The Impact of Ginger Extract (*Zingiber officinale* Rosc.) Addition on Overrun Value, Melting Resistance, Viscosity, and Hedonic Ratings of Gelato

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Abstract

Incorporating ginger into gelato can significantly enhance its physical properties and sensory attributes. Ginger contains bioactive compounds like gingerol, which contribute to its distinctive flavor and health benefits, such as anti-inflammatory and antioxidant properties. Ginger can contribute to a smoother texture by interacting with the fat and protein structures in the gelato as well as can enhance the melting resistance of gelato, making it more stable and enjoyable to consume over a longer period. The addition of ginger provides a refreshing, spicy flavor that can elevate the overall taste profile of gelato. This study analyzed the impact of adding ginger extract at different concentrations on the overrun value, melting resistance, viscosity, and hedonic properties of gelato. A completely randomized design was used, with treatments including 0% (T0), 0.5% (T1), 1% (T2), and 1.5% (T3) ginger extract. Higher concentrations of ginger extract affected all parameters: overrun values ranged from 15.72% to 22.03%, melting resistance from 36.64 to 42.06 minutes, and viscosity from 10.06 to 12.76 dPas. Hedonic testing revealed that panelists preferred gelato with 0.5% ginger extract (T1). In conclusion, adding ginger extract to gelato significantly affects its overrun value, melting resistance, and viscosity, with the 0.5% concentration being most preferred by consumers.

Introduction

Ginger is a spice plant with numerous benefits, extensively used in traditional medicine and culinary applications. In Indonesia, ginger is highly diverse, with one easily accessible variety being elephant ginger. Ginger is available both fresh and processed. It contains antioxidants, specifically oleoresin, commonly known as gingerol. According to Purba et al. (2023), ginger is rich in active components, such as phenolic and terpene compounds. The phenolic compounds found in ginger include gingerol, shogaol, and parasol.

According to data from the Central Statistics Agency (BPS), ginger production in Indonesia reached 247.34 thousand tons in 2022. Over the past decade, ginger production in Indonesia has shown fluctuating trends. In 2022, production decreased by 19.49% compared to 2021, when it was 307.24 thousand tons. The high production figures in 2021 can be attributed to the surge in demand for ginger as an alternative treatment and immune system booster during the Covid-19 pandemic. Consequently, the increase in ginger production in 2021 was significant compared to 2020, which recorded 183.51 thousand tons.

The primary issue with using ginger as an extract lies in the improper processing or extraction methods, which can damage or diminish the bioactive compound content. Generally, ginger extract is obtained either by boiling and extracting the water or by grating/blending and squeezing to obtain ginger juice. These methods can compromise the bioactive compounds in ginger, particularly when boiling is done for extended periods or at high temperatures. Active compounds such as gingerol are susceptible to decomposition or evaporation during the heating process.

The maceration method involves soaking sample powder without heating, thereby preserving active compounds that are easily damaged by high temperatures (Istiqomah et al., 2023). Ginger is macerated using 96% ethanol solvent due to ethanol's polar properties, which allow it to penetrate cell wall

materials, facilitating cell diffusion and rapid extraction of bioactive compounds. This method effectively extracts phenolic compounds such as flavonoids. Research by Wijayanti et al. (2018) indicates that testing the total phenolic content of ginger in a 96% ethanol extract yields a relatively high value of 4.85 ± 0.04 µg/mL, equivalent to a standard gallic acid solution of 485.18 ± 3.70 mg GAE/g in 100 g of ginger.

Thick ginger extract can be incorporated into food products, such as gelato. Ginger is a versatile ingredient known for its distinctive flavor and numerous health benefits, making it an excellent addition to gelato. The incorporation of ginger not only enhances the flavor profile but also brings various nutritional benefits. Ginger contains bioactive compounds like gingerol, which have anti-inflammatory and antioxidant properties, aiding in digestion and improving overall health. Gelato, a frozen dessert originating from Italy, is made primarily from milk and has a denser texture compared to ice cream. The addition of thick ginger extract can affect the total soluble solids in gelato (Kusumastuti et al., 2023). Moreover, adding thick ginger extract influences the chemical properties of gelato, as it contains bioactive compounds that can increase both the total phenol content and antioxidant activity. Ginger extract can also impact the sensory characteristics of gelato. The objective of this research is to determine the effect of adding ginger extract (*Zingiber officinale Rosc.*) at varying concentrations on the the overrun value, melting resistance, viscosity, and hedonic properties of gelato.

Materials and Methods
Materials
The materials used in this study were cow's milk obtained from fresh cow's milk, fresh ginger, whipping cream, granulated sugar, egg yolks, cornstarch, ethanol pro analyst, and distilled water.

Methods
This research was conducted from November 2023 to February 2024 at the Laboratory of Food Chemistry and Nutrition, the Laboratory of Food Engineering and Agricultural Products, Faculty of Animal Husbandry and Agriculture, and the integrated laboratory of Diponegoro University, Semarang.

Ginger Extraction
Ginger extraction was carried out using the cold extraction method, specifically maceration. A total of 200 g of ground ginger was soaked in a solvent at a ratio of 1:5. Specifically, 1000 ml of 96% ethanol was measured, and 750 ml of it was used for the initial maceration. The mixture was covered and left for 24 hours at room temperature, with occasional stirring to ensure complete extraction of the active substances. After 24 hours, the extract was filtered using a filter cloth. The residue was then re-macerated with the remaining 250 ml of 96% ethanol for another 48 hours, followed by filtration using a filter cloth. The combined filtrates were further filtered using Whatmann filter paper no. 42 and concentrated using a rotary evaporator at 50–60 °C until a thick extract was obtained. The extract was then weighed to determine its yield (Luhurningtyas et al., 2021).

Gelato Preparation
The gelato was prepared following a modified procedure by Goff & Hartell (2013). Fresh cow's milk was pasteurized at 75°C for 15 seconds and then allowed to cool to room temperature. The gelato ingredients, including sugar, egg yolks, and corn starch, were beaten using a mixer. The milk and whipping cream were mixed and heated to 60°C. Tempering was then carried out by combining the milk and cream mixture with the beaten sugar, egg yolks, and corn starch. This mixture was heated again until it thickened or reached 85°C. After cooling, ginger extract was added according to the treatment groups: 0% (P0), 0.5% (P1), 1% (P2), and 1.5% (P3), and mixed until homogeneous. The gelato mixture was then aged for 4 hours before being placed in a gelato maker (DeLonghi II Gelataio ICK 6000 manual, Italy) for agitation (32 rpm). The final gelato mixture was frozen for 24 hours.

Quality Testing
The gelato with various concentrations of ginger extract was tested for quality to determine its physical and sensory characteristics. This includes overrun, melting resistance, viscosity and hedonic properties.

Overrun (Singo and Beswa, 2019)
The testing was conducted by comparing the weight of the gelato mixture after the aging process and the weight of the gelato after churning and cooling in the ice cream maker. The steps were as follows: a container or measuring cup with a volume of 100 ml was weighed. The gelato mixture after aging was poured into the measuring cup up to the 100 ml mark and then weighed. The gelato, after the churning and cooling process, was placed into the pre-weighed 100 ml measuring cup, leveled, and then weighed again.

Melting Resistance (Kho et al., 2022)
Testing was conducted by observing the gelato until it completely changed shape or melted. The gelato mixture, which had undergone churning and cooling in the ice cream maker, was weighed to 30 grams and placed in a plastic cup, then frozen in a freezer for 48 hours. The gelato was taken from the freezer and transferred to a room with a temperature of approximately 25 ± 1 °C (Hanafi et al., 2022). A stopwatch was started when the gelato was removed from the freezer and stopped when the gelato had completely melted.

Viscosity (Amalya et al., 2023)
The testing utilized a cup and bob viscometer (Rion Co, Japan), which operates on the principle of shearing the sample between the outer wall of the bob and the inner wall of the cup, with the bob positioned precisely in the center. Approximately 200 ml of the sample was prepared and placed into the cup. The bob was then placed in the center of the cup, fully submerged but not touching the bottom. The device was turned on, causing the bob to rotate. The viscosity reading, frequently displayed on the screen, was recorded as the sample's viscosity level. The results from this viscometer are measured in dPas (deciPascal-seconds).

Hedonic Properties (Harfika et al., 2023)

Sensory evaluation (hedonic) of gelato involves directly assessing its sensory attributes using human senses. These attributes include color, taste, texture, and aroma. Hedonic evaluation of gelato refers to Harfika et al. (2023). The testing was conducted using a scoring method with the assistance of 30 untrained panelists. The evaluation covered five parameters: color, aroma, texture, taste, and overall preference (Sharmin et al., 2022). The testing involved panelists tasting and rating their liking of the samples by filling out the provided assessment forms. The scoring scale used was 1 = strongly dislike; 2 = dislike; 3 = like; and 4 = strongly like.

Statistical Analysis

The obtained data were statistically analyzed using one-way Analysis of Variance (ANOVA) with a significance level of 5%, followed by Duncan's Multiple Range Test (DMRT) to identify differences between treatments. The analysis was conducted using the SPSS 26.0 application.

Results and Discussion

Overrun

Table 1 demonstrates that varying concentrations of ginger extract added to gelato have a significant effect ($p < 0.05$) on the overrun value. Overrun is a measure of the amount of air incorporated into gelato during the agitation or mixing process. According to Table 1, the lowest overrun value is observed in sample T3, while the highest is in sample T0. This indicates that the overrun value decreases as the concentration of the added extract increases, due to the increased viscosity of the gelato.

Table 1 Ginger Extract Gelato Overrun Test Results

Treatment	Ginger extract (%)	Overrun (%)
T0	0	22.03 ± 0.99[c]
T1	0.5	20.76 ± 1.35[c]
T2	1	18,10 ± 1.26[b]
T3	1.5	15.72 ± 1.18[a]

Note: [a-c] overrun values show significant differences ($p < 0.05$)

This observation aligns with Zahro and Nisa's (2015) assertion that high viscosity makes it difficult for air to penetrate the gelato mixture, resulting in lower expansion. Additionally, the addition of ginger extract reduces the fat content in the gelato, leading to a lower overrun. The fat content decreases because the lipase enzyme in ginger breaks down fat into saturated or unsaturated fatty acids. Lower fat content diminishes the gelato's overrun since it reduces the capacity of fat globules to form structures around air pockets (Simanjuntak, et al., 2022).

Melting Resistance

Table 2 indicates that the different concentrations of ginger extract added to gelato exert a significant effect ($p < 0.05$) on the melting resistance value. Melting resistance refers to the gelato's capacity to maintain its solid form before melting. As depicted in Table 2, the addition of ginger extract to gelato correlates with an increase in melting resistance. This phenomenon is attributed to the viscosity or thickness of the gelato

mixture; denser mixtures take longer to melt due to the closer proximity of components within the matrix. Consequently, gelato with a thicker consistency drips more slowly than gelato with a thinner consistency. Moreover, incorporating ginger extract into gelato ingredients reduces the fat content, resulting in lower density and favorable melting properties (Nusa et al., 2019).

The melting resistance of gelato is further influenced by the overrun value; higher overrun values correspond to faster melting times, leading to lower melting resistance in gelato. Gelato is a dairy product with lower fat content compared to ice cream. This characteristic influences its overrun value. According to Parera et al. (2018), the overrun of gelato ranges from no air to about 15-20% or more. Therefore, the ideal condition for desired gelato is to have a low overrun value, which results in higher melting resistance.

Table 2 Ginger Extract Gelato Melting Resistance Test Results

Treatment	Ginger extract (%)	Melting Resistance (minutes)
T0	0	36.64 ± 1.50[a]
T1	0.5	37.87 ± 1.18[ab]
T2	1	39.94 ± 1.26[b]
T3	1.5	42.06 ± 2.09[c]

Note: [a-c] melting resistance values show significant differences ($p < 0.05$)

Viscosity

Table 3 shows that different concentrations of ginger extract added to gelato have a significant effect ($p < 0.05$) on the melting resistance value. Viscosity is a measure of the thickness of a liquid. Based on Table 3, it is evident that viscosity increases with the addition of ginger extract to the gelato mixture. According to Rizka et al. (2019), viscosity is directly proportional to the amount of dissolved solids. The increase in viscosity in gelato is due to the addition of ginger extract, which raises the soluble solids content in the gelato mixture, thereby reducing the amount of air captured during the agitation process. This aligns with Chamchan et al. (2017), who state that adding herbal extracts like ginger to ice cream can increase its fat and protein content, resulting in less air in the mixture and a lower overrun value.

Table 3 Ginger Extract Gelato Viscosity Test Results

Treatment	Ginger extract (%)	Viscosity (dPas)
T0	0	10.60 ± 0.06[a]
T1	0.5	11.20 ± 0.44[b]
T2	1	11.81 ± 0.61[b]
T3	1.5	12.76 ± 0.81[c]

Note: [a-c] viscosity values show significant differences ($p < 0.05$)

The increased viscosity in gelato is also attributed to the presence of protease enzymes in ginger extract, as noted by Anggoro (2023). Protease enzymes can increase the viscosity of food products, including gelato, by breaking down proteins into smaller peptides and amino acids, which then interact with other ingredients to form a more stable and thicker structure. This process, known as protein hydrolysis, results in the formation of

peptides that can enhance water-binding capacity, leading to an increase in the overall viscosity of the product (Khan, et. al., 2022). Ginger rhizomes contain protease enzymes, commonly referred to as zingibain, which is a cysteine protease with glycosylation at asparagine-99 and asparagine-156.

Table 4 Ginger Extract Gelato Hedonic Test Results

Treatment	Sensory Attributes				
	Color	Aroma	Texture[ns]	Flavor	Overall
T0	3.20 ± 0.76^b	2.60 ± 0.62^a	3.23 ± 0.68	2.70 ± 0.95^b	2.77 ± 0.77^b
T1	3.30 ± 0.54^b	3.03 ± 0.49^c	3.37 ± 0.67	3.30 ± 0.63^c	3.40 ± 0.62^c
T2	2.70 ± 0.70^a	2.90 ± 0.55^{bc}	3.20 ± 0.80	2.53 ± 0.82^b	2.73 ± 0.78^b
T3	2.40 ± 0.77^a	2.70 ± 0.65^b	3.40 ± 0.72	1.90 ± 0.76^a	2.13 ± 0.73^a

Note: different letters in the same column indicate significant differences ($p<0.05$). Scoring scale 1 = strongly dislike; 2 = dislike; 3 = like; and 4 = strongly like.

Hedonic Test

The testing was conducted to assess the overall acceptability and preference of a product by measuring the sensory attributes such as taste, aroma, texture, color, and overall liking. This type of evaluation is typically conducted using human subjects, often referred to as panelists, who provide feedback on their personal likes and dislikes regarding the product. The outcomes of the hedonic test analysis of gelato are presented in Table 4.

Color

Based on Table 4, it can be seen that the lowest hedonic value for gelato color is observed in treatment with 1.5% ginger extract, while the highest hedonic value for gelato color is found in treatment with 0.5% ginger extract. Based on data from previous research, it was found that the higher the concentration of ginger extract added, the more the color of the gelato becomes brownish-yellow. It is known that the more brownish-yellow the color, the less it is preferred by the panelists. This observation corresponds with the highest average liking score for color, namely 3.30 (like), recorded in treatment with 0.5% ginger extract, and the lowest average liking score for color, namely 2.40 (very dislike), observed in treatment with 1.5% ginger extract. The brownish hue originates from the natural color of the ginger utilized, specifically elephant ginger. The brownish color is attributed to the oleoresin present in ginger extract, consistent with the findings of Nurdiana et al. (2021), which indicate that ginger oleoresin typically comprises 15–35% essential oil and appears as a dark brown and slightly thick liquid.

Aroma

Based on Table 4, it is apparent that the stronger the concentration of ginger extract added, the more pronounced the typical ginger aroma becomes in the gelato, which is less favored by the panelists. This aligns with the highest average liking score for aroma, recorded at 3.03 (like), observed in treatment T1 (0.5%), and the lowest average liking score for aroma, noted at 2.60 (dislike), seen in treatment T0 (0%). This trend indicates that increasing the amount of ginger extract results in a stronger aroma that deviates from the typical ginger scent, eventually leading to a distinctive ginger aroma in the gelato. The distinctive aroma of ginger is primarily attributed to the presence of essential oils in ginger extract. According to Ningsih (2020), ginger essential oil comprises approximately 2.58–2.72% of the ginger's dry weight. Typically, ginger essential oil is yellowish in color, slightly viscous, and serves as the compound responsible for the distinctive aroma of ginger (Retni and Damansyah, 2022).

Texture

Based on Table 3, the addition of ginger extract at different concentrations to gelato does not significantly impact the panelists' preference levels, as the resulting texture remains largely consistent across treatments. Panelists expressed positive sentiments towards the gelato texture in all treatments, indicating a general preference for the smooth and creamy texture characteristic of gelato. Texture refers to the sensation of pressure experienced in the mouth (during biting, chewing, and swallowing) or felt on the skin. The test results indicate that higher concentrations of ginger extract did not produce a noticeable effect on the gelato's texture. According to Liana et al. (2017), the softness of ice cream texture can be influenced by the presence of fat globules and air bubbles trapped within the mixture. Gelato texture is directly related to its physical properties, and the addition of more extracts tends to increase the mixture's thickness, indicating a higher concentration of solids present (Seno and Lewerissa, 2021).

Flavor

Based on Table 4, the increasing of the amount of ginger extract added results in a stronger spicy and bitter taste in the gelato, which is less favored by the panelists. Panelists preferred the gelato in treatment T1 because the spicy taste of ginger was not overpowering, allowing the gelato to be enjoyed without a bitter aftertaste in the throat. As the concentration of ginger extract rises, the distinctive taste of ginger becomes more pronounced. According to Karmila et al. (2022), the spicy taste of ginger is attributed to the presence of oleoresin compounds, which include zingerol, shogaol, and resin components.

Overall

Based on Table 4, the increasing of the amount of ginger extract added results in a gelato with a more pronounced brownish-yellow color, a stronger typical aroma of ginger, and a more intense spicy and bitter taste, which is generally less favored by the panelists. This trend is consistent with the highest average panelist liking score for the overall parameter, recorded at 3.40 (like), observed in treatment T1 (0.5%), and the lowest average panelist liking score for the overall parameter,

noted at 2.13 (very dislike), seen in treatment T3 (1.5%). Gelato products with ginger extract that were deemed acceptable by the panelists were those treated with P1 (0.5%), garnering average scores of 3.30 (like) for color, 3.03 (like) for aroma, 3.37 (like) for texture, and 3.43 (like) for taste attributes.

Conclusion

Based on the results of the research, it can be concluded that the addition of ginger extract to making gelato reduces overrun values, increases melting resistance and viscosity. Based on the physical properties of gelato, the best treatment was treatment with 1.5% ginger extract. Otherwise, from the hedonic properties assessment by the panelists, the gelato most liked by the panelists was gelato with 0.5% ginger extract. The researchers suggest that to optimize the physical characteristics of gelato while maintaining consumer preference, it is necessary to adjust the concentration of ginger extract. Based on related research findings, a ginger extract concentration of 1.5% is also favored by panelists, especially adults aged 25-50 years.

Acknowledgment

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