JAFOST
Journal of Agri-Food Science and Technology

P-ISSN 2686-0716 | E-ISSN 2746-5519

Journal homepage http://journal2.uad.ac.id/index.php/jafost
Journal email jafost@tp.uad.ac.id

Sensory Evaluation and Antioxidant Activity of Functional Ice Cream with The Ratio of Cardamom Powder and Dragon Fruit Peel Puree

Ida Ayu Tisna Wahyuniari[a], I Gede Arie Mahendra Putra[a*], Made Dita Dewi Devani[a], Putu Wedananta Darma Wiguna[a], Dina Puti Kartika[b]

[a]Department of Food Technology, Faculty of Agricultural Technology, Udayana University, Badung, Indonesia
[b]Division of Medicine, Msc Clinical and Public Health Nutrition, University College London, London, United Kingdom

[*]Corresponding author, Email: ariemahendra@unud.ac.id

Received 11/03/2025 Revised 04/05/2025 Accepted 04/06/2025

ABSTRACT
Functional food products are emerging due to increased public health awareness. Cardamom (Amomum cardamomum L.), a spice cultivated in Manukaya Village, Bali, is rich in flavonoids and essential oils such as 1,8-cineole, α-terpinyl acetate, α-terpineol, limonene, linalool, and α-pinene. These compounds act as natural flavorings and antioxidants, making cardamom a potential ingredient for functional ice cream. To enhance the ice cream's appearance, natural colorants like dragon fruit peel waste, which are rich in anthocyanins, can be used. This study contributed to determine the optimal ratio of cardamom powder and dragon fruit peel puree to produce ice cream with favorable characteristics and functional potential. A Randomized Group Design (RGD) was applied with 10 treatment ratios (100:0; 10:90; 20:80; 30:70; 40:60; 50:50; 60:40; 70:30; 80:20; and 90:10) and two replications, totaling 20 experimental units. Ice cream was produced by mixing the ingredients according to each treatment, followed by freezing for 10 hours. The data were analyzed using ANOVA and Tukey's test. The results indicated that the 10:90 ratio of cardamom powder to dragon fruit peel puree produced the best ice cream, with average sensory scores of 4.82 (slightly liked) for color, 4.65 (slightly liked) for taste, and 4.59 (slightly liked) for overall acceptance. This formulation also showed 20.19% antioxidant activity and had a rosy brown appearance with color values of L^* 61.90, a^* 10.64, and b^* 3.85, supporting its potential as a functional food product.

KEYWORDS
Cardamom; Dragon fruit peel; Functional food; Ice cream; Ratio

1. INTRODUCTION

Indonesia is well known for its rich spice resources, and Bali likewise reflects this diversity. Manukaya Village, located in the Tampaksiring District of Gianyar Regency, is one of the villages in Bali that cultivates cardamom. Recently, Udayana University conducted a community service initiative in Manukaya Village, focusing on using local cardamom commodities to create innovative and economical products. One of the cardamom-based products that has captured the attention of the community in Manukaya Village is cardamom ice cream.

Ice cream is a widely loved processed food enjoyed around the globe. The addition of cardamom to ice cream aims to enhance its flavor and aroma. Cardamom (*Amomum cardamomum* L.) is known as the "Queen of Spices," due to its distinctive flavor, strong and slightly sweet taste [1]. The 1,8-Cineole compounds found in cardamom have bioactive properties that may help reduce the risk of cardiovascular disease [2]. In the future, plants containing the 1,8-Cineole compound could be effectively utilized as medicinal treatments for various diseases or processed into functional food products, especially as health awareness continues to grow. The incorporation of cardamom in ice cream production has been shown to influence its sensory characteristics, particularly the resulting color. To enhance the sensory appeal of the

final product, the addition of dragon fruit peel puree has been proposed as a way to utilize organic waste, especially considering the prevalence of dragon fruit in religious ceremonies in Bali. The skin of red dragon fruit contains anthocyanins, which act as natural red pigments [3]. Additionally, dragon fruit peel extract contains bioactive compounds which can act as an antioxidant such as betalains, phenolics, flavonoids, and contains 70.3% dietary fiber [4]. As a result, incorporating dragon fruit peel extract can enhance both the sensory and functional properties of cardamom ice cream.

The addition of large quantities of cardamom powder can significantly change the aroma and flavor profile of ice cream. Conversely, not using enough cardamom powder may prevent the ice cream from achieving its optimal functional benefits. This effect is due to the natural compounds found in cardamom seeds. Notably, cardamom seeds contain volatile compounds such as α-pinene, β-pinene, p-simene, 1,8-cineole, and α-terpineol, which contribute to their unique aroma [5]. The presence of α-pinene (4.47%), 1,8-cineole (45.59%), and α-terpineol (9.23%) were identified in cardamom fruit [6]. Additionally, using excessive amounts of dragon fruit peel has been shown to negatively affect the flavor and texture of ice cream. In a related study, ice cream made with a blend of soy milk and dragon fruit peel extract (in a 60:40 ratio) had a less favorable taste and slightly rough texture [7]. On the other hand, using an insufficient amount of dragon fruit peel did not significantly affect the ice cream's color. Red dragon fruit skin contains a chemical compound called betacyanin, which gives the fruit its red-violet color. That compound is present in 56.0 mg/100 g of fruit [8].

Thus, it is crucial to carefully consider the ratio of cardamom powder to dragon fruit peel puree during the ice cream production process to ensure that the sensory characteristics of the final product are well-received by the panelists. An imbalance in this ratio can negatively affect the flavor and texture of the ice cream. To our knowledge, there have been no previous reports on the development of ice cream products with a specific ratio of cardamom powder to dragon fruit peel puree. A review of the background indicates that the author has proposed the creation of a cardamom ice cream product that utilizes a combination of cardamom powder and dragon fruit peel puree as a functional food preparation. This study contributed to determine the optimal ratio of cardamom powder and dragon fruit peel puree for the best ice cream characteristics and its potential as a functional food.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in the research process include cardamom sourced from Manukaya Village in the Tampaksiring District of Gianyar Regency, Bali, and dragon fruit peels obtained from religious ceremonial waste in Bali. Additionally, the materials consist of full cream milk (Ultramilk, Indonesia), granulated sugar (Gulaku, Indonesia), sweetened condensed milk (Indomilk, Indonesia), SP (cake emulsifier) (Koepoe Koepoe, Indonesia), cornstarch (Maizenaku, Indonesia), creamer (MaxCreamer, Indonesia), water (Aqua, Indonesia), distilled water (Rofa, Indonesia), methanol (Merck, Germany), and 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Sigma Aldrich, USA).

The following equipment was utilized during the research: mixer (Miyako), scale (Fujitsu), freezer (Modena), analytical balance (Shimadzu), spectrophotometer (Biochrom Sn 133467), vortex (Maxi Mix II Type 367000), test tubes (Pyrex), filter paper (Whatmann No. 1).

2.2. Preparation of Cardamom Powder

The preparation begins by selecting purplish-red cardamom pods with a distinctive aroma of cardamom, which are washed with clean water. After washing, the pods are dried under indirect sunlight for 8 days from 08:00 to 15:00, until the cardamom pods are blackish brown and crumble easily when pressed with two fingers. Once completely dry, the cardamom seeds are ground in a blender and sifted using a 40-mesh sieve to produce a cardamom powder [9].

2.3. Preparation of Dragon Fruit Peel Puree

The preparation of dragon fruit peel puree is based on Sugiyanto et al., (2020) [10], with modifications. It begins by weighing 255 g of dragon fruit peel and washed. After that, the peel is steamed

at 60 °C for two minutes to blanch it. After blanching, the softened peel is added to 15 mL of water and blended until the mixture becomes smooth, resulting in a creamy fruit peel puree.

2.4. Preparation of Ice Cream

The production of ice cream based on Wangsaputri et al., (2024) [11], with modifications. It begins by mixing 320 mL of full-cream milk with 15 g of creamer powder, 20 mL of sweetened condensed milk, and 25 g of sugar in a saucepan and stirring until it reaches 80 °C. The cardamom powder and dragon fruit peel puree are added in proportions according to treatment. After that, 18 g of cornstarch is added, and the mixture is stirred thoroughly. The mixture was filtered and rested at room temperature for 20 minutes. This is followed by freezing for 45 minutes. After freezing, the ice cream is taken out of the freezer, and 2 g of stabilizer (SP) is added. The mixture is stirred until it reaches a fluffy consistency. Pour into plastic cups and freeze for 10 hours.

2.5. Sensory Evaluation of Ice Cream

Sensory evaluation of ice cream was conducted at the Process Engineering and Quality Management Laboratory, Faculty of Agricultural Technology, Udayana University involving 30 panelists. Sensory evaluation method according to Lawless & Heymann (2010) [12], all ice creams were evaluated for the attributes of color, aroma, taste, texture, and overall acceptances presented on a five-point hedonic scale, 1–5 (1, disliked; 2, slightly disliked;3, neutral; 4, slightly liked; 5, liked).

2.6. Antioxidant Analysis of Ice Cream

The antioxidant activity was determined by the DPPH method according to Shah & Modi (2015) [13]. 1 mL of 0.1 mM DPPH solution was combined with 2 mL of the sample in a test tube. The mixture was vortexed and left to incubate in the dark for 30 minutes. Absorbance was then measured at 517 nm using a spectrophotometer, with ethanol serving as the blank. The control was prepared in the same way as the sample, but without adding the sample. The antioxidant activity percentage was calculated using the equation (1).

$$Antioxidant\ activity\ (\%) = \frac{absorbance\ of\ control - absorbance\ of\ sample}{absorbance\ of\ control} \quad (1)$$

2.7. Color Profile of Ice Cream

The color profile method according to Zhao et al., (2020) [14] was measured with colorimeter using L^* (lightness), a^* (red-green), and b^* (blue-yellow) color scale.

2.8. Experimental Design

The experiment was designed using a simple Randomized Group Design (RGD) with treatment, comparing cardamom powder and dragon fruit peel puree. The puree included 10 treatment levels, which can be seen in Table 1. The experiment was based on 100 g total of both ingredients. The variables observed were sensory characteristics, specifically through a hedonic test assessing color, taste, aroma, texture, and overall acceptance. The results from the hedonic test identified the highest score of samples, which were then selected for further testing of their physical characteristics, measured by L^*, a^*, and b^* values. Additionally, the antioxidant activity was evaluated to determine the potential of the ice cream as a functional food.

2.9. Data Analysis

This study utilized data analysis to investigate sensory characteristics. The collected data will be analyzed statistically using Analysis of Variance (ANOVA) with the support of Minitab 19 software. If the treatment has a significant effect on the variable ($P<0.05$ and/or $P<0.01$), the Tukey Difference Test will be conducted to identify any further differences.

Table 1. Ice cream treatments with the ratio of cardamom powder and dragon fruit peel puree.

Treatments	Cardamom powder (%)	Dragon fruit peel puree (%)
F1	100	0
F2	10	90
F3	20	80
F4	30	70
F5	40	60
F6	50	50
F7	60	40
F8	70	30
F9	80	20
F10	90	10

3. RESULTS AND DISCUSSION

3.1. Color

The variance results indicated that the addition of cardamom powder and dragon fruit peel puree has a significant effect (P<0.01) on the color hedonic test of ice cream produced, as shown in Figure 1.

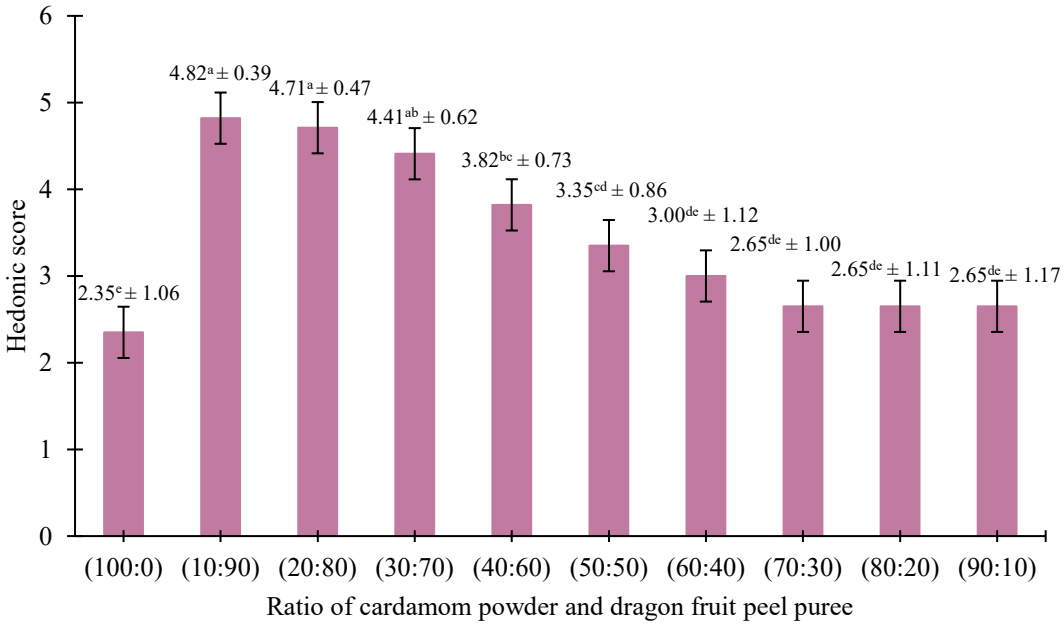

Figure 1. Color hedonic test result.

Based on Figure 1, the average score of the hedonic test on color ranged from 2.35 (slightly dislike) to 4.82 (slightly like). The highest rating was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F2, scoring 4.24 (slightly like). This result was not significantly different from the addition ratio of cardamom powder and dragon fruit peel puree (20:80), which scored 4.71 (slightly like), and the addition ratio of cardamom powder and dragon fruit peel puree (30:70), which scored 4.41 (slightly like). The lowest score was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F1, resulting in a score 2.35 (slightly dislike). This outcome can be attributed to the

addition of dragon fruit peel puree, which has a significant impact on the color characteristics of the ice cream produced. Dragon fruit skin is a potential source of betacyanins, a compound that yields a red-purple pigment [15]. This finding aligns with research by Ren et al., (2020) [8], which documented a betacyanins content of 56.0 mg/100 g of dragon fruit skin. The data, which includes values ranging from F2 to F7 for the ratio of cardamom powder and dragon fruit peel puree, indicates that panelists can accept the color of ice cream when these two ingredients were combined.

3.2. Aroma

The variance results indicated that the addition of cardamom powder and dragon fruit peel puree has a significant effect (P<0.01) on the aroma hedonic test of ice cream produced, as shown in Figure 2. Based on Figure 2, the mean score of the hedonic test on aroma ranged from 2.53 (slightly dislike) to 4.24 (slightly like). The highest rating was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F2, which received a score of 4.24 (slightly like). This score was not significantly different from the addition ratio of cardamom powder and dragon fruit peel puree F3, which also scored 4.24 (slightly like), the ratio of cardamom powder and dragon fruit peel puree F4, which scored 3.88 (neutral), and the ratio of cardamom powder and dragon fruit peel puree F5, which scored 3.82 (neutral).

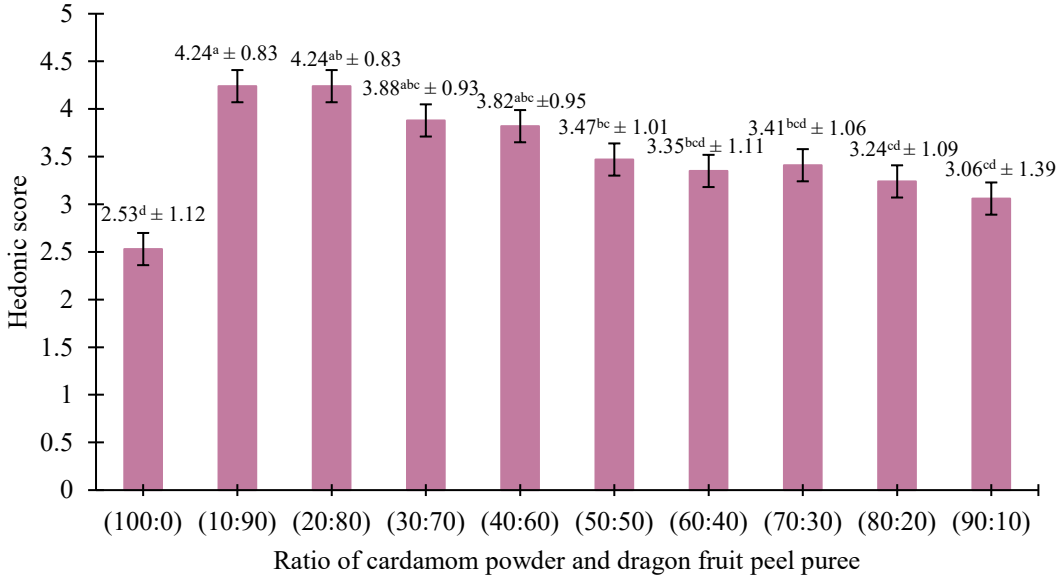

Figure 2. Aroma hedonic test result.

The lowest value was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F1, which received a score of 2.53 (slightly dislike). This finding suggests that adding cardamom powder influences ice cream's aroma. Cardamom powder contains essential oil, which consists of components such as 1,8-cineole (43.47%), α-terpinyl acetate (21.56%), linalool (10.26%), α-terpineol (6.98%), sabinene (2.11%), and α-pinene (0.57%) [16]. The main components responsible for the distinctive aroma in cardamom essential oil are α-terpinyl acetate and 1,8-cineole [17]. This aligns with the findings of Alagupalamuthirsolai et al., (2024) [18], 1,8-cineol was an ether compound with a low boiling point, imparts a fresh, camphoraceous, and cooling aroma and taste, while α-terpineol contributes floral notes with pleasant citrus-woody tones and subtle lemon-lime nuances. Consequently, a higher proportion of cardamom powder is likely to result in ice cream with a more pronounced aroma. The data presented indicates that panelists can accept the aroma of ice cream by adding cardamom powder and dragon fruit peel puree at a ratio ranging from F1 to F9.

3.3. Taste

The variance results indicated that the addition of cardamom powder and dragon fruit peel puree has a significant effect (P<0.01) on the taste hedonic test of ice cream produced, as shown in Figure 3. Based on Figure 3, the mean score of the hedonic test on taste ranged from 1.88 (dislike) to 4.47 (slightly like). The highest score was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F2, which received a rating of 4.47 (slightly like). This result was not significantly different from the addition ratio of cardamom powder and dragon fruit peel puree F3, which scored 4.53 (slightly like), the ratio of cardamom powder and dragon fruit peel puree F4, which scored 4.18 (slightly like), and the ratio of cardamom powder and dragon fruit peel puree F5, which scored 4.00 (slightly like). Conversely, the lowest result was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F1, which was rated at 1.88 (dislike). This result can be attributed to bioactive compounds such as cineole that are commonly found in cardamom, which significantly affect the taste profile of the ice cream to be more pungent. This finding aligns with the report by Cai et al., (2021) [19], which identified 1,8-Cineole as the predominant bioactive compound in cardamom fruit, known for its distinctive and robust herbal flavor. Overall, the results suggest that panelists can accept the taste of ice cream with the addition of cardamom powder and dragon fruit peel puree at a ratio ranging from F2 to F6.

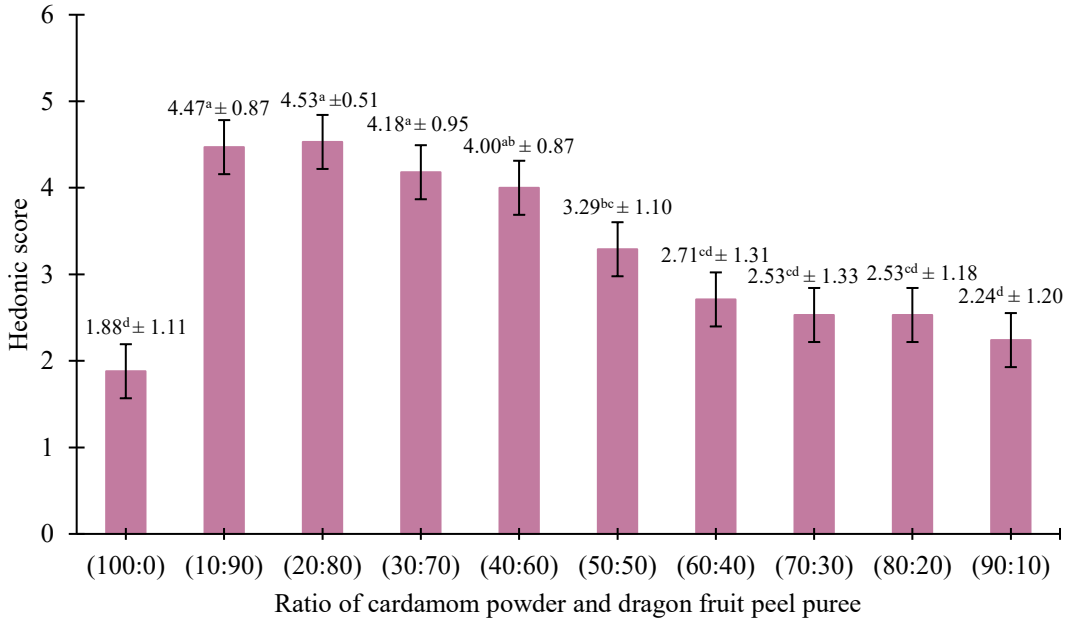

Figure 3. Taste hedonic test result.

3.4. Texture

The variance results indicated that adding cardamom powder and dragon fruit peel puree has a significant effect (P<0.01) on the texture hedonic test of ice cream produced, as shown in Figure 4. Based on Figure 4, the mean score of the hedonic test on texture ranged from 2.82 (slightly dislike) to 4.29 (slightly like). The highest score was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F2, which received a rating of 4.29 (slightly like). This result was not significantly different from the addition ratio of cardamom powder and dragon fruit peel puree F3, which scored 3.76 (neutral), the ratio of cardamom powder and dragon fruit peel puree F4 which scored 4.06 (slightly like), the ratio of cardamom powder and dragon fruit peel puree F5, which scored 3.94 (neutral), the ratio of cardamom powder and dragon fruit peel puree F6, which scored 3.53 (neutral), the ratio of cardamom powder and dragon fruit peel puree F7, which scored 3.24 (neutral). The lowest value was obtained in ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F1, which rated at 2.82 (slightly dislike).

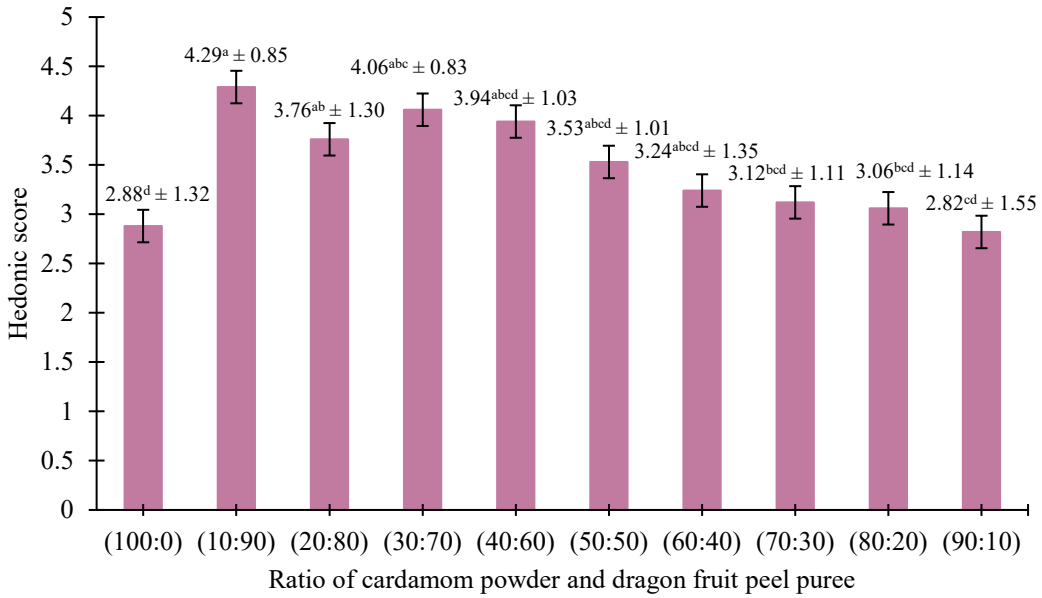

Figure 4. Texture hedonic test result.

These findings indicated that the addition of cardamom powder negatively impacted the panelists' liking for the ice cream, while the addition of dragon fruit peel enhanced their preference. The texture of the ice cream is affected by the size of the cardamom powder particles, which are relatively large and contribute to a rough texture. In contrast, the addition of dragon fruit peel puree produces a softer texture. Dragon fruit peel contains 18.94% pectin, which functions as a gelling agent, stabilizer, emulsifier and thickener, which adds elasticity and softness to the ice cream texture [20]. Based on the range of score, the panelists can accept the texture of ice cream with the addition of cardamom powder and dragon fruit peel puree at a ratio ranging from F2 to F9.

3.5. Overall Acceptance

The variance results indicated that adding cardamom powder and dragon fruit peel puree has a significant effect ($P<0.01$) on the overall hedonic acceptance test of ice cream produced, as shown in Figure 5. Based on Figure 5, the mean score of the hedonic test for overall acceptance ranged from 2.47 (slightly dislike) to 4.59 (slightly like). The highest score, 4.59 (slightly like), was achieved by the ice cream with the addition ratio of cardamom powder and dragon fruit peel puree F2. Conversely, the lowest score, 2.47 (slightly dislike), was recorded for ice cream with cardamom powder and dragon fruit peel puree F1. The overall average score indicates that ice cream with cardamom powder and dragon fruit peel puree at a ratio ranging from F2 to F6 was generally acceptable to the panelists.

The sensory attributes of cardamom ice cream, combined with dragon fruit peel puree, greatly affect the overall consumer acceptance of the product. This is in line with Čolić et al., (2023) [21] who stated that sensory attributes such as color, aroma, texture and taste become a key role in the overall acceptance of turmeric and black pepper enriched ice cream. Specifically, attributes such as sweetness, creaminess, smoothness, and pleasant aroma tend to increase overall liking, while unpleasant taste, rough texture, and visually unappealing color may negatively impact acceptance.

3.6. Color Profile and Antioxidant Activity

Color profile and antioxidant activity were then tested to evaluate its potential as a functional food on the sample with the best treatment selected based on the sensory characteristics most preferred by the panelists, namely sample F2. The results of this analysis are presented in Table 2.

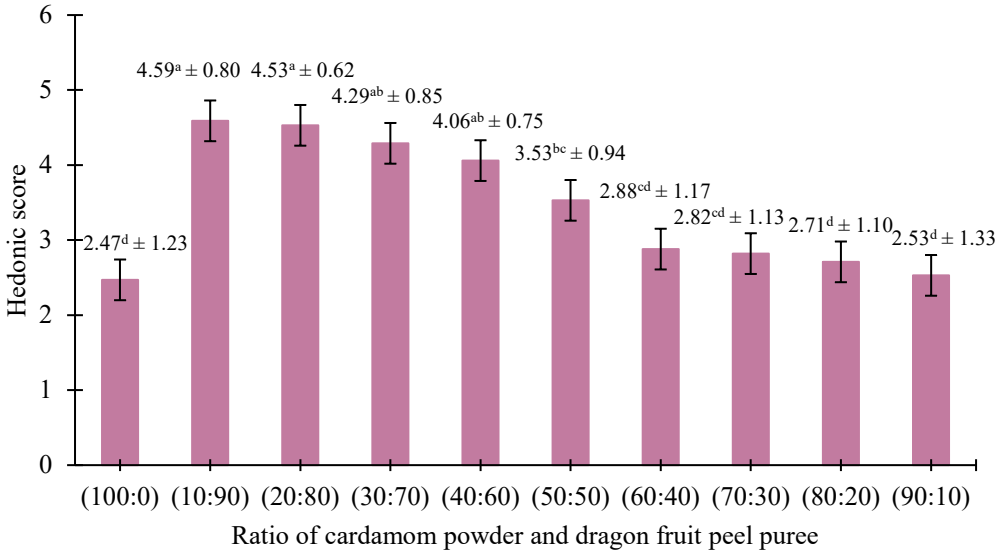

Figure 5. Overall hedonic test result.

The color test was performed with a colorimeter on the ice cream with the best sensory characteristics, which was the ice cream with a ratio of cardamom powder and dragon fruit peel puree (10:90). Based on Table 2, the average values of L^*, a^* and b^* are 61.90, 10.64 and 3.85 with rosy brown color characteristics. The L^* (lightness) value is influenced by the high proportion of dragon fruit peel puree in the ice cream, which leads to a more intense red-purple color and a decrease in the lightness value. The a^* (red-green) value is mainly affected by the betacyanin pigment found in the dragon fruit rind. Betacyanin is heat-sensitive; lower temperatures help preserve the stability of betacyanin, whereas higher temperatures (80 °C) promote its conversion to betaxanthin, leading to a color shift in the extract from red-purple to yellow [22]. Consequently, the ice cream's color can become pale due to the degradation of betacyanin during the cooking process. The total phenolics and flavonoids influence the b^* (blue-yellow) value in the cardamom fruit. This is consistent with the findings of Nurcholis et al., (2022) [23], which revealed that cardamom contains 1.263 mg QE/g DW of total phenolics and 3.187 mg QE/g DW of flavonoids. These compounds contribute to the light green/yellow pigments observed in the fruit.

Table 2. Results of L^*, a^*, and b^* color analysis and antioxidant activity.

Treatment	Color profile				Antioxidant activity
	L^*	a^*	b^*	Color criteria	(%)
F2	61.90 ± 4.99	10.64 ± 2.97	3.85 ± 3.60	Rosy brown	20.19 ± 1.59

An antioxidant activity was evaluated to assess the potential of cardamom ice cream enhanced with dragon fruit peel puree as a functional food. As shown in Table 2, the average antioxidant activity of the ice cream with the optimal treatment was 20.19%. This activity is influenced by the bioactive compounds present in both cardamom and dragon fruit peel. One of the significant compounds identified in the essential oil of cardamom fruits (seeds and pods) is 1,8-cineole, which accounts for 45.59% of the oil [6]. Known as eucalyptol, 1,8-cineole is a natural monoterpene recognized for its antioxidant, antimicrobial, anti-inflammatory, and anticancer properties [19]. Additionally, the secondary metabolites found in cardamom also contribute to the antioxidant activity of its essential oil [6]. On the other hand, the rind of dragon fruit is rich in pectin (10.93–20.22%), betacyanin (20.74–50.65 mg/L), and vitamin C (349.139 mg AA/100 g) [24], [25]. Betacyanin is a red-purple pigment that possesses antioxidant and antibacterial properties [26]. Furthermore, dragon fruit peel contains phenolic compounds, including polyphenols and flavonoids, which

are closely linked to the antioxidant activity of the material [27]. Dragon fruit skin includes 352.09 mg RE/g of flavonoids and 355.033 mg/g of total phenolics [28].

3.7. Potential as Functional Food

Functional food is defined as food that has been modified to contain active components positively impacting health and disease prevention. These added ingredients can include nutrients, dietary fibre, phytochemicals, and biologically active components such as antioxidants, flavonoids, phenolics, and prebiotics [29]. Foods that can potentially be classified as functional foods can be identified by their content of bioactive components that positively influence health, such as antioxidants. Cardamom ice cream with the addition of dragon fruit peel puree has relatively high antioxidant activity, namely 20.19%. This is especially noteworthy compared to the findings of Ozdemir et al., (2022) [30], who reported an antioxidant activity level of 0.91% in ice cream enriched with carob molasses pulp. Adding 1.5% dragon fruit peel flour to yellow sweet potato ice cream yielded an antioxidant activity of 13.24% [31]. These results indicate that the antioxidant activity of cardamom ice cream with dragon fruit peel puree surpasses the levels reported in these previous studies.

A molecule that can counteract or inhibit free radicals by neutralizing reactive oxygen species (ROS) to protect cells from damage is known as an antioxidant [32]. Research indicates the potential of antioxidants in both preventing and treating diseases, suggesting they may enhance therapeutic efficacy and slow disease progression. Intake of antioxidant-rich natural products has shown positive effects in lowering the risk of cardiovascular disease (CVD) events by acting through multiple pathways, including blood pressure reduction, enhancement of lipid metabolism, suppression of oxidative stress, inflammation control, and modulation of gut microbiota [33]. The increased antioxidant activity in this ice cream can be attributed to the bioactive components found in both cardamom fruit and dragon fruit peel, which include 1,8-Cineole, betacyanin, polyphenols, and flavonoids. The flavonoids found in dragon fruit skin can reduce blood glucose levels by 45.6% in experimental animals with hyperglycemia, indicating a potential therapeutic benefit for diabetes management [34]. This effect is believed to result from the flavonoids' ability to enhance antioxidant enzymes and donate electrons, which helps prevent reactive oxygen species formation. Additionally, cardamom extract demonstrated anti-inflammatory effects in macrophages by decreasing oxidative stress and promoting the gene expression of nuclear receptors, indicating its potential for use in managing inflammatory diseases [35]. The anti-inflammatory activity of cardamom extracts has been linked to 1,8-cineole (eucalyptol), a compound that is present in significant amounts in cardamom. These findings suggest that F2 treatment could serve as functional foods with considerable health benefits.

4. CONCLUSION

Ice cream formulated with a 10:90 ratio of cardamom powder and dragon fruit peel puree showed the most favorable sensory characteristics, particularly in color, aroma, taste, texture, and overall acceptance. In a hedonic test, the ice cream received high scores: color (4.82–slightly liked), aroma (4.41–slightly liked), taste (4.65–slightly liked), texture (4.29–slightly liked), and overall acceptance (4.59–slightly liked). The color profile (L^* 61.90; a^* 10.64; b^* 3.85) indicated a rosy brown color. Additionally, this formulation demonstrated strong potential as a functional food, with an antioxidant content of 20.19%.

AUTHOR CONTRIBUTION

Ida Ayu Tisna Wahyuniari Writing (original draft, review & editing), antioxidant analysis. **I Gede Arie Mahendra Putra**: Writing (original draft, review & editing), investigation, conceptualization, funding acquisition, and supervision. **Made Dita Dewi Devani**: Investigation, writing (review & editing), color analysis, and data analysis. **Putu Wedananta Darma Wiguna:** Product preparation, sensory analysis, and data analysis. **Dina Puti Kartika:** Writing (original draft, review & editing) and proofreading the articles.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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