

The physical and chemical properties of aloe vera ice cream and the effects of varying gel and stabilizer concentrations

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Abstract

Aloe vera gel is known as a source of antioxidants because it contains phenolic compounds from the flavonoid group. However, flavonoids are easily damaged, mainly by heating. Therefore, it is necessary to develop aloe vera gel products that can suppress flavonoid damage without using high temperatures to inhibit antioxidant damage. Ice cream is a frozen food in the form of an emulsion of fat in water. It has a high melting rate to maintain flavonoid resistance during processing. This research aimed to produce aloe vera ice cream with appropriate chemical properties (total solid, sugar content, protein, fat) and physical properties (overrun, melting point) with high and favorable antioxidant activity. The research was carried out in a completely randomized design with two factors, namely the amount of aloe vera gel with variations: 250 g, 300 g, and 400 g, and the concentration of carboxyl methyl cellulose (CMC) stabilizer is 0.3%; 0.5%; 0.7% per total ingredients. Data were processed factorially using SPSS for Windows 19, and differences between samples were calculated using Duncan's Multiple Range Test. The most preferred aloe vera ice cream was tested for FT-IR absorption bands to determine the functional changes in aloe vera due to the addition of CMC. The results showed that the amount of aloe vera gel had no significant difference in the chemical properties of ice cream and its antioxidant activity. Meanwhile, adding CMC increased total solids, but the sugar content and overrun were lower. Ice cream with the addition of 250-300 g of gel with 0.5% CMC was most preferred, and the presence of hydroxyl groups proved the presence of antioxidant activity in the ice cream according to the standard flavonoid quercetin in the preferred aloe vera samples.

1. Introduction

Aloe vera is a tropical and subtropical plant that is beneficial for health. The gel part of the leaves contains flavonoid compounds, which have been proven to have anti-oxidative activity. According to Khaldoune *et al.* (2024) flavonoid compounds in aloe vera gel include rutin, kaempferol dan quercetin. As antioxidants, flavonoids contain many hydroxyl groups that can capture free radicals (Zou *et al.*, 2020). The anti-oxidation activity of aloe vera gel is still very high even though it has been processed into several products such as aloe vera gel drinks, powder, or instant. Aloe vera gel extract has antioxidant activity expressed as RSA (Radical Scavenging Activity) of 11.93% and 6.56% in ethanol extract gel (Hęś *et al.*, 2019). In instant aloe vera gel made with the encapsulating agent maltodextrin 2.5%, the RSA value was 35.59±2.65%, and the

inhibition of lipid peroxidation was 16.15±0.73% (Wariyah and Riyanto, 2016). According to Wariyah and Riyanto (2016), making aloe vera powder using a simple method using the encapsulating agent maltodextrin 5% and drying with a blower oven at a temperature of 50°C produces powder with a still high RSA value, namely 15.01±1.50%.

The problem is that flavonoid compounds, a group of phenolic compounds, are easily damaged during storage. According to Lu *et al.* (2019), flavonoids in orange juice, such as hesperidin, narirutin, apigenin-6,8- di-C-Glucoside, narirutin-4' -O- Glucoside decreased during storage for 0 - 16 weeks at a temperature of 0-40°C. Processing aloe vera using higher temperatures for a long time can result in a decrease in antioxidant activity. Therefore, the alternative of making aloe vera ice cream,

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a frozen food product, is an effort to maintain high and acceptable antioxidant activity. According to the Indonesian National Standard (SNI 01-3713-2018), ice cream is a semi-solid food made by freezing ice cream flour or a mixture of milk, animal fat or vegetable fat, sugar, and with or without food ingredients. Other permitted food ingredients include flavoring. The addition of aloe vera gel as a source of antioxidants is necessary, considering its potential health benefits. With the high-water content of aloe vera gel, namely $99.07 \pm 0.24\%$ (Wariyah *et al.*, 2022), the alternative of processing it into ice cream is very appropriate.

The problem in making ice cream is that the ingredients' components broadly determine the emulsion formation's stability. Unstable emulsions are characterized by the rapid melting of ice cream, which is less favorable when consumed. According to Verma *et al.* (2018), in making aloe vera ice cream with mint flavoring using 0.5% stabilizer and aloe vera ice cream formula with a ratio of ice cream base mixture: aloe vera pulp: mint flavoring of 1: 90: 0.5, producing ice cream with melting resistance, tall and well-liked. Aprillia *et al.* (2023) stated that making ice cream using different types of stabilizers, namely CMC, gum arabic, gelatin, and carrageenan, as much as 0.5%, did not show a real difference in the melting rate, but the overrun value was significantly different. Other research states that adding carboxyl methyl cellulose (CMC) is very good for stabilizing ice cream emulsions and is no different from gelatin (Lestari *et al.*, 2019). CMC is a compound obtained by carboxymethylating cellulose, one of the modified cellulose commonly used as a thickener, emulsion stabilizer, and gel enhancer in the food and pharmaceutical industries. However, differences in the formula when adding aloe vera or CMC can change the properties and antioxidant activity of the ice cream. Therefore, this study aimed to evaluate the effect of the amount of aloe vera gel and CMC on the physical and chemical properties, antioxidant activity, and the acceptability of ice cream.

2. Materials and methods

2.1 Materials

The raw material used in making aloe vera ice cream is aloe vera leaves (*Aloe vera* var. *chinensis*) with a harvest age of 2 years, a length of 40-50 cm, and a weight of 700-900 g. Aloe vera leaves were obtained from the Ghra Sambiroto Aloe vera Garden, Kulon Progo Regency, Special Region of Yogyakarta, Indonesia. Chemicals with pro-analysis qualifications from Merck (Darmstadt, Germany) were used to analyze ice cream, DPPH (1,1-Diphenyl-2-picrylhydrazyl) solution, gallic acid as a phenol analysis standard, and

quercetin as a flavonoid standard were purchased from Sigma Aldrich Chemical Co. (USA). Ingredients for making ice cream, such as skim milk, whipping cream, sucrose sugar, stabilizer (CMC), and skim milk (MSNF), were obtained from Brataco Chemical and Dioni ingredients shop in Yogyakarta, Indonesia.

2.2 Analysis of raw materials

The analysis carried out on fresh aloe vera gel was moisture content using the static gravimetric method (Apriyantono *et al.*, 1989), phenolic content using the Folin-Ciocalteu method with a gallic acid standard (Ling *et al.*, 2019), flavonoids content were determined using the colorimetric method and calculated as equivalent to quercetin (Ling *et al.*, 2019), and the antioxidative activity of the samples was determined based on the ability to capture DPPH radicals (Galaz *et al.*, 2017) using a Spectrophotometer (Shimadzu UV mini 1240, Japan), a spectrophotometer for qualitative identification of functional groups of aloe vera gel with Fourier Transform Infra-Red (FTIR, Bucker Alpha II, Germany). Equipment for making ice cream is a set of mixing tools (Sojiko classic), mixer (Turbo EHM 9090, China), ingredient scale (Electronic Kitchen scale SF 400, Indonesia), blender (Philips HR 2116, Indonesia), freezer (AQF-450EC, China) and plastic standing cups for packaging ice cream.

2.3 Research procedures

Making ice cream refers to Lestari *et al.* (2019) with modifications. In this study, variations in the amount of aloe vera gel used were 250 g, 300 g, 400 g (based on preliminary research), and CMC stabilizer with variations: 0.3%, 0.5%; 0.7% per dough weight. Equipment for making ice cream is a set of mixing tools (Sojiko classic), ingredient scales (Electronic Kitchen scale SF 400), blender (Philips HR 2116, Indonesia), mixer (Turbo EHM 9090, China), plastic standing cup for packaging ice cream and freezer (AQF-450EC, China).

The aloe vera leaves used in making ice cream are peeled in running water until clean and drained. The aloe vera gel was weighed and then sliced into 2-3 cm pieces, and 3×3 samples were prepared according to the number of treatments. Each aloe vera sample was blanched at 90°C for 10 min, stirred until smooth using a blender (Philips HR 2116, Indonesia) for 1 min, and filtered. Each supernatant was added with 120 g of whipped cream CMC, 150 mL water, 50 g sugar, and 50 g sweetened condensed milk. The mixture was stirred with a mixer (Turbo EHM 90090, China) for 15 min, then the ice cream mixture was packaged in plastic ice cream cups with a volume of 100 mL, closed, and put into the

freezer (AQF-450EC, China). Ice cream samples were analyzed for their chemical, physical, and acceptability properties.

2.4 Chemical analysis of aloe vera ice cream

Chemical analysis carried out on each ice cream sample was total solids, total sugar analysis using the Nelson Somogyi method, fat using the Soxhlet distillation method, protein using micro Kjeldhal (Apriyantono *et al.*, 1989), and antioxidant activity based on the ability to capture DPPH free radicals (Galaz *et al.*, 2017).

2.4.1 Analysis of total solids

A sample of 1.0 g of ice cream was weighed in a porcelain cup of known weight (A) and then heated in a water bath until slightly dry. Then, it was put into an oven (Memmert DIN 40050 IP 20) at a temperature of 105°C for 1 h and weighed repeatedly until a constant weight (B). Total solids were calculated based on the formula:

$$\text{Total solids} = ((B - A) / \text{sample weight (g)}) \times 100\% \quad (1)$$

Where A = weight of porcelain cup, B = dry weight of sample and porcelain cup

2.4.2 Analysis of total sugar

Total sugar was analyzed using the Nelson-Somogyi method. A 50 mL Pb-free sample was put into an Erlenmeyer flask, 25 mL of distilled water and 10 mL of 30% HCl were added, then homogenized by shaking. The solution was heated in a water bath (Memmert WTB15 Waterbath) at 70°C for 10 min; then, the sample was cooled. The sample solution was neutralized with 45% NaOH, then distilled water was added to a measuring flask to 200 mL, then 1 mL of the sample was taken and diluted with 50 mL of distilled water in a measuring flask, and 1 mL of Nelson's reagent was then vortexed. After that, the sample was heated to boiling for 20 min and cooled. After that, 1 mL of arsenomolybdate reagent and 7 mL of distilled water were added and vortexed. After that, it was measured using a spectrophotometer (UV-VIS Spectrophotometer Shimadzu 1240) with a wavelength of 540 nm. The amount of sugar is determined based on the optical density or absorbance of the sample solution and the standard curve of the glucose solution in units of µg/mL. The total sugar content is calculated based on the formula:

$$\text{Total sugar (\%)} = (\text{concentration} \times \text{dilution factor}) / (\text{sample weight (g)} \times 1000) \times 100\% \quad (2)$$

2.4.3 Analysis of fat

Fat content was determined using the Soxhlet

method. A 7-10 g sample was wrapped in filter paper and inserted into a Soxhlet tube extractor flask connected to a fat flask of known weight (A). The sample was extracted using hexane solvent (6 h), which had been connected to a distillation apparatus attached to the fat flask. Furthermore, the fat extract in the flask was dried using an oven at a temperature of 105°C until constant weight (B). The fat extract was cooled and weighed (drying was repeated until constant weight was achieved). Fat content is calculated using the formula:

$$\text{Fat content} = (B - A) / (\text{sample weight}) \times 100\% \quad (3)$$

Where A = weight of flask prior to extraction; B = weight of flask after extraction.

2.4.4 Analysis of protein

Determination of protein content was carried out using the micro Kjeldahl method. The stages of protein analysis include destruction, distillation, and titration. In the destruction stage, the sample was weighed as much as 0.1-0.5 g and put into a Kjeldahl flask, after which 40 mg of HgO, 1.90 mg of K₂SO₄, and 2 mL of H₂SO₄ were added. Furthermore, destruction was carried out by heating the sample in an acid chamber. Destruction occurred until the solution became clear (1-1.5 h). The destruction results were cooled and diluted with 10-20 mL of distilled water slowly.

The Kjeldahl flask containing the digestion sample was transferred to the distillation apparatus, washed, and rinsed 5-6 times with 1-2 mL of distilled water. A 125 mL Erlenmeyer flask containing 5 mL of HBO₃ solution (boric acid) was prepared, and three drops of BCG-MR indicator were added to capture the distillate from the distillation results just before the distillation began. The tip of the condenser must be submerged under the HBO₃ solution (boric acid), then the digestion sample was added with 8-10 mL of NaOH-Na₂S₂O₃ solution (sodium thiosulfate). Distillation was carried out until approximately 15 mL of distillate was collected in the Erlenmeyer, then diluted to approximately 50 mL. The solution was titrated using 0.02 N HCl until the color of the sample solution changed to pink. The volume of HCl used was recorded, and the protein content could be calculated using the formula:

$$\text{Protein content} = ((A - B) \times N \text{ HCl} \times 14) / (\text{mg sample}) \times 100\% \times \text{conversion factor} \quad (4)$$

Where A = mL titration sample; B = mL titration blank; Conversion factor = 6.25; Protein content = % N × Conversion factor.

2.4.5 Antioxidant activity

The antioxidant activity of aloe vera gel ice cream was determined based on the ability to capture free

radicals 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Galaz *et al.*, 2017). DPPH stock solution was prepared using an ethanol solvent with a concentration of 0.1 mM. A sample of 1 mL of extracted ice cream was added with 2.5 mL of DPPH solution and then stirred evenly using a vortex (Vortex Mixer DLAB MX-S). The absorbance of the sample was measured using a spectrophotometer (Shimadzu UV mini-1240) at a wavelength of 517 nm, at $t = 0$ and $t = 30$ min, after incubating in a dark room. Antioxidant activity was calculated as RSA or Radical Scavenging Activity (%), with the formula:

$$\text{Radical Scavenging Activity (\%)} = \frac{[1 - (AT/Ao)] \times 100\%}{100\%} \quad (5)$$

Whereas Ao = absorbance value at $t = 0$ min, and AT = absorbance value at $t = 30$ min.

2.5 Determination of physical properties of ice cream

Physical properties testing includes overrun and melting rate tests, according to Lestari *et al.* (2019). The overrun is calculated based on the volume of the ice cream mixture before stirring and homogenization with the mixture after it has been processed into ice cream. The formula is:

$$\text{Overrun (\%)} = \frac{\text{volume of processed ice cream} - \text{volume of ice cream mixture} \times 100\%}{\text{volume of ice cream mixture}} \quad (6)$$

The melting rate was measured by placing 10 g of ice cream sample in a sieve under which there was a glass as a holding container. The ice cream is allowed to thaw at room temperature. The time it takes for the ice cream to melt completely is measured using a stopwatch.

2.6 Acceptability test of aloe vera ice cream

Acceptability testing of the aroma, color, texture, taste, and overall aloe vera ice cream preference used the hedonic test method (Fauzi *et al.*, 2022) with modifications using 25 semi trained panelists. The most preferred ice cream was tested for functional groups that act as antioxidants using FT-IR, compared to aloe vera gel and the standard flavonoid quercetin.

2.7 Experimental design

This study used a completely randomized design with two factors: the amount of aloe vera gel and the CMC concentration. Differences between treatments were determined using the F test, while fundamental differences between samples were determined using Duncan's Multiples Range Test (DMRT) and data processing using SPSS for Windows 19.

3. Results and discussion

3.1 Chemical properties of aloe vera gel

The results show that the moisture content of aloe vera gel was $98.76 \pm 0.076\%$, phenol content 168.27 ± 0.26

mg/g dry matter, flavonoid content 36.88 ± 1.72 mg/g dry matter, and the antioxidant activity of aloe vera gel indicated by the Radical Scavenging Activity (RSA) was $31.60 \pm 0.12\%$.

The moisture content of aloe vera gel is almost the same as previous research, namely $99.07 \pm 0.24\%$ (Wariyah *et al.*, 2022). However, according to Kusrina *et al.* (2024), the water content of aloe vera gel is $99.19 \pm 0.03 (\%)$ at a harvest age of two years. The phenol content of aloe vera gel is 1.39 ± 0.24 g/100 g gel and flavonoids 0.26 ± 0.03 g/100 g gel (Royani *et al.*, 2023). The antioxidant activity of aloe vera gel with RSA was 11.93% in the gel extract and 13.52% in the methanol extract (Hez *et al.*, 2019), while Wariyah and Riyanto (2016) found that the RSA value of the gel was $12.09 \pm 1.79\%$. Factors that influence the compound content in aloe vera gel extract include variety, growing conditions, and soil type (Quispe *et al.*, 2018), while Hu *et al.* (2003) stated that the phenol and flavonoid content of aloe vera gel is determined by the harvest age of the aloe vera plant and is optimal at three years of age. This research used aloe vera leaves of the *Aloe vera* var. *chinensis* from a hilly area in Kulon Progo Regency, Special Region of Yogyakarta, Indonesia, which is a hilly area, so it has chemical characteristics such as flavonoid levels in the gel, which result in different antioxidant activity expressed as RSA.

3.2 Chemical properties of aloe vera ice cream

Based on the ice cream quality standards according to the Indonesian National Standard (SNI 01-3713-2018), the chemical properties analyzed in this research are total solids, sugar content (as sucrose), fat content, and protein content. The results of the analysis of the chemical components and antioxidant activity of ice cream made with varying amounts of aloe vera gel and CMC percentage can be seen in Table 1.

3.2.1 Total solid

The statistical analysis results showed no significant difference in the interaction between the amount of aloe vera gel and the amount of CMC. Still, the amount of CMC affected the total solids of ice cream. CMC is a white solid, which means that if more CMC is added to the ice cream, the total solids in the ice cream will also increase. Additions in the range of 0.2% show a real difference. The solids in ice cream also come from sugar, skim milk, whipping cream, or aloe vera gel. According to SNI 01-3713-2018, the total solids in ice cream are at least 31% (w/w), but ice cream with a CMC of 0.3% has an average total solids content of $28.02 \pm 0.36\%$, meaning it does not meet the requirements. Research by Lestari *et al.* (2019), which is similar to this study, found that the

Table 1. Chemical components and radical scavenging activity (RSA) of *Aloe vera* ice cream.

<i>Aloe vera</i> gel (g)	CMC (%)	Component				
		Total solid (%)	Total sugar (%)	Fat (%)	Protein (%)	RSA** (%)
250	0.3	28.02±0.52	21.56±0.29	5.27±0.49 ^c	9.74±1.98 ^c	5.27±0.54
300	0.3	28.37±0.66	23.17±4.11	4.52±0.36 ^{ab}	7.54±0.28 ^{ab}	5.68±0.27
400	0.3	27.66±0.21	21.32±0.88	4.34±0.30 ^a	6.90±0.13 ^a	5.18±0.82
Average		28.02±0.36 ^A	22.02±1.01 ^B	4.71±0.49	8.06±1.49	5.38±0.27
250	0.5	31.60±0.09	18.54±0.88	4.33±0.17 ^a	9.10±0.27 ^{bc}	6.57±0.22
300	0.5	31.48±0.45	20.79±0.13	5.08±0.06 ^{bc}	7.18±0.60 ^a	6.98±0.57
400	0.5	31.58±0.06	18.44±0.91	4.49±0.02 ^{ab}	7.54±1.32 ^{ab}	6.31±0.44
Average		31.55±0.06 ^B	19.26±1.33 ^A	4.63±0.40	7.94±1.02	6.62±0.34
250	0.7	37.15±0.03	18.88±1.94	4.32±0.11 ^a	6.86±0.26 ^a	6.39±0.34
300	0.7	36.27±0.19	20.89±1.13	4.43±0.12 ^a	7.68±0.36 ^{ab}	5.95±0.27
400	0.7	36.88±1.22	18.54±1.03	4.22±0.10 ^a	8.10±0.92 ^{ab}	5.82±0.55
Average		36.77±0.45 ^C	19.44±1.27 ^A	4.32±0.11	7.55±0.63	6.05±0.30

Values are presented mean±SD. Values with different superscripts in the same column are statistically significantly different (P≤0.05). **not significantly different.

total solids were 42.14±0.92%, higher than the results of this study. This is due to the addition of less water, which proportionally increases the total solids.

3.2.2 Total sugar

The results showed no significant difference in the interaction between the amount of aloe vera gel and the amount of CMC, but the amount of CMC affected the total sugar in ice cream. The total sugar in ice cream comes from the sucrose used and other components, such as sweetened condensed. The sugar added to each ice cream sample is the same, but the average sugar content is lower with more CMC. This is because the amount of CMC proportionally increases the number of solids, so that the sugar percentage becomes lower. According to Ilmi *et al.* (2023), in ice cream on the market, the amount of sugar (sucrose) is between 13.28 - 20.56%. According to SNI 01-3713-2018, the minimum sugar content is 8% (wb), so the sugar content of aloe vera ice cream is by the provisions.

3.2.3 Fat

The fat content of aloe vera ice cream shows that the amount of gel and CMC are significantly different. The more aloe vera gel used, the higher the CMC concentration and the lower the fat content. According to SNI 01-3713-2018 concerning ice cream, the minimum fat content requirement is 5.0%, while this research shows that ice cream fat content is between 4.22-5.27% (wb). The formulation of ingredients used in making ice cream produces fat content almost the same as the requirements of SNI 01-3713-2018. The addition of whipping cream and sweetened condensed milk to make ice cream contributes to the fat content of aloe vera ice cream. The higher the addition of CMC, the greater the

total solids (Table 1), resulting in a proportional decrease in fat. According to Lestari *et al.* (2019), the fat content of ice cream with gelatin stabilizer from several different sources is between 9.38-10.85%, while Aprillia *et al.* (2023) stated that ice cream with the addition of yellow sweet potato has a fat content of around 22.18%. This result shows that differences in formulation result in differences in ice cream composition. In this study, the fat content of ice cream was between 4.32% and 4.71%; this is because aloe vera gel only contains around 0.0168 ±0.0006 g/100 g fat (Añibarro-Ortega *et al.*, 2019). The low-fat content in aloe vera ice cream is beneficial, considering that fat is an easily oxidized material, so antioxidant activity can be effective for consumers of this functional ice cream.

3.2.4 Protein

The protein in ice cream comes from whipping cream, sweetened condensed milk, or aloe vera gel. The results of protein analysis of aloe vera ice cream showed significant differences. The more aloe vera gel and CMC, the lower the protein levels. According to SNI 01-3713-2018, protein content requirements are a minimum of 2.7% (wb). Adding aloe vera gel and CMC reduced the protein content of ice cream. This result is because the main component of aloe vera gel is water (Table 1). The protein content of aloe vera gel is only around 0.044 ±0.001 g/100 g (Añibarro-Ortega *et al.*, 2019), while CMC is a non-protein component; therefore, the protein percentage decreases with more CMC.

3.2.5 Antioxidant activity of aloe vera ice cream

Antioxidant activity is expressed as the ability to capture free radicals or as the RSA (Radical Scavenging Activity) value. The results of the analysis of the

antioxidant activity of aloe vera ice cream can be seen in Table 1.

The antioxidant activity of ice cream with variations in the amount of gel and CMC showed no significant difference ($p>0.05$). Adding more aloe vera gel and CMC did not affect the magnitude of the antioxidant activity. This result is because the main component of aloe vera gel is water, and the content of antioxidant compounds, namely phenolic compounds, especially flavonoids, is relatively low (36.88 ± 1.72 mg/g dry matter), so the presence of CMC proportionally reduces the percentage of antioxidants. As a result, the antioxidant activity is not significantly different. According to Salsabila *et al.* (2022), dragon fruit pulp ice cream mixed with aloe vera in a ratio of 560 g/210 g has antioxidant activity with an IC_{50} of 73.42 ppm or the ability to capture 50% DPPH radicals. In this study, the antioxidant activity of aloe vera ice was between 5.18% and 6.98%. The flavonoid compounds in aloe vera cause this difference as antioxidants, only 36.88 ± 1.72 mg/g dry matter or around 3.78 ± 0.15 g/100 g, while in dragon fruit, the flavonoid content is higher, namely 5.92 mg QE/g dried fruit (Puspawati *et al.*, 2022). Thus, aloe vera ice cream has antioxidative activity because it contains flavonoids as antioxidants.

3.3 Physical properties of aloe vera ice cream

3.3.1 Overrun

Overrun in making ice cream is the percentage of volume expansion, namely, the increase in ice volume between before and after freezing. During freezing, the trapped air determines the high or low overrun score using the ice cream maker. According to Choirunnisa *et al.* (2022), a good overrun percentage is between 30 – 140%. Table 2 shows the overrun of aloe vera ice cream. The results showed that the overrun of aloe vera ice cream decreased along with the increase in CMC, and significantly increased the total solids of ice cream (Table 1). According to Kamińska-Dwórznička *et al.* (2022), the higher the total solids of ice cream, the greater the resulting overrun, but it depends on the type of stabilizer. Dough with high CMC produces a thick texture; the higher the solid content in the dough, the lower the overrun because air is difficult to enter the

dough. Wu *et al.* (2019) also found that the more stabilizer used, the higher the overrun. Using 0.4% carrageenan stabilizer produces ice cream with an overrun of around 100%.

3.3.2 Melting rate

Melting rate, often called melting time, is the length of time it takes for ice cream to change form from frozen to completely liquid at room temperature after freezing in the freezer (Haryanti and Zueni, 2015) or the speed at which ice cream melts per unit time. The results of measuring the melting rate of aloe vera can be seen in Figure 1.

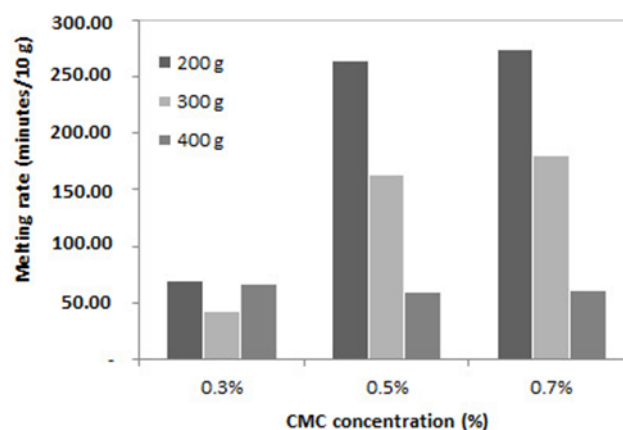


Figure 1. Melting rate of *Aloe vera* gel ice cream made with varying amounts of gel and CMC concentration e caption.

The time it takes for ice cream to melt after being removed from the freezer is greatly influenced by its constituent components. The melting point test results for aloe vera ice cream showed a significant difference ($p<0.05$); the more aloe vera gel, the lower the melting rate, but the higher the CMC, the higher the melting rate. Carboxymethyl cellulose (CMC) is a water-soluble polysaccharide that functions as a stabilizer. Stabilizers can improve the texture because they can keep the water in the ice cream from freezing too much and reduce the formation of large ice crystals. CMC can act as a stabilizer because it is a water binder (Costa *et al.*, 2023), so the ice cream does not melt as quickly, the more CMC.

Meanwhile, aloe vera extract contains 7.7 g/100 g db of protein and 2.2 g/100 g db of fat, but the fiber content

Table 2. Overrun of *Aloe vera* ice cream.

Aloe vera gel (g)	CMC (%)			Average
	0.3	0.5	0.7	
250	157.68±21.32	112.72±32.89	101.82±3.45	124.07±19.6
300	136.22±1.84	138.61±23.29	100.31±21.74	125.05±11.5
400	130.74±9.26	132.35±4.90	129.71±0.86	130.93±1.13
Average	141.55±14.24 ^B	127.89±13.51 ^{AB}	110.61±10.56 ^A	

Values are presented mean±SD. Values with different superscripts in the same column are statistically significantly different ($P \leq 0.05$).

reaches 23.8 g/100 g db (Zhang *et al.*, 2018). According to Muñoz *et al.* (2015), lyophilized aloe vera extract contains soluble fiber $16.58 \pm 1.81\%$ dry weight and insoluble fiber $48.22 \pm 2.64\%$ dry weight. The more insoluble fiber, the less final holding ability. Therefore, the more aloe vera gel, the lower the melting rate. According to Kusumawardani and Juwanto (2020), the melting rate of ice cream with the addition of sweet corn and using CMC 0.3% ice cream starts to melt at 50 min with a melting amount of 2 g. The results of this research are in line with this research. In this study, 10 g of ice cream was melted, and the melting time was around 75 min (with a CMC of 0.3%). The longer the melting took, the longer it took. Ice cream is preferred if it doesn't melt quickly, so aloe vera can fulfill this preference.

3.4 Acceptability of the aloe vera ice cream

The result of the sensory testing showed differences between ice cream made with variations in aloe vera gel and CMC concentration ($p < 0.05$) (Table 3). The preferred aloe vera ice cream is made with up to 300 g of aloe vera gel, but the CMC amount is up to 0.3-0.5%. Table 3 shows that the panelists liked the taste of ice cream with the addition of between 250 g of aloe vera gel with a stabilizer of 0.3-0.7% and 300 g of aloe vera with a stabilizer of 0.3-0.5% with a value of between 2.33-2.76. The panelists' liking scores showed that they liked aloe vera ice cream's aroma, color, texture, and taste. However, ice cream with a CMC of 0.3% has less than 31% total solids (Table 1), so the ice cream does not meet SNI standards. Meanwhile, based on the overrun (Table 2), ice cream with a good overrun has a CMC of 0.5%, namely $127.89 \pm 13.51\%$, and melting rate as an indicator means the ice cream does not melt quickly, so it is preferred. Therefore, it can be concluded that ice cream with excellent and favorable chemical and physical properties is made by adding 250 g and 300 g of aloe vera gel with 0.5% CMC.

3.5 Functional groups of aloe vera gel in ice cream

Aloe vera ice cream has antioxidant activity, as shown by its ability to capture DPPH free radicals or Radical Scavenging Activity (RSA) of 5.18-6.98%. The flavonoid antioxidant compounds in aloe vera (such as quercetin) were 36.88 ± 1.72 mg/g dry matter. The results for active groups in aloe vera gel with quercetin standards are shown based on the wave numbers of specific groups in aloe vera gel and aloe vera ice cream, as presented in Figure 2.

Figure 2 shows that the dominant wave numbers are 3284.90 cm^{-1} and 2922.36 cm^{-1} . According to Ray and Ghost (2018), frequencies between $3600 - 3200 \text{ cm}^{-1}$ are phenolic -OH stretching, a functional group of phenolic compounds. In Figure 2, it is shown that peak one and peak two frequency is $2960 - 2850 \text{ cm}^{-1}$, while the other peaks between 1580 to 1000 cm^{-1} are aliphatic C-H stretching, = C-O stretching, CH₃ scissoring and bending and C-O-C glycoside stretching vibration which is the functional group of the compound methylene -CH₂-, an amino acid. Carrillo-Martinez *et al.* (2024) stated that the active group in quercetin, or generally flavonoid compounds, is the hydroxyl group (-OH) in the basic

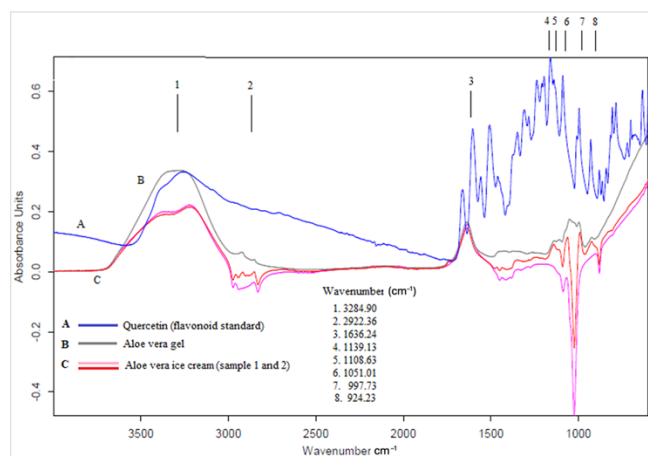


Figure 2. FT-IR spectrum of *Aloe vera* gel, aloe vera ice cream and quercetin.

Table 3. Acceptability of *Aloe vera* ice cream.

Amount of <i>Aloe vera</i> gel (g)	CMC (%)	Aroma	Color	Texture	Taste	Overall acceptance
250	0.3	2.15 ^a	2.00	2.93	2.41 ^a	2.33 ^a
250	0.5	2.63 ^{abc}	2.42	2.88	2.29 ^a	2.50 ^{ab}
250	0.7	2.29 ^{ab}	2.08	3.04	2.67 ^{ab}	2.67 ^{abc}
300	0.3	2.88 ^{abc}	2.16	2.92	2.88 ^{abc}	2.96 ^{abcde}
300	0.5	2.60 ^{abc}	2.24	2.76	2.84 ^{abc}	2.76 ^{abcd}
300	0.7	3.40 ^c	2.04	3.00	3.96 ^d	3.52 ^c
400	0.3	2.64 ^{abc}	2.16	2.92	3.44 ^{bcd}	2.96 ^{bcde}
400	0.5	3.00 ^{bc}	2.20	3.28	3.56 ^{cd}	3.28 ^{cde}
400	0.7	3.04 ^{bc}	2.24	3.16	3.64 ^{cd}	3.40 ^{de}

Values are presented as mean. Values with different superscripts in the same column are statistically significantly different ($P \leq 0.05$).

structure of the diphenyl propane structure (C6-C3-C6). An -OH group acts as an electron donor and can capture free radicals. There is also a catechol or dehydroxylated B-ring structure group, which in Figure 2 is shown at a wave number between 1139-924 cm^{-1} . In two samples, this active group was also found in aloe vera gel and aloe vera ice cream. This result shows that the antioxidant activity in ice cream is due to the presence of these flavonoid compounds.

Aloe vera contains phenolic compounds in the form of flavonoids such as flavones, flavanones, isoflavones, and flavan-3-ol. Flavonoid compounds in aloe vera gel include quercetin, rutin, and kaempferol (Khaldoune *et al.*, 2024), while Mensah *et al.* (2025) stated that the flavonoids in aloe vera gel are rutin, rhamnetin, apigenin and quercetin. Li *et al.* (2019) state that these flavonoid compounds have many -OH groups on the aromatic ring. The hydroxyl group can function as an antioxidant by donating hydrogen to free radicals produced when fat oxidation occurs (Ahmed *et al.*, 2016).

The research results in Figure 2 show that, based on the peak area, it can be seen that the -OH groups in every 0.1 g of sample, the number of -OH groups in standard quercetin is the highest, then in aloe vera gel and ice cream. Quercetin is a standard flavonoid, so its purity is the highest; therefore, the -OH group detected is the highest. In aloe vera gel, the peak area is lower than that of quercetin. The low peak area is because in aloe vera gel, besides phenolic compounds, there are water, protein, fat, carbohydrates, and organic acids (Zhang *et al.*, 2018). However, the high level of -OH groups may also detect the -OH groups of flavonoid compounds other than quercetin. The -OH group was detected as the lowest in aloe vera ice cream. The lowest group is because the components in the ice cream, apart from aloe vera gel, also contain cream, sugar, stabilizer, and sweetened condensed milk, so the number of flavonoids is proportionally lower.

4. Conclusion

The research concludes that making ice cream by adding aloe vera gel with the stabilizer CMC can produce ice cream with antioxidant activity and chemically meets the requirements for ice cream. Physically, the overrun value of ice cream is high, and the melting rate is long, but it is still preferred. Ice cream with high acceptability is made by adding 250-300 g of aloe vera gel and 0.5% CMC stabilizer with an antioxidant activity of 5.18-6.98%. Therefore, aloe vera ice cream can be used as a functional food source of antioxidants that are beneficial for health and can be developed in the food industry.

Conflict of interest

The authors declare no conflict of interest.

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