon citratus*) and butterfly pea flowers (*Clitoria ternatea*) obtained from Badung Market, soy milk (Soya), coconut cream (Kara), honey (TJ Honey), carrageenan, TBM emulsifier (Kopoe-Kopoe), cornstarch (Rose Brand), and vanilla powder (Kapal Lajar). The chemical reagents used is distilled water (Rofa, Indonesia), DPPH pro analysis (Sigma-Aldrich, USA), and methanol as a solvent.

The equipment used in this study included a mixer (Miyako), basin, ice cream cups, measuring cylinders (Pyrex), an analytical balance (Shimadzu), strainer, knife, blender (Philips), spatula, stirrer, glassware, tablespoon, ruler, beakers (Pyrex), test tubes (Pyrex), and tweezers.

This study used an experimental treatment followed a completely randomized arrangement with different levels of lemongrass extract addition, consisting of four treatments: P0 (0 percent), P1 (2 percent), P2 (4 percent), and P3 (6 percent). Each treatment then was replicated four times, resulting in total of 16 units. The experimental units were subjected to physical characteristic analyses, including melting time and overrun, as well as hedonic sensory evaluation conducted by 30 panelists, which assessed color, taste, aroma, texture, and overall acceptability. The optimal treatment was determined using a matrix table, followed by antioxidant activity and melting time analysis, which were compared with those of a commercial ice cream product.

FORMULATION

The determination of treatments for each product required an appropriate formulation to obtain an optimal content of bioactive compounds. The ice cream formulation with the addition of lemongrass (*Cymbopogon citratus*) extract was based on the study by Wulan et al., (2020) with several modifications. The formulation of plant-based ice cream with lemongrass extract addition is presented in Table 1.

Table 1. Ice cream formulation with the addition of lemongrass juice

Ingredients	Treatment (g)			
	P0	P1	P2	P3
Lemongrass Juice	0%	2%	4%	6%
Butterfly Pea Flowers	2,5	2,5	2,5	2,5
Soy Milk	50	50	50	50

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Coconut Cream	50	50	50	50
Honey	17,5	17,5	17,5	17,5
Carrageenan	0,25	0,25	0,25	0,25
Emulsifier (TBM)	3	3	3	3
Cornstrach	2,5	2,5	2,5	2,5
Vanilla	0,25	0,25	0,25	0,25
Total Ingredients	125			

Source: Modified from Wulan et al., (2020)

Note: Lemongrass juice percentage was calculated based on the total ice cream formulation (125 g).

PROCESSING STEPS

The processing stages in the production of ice cream with lemongrass addition consisted of several steps, including lemongrass juice preparation, butterfly pea flower extract preparation, and ice cream production with lemongrass addition. The processing steps are described as follows.

LEMONGRASS JUICE PREPARATION

The preparation of lemongrass juice began with the selection of lemongrass stalks, followed by sorting to obtain stalks without leaves. The lemongrass stalks (*Cymbopogon citratus*) were washed thoroughly with clean water until completely clean. The stalks were then cut into small pieces and weighed using a 2:1 ratio (lemongrass to water). The mixture was subsequently blended at maximum speed for 10 minutes until a homogeneous lemongrass pulp was obtained. The pulp was then filtered to obtain lemongrass juice. The flow diagram for lemongrass juice preparation is presented in Figure 1.

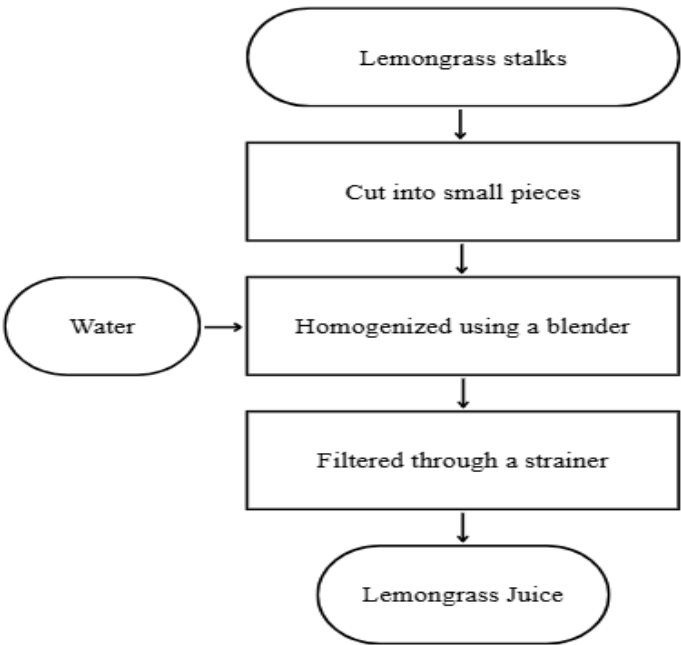


Figure 1. Flow Diagram of Lemongrass Juice Preparation
 Source: Modified from Wulan et al., (2020)

ICE CREAM PRODUCTION WITH LEMONGRASS ADDITION

Ice cream production, as described by Putra et al., (2024) with modification, began by mixing soy milk and coconut cream, then adding butterfly pea flowers. The mixture was heated to 80°C for 5 minutes, stirred until homogeneous, and then cooled to

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room temperature. Subsequently, cornstarch, carrageenan, and honey were added to the hot mixture and stirred until all ingredients were completely dissolved. The mixture then cooled to room temperature over approximately 3 hours. After cooling, the mixture was mixed at high speed for 20 minutes, then an emulsifier (TBM) and vanilla powder were added, and the mixture was mixed again until it expanded and reached a smooth texture. The mixture was weighed to 80 g for each treatment, and lemongrass extract was added to the designated concentration, then mixed until homogeneous. The mixture was frozen for 2 hours until solid, then mixed again for 20 minutes. This freezing and mixing process was repeated 4 times to achieve a smooth, stable ice cream texture. After the final mixing, the mixture was transferred to containers and frozen until ready for sensory evaluation. The flow diagram of ice cream production is presented in Figure 2.

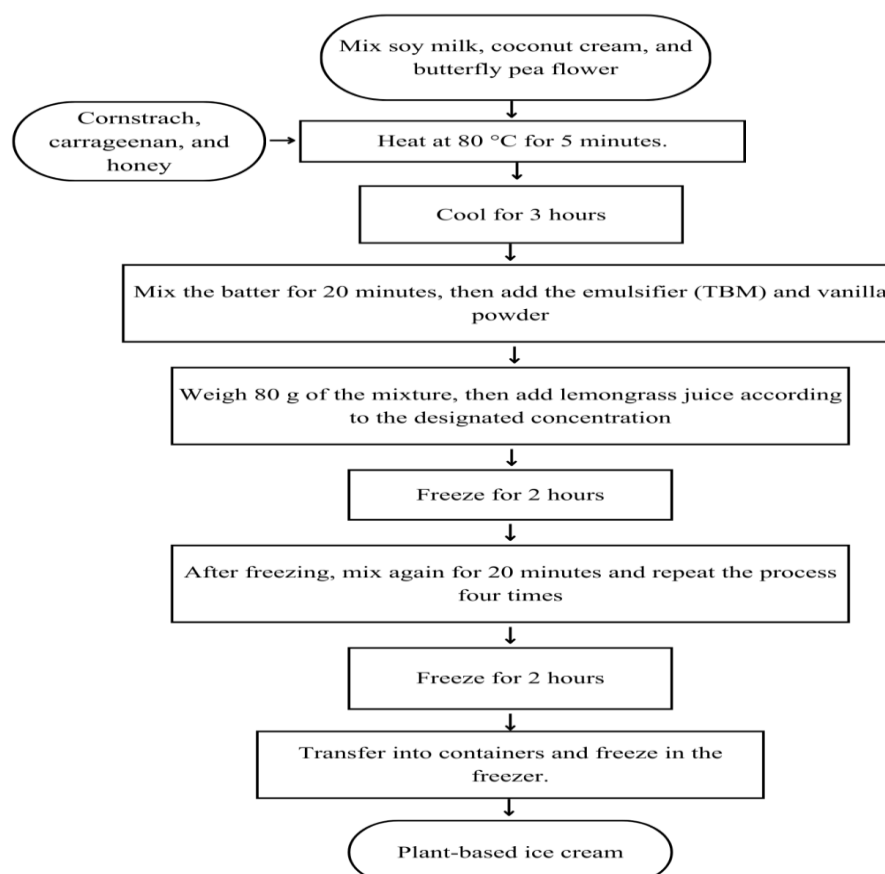


Figure 2. Flow Diagram of Ice Cream Production with Lemongrass Juice Addition
Source: Modified from Putra et al., (2024)

OBSERVED VARIABLES

The variables observed to showed the characteristics of plant-based ice cream with lemongrass addition (Cymbocream) included physical analysis, sensory analysis, and chemical analysis. The study began with physical analyses conducted on all treatments, including overrun (Zahro et al., 2015) and melting time (Zahro et al., 2015), followed by sensory evaluation (Lawless & Heymann, 2010) , which consisted of hedonic tests for color, texture, aroma, taste, and overall acceptability. Subsequently, antioxidant activity analysis using the DPPH method (Shah & Modi, 2015) was performed on the best treatment and a commercial ice cream product.

1. OVERRUN

Overrun measurement was conducted according to the method described by Zahro et al., (2015). Overrun refers to the increase in ice cream volume, calculated as the percentage of expansion calculated from the difference between the volume of the final ice cream and the initial mix at the same mass, or alternatively from the difference in mass between ice cream and mix at an equivalent volume.

Overrun measurement was performed by first weighing an empty container. The ice cream mix was then poured into the container up to a volume of 100 mL and weighed. The processed ice cream was also placed into a 100 mL container with a known initial weight. After freezing, the surface of the ice cream then was leveled

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to ensure a volume of 100 mL, and the sample then was weighed again. The overrun then calculated by the following formula below:

$$\text{Overrun} = \frac{v(\text{ice cream}) - v(\text{mix})}{v(\text{mix})} \times 100\%$$

Where:

V (mix) = volume of ice cream mix before freezing

V (ice cream) = volume of ice cream after freezing

2. MELTING TIME

Melting time analysis was conducted according to Arbuckle (2013). The melting time was determined at room temperature ($\pm 28^\circ\text{C}$) with three replications. Frozen ice cream samples (25 g) were placed in an open container and allowed to melt, and the time required for complete melting was recorded, calculated, and averaged.

3. SENSORY EVALUATION

Sensory evaluation was conducted following the method described by Lawless & Heymann, (2010) using a hedonic test, which is based on the level of panelists' preference for the presented samples. Hedonic sensory evaluation involved 30 semi-trained panelists using a scoring method. The hedonic scale ranged from 1 to 7, where 7 = like extremely, 6 = like, 5 = slightly like, 4 = neutral, 3 = slightly dislike, 2 = dislike, and 1 = dislike extremely.

The sensory attributes evaluated included color, aroma, taste, texture, and overall acceptability of the plant-based ice cream with lemongrass juice addition. The criteria and numerical scale for the hedonic test are presented in Table 2.

Table 2. Hedonic criteria and numerical scale for color, texture, aroma, taste, and overall acceptability of plant-based ice cream with lemongrass juice addition

Criteria	Numerical Scale
Like extremely	7
Like	6
Slightly like	5
Neutral	4
Slightly dislike	3
dislike	2
Dislike extremely	1

4. ANTIOXIDANT ACTIVITY

Antioxidant activity was analyzed using the DPPH method based on the procedure described by Shah & Modi, (2015). A total of 1 mL of 0.1 mM DPPH solution in ethanol was mixed with 2 mL of ice cream sample in a test tube. The mixture was vortexed and incubated for 30 minutes at room temperature in the dark. Absorbance was then measured at a wavelength of 517 nm using a spectrophotometer.

Ethanol was used as a blank, while the control being prepared using the same procedure without sample addition. The percentage of radical scavenging activity (antioxidant activity) was calculated using the following formula:

$$\text{Antioxidant activity (\%)} = \frac{\text{Absorbance control} - \text{Absorbance sample}}{\text{Absorbance control}} \times 100\%$$

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DATA ANALYSIS

Observed data then statistically analyzed using Microsoft Excel, SPSS, and Minitab 22. Sensory evaluation data were first analyzed to determine the best treatment. Subsequently, the best treatment obtained from the sensory analysis was subjected to antioxidant activity analysis as the second stage.

Antioxidant activity data then analyzed using the non-parametric Kruskal–Wallis test because the homogeneity test indicated that the data were not homogeneous ($p < 0.05$). Meanwhile, sensory variables, melting time, and overrun were analyzed using one-way analysis of variance (ANOVA) because the data met the assumptions of normality and homogeneity ($p > 0.05$). When ANOVA results showed a significant treatment effect ($p < 0.05$), further analysis was conducted using the Tukey test at a 5% significance level.

III. RESULT AND DISCUSSION

The results of the physical characteristics, including overrun and melting time of Cymbrocream, are presented in Table 3.

Table 3. Differences in Overrun (%) and Melting Time of Cymbrocream

Treatment	Overrun (%)	Melting Time (Minutes)
0%	$18.00 \pm 2.16a$	$17,3 \pm 0,49b$
2%	$20.75 \pm 2.22a$	$16,2 \pm 0,91bc$
4%	$18.25 \pm 1.26a$	$16,5 \pm 0,59bc$
6%	$17.75 \pm 2.63a$	$15,8 \pm 0,52c$
Commercial	-	$19,8 \pm 0,56a$
P-value	$>0,05$	$0,000^*$

Note: Mean values followed by the same letter within the same column indicate no significant difference ($p > 0.05$), whereas different letters indicate a significant difference among treatments ($p < 0.05$).

A. OVERRUN

As presented in Table 2, the overrun values of Cymbrocream varied within a relatively narrow range, from 17.75% to 20.75%. The formulation containing 2% lemongrass extract (P1) produced the highest expansion ($20.75 \pm 2.22\%$), whereas the 6% treatment (P3) showed the lowest value ($17.75 \pm 2.63\%$). Despite these numerical differences, statistical analysis indicated that the treatments did not differ significantly ($p > 0.05$). Even so, a slight downward trend can be observed as the concentration of lemongrass extract increases. This pattern suggests that moderate incorporation does not compromise aeration, but higher levels may begin to limit the efficiency of air incorporation during freezing (Manurung et al., 2021).

One possible explanation relates to changes in mix viscosity. As the proportion of lemongrass extract rises, the ice cream base likely becomes more viscous. Highly viscous mixes are known to restrict air diffusion during dynamic freezing, which can reduce bubble formation and ultimately lower overrun values (Hossain et al., 2021). Although a thicker mix may contribute to structural firmness, it can also hinder optimal aeration. Additionally, lemongrass extract introduces extra water and phenolic compounds into the system. An increased liquid fraction may weaken the protein fat film that surrounds and stabilizes air cells, making trapped air more susceptible to release during freezing and storage (Manurung et al., 2021).

The presence of butterfly pea flower may also contribute to the overall structural behavior of the ice cream. Anthocyanins and other phenolic compounds in the flower can interact with proteins through non-covalent bonding, potentially influencing air bubble stabilization. However, its impact on overrun appears limited compared with its primary role in color development and antioxidant enhancement (Seah et al., 2025). Previous work by Soukoulis et al., (2008) similarly noted that while small amounts of plant extracts can support structural quality, excessive concentrations may disturb air liquid interfacial balance, leading to reduced expansion.

Taken together, the present findings indicate that increasing lemongrass extract does not substantially alter overrun, but subtle structural adjustments occur as concentration rises. These findings are consistent with the present study, indicating that increasing lemongrass extract concentration does not necessarily lead to an increase in overrun. Compared to the values reported by Putra, Maharani, et al., (2024), the overrun values observed in the present study were relatively lower. (Putra, Maharani, et al., 2024) reported an overrun value of 41.63% for ice cream formulated with 30% soy whey and 70% moringa leaf puree, which was classified as household ice cream. The higher overrun value observed in that study was presumably influenced by differences in ingredient composition, particularly the protein content and total soluble solids from soy whey and moringa leaf puree, which contribute to enhancing the ability of the mix to retain air during churning and freezing. These differences in functional ingredients

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suggest that liquid-based functional additives, such as lemongrass extract and butterfly pea flower, do not necessarily contribute to increasing overrun but instead exert a greater influence on the functional and sensory properties of the product. Overall, the results of this study indicate that the addition of lemongrass extract up to a concentration of 6% did not significantly affect the overrun values of ice cream. The low to moderate overrun values reflect ice cream characteristics with a denser aeration structure and a creamier texture, which are consistent with the intended product formulation. Furthermore, the resulting physical characteristics remain in line with the general quality requirements for ice cream as stipulated in SNI 01-3713 2018 (BPOM, 2014).

B. MELTING POINT

Melting rate is an physical parameter indicating the structural of stability ice cream when exposed to room temperature. As shown in Table 7, the melting time of Cymbocream ranged from 15.8 to 19.8 minutes, which is still within the acceptable range for ice cream product (Puspitasari et al., 2021). Statistical analysis showed that the addition of lemongrass extract increase the affected of melting rate ($p < 0.05$). The control sample (P0) exhibited a melting time of 17.3 ± 0.49 minutes, while samples with 2% and 4% lemongrass extract (P1 and P2) showed melting times of 16.2 ± 0.91 minutes and 16.5 ± 0.59 minutes, respectively. The shortest melting time was observed in P3 (6% lemongrass extract), with a value of 15.8 ± 0.52 minutes.

The decrease in melting time with increasing lemongrass concentration is likely related to the higher water content introduced by the liquid extract, which weakened the fat protein matrix and accelerated ice crystal melting. Similar findings were reported by Pangastuti et al., (2025), who stated that excessive addition of liquid plant extracts can reduce ice cream melting resistance. In addition, lower overrun values at higher lemongrass concentrations may have contributed to reduced melting stability due to less uniform air distribution within the ice cream structure (Hossain et al., 2021).

Commercial ice cream showed a significantly longer melting time (19.8 ± 0.56 minutes) compared to all Cymbocream treatments, likely due to the use of optimized synthetic stabilizers and emulsifiers (Mawarno & Lewerissa, 2025). Overall, the formulation with 2% lemongrass extract (P1) exhibited a balanced melting resistance while maintaining the highest sensory acceptance, indicating its potential as the optimal formulation.

C. SENSORY CHARACTERISTIC

HEDONIC TEST

The results of the hedonic sensory evaluation, as presented in Table 4, and analyzed using Tukey's post-hoc test, then showed significant differences ($p < 0.05$) among all treatments for the assessed parameters, namely color, aroma, texture, taste, and overall acceptance. These findings indicate that variations in formulation significantly influenced the panelists' level of preference toward the developed ice cream product.

Table 4. Sensory scores of ice cream with lemongrass extract addition

Treatment	Color	Aroma	Texture	Taste	Overall
0%	5,57 $\pm$ 0,504c	5,27 $\pm$ 0,944b	5,47 $\pm$ 0,819c	5,20 $\pm$ 0,847c	5,43 $\pm$ 0,817c
2%	6,50 $\pm$ 0,509a	6,00 $\pm$ 0,743a	6,40 $\pm$ 0,563a	6,37 $\pm$ 0,837a	6,43 $\pm$ 0,568a
4%	6,13 $\pm$ 0,819b	6,10 $\pm$ 0,803a	5,97 $\pm$ 0,615b	5,70 $\pm$ 0,837b	5,93 $\pm$ 0,640b
6%	6,07 $\pm$ 0,785b	6,07 $\pm$ 0,740a	5,87 $\pm$ 0,730b	5,80 $\pm$ 0,805b	5,70 $\pm$ 0,702bc
P-value	0,000*	0,000*	0,000*	0,000*	0,000*

Noted: Different superscript letters within the same column showed significant differences at $p < 0.05$. Hedonic criteria: 7 (like extremely); 6 (like); 5 (slightly like); 4 (Neutral); 3 (slightly dislike); 2 (dislike); 1 (dislike extremely)

1. COLOR

The analysis of variance showed that the addition of lemongrass extract increasing color preference of the ice cream ($p < 0.05$). Based on Table 6, the mean hedonic scores for color ranged from 5.57 (slightly liked) to 6.50 (liked). The highest color acceptance was obtained in treatment P1 with the addition of 2% lemongrass extract, which achieved a score of 6.50 (liked) and was significantly different from the other treatments. In contrast, the lowest hedonic score for color was observed in the control sample (P0), without lemongrass extract, with a value of 5.57 (slightly liked). The enhanced color perception at this concentration is likely due to the synergistic interaction between the anthocyanin pigments from butterfly pea flowers and the naturally occurring phenolic compounds in lemongrass. This interaction may stabilize pigment expression, producing a visually appealing bluish-purple hue. In contrast, increasing the extract concentration beyond this level tended to reduce color intensity and clarity, possibly due to non-pigment constituents that interfered with light reflection and visual uniformity. Comparable findings were reported by WULAN ET AL., (2020), who observed that the inclusion of herbal extracts in plant-based frozen desserts could alter

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color perception by modifying transparency and pigment stability. Based on the hedonic color evaluation, it can be concluded that panelists liked and still accepted the color of the ice cream produced across all treatments with lemongrass extract.

2. AROMA

Statistical analysis showed that lemongrass extract had a significant effect on aroma preference ($p < 0.05$). As presented in Table 6, hedonic scores for aroma ranged from 5.27 to 6.10, indicating that all formulations were generally well accepted. The highest score was obtained in treatment P2 (4% lemongrass extract), which reached 6.10 ("liked"). Although this value was not significantly different from P1 and P3, it was significantly higher than the control (P0), which recorded the lowest score (5.27, "slightly liked"). These findings suggest that the incorporation of lemongrass extract contributed positively to the aromatic profile of the ice cream. Moderate concentrations appeared to produce a fresher and more appealing aroma. This effect is likely associated with volatile compounds such as citral, which provide a distinct citrus-like fragrance. The presence of this compound may help mask the typical beany notes of soy-based formulations, thereby improving overall sensory perception. However, increasing the concentration beyond moderate levels did not further enhance aroma preference. In fact, higher extract levels tended to reduce acceptance slightly, possibly because the stronger herbal notes became too dominant and disrupted the balance of the product's aroma. A similar trend was reported by Yuliningtyas & Syauqi, (2021), who found that excessive lemongrass aroma could lead to decreased consumer preference due to its sharp and lingering character. Overall, while all treatments remained within the acceptable range, the 4% lemongrass formulation demonstrated the most favorable aroma response compared with the control.

3. TEXTURE

The analysis of variance indicated that the addition of lemongrass extract significantly affected ice cream texture preference ($p < 0.05$). Based on Table 6, the mean hedonic scores for texture ranged from 5.47 (slightly liked) to 6.40 (liked). The highest texture acceptance was observed in treatment P1, which achieved a score of 6.40 (liked) and was significantly different from the other treatments. In contrast, the lowest texture score was recorded in the control sample (P0), with a value of 5.47 (slightly liked). These results indicate that the addition of lemongrass extract improved the texture preference of the ice cream. The decrease in texture preference at higher extract concentrations (P2 and P3) may be associated from the liquid phase within the ice cream matrix, leading to reduced structural compactness and lower matrix uniformity. These structural changes can reduce viscosity and overrun stability, resulting in a softer, less cohesive texture. Overall, these findings suggest that a 2% addition of lemongrass extract provides an optimal balance between solid and liquid components, producing a smoother, more uniform, and texturally appealing ice cream that aligns with consumer preferences. The texture from the ice cream produced across all treatments was still considered acceptable by the panelists.

4. TASTE

The analysis of variance indicated that the addition of lemongrass extract had a significant effect ($P < 0.05$) on the hedonic taste score of ice cream. As shown in Table 6, the mean taste preference scores ranged from 5.20 (slightly liked) to 6.37 (liked). The highest score was observed in treatment P1, with a value of 6.37 (liked), which was significantly different from the other treatments. The lowest score was obtained in treatment P0, with a value of 5.20 (slightly liked). The higher taste preference for treatment P1 suggests that the addition of lemongrass extract at a low concentration provided a distinctive lemongrass flavor and sweetness in ice cream while effectively masking the beany flavor of soy milk. In contrast, increasing concentrations of lemongrass extract in treatments P2 and P3 tended to decrease taste acceptance, which is presumably due to the emergence of a bitter aftertaste and an excessively strong herbal flavor. According to Utomo & Ariska, (2020), phenolic compounds in lemongrass at high concentrations can impart a bitter sensation, negatively affecting sensory acceptance.

5. OVERALL ACCEPTABILITY

The analysis of variance revealed that the addition of lemongrass extract had a significant effect ($P < 0.05$) on the overall acceptability of ice cream. As presented in Table 6, the mean overall acceptability scores ranged from 5.43 (slightly liked) to 6.43 (liked). The highest score was obtained in treatment P1 (6.43; liked), which was significantly higher than the other treatments, while the lowest score was recorded in treatment P0 (5.43; slightly liked). These results indicate that adding 2% lemongrass extract provided the best balance of color, aroma, texture, and taste, resulting in the highest overall acceptance by the panelists. Overall, the hedonic sensory evaluation indicated that treatment P1 was the best formulation, achieving the highest acceptance across all sensory attributes. This finding confirms that an appropriate formulation not only affects the product's physical and chemical characteristics but also plays a crucial role in determining consumer acceptance. Therefore, Cymbocream formulated with treatment P1 has the greatest potential for further development as a consumer-preferred product, as it effectively meets sensory preferences across the board.

D. ANTIOXIDANT ACTIVITY

Table 5. Antioxidant Activity of Cymbocream with Lemongrass Extract Addition

TREATMENT	ANTIOXIDANT ACTIVITY (%)
0%	12.25 ± 0.317 ^b
2%	17.55 ± 0.659 ^a
PC (commercial product)	2.56 ± 0.864 ^c

***Different superscript letters within the same column showed significant differences at $p < 0.05$.**

The addition of lemongrass extract clearly influenced the antioxidant capacity of the plant-based ice cream ($p < 0.05$), as measured using the DPPH radical scavenging method (Shah & Modi, 2015). Among the tested formulations, the sample containing 2% lemongrass extract (P1) demonstrated the highest antioxidant activity ($17.55 \pm 0.659\%$). This value was notably higher than that of the control without extract ($12.25 \pm 0.317\%$), and substantially greater than the commercial ice cream sample, which showed only $2.56 \pm 0.864\%$. The enhancement observed in P1 suggests that even a moderate concentration of lemongrass extract can meaningfully increase the radical-scavenging potential of the product. Lemongrass is known to contain phenolic compounds and other bioactive constituents that contribute to antioxidant activity, and their presence likely strengthened the functional profile of the ice cream matrix. Similar patterns have been described in earlier studies, where the incorporation of herbal extracts improved the antioxidant performance of various food systems (Yuliningtyas & Syauqi, 2021). Taken together, these findings highlight the importance of formulation strategy in developing plant-based frozen desserts with improved functional properties. Even small adjustments in botanical extract concentration can lead to measurable changes in antioxidant performance.

The increased antioxidant activity in plant-based ice cream enriched with lemongrass extract can be attributed to the presence of phenolic compounds, flavonoids, and essential oil constituents such as citral, which possess strong free radical scavenging properties (Utomo & Ariska, 2020). These bioactive compounds are capable of donating hydrogen atoms or electrons to neutralize DPPH radicals, resulting in higher antioxidant values. In contrast, the antioxidant activity in the control formulation was mainly derived from butterfly pea flower anthocyanins and honey; however, anthocyanins are known to be sensitive to thermal processing, which may reduce their stability during ice cream preparation (Handito et al., 2022). Phenolic compounds from lemongrass are relatively more resistant to heat treatment, allowing better retention of antioxidant activity in the final product. The very low antioxidant activity observed in the commercial ice cream sample highlights the limited use of natural antioxidant-rich ingredients in conventional products. Overall, these findings support the potential of Cymbocream as a functional plant-based ice cream with enhanced antioxidant properties and nutraceutical value.

IV. CONCLUSION

Based from the study obtained, it can be concluded that:

1. The addition of lemongrass (*Cymbopogon citratus*) extract to plant-based ice cream significantly affected the overrun value, melting time, and hedonic sensory characteristics, including color, aroma, texture, taste, and overall acceptability.
2. The treatment with 2% lemongrass extract was identified as the best formulation, yielding plant-based ice cream with an overrun value of 20.75, a melting time of 16.2 minutes, a color score of 6.50, an aroma score of 6.00, a taste score of 6.37, a texture score of 6.40, and an overall acceptability score of 6.43 with all attributes meeting the criteria of "liked". In addition, this formulation exhibited an antioxidant activity of 17.55%, which was substantially higher than commercial ice cream (2.26%).

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