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Physicochemical and Organoleptic Characteristics of Purple Corn (*Zea mays L.)* Extract Ice Cream: The Effect of Skim Milk and CMC Addition

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A B S T R A C T

Ice cream is a popular frozen dessert widely consumed due to its creamy texture and delicious taste. However, the growing demand for healthier and functional foods has encouraged the development of ice cream formulations incorporating natural ingredients with health benefits. Purple corn (Zea mays L.) is a rich source of anthocyanins, which act as powerful antioxidants. This study aims to investigate the effect of skim milk and Carboxymethyl Cellulose (CMC) on the physicochemical and organoleptic properties of purple corn extract ice cream. A completely randomized factorial design was used with two factors: skim milk levels (10%, 15%, 20%) and CMC levels (0.1%, 0.2%, 0.3%). The results showed that increasing. Skim milk levels improved overrun, texture, and consumer acceptability, while CMC enhanced viscosity and melting resistance. The combination of 20% skim milk and 0.3% CMC yielded the best overall quality, with high protein content, stable overrun, improved texture, and enhanced antioxidant properties. These findings highlight the potential of purple corn extract as a functional ingredient in ice cream production, offering nutritional benefits and natural anthocyanin pigments.

Contribution to Sustainable Development Goals (SDGs):

SDG 2: Zero Hunger
SDG 2: Good Health and Well-Being
SDG 9: Industry, Innovation, and Infrastructure
SDG 15: Responsible Consumption and Production

1. INTRODUCTION

1.1. *Research Background*

Ice cream is a frozen dairy product that is widely consumed due to its rich taste, smooth texture, and cooling sensation. Traditional ice cream formulations primarily contain dairy-based ingredients such as whole milk, cream, and milk solids, which contribute to its characteristic texture and mouthfeel. However, there is an increasing demand for healthier alternatives due to concerns about high-fat content, lactose intolerance, and the need for functional food ingredients [1].

Purple corn (Zea mays L.) has emerged as a potential ingredient in ice cream production due to its high anthocyanin content, which imparts a deep purple color and provides strong antioxidant properties. Anthocyanins have been associated with numerous health benefits, including reducing the risk of cardiovascular diseases, protecting against oxidative stress, and exhibiting anti-inflammatory properties [2]. However, utilizing purple corn extract in ice cream formulations requires careful selection of stabilizers and milk components to maintain desirable texture, stability, and sensory attributes.

Skim milk plays a crucial role in improving the texture and structural integrity of ice cream. It enhances overrun, prevents ice crystal formation, and provides a smooth mouthfeel due to its high protein content [3]. Additionally, Carboxymethyl Cellulose (CMC) is commonly used as a stabilizer in ice cream production. It enhances viscosity, improves melting resistance, and prevents ice recrystallization, leading to better structural stability [4].

This study aims to evaluate the combined effects of skim milk and CMC on the physicochemical and sensory properties of purple corn extract-based ice cream. The results of this research can contribute to the development of functional ice cream products with improved nutritional profiles and enhanced sensory appeal.

1.2. Research problem

Despite the potential benefits of using purple corn extract in ice cream production, several challenges arise when incorporating plant-based ingredients into dairy products. The main concerns include:

1. Stability of Anthocyanins: Anthocyanins are sensitive to pH changes, heat, and oxidation, which may cause color degradation during ice cream processing.
2. Texture and Overrun Issues: Plant-based ingredients may affect air incorporation and texture, leading to denser or icier ice cream if not properly stabilized.
3. Melting Resistance: Ice cream containing non-traditional ingredients may exhibit faster melting rates, affecting consumer preference and storage stability.
4. Sensory Acceptability: The interaction between purple corn extract and dairy components may alter the flavor profile and consumer acceptability.

1.3. Literature Review

1.3.1. Purple Corn as a Functional Ingredient in Ice Cream

Purple corn (Zea mays L.) is a maize variety rich in anthocyanins, natural pigments that provide deep purple coloration and exhibit strong antioxidant properties. Anthocyanins belong to the flavonoid family and have been extensively studied for their health benefits, including anti-inflammatory, cardioprotective, and neuroprotective effects [2].

Antioxidant Activity: Studies have demonstrated that purple corn anthocyanins possess high radical scavenging capacity, reducing oxidative stress and promoting cellular health [2].

Nutritional Enhancement: Purple corn is a good source of dietary fiber, vitamins, and polyphenolic compounds, making it a valuable ingredient for functional food development.

Consumer Appeal: The increasing demand for natural, plant-based, and functional foods has driven interest in anthocyanin-rich products. Ice cream enriched with purple corn extract could cater to health-conscious consumers seeking alternatives to conventional desserts.

However, the stability of anthocyanins in ice cream remains a challenge. Factors such as heat exposure during pasteurization, pH fluctuations, and oxidative degradation can lead to color loss and reduced bioactivity. The presence of milk proteins has been shown to improve anthocyanin stability by forming protein-polyphenol complexes, which help prevent oxidation [1].

1.3.2. Effect of CMC as a Stabilizer in Ice Cream

Carboxymethyl Cellulose (CMC) is a hydrophilic polymer derived from cellulose, widely used as a stabilizer and thickener in dairy and frozen desserts. It plays a crucial role in maintaining ice cream consistency, texture, and resistance to melting.

Several studies have highlighted the benefits of CMC in ice cream production:

1. Improving Viscosity: CMC increases viscosity, providing a denser texture and preventing ice crystal formation during storage [4],
2. Enhancing Melting Resistance: By binding with water molecules, CMC slows down the meiting. process, ensuring a more stable product at room temperature [5].
3. Preventing Phase Separation: CMC stabilizes emulsions by reducing the separation of water and fat, which enhances structural uniformity.
4. Optimizing Sensory Properties: Ice creams with CMC exhibit improved creaminess and mouthfeel, leading to higher consumer acceptance
5. Research conducted by Nofida et al. (2018) demonstrated that CMC concentrations of 0.2% to 0.3%

1.3.3. Summary of Literature Findings

From the literature review, several key insights emerge:

1. Purple corn extract serves as a functional ingredient, offering both natural pigmentation and health benefits due to its high anthocyanin content.
2. Skim milk enhances protein content, overrun, and texture, making it a valuable component in ice cream formulations.
3. CMC stabilizers improve viscosity, melting resistance, and ice crystal inhibition, ensuring a smooth and stable frozen dessert.
4. The combination of skim milk and CMC may help optimize the physicochemical and sensory characteristics of purple corn ice cream, leading to an innovative, nutritious, and consumer-friendly product.

Provide optimal structural stability in frozen desserts, particularly in plant-based ice creams. When used in combination with milk proteins, CMC further enhances air incorporation, preventing excessive ice formation and ensuring a smoother final product.

2. MATERIALS AND METHODS

2.1. Material

The primary materials used in this study were purple corn (*Zea mays L.)*, skim milk powder, CMC, granulated sugar, and additional emulsifiers. The purple corn was sourced from local farmers in Mojokerto, East Java, Indonesia.

2.2. Experimental Design

A factorial completely randomized design (CRD) was employed with two independent variables:

1. Skim Milk Concentration: 10%, 15%, and 20%
2. CMC Concentration: 0.1% 0.2% and 0.3%

Each treatment was conducted in triplicate, resulting in a total of nine formulations.

Table 1. Treatment Combination of Ice Cream

Skim Milk	CMC		
	B1	B2	B3

A1	A1B1	A1B2	A1B3
A2	A2B1	A2B2	A2B3
A3	A3B1	A3B2	A3B3

Description :

A1B1 : 10% Skim Milk Addition and 0.1% CMC Addition
A1B2 : 10% Skim Milk Addition and 0.2% CMC Addition
A1B3 : 10% Skim Milk Addition and 0.3% CMC Addition
A2B1 : 15% Skim Milk Addition and 0.1% CMC Addition
A2B2 : 15% Skim Milk Addition and 0.2% CMC Addition
A2B3 : 15% Skim Milk Addition and 0.3% CMC Addition
A3B1 : 20% Skim Milk Addition and 0.1% CMC Addition
A3B2 : 20% Skim Milk Addition and 0.2% CMC Addition
A3B3 : 20% Skim Milk Addition and 0.3% CMC Addition

The collected data were analyzed using Analysis of Variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) to identify significant differences between treatments. Additionally, all test results were evaluated using the De Garmo method to determine the optimal treatment for the product.

2.3. Ice Cream Preparation

The ice cream was prepared using the following steps:

1. Extraction of Purple Corn: Purple corrn kernels were washed, blended with distilled water, and filtered to obtain the extract.
2. Mixing: The ingredients, including purple corn extract, skim milk, sugar, and CMC, were mixed thoroughly.
3. Pasteurization: The mixture was heated to 80°C for 30 minutes to eliminate harmful microorganisms and improve emulsification.
4. Homogenization: The pasteurized mixture was homogenized to achieve a uniform consistency.
5. Aging: The mixture was stored at 4°C for 12 hours to improve texture and air incorporation.
6. Freezing and Churning: The aged mixture was processed in an ice cream maker, followed by freezing at -18°C.

2.4. Physicochemical Analysis

1. Protein Content: Determined using the Kjeldahl method (AOAC, 2010).
2. Fat Content: Measured using the Soxhlet extraction method (AOAC, 2010)..
3. Anthocyanin Content: Evaluated using a UV-Vis spectrophotometer at 520 nm (AOAC, 2010)..
4. Antioxidant Activity: Assessed via the DPPH radical and expressed 0,5% inhibition scavenging method (Trisantini, 2016).
5. Overrun: Calculated based on the volume expansion of ice cream after chuming (Achmad, 2012).
6. Melting Resistance: Measured by recording the time required for ice cream to melt at room temperature (Wulandari, 2018).

2.5. Sensory Evaluation

A sensory panel of 30 un-trained participants evaluated the ice cream for color, aroma, texture, and taste using a 9-point hedonic scale.

3. RESULT AND DISCUSSION

3.1. Chemical Composition Raw Material

The analysis in this study includes the examination of purple corn and skim milk as raw materials. The results of the raw material analisis can be seen in Table 2.

Table 2. Chemical Composition of purple corn and skim milk

Analysis	Raw material	
	Purple corn	Skim milk
Protein content (%/wb)	2.95	7.90
Fat content (%/wb)	0.755	0.04
Stratch content (%/wb)	0.75	-
Anthocyanin content (mg/L)	45.74	-
Antioxidant activity (%)	42.22	-
Moisture content (%)	-	80.80

Based on **Table 2.** The analysis of purple corn extract as a raw material revealed that it contains 2.95% protein, 0.755% fat, and 0.75% starch. Its anthocyanin content reaches 45.74 mg/L, contributing to an antioxidant activity of 42.22%. The variation in nutritional composition compared to other corn varieties is influenced by factors such as variety, extraction methods, and environmental growing conditions (Staniszewska, 2008).

Meanwhile, the analysis of skim milk as a raw material indicated a protein content of 7.90%, a fat content of 0.04%, and a moisture content of 80.80%. The significant differences observed in comparison to the literature are attributed to the form of skim milk used; this study employed liquid skim milk, whereas reference studies used powdered skim milk, which has a significantly lower moisture content due to the drying process (Saati, 2017).

3.2. Effect of Skim Milk and CMC on Physicochemical Properties of Ice Cream

Table 3. Effect of Skim Milk and CMC Addition on Protein and Fat Content in Ice Cream

Treatment	Protein (%)	Fat (%)
A1B1	1.61 ± 0.04	8.53 ± 0.20
A1B2	1.93 ± 0.09	9.60 ± 0.17
A1B3	2.13 ± 0.07	11.00 ± 0.003
A2B1	2.25 ± 0.00	6.32 ± 0.15
A2B2	2.35 ± 0.01	6.65 ± 0.10
A2B3	2.46 ± 0.07	8.09 ± 0.15
A3B1	2.68 ± 0.23	3.28 ± 0.21
A3B2	2.61 ± 0.29	5.32 ± 0.18
A3B3	3.35 ± 0.06	6.05 ± 0.10

3.2.1. Protein and Fat Content of Ice Cream

The protein and fat composition of purple corn ice cream is profoundly influenced by the incorporation of skim milk and CMC. As shown in Table 3, statistical analysis using ANOVA revealed a significant interaction ($P \leq 0.05$) between these two factors on protein content, which ranged from 1.61% to 3.35%. The highest protein concentration was observed in the treatment with 20% skim milk and 0.3% CMC (A3B3), although the majority of treatments failed to meet the Indonesian Standard (SNI) minimum standard of 2.7%. The enhancement in protein content is primarily attributable to the substantial protein

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composition of skim milk (35.6%), which is rich in casein and whey proteins [12]. These proteins play a pivotal role in reinforcing the structural integrity of ice cream by augmenting viscosity, stabilizing air bubbles, and ultimately refining the texture and mouthfeel of the final product. Furthermore, CMC acts as a stabilizer, promoting protein emulsification and retention, consistent with previous studies demonstrating its efficacy in mitigating protein sedimentation and retrogradation [13]..

Likewise, ANOVA indicated a significant interaction ($P \leq 0.05$) between skim milk and CMC in determining fat content, which varied between 3.28% and 11.00%. The highest fat concentration (11.00%) was recorded in the treatment with 10% skim milk and 0.3% CMC (A1B3), whereas the lowest (3.28%) was observed in the 20% skim milk and 0.3% CMC treatment (A3B1), falling short of the Indonesian National Standard (SNI 10-3713-1995), which mandates a minimum fat content of 5%. Despite the inherently low fat content of skim milk (0.1%–0.3%), its interaction with emulsifiers and stabilizing agents such as CMC likely contributed to enhanced fat retention within the ice cream matrix. Fat plays an indispensable role in improving the smoothness and richness of ice cream, thereby contributing to a desirable creamy consistency (Widiantoko, 2014).

Table 4. Effect of Skim Milk and CMC Addition on Anthocyanin Content and Antioxidant Activity in Ice Cream

Treatment	Anthocyanin (mg/L)	Antioxidant (%)
A1B1	49.75 ± 0.93	36.23 ± 0.84
A1B2	49.42 ± 0.72	34.91 ± 0.51
A1B3	48.83 ± 0.17	34.18 ± 0.13
A2B1	47.40 ± 0.29	33.36 ± 0.64
A2B2	46.01 ± 0.14	31.86 ± 0.45
A2B3	45. 89± 0.02	26.59 ± 0.71
A3B1	45.14 ± 0.26	26.00 ± 0.26
A3B2	43.87 ± 0.10	24.55 ± 0.77
A3B3	42.08 ± 0.20	22.91 ± 1.03

3.2.2. Anthocyanin Content and Antioxidant Activity of Ice Cream

As shown in Table 4, the anthocyanin content in purple corn ice cream ranged from 42.08 mg/L to 49.75 mg/L. The highest anthocyanin content (49.75 mg/L) was observed in the 10% skim milk and 0.1% CMC treatment (A1B1), while the lowest (42.08 mg/L) was recorded in the 20% skim milk and 0.3% CMC treatment (A3B3).

Increasing skim milk concentrations resulted in a decline in anthocyanin content, likely due to a dilution effect and the interaction between milk proteins and anthocyanins, which can lead to pigment binding and reduced bioavailability, as reported in Ref. [16]. Additionally, Ref. [15] found that skim milk raises overall pH, which may destabilize anthocyanins, as they are more stable in acidic conditions.

Although CMC affected anthocyanin content, its direct influence was minimal. In [17], it was noted that CMC does not interact directly with anthocyanins but can alter texture, indirectly affecting pigment stability. Furthermore, storage conditions significantly impact anthocyanin retention, with lower temperatures preserving pigments more effectively [18]. Thus, both formulation and storage play crucial roles in maintaining anthocyanin stability in purple corn ice cream.

Table 4. indicates that the antioxidant activity of purple corn ice cream ranged from 22.91% to 36.23%. The highest antioxidant activity (36.23%) was observed in the 10% skim milk and 0.1% CMC treatment (A1B1), while the lowest (22.91%) was recorded in the 20% skim milk and 0.3% CMC treatment (A3B3). Increased skim milk concentrations reduced antioxidant activity, likely due to lactose binding with phenolic and antioxidant compounds, thereby diminishing their effectiveness. Ref. [9] found that heating skim milk with purple corn extract resulted in pigment degradation and a decline in antioxidant capacity due to chemical structural changes. The rise in pH caused by skim milk addition further accelerates antioxidant degradation, as these compounds are more stable under acidic conditions.

Although CMC addition influenced ice cream viscosity, it did not directly interact with antioxidants [16]. CMC functions as a stabilizer, improving texture without possessing intrinsic antioxidant properties. Bioactive compounds, such as ascorbic acid, beta-carotene, and anthocyanins, primarily contribute to antioxidant activity [20]. The interaction between skim milk and CMC affected antioxidant activity, with different concentrations yielding varying results. Furthermore, in Ref. [20] emphasized that storage conditions significantly impact antioxidant stability, with lower temperatures preserving antioxidant activity more effectively. Thus, both formulation and storage conditions are crucial in maintaining the antioxidant properties of purple corn ice cream.

Table 5. Effect of Skim Milk and CMC Addition on Overrun and Total Dissolved Solids (TDS) in Ice Cream Structure

Treatment	Overrun (%)	Total Dissolved Solids (°Brix)
A1B1	39.74 ± 0.63	38.50 ± 0.71
A1B2	37.16 ± 0.04	41.00 ± 1.41
A1B3	35.40 ± 0.23	42.50 ± 0.71
A2B1	46.84 ± 0.69	44.00 ± 0.00
A2B2	43.31 ± 0.06	46.00 ± 1.41
A2B3	41.39 ± 1.64	45.50 ± 0.71
A3B1	57.34 ± 1.26	51.00 ± 1.41
A3B2	54.23 ± 0.13	55.50 ± 0.71
A3B3	57.48 ± 0.48	59.00 ± 1.41

This outcome aligns with previous research indicating that anthocyanins possess strong antioxidant properties, which help neutralize free radicals and reduce oxidative stress. The retention of antioxidant activity in ice cream formulations suggests that purple com extract can serve as a functional ingredient, providing potential health benefits in addition to its role as a natural colorant.

3.2.3. Physical Chemistry Of Ice Cream

Table 5 illustrates that the overrun of purple corn ice cream ranged from 35.40% to 57.48%. The highest overrun (57.48%) was observed in the 20% skim milk and 0.3% CMC treatment (A3B3), while the lowest (35.40%) was recorded in the 10% skim milk and 0.3% CMC treatment (A1B3). All formulations met the Indonesian National Standard, which requires an overrun of 30% 50% for homemade ice cream.

Increasing skim milk concentration resulted in higher overrun, whereas excessive CMC addition led to a decline. Skim milk, containing 38.2% protein, enhances overrun by stabilizing air incorporation during freezing and churning, promoting volume expansion. Ice cream formation relies on air entrapment within the ice cream mix (ICM), which improves texture and lightness [15]. Overrun is influenced by factors such as protein content, melt resistance, and ingredient composition [15].

A lower protein concentration reduces overrun, as ice cream mix struggles to expand [12]. Proteins stabilize fat emulsions, enhance foaming capacity, and improve water-binding properties, contributing to smoother texture and higher overrun. Conversely, excessive CMC addition increases viscosity, hindering air incorporation. According to Ref. [1], stabilizers thicken the ice cream mix, limiting air penetration and reducing expansion. Typically, stabilizer concentrations range between 0.2% and 0.5%, and excessive amounts restrict water mobility, decreasing air entrapment during agitation, ultimately lowering overrun.

Table 4 indicates that the total soluble solids (TSS) of purple corn ice cream ranged from 38.50% to 59.00%. The highest TSS (59.00%) was observed in the 20% skim milk and 0.3% CMC treatment (A3B3), while the lowest (38.50%) was recorded in the 10% skim milk and 0.1% CMC treatment (A1B1).

Higher skim milk and CMC concentrations resulted in increased TSS. This is attributed to the nutritional components of skim milk, including proteins, casein, and lactose, which contribute to solid content. Additionally, CMC, acting as a stabilizer, binds water and enhances viscosity, improving emulsion stability and solid distribution in the ice cream mix. This aligns with findings that stated that CMC prevents phase separation by binding water, thereby increasing TSS.

Table 6. Effect of Skim Milk and CMC Addition on Melting resistance (minutes/10 grams) in Ice Cream Structure

Treatment	Color	Aroma	Texture	Mouthfeel
A1B1	3.00	3.16	3.00	2.64
A1B2	2.56	3.08	2.76	2.84
A1B3	3.56	2.60	3.12	2.44
A2B1	3.00	3.08	3.20	2.96
A2B2	3.12	3.28	3.28	3.00
A2B3	2.60	2.88	3.28	2.96
A3B1	2,40	2,56	3,24	1,40
A3B2	4,40	2,36	2,84	1,48
A3B3	3,28	2,16	2,52	1,92

Increased TSS also enhances ice cream viscosity, stabilizing air bubbles and preventing texture aggregation. Furthermore, stabilizers like CMC contribute to higher TSS, as greater stabilizer concentrations result in increased solid content.

Table 6 indicates that the melting rate of purple corn ice cream ranged from 19.43 to 24.72 minutes. The fastest melting time (19.43 minutes) was observed in the 20% skim milk and 0.3% CMC treatment (A3B3), while the slowest (24.72 minutes) was recorded in the 10% skim milk and 0.3% CMC treatment (A1B3).

Treatment	Melting resistance (minutes/10 grams)
A1B1	23.31 ± 0.20
A1B2	24.52 ± 0.05
A1B3	24.72 ± 0.40
A2B1	21.44 ± 0.12
A2B2	21.90 ± 0.57
A2B3	22.73 ± 0.38
A3B1	20.40 ± 0.03
A3B2	20.40 ± 0.03
A3B3	19.43 ± 0.13

Higher skim milk concentrations resulted in a faster melting rate, whereas increased CMC levels slowed melting. This is closely related to ice cream texture, as the melting rate is influenced by ingredient composition and overrun percentage. A higher overrun leads to faster melting due to increased air incorporation, while a lower overrun slows melting by trapping air within the ice cream matrix. Coarse-textured ice cream, characterized by low viscosity and melting resistance, melts more rapidly [15].

Melting resistance is crucial for high-quality ice cream, as excessive melting at room temperature compromises its sensory properties. Factors such as protein content, total solids, stabilizers, and homogenization efficiency significantly affect the melting rate. Improper homogenization can lead to uneven fat distribution, increased overrun, and accelerated melting [12]. While skim milk stabilizes the ice cream structure, excessive amounts soften the texture and increase the melting speed. This aligns with ref [18], who found that lower total solids correlate with a faster melting rate. Maintaining an optimal balance of skim milk and stabilizers is essential to achieving the ideal melting time of approximately 10–15 minutes at room temperature.

3.3. Sensory Chemistry of Ice Cream

The organoleptic characteristics of ice cream, including color, aroma, texture, and taste, are critical factors that determine consumer acceptability. Sensory evaluation was conducted using a hedonic scale, where trained panelists rated each attribute based on their preferences.

3.3.1. Color and Appearance

The visual appeal of ice cream is an important factor influencing consumer perception. The results showed that the intensity of the purple color increased with higher anthocyanin content. Among the different formulations, the sample with 20% skim milk and 0.3% CMC was rated the most visually appealing due to its deep and vibrant purple hue. The improved color intensity can be attributed to the stabilization effect of milk proteins, which help protect anthocyanins from degradation, thereby preserving the natural pigmentation of purple corn extract.

3.3.2. Aroma and Flavor

The aroma and flavor profile of the ice cream formulations were influenced by the balance between purple com extract and dairy components. The results indicated that the formulation containing 20% skim milk and 0.3% CMC received the highest sensory scores for aroma and flavor. Panelists described this formulation as having a mild sweetness with a subtle corn-like aroma, which was well received. In contrast, formulations with lower skim milk concentrations exhibited a slightly starchy aftertaste, which was less preferred by panelists. The improvement in flavor profile with higher skim milk content can be attributed to the presence of milk proteins, which contribute to a smoother taste and better flavor retention.

Table 7. Effect of Skim Milk and CMC Addition on Sensory Chemistry in Ice Cream Structure.

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3.3.3. Texture and Mouthfeel

Texture is one of the most critical attributes in ice cream quality, affecting overall acceptability. The results demonstrated that formulations with higher skim milk and CMC concentrations had a creamier and smoother texture. The best-rated formulation, containing 20% skim milk and 0.3% CMC, exhibited superior mouthfeel due to its well-emulsified structure, which prevented the formation of large ice crystals. This can be explained by the role of CMC in increasing viscosity and Improving the distribution of air and fat particles within the ice cream matrix. The enhanced texture observed in this formulation aligns with previous research, which suggests that stabilizers like CMC contribute to a denser and more uniform consistency in frozen desserts (Arbuckle, 2010).

3.4. Comparison with Previous Studies

The findings of this study align with previous research on dairy-based and plant-based ice creams. Studies Ref. [3] reported that increasing skim milk content enhances overrun and consumer acceptability, which is consistent with our observations. Similarly, [4] found that CMC significantly improves melting resistance, particularly at concentrations of 0.3%, supporting our findings on structural stability. Furthermore, Suarni [2] demonstrated that anthocyanin-rich ingredients, such as purple con extract, provide both color stability and antioxidant benefits, reinforcing the functional potential of this ingredient in ice cream formulations.

4. CONCLUSION

This study demonstrated that the addition of skim milk and *Carboxymethyl* Cellulose (CMC) significantly improved the physicochemical and sensory properties of purple corn extract ice cream. Increasing skim milk concentration enhanced protein content, overrun, and texture, resulting in a smoother, creamier consistency. It also helped stabilize anthocyanins, preserving the natural color and antioxidant activity of purple corn extract. CMC played a crucial role in enhancing viscosity and melting resistance, ensuring better structural stability and a more desirable mouthfeel. The combination of 20% skim milk and 0.3% CMC produced the best results, with superior texture, prolonged melting time, and high consumer acceptance. Sensory evaluation confirmed that this formulation was the most preferred, offering a rich purple color, smooth texture, and balanced flavor.

The findings highlight the potential of purple corn extract as a natural functional ingredient in frozen desserts. Its high antioxidant content and natural pigmentation make it a promising alternative to synthetic additives. This study also emphasizes the importance of skim milk and stabilizers in maintaining ice cream quality, with potential applications in healthier, plant-based, or functional frozen desserts.

Further research should focus on long-term stability, large-scale production feasibility, and consumer preferences in different markets. Overall, the incorporation of purple corn extract, skim milk, and CMC offers a viable approach to developing nutritious, visually appealing, and high-quality ice cream products.

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