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Physical Characteristics of Ice Cream with the Addition of Butterfly Pea Flower Extract and Porang Glucomannan Flour (*Amorphophallus muelleri*)

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A B S T R A C T

This study aims to determine the interaction between the use of various butterfly pea flower extracts with the concentration of porang glucomannan flour on the physical characteristics of ice cream. This study employed a Factorial Completely Randomised Design (CRD) with two factors: butterfly pea flower extract and different concentrations of porang glucomannan flour. Each treatment was repeated 3 times. Data analysis was conducted using Analysis of Variance (ANOVA), followed by Duncan's New Multiple Range Test (DMRT) at a significance level of 5%. There is an interaction between variations in various different butterfly pea flower extracts and the concentration of porang glucomannan flour on the Hue and viscosity of ice cream. Variations in various butterfly pea flower extracts significantly affect the melting power, and viscosity of ice cream. The concentration of porang glucomannan flour significantly affects the Hue, melting power, and viscosity of ice cream. The best product is the treatment with the addition of 35% butterfly pea flower extract and 0.3% porang glucomannan flour, characterised by an average Hue value of 253.56°, an overrun of 36.37%, a melting power of 37.67 minutes, and a viscosity of 62 Cp.

Contribution to Sustainable Development Goals (SDGs):
SDG 3: Good Health and Well-being
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation and Infrastructure
SDG 12: Responsible Consumption and Production

1. INTRODUCTION

1.1. Research Background

Ice cream is a type of food that is very popular among all groups of people and is typically consumed as a dessert. The demand for ice cream products in Indonesia has increased quite significantly from year to year. This can be seen from the level of ice cream consumption in Indonesia which has increased. In 2020, the average per capita consumption of ice cream reached 0.73 litres, an increase from 2019, which was 0.7 litres [1].

The development of ice cream products using butterfly pea flowers will produce more functional ice cream. The purple-blue colour of the crown, typical of butterfly pea flowers, is one of the attractions for consumers to purchase ice cream. This colour is attributed to the presence of anthocyanin compounds [2]. Especially the ternatin type, including delphinidin 3-o-glycoside [3]. Butterfly pea flowers (Clitoria ternatea) contain one of the natural pigments, namely blue anthocyanin. Anthocyanin content can be obtained through the extraction process. The simplest and most widely used method for extracting anthocyanin from butterfly pea flowers is the maceration extraction method. The maceration extraction method can also avoid damage to compounds that are unstable to heat [4].

Based on preliminary research, ice cream with the use of butterfly pea flower extract with three levels of 20%, 25%, and 30%, it turned out that the best treatment in the study was the use

of 30% resulting in ice cream characteristics in the form of color, aroma, and taste, the panelists' assessment was like and texture with a very like assessment [5].

Problems that often arise during the ice cream-making process include low viscosity, low overrun, and relatively rapid melting, as well as a rough ice texture. One effort that can be made is to add porang flour as a stabilizer in making ice cream.). The use of natural stabilizers will be safer for health, one of which is porang glucomannan (Amorphophallus muelleri). Porang glucomannan has properties that bind water, forming a thick solution that can be used as an ice cream stabiliser. The level of glucomannan use is 0.1%, 0.3%, 0.5%, and 0.7% of the weight of Ice Cream Mix (ICM). The most effective treatment, according to the results of ice cream research, is the addition of 0.3% glucomannan, with an overrun of 31.40% and a sensory value that increases liking and decreases economic costs by up to 41% [6].

1.2. Literature Review

1.2.1. Butterfly Pea Flower

Butterfly pea flower (Clitoria ternatea) is a climbing plant belonging to the Papilionaceae or Fabaceae (legumes) family. This plant originates from tropical Asia, but has now spread widely to various other tropical regions. Butterfly pea flowers are often found growing in yards or on the edges of forests and have long been cultivated as ornamental plants due to their attractive flower shape. The name of this flower varies in various regions in Indonesia. In Sumatra, it is known as the blue flower, the kelentit flower, or the butterfly pea flower. Butterfly pea flower (Clitoria ternatea) is a plant that contains anthocyanin pigments and has the potential to be developed as a local natural dye in various food products. In addition to improving visual quality, especially in terms of colour attributes, natural dyes from butterfly pea flowers also offer functional benefits, including antioxidant, anticancer, and anti-inflammatory properties. The resulting colour has an intensity that is almost equivalent to that of the synthetic food-grade dye Diamond Blue (CI 42090), is concentrated, and remains stable even after freezing [7].

The color of anthocyanins comes from the excitation of electrons in the double bonds in the anthocyanin molecule due to the absorption of light energy. Anthocyanins are included in flavonoids because they have a $C_6C_3C_6$ carbon skeleton and are O-heterocyclic compounds. The anthocyanin content in butterfly pea flowers is delphinidin, which gives them a blue to purple colour. Delphinidin has three hydroxyl groups on ring B; delphinidin can form complexes with metal ions, such as iron and aluminium, and produce a distinctive blue colour. The pH of the solution significantly affects the stability of anthocyanin colour in butterfly pea flowers.

1.2.2. Porang

Porang flour is obtained from porang tubers (Amorphophallus muelleri) by drying. Porang tubers offer several benefits as food ingredients, including serving as syrup thickeners and ice cream adhesives [8]. Glucomannan from porang tubers has been shown to have positive physiological effects, especially in reducing total cholesterol levels. Porang tubers contain a relatively high amount of glucomannan, even the highest among other tubers. The extraction method using ethanol with graded concentrations has been shown to produce higher glucomannan levels compared to the extraction method using 60% ethanol, as determined by three repetitions. The glucomannan content of porang can increase from 16.43% to 62.2% [9].

Glucomannan is a type of hemicellulose polysaccharide composed of a chain of glucose, mannose, and galactose bonds. Based on microscopic observations, slices of porang tubers reveal that most of the tissue consists of glucomannan cells, measuring 0.5–2 mm, which are approximately 10–20 times larger than starch cells [10]. In addition to glucomannan, various organic compounds, including β-carotene, choline, niacin, riboflavin, thiamine, and bioactive compounds such as serotonin and its derivatives, have also been identified in fresh porang tuber tissue.

Glucomannan is characterised by its excellent water-binding capacity and the ability to form gels and absorb saccharides, proteins, and cholesterol. The colour of the flour produced significantly affects the quality of glucomannan; however, the colour of glucomannan flour is typically brownish yellow. The degree of whiteness of glucomannan flour is greatly influenced by the content of starch, calcium oxalate, and temperature during the processing. Calcium oxalate contained in porang tubers can cause an itchy sensation when consumed. If not reduced, this compound will affect the sensory quality and quality of the glucomannan flour produced [11]. Therefore, a process is needed to reduce calcium oxalate levels during extraction. One of the important stages is soaking, where the concentration, duration and temperature of soaking are the main factors that affect the effectiveness of reducing oxalate compounds in raw materials. Soaking porang tubers using NaCl (salt) solution at a concentration of 8% can reduce oxalate compounds by 57.8% [12].

1.3. Research Objective

This study aims to analyze the interaction between the use of various butterfly pea flower extracts with the concentration of porang glucomannan flour on the physical characteristics of ice cream.

2. MATERIALS AND METHODS

The making of this ice cream was carried out in the Processing and Post-Harvest Laboratory of Politeknik Pertanian Negeri Payakumbuh. Ice cream analysis was conducted in two locations: the Quality Testing and Analysis Laboratory of Politeknik Pertanian Negeri Payakumbuh and the CV. Vahana Scientific Laboratory located at Jalan Medan Blok B No. 5 Wisma Indah IV Siteba, Padang, West Sumatra.

The design used in this study was a Factorial Completely Randomised Design (CRD) with two factors: butterfly pea flower extract and different concentrations of porang glucomannan flour. Each treatment was repeated 3 times. The analysis data obtained were analysed using variance analysis in a factorial Completely Randomised Design (CRD). If the treatment had a significant effect, it was further analysed using Duncan's Multiple Range Test (DMRT) at a 5% level of significance. The first factor is the butterfly pea flower extract, with concentrations of 25%, 30%, and 35%. The second factor is the concentration of porang glucomannan flour at levels of 0.1%, 0.2%, and 0.3%.

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2.1. Formulation

The formulation for making this ice cream is based on a formula developed in preliminary research and has been slightly modified. The formula for making ice cream is 13% full-cream milk, 10% skim milk, 15% sugar, 0.25% egg yolk, 0.1% salt, stabiliser, and butterfly pea flower (according to treatment), and water (making up the remaining total of all ingredients).

2.2. Butterfly Pea Flower Extraction

The manufacture of butterfly pea flower extract was carried out using the maceration method, as described in preliminary research with several modifications [13]. The butterfly pea flowers that had been sorted were taken from the flower crown and separated from the stems. Furthermore, 50 grams of butterfly pea flower crowns were weighed and washed clean; then, distilled water was added at a ratio of 1:6 (w/v). The mixture was then heated for 15 minutes at a temperature of 70 °C. After the heating process, the solution was allowed to cool, then 2% citric acid was added. The brewing results were filtered using filter paper. The extract obtained was placed in a dark bottle, tightly closed, and stored at 4 °C.

2.3. Porang Flour

In making porang flour, preliminary research was conducted with modifications [14]. Fresh porang tubers are weighed, peeled, and washed thoroughly, then cut randomly. The tuber pieces are soaked in distilled water with a ratio of 1:10 (w/v) and 8% NaCl solution is added for 20 minutes to remove the oxalic acid content (sap). After soaking, the tubers are rinsed with clean water until no more sap remains attached. The clean tubers are then dried first in the sun for 8 hours or for 2 days. After that, drying is continued using an oven at a temperature of 50–55°C for 24 hours or until the water content reaches ≤12%. The dried tubers are then mashed and sieved using an 80 mesh sieve.

2.4. Porang Glucomannan Flour Extraction

The previously sieved porang flour was first extracted for its glucomannan content using 40% ethanol, with a ratio of 1 gram of porang flour per 15 ml of solvent. The mixture was stirred for 1 hour using a magnetic stirrer at a speed of 1000 rpm, then filtered through a filter cloth. The sample was then extracted again with 60% and 80% ethanol with the same treatment. The precipitate was dried in an oven at 45 ˚C for 12 hours or until the water content reached ≤12%. The dried sample was then ground and sieved using an 80-mesh sieve, resulting in the production of porang glucomannan flour [9].

2.5. Ice Cream Making Process

The process of making ice cream is described in [15] and [16]. The process of making butterfly pea flower ice cream begins with mixing ingredients in the form of full cream milk (13%), skim milk (10%), sugar (15%), egg yolk (0.25%), salt (0.1%), water, coloring from butterfly pea flower extract and stabilizer in the form of porang glucomannan flour according to treatment. The mixture is then pasteurized at a temperature of 75°C for 15 seconds while continuing to stir. After pasteurization, the temperature of the mixture is lowered to 10–15°C. Furthermore, the homogenization process is carried out using a food processor at a speed of 3828 rpm for 30 minutes, then butterfly pea flower extract is added. The ice cream mixture is then aged at a temperature of 4°C for 3–4 hours. The agitation process is carried out using an ice cream maker at a temperature of -18°C for 5 minutes. The expanded ice cream is then placed into polypropylene cup packaging and stored in a freezer at a temperature of -20°C to -50°C for 24 hours to complete the freezing process.

2.6. Yield

The yield of porang glucomannan flour is obtained from the comparison between the weight of the flour produced and the initial weight of the raw material (fresh porang) [17]. The yield is determined by the formula:

$$\text{Yield (\%)} = \frac{\text{Initial weight}}{\text{Final weight}} \text{ x } 100\%$$

2.7. Hue

Hue value analysis of butterfly pea flowers and ice cream using a Colorimeter (Hunterlab color Flex EZ spectrophotometer) [18]. The formula determines the Hue butterfly pea flower extraction:

$$Hue = 360 + \tan\left(\frac{b*}{a*}\right)$$

The formula determines the Hue ice cream extraction:

$$Hue = 180 + \tan\left(\frac{b*}{a*}\right)$$

2.8. Overrun

Overrun is the development of ice cream between the stages of before and after. The[19]. The ice cream maker then measures the wall to give a precise measurement. Overrun measurement in this study was carried out by measuring the volume of ice cream dough before and after being processed in the ice cream maker using a measuring cup, then the results obtained were entered into the following formula:

$$\%\ Overrun = \frac{\text{Final volume} - \text{initial volume}}{\text{initial volume}} \text{ x } 100\%$$

2.9. Melting Power

The measurement of melting time was carried out by weighing a 2-g sample, then placing it in a plastic cup and sealing it tightly. Then stored in the freezer for 2 days, then the sample was removed from the freezer and placed in an open place (room temperature). The measurement was carried out using a stop watch starting from when the ice cream was removed from the freezer until it completely melted or there were no more ice crystals [20].

2.10. Viscosity

The viscosity measurements of the mixture were taken after it had aged overnight at 4 °C. The viscosity of the mixture was measured at 5±1 °C using a Brookfield viscometer, model DV-II, with some modifications, using spindle number 1 [21].

3. RESULT AND DISCUSSION

3.1. Raw Material Analysis

Analysis of raw materials is conducted to determine their feasibility and the components they contain. The raw materials used in making this ice cream are butterfly pea flower extract and porang glucomannan flour. The analysis carried out on butterfly pea flower raw material is Hue test. Testing of porang glucomannan flour is yield.

Hue testing is also an essential parameter for determining the dominant colour in butterfly pea flower extract. The Hue value obtained in the butterfly pea flower extract test is 326.09o ° ± 0.63. The Hue value is included in the chromaticity colour range, or the colour appears visually purple. The colour change occurs due to a shift in light absorption from blue to violet/purple, also known as a lypsochromic shift, because the ability to donate electrons to the methylation group is greater, causing the colour to become violet and increasing pigment stability [22].

The yield of porang glucomannan flour produced is 8.73%. The yield of flour produced is influenced by the water content in the material. The yield of flour produced will increase if the water content in a material is low [23]. The yield value is also influenced by the flour-making process, including peeling, drying, flouring, and sieving. Additionally, it is influenced by the age of the porang plant [24].

3.2. Hue

The results of the analysis of variance showed that there was an interaction between variations in various concentrations of butterfly pea flower extract and the concentration of porang glucomannan flour. The interaction between butterfly pea flower extract and porang glucomannan flour concentration on the hue of ice cream is shown in Table 1.

Based on the results of the Hue test of ice cream with the addition of butterfly pea flower extract and porang glucomannan flour, the values ranged from 240.61 to 253.56 °. The highest Hue value was observed in the treatment with the addition of 30% butterfly pea flower extract and 0.1% porang glucomannan flour, which was 253.56 °. Table 1 shows that the Hue values of all treatments fall within the range of chromaticity or visual colour associated with blue. The colour of the ice cream produced differs from the colour of the butterfly pea flower extract. This can be caused because the anthocyanin in butterfly pea flowers is a water-soluble pigment, providing various colours, including red, purple, blue, and green. Anthocyanin in butterfly pea flowers produces a blue color when the pH of the solution is neutral or slightly alkaline, such as in ice cream. Butterfly pea flower extract at a pH of 4-5 has a purple colour, and its stability is excellent [25].

Anthocyanins are generally one of the most unstable types of natural dyes. The stability of anthocyanins can be affected by various factors, including chemical structure, temperature, light exposure, water activity, the presence of enzymes, metal ions, pressure, and the presence of other chemical compounds. Anthocyanins are stable in acidic solutions and are strongly affected by changes in pH, with the color changing from blue to purple or red as the pH increases [26].

Table 1. Hue

Hue(°) ± Standard Deviation			
Butterfly Pea Flower Extract	Porang Glucomannan Flour Consentration		
	0,1%	0,2%	0,3%
25%	240.61 ± 0,48 b C	241.00 ± 0,59 b C	244.31 ± 1,46 a C
30%	247.81 ± 0,60 b B	248.88 ± 0,57 b B	248.93 ± 0,66 a B
35%	252.38 ± 0,11 b A	252.86 ± 0,15 b A	253.56 ± 0,55 a A

Description: Numbers followed by the same letter in the same column are significantly different at the 5% level according to DMRT (capital letters are read vertically and small letters are read horizontally).

The increase in Hue value occurs due to a shift in light absorption from violet to blue, known as a bathochromic shift. The auxochrome group causes the bathochromic effect, if the group is bound to anthocyanin, it will increase the Hue value. The auxochrome group in ice cream has a higher number of hydroxyl groups, so the blue color of the anthocyanin will increase [22]. The addition of more porang glucomannan flour will make the ice cream's colour lighter. This is due to the presence of carotenoid pigments in porang glucomannan flour [27], which makes porang glucomannan flour bright yellow. So that the colour of the ice cream becomes lighter with the increase in the concentration of porang glucomannan flour added.

3.3. Overrun

The results of the analysis of variance showed that there was no interaction between variations in various concentrations of butterfly pea flower extract and porang glucomannan flour on ice cream overrun. The overrun value of ice cream with different treatments of butterfly pea flower extract and porang glucomannan flour concentration ranged from 36.67% to 37.47%. The average overrun of ice cream with different variations of butterfly pea flower extract and porang glucomannan flour concentration can be seen in Figure 1.

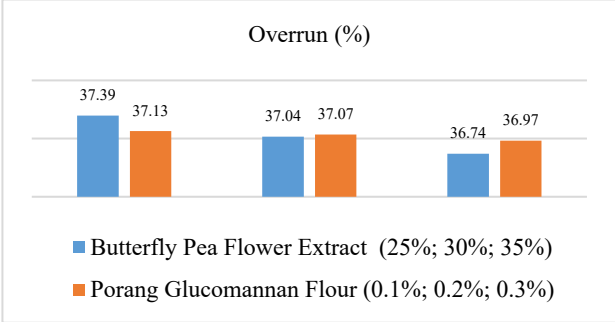

Figure 1. Overrun

The lowest overrun was observed in the addition of 35% butterfly pea flower extract, at 36.74%, and the highest overrun was observed in the addition of 25% butterfly pea flower extract, at 37.39%. The lowest overrun value was observed in the addition of 0.3% glucomannan flour, at 36.97%, and the highest overrun was observed in the addition of 0.1% porang glucomannan flour, at 37.13%. The overrun of ice cream is included in the household scale, specifically 30%- 50% [28]. The overrun of ice cream produced was higher than in previous research [29], with the highest value reaching only 30.67%. Differences in ice cream formulation and processing methods can yield varying results compared to previous research [16]. The addition of more butterfly pea flower extract can increase the total solids and reduce the overrun value of ice cream. Likewise, the higher the concentration of porang glucomannan flour. The higher the concentration of porang glucomannan flour, the lower the overrun will be. The decrease in dough viscosity causes free water in the dough to be less optimally bound, resulting in a decrease in surface tension that allows air to more easily penetrate the surface more easily, thereby increasing the ice cream overrun value [30]. The more air trapped in the dough, the greater the volume of ice cream produced [31].

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Overrun values that are too low (<30%) tend to produce hard ice cream textures, while overruns that are too high (>140%) can produce ice cream that is too soft and melts quickly [32]. Data from the melting power test shows that the higher the overrun, the faster the ice cream melts. This is in line with previous opinions [33], which state that higher overruns will accelerate the melting process of ice cream.

3.4. Melting Power

The results of the analysis of variance showed that there was no interaction between variations in various concentrations of butterfly pea flower extract and porang glucomannan flour, but there was a significant effect on variations in various concentrations of butterfly pea flower extract and porang glucomannan flour on the melting power of ice cream. The melting power value of ice cream with different treatments of butterfly pea flower extract variations and porang glucomannan flour concentrations ranged from 25.36 to 37.67 minutes.

Based on Table 2. The lowest melting power is observed with the addition of 25% butterfly pea flower extract, at 27.34 minutes, and the highest melting point is observed with the addition of 35% butterfly pea flower extract, at 35.84 minutes. The lowest melting power in the addition of 0.1% glucomannan flour of 29.89 minutes and the highest melting power in the addition of 0.3% porang glucomannan flour of 33.11 minutes. The melting point of ice cream can be influenced by the ingredients used, such as skim milk solids, full-cream milk, stabilisers, and several other types of modified ingredients [34]. The melting power value exceeds the requirements specified in SNI No. 01-3713-1995 [35], which states that good ice cream should melt within a 20-25 minute time span. In addition, the melting power value is also higher than that reported in previous research [36], which is 15 minutes.

Table 2. Melting Power

Variable	Concentration	Melting Power (minutes)
Butterfly pea flower extract	25%	27.34 *b*
	30%	31.49 *b*
	35%	35.84 *a*
Porang glucomannan flour	0.1%	29.89 *c*
	0.2%	31.67 *b*
	0.3%	33.11 *a*

Description: Numbers followed by the same letter in the same column are significantly different at the 5% level according to DMRT.

Ice cream that melts too quickly is generally less preferred by consumers, but ice cream with a melting power that is too slow can also reduce consumer appeal because the texture is too dense [33]. Previous research [37] has shown that the melting point of ice cream increases with an increasing concentration of porang flour. The addition of porang glucomannan flour enhances the dough's ability to bind water, thereby slowing the melting of ice cream. The higher the concentration of porang flour, the more difficult it is to melt. This is due to the ability of glucomannan to bind water and increase the viscosity of the dough before freezing.

3.5. Viscosity

The results of the analysis of variance showed that there was an interaction between variations in various concentrations of butterfly pea flower extract and porang glucomannan flour on the viscosity of ice cream. The interaction between butterfly pea flower extract and porang glucomannan flour concentration on the viscosity of ice cream is shown in Table 3.

Based on Table 3, it can be seen that the viscosity of ice cream ranges from 55.00 to 69.40 cp. The highest viscosity is the treatment of 25% butterfly pea flower extract with a concentration of 0.3% porang glucomannan flour, which is 69.40 Cp. The higher the addition of butterfly pea flower extract and the concentration of porang glucomannan flour, the higher the viscosity of the ice cream produced. The glucomannan content in porang flour influences this property, which can absorb approximately 50 times its weight, resulting in a thicker ice cream mixture [38]. Glucomannan solution in water forms mucilage, which has the same viscosity as gum arabic [39]. The addition of more butterfly pea flower extract will increase the water content of the ice cream, resulting in a lower viscosity. The viscosity value, when compared with previous research [40], indicates that the viscosity of ice cream produced using 0.2% - 0.8% porang flour ranges from 69.38 to 129.45 Cp. The viscosity value of the ice cream produced is almost the same as that obtained using 0.2% porang flour.

Table 3. Viscosity

Viscosity (Cp) ± Standard Deviation			
Butterfly Pea Flower Extract	Porang Glucomannan Flour		
	0,1%	0,2%	0,3%
25%	55.77 ± 0,12 c A	61.57 ± 0,06 b A	69.40 ± 0,36 a A
30%	55.67 ± 0,06 c B	57.97 ± 0,06 b B	67.30 ± 0,26 a B
35%	55.00 ± 0,00 c C	57.00 ± 0,00 b C	62.00 ± 0,00 a C

Description: Numbers followed by the same letter in the same column are significantly different at the 5% level according to DMRT (capital letters are read vertically and small letters are read horizontally).

The viscosity of the dough in making ice cream plays a crucial role and can impact the melting point and overrun of the ice cream. Viscosity, when compared to melting power, increases with the higher concentration of porang glucomannan flour added. The viscosity of a high or very thick ice cream dough will cause it to melt more slowly, while a lower viscosity will cause the ice cream structure to melt faster [31]. The increase in viscosity can occur because the glucomannan content in porang flour undergoes a gelatinization process during the heating process, causing the ice cream dough to become thick [16]. Thick ice cream dough makes it difficult for air to enter during aeration during the freezing process, resulting in lower overrun [41].

4. CONCLUSION

Based on the research conducted, several conclusions can be drawn, namely, that there is an interaction between variations of different butterfly pea flower extracts and the concentration of porang glucomannan flour on the Hue and viscosity of ice cream. Variations of various butterfly pea flower extracts have a significant effect on the melting power, and viscosity of ice cream. The concentration of porang glucomannan flour has a significant effect on the Hue, melting power, and viscosity of ice cream. The ice cream Treatment with the addition of 35% butterfly pea flower extract and 0.3% porang glucomannan flour is the most effective treatment. The parameters in this treatment are Hue 253.56°, overrun 36.37%, melting power 37.67 minutes, and viscosity 62 cP.

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