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Physicochemical and Sensory Characteristics of Kecombrang (*Etlingera elatior*) Flower Leather (The Study of Type and Concentration of Hydrocolloids Treatment)

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A B S T R A C T

Flower leather is a processed food product made primarily with flowers as the main ingredient. It is a thin, sheet-like product with a distinctive consistency and taste, depending on the type of raw material used. The addition of various types of hydrocolloids is carried out to improve the texture of flower leather. Other ingredients used include granulated sugar and citric acid. The method used was a Completely Randomized Design (CRD) with a factorial pattern, where Factor I was the type of hydrocolloid (carrageenan, gum arabic, and CMC), and Factor II was the hydrocolloid concentration (0.3%, 0.6%, 0.9%). The obtained data were analyzed using ANOVA, followed by the DMRT post hoc test at a 5% significance level. The results showed a significant interaction ($p \leq 0.05$). Flower leather with the addition of carrageenan at a concentration of 0.9% is the best treatment with the characteristics of water content 7.99%, water activity 0.5, yield 27.05%, pH 4.84, crude fiber content 2.32%, and tensile strength 2.781 N. The results of organoleptic properties, including color, aroma, taste, texture, and overall preference, were rated at 4.2 (like), 3.4 (somewhat like), 3.08 (somewhat like), 3.44 (somewhat like), and 3.28 (somewhat like).

Contribution to Sustainable Development Goals (SDGs):
SDG 3: Good Health and Well-being
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production
SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

The advancement of science and technology has led to an increasing trend in consumer demand for practical and healthy food. Food leather is one of the practical and healthy food products made from pureed fruits, vegetables, or flowers, which is then dried into thin sheets using an oven or dehydrator.

Flower leather can serve as a healthy snack alternative as it contains various vitamins and minerals beneficial to the body. Several types of flowers can be used as raw materials for flower leather, one of which is kecombrang (Etlingera elatior). Kecombrang belongs to the Zingiberaceae family and is widely distributed across Indonesia. Traditionally, its flowers and fruits are used as flavor enhancers in dishes such as urap and pecel. Additionally, kecombrang leaves are utilized in sour vegetable soup, while its stems are incorporated into certain meat-based dishes.

The formulation of flower leather needs to be optimized to achieve its characteristic properties, particularly its flexibility, preventing it from breaking easily. One approach to enhancing these properties is by using hydrocolloids such as carrageenan and gum arabic. A common challenge in leather production is its plasticity. The use of raw ingredients like sugar, pectin, and citric acid alone is insufficient to improve the plasticity of flower leather. Therefore, the addition of hydrocolloids is necessary to reduce the free water content in the product.

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Hydrocolloids significantly influence the texture and appearance of the resulting leather, making their addition essential in the production of kecombrang flower leather. Some hydrocolloids that can be used in flower leather production include carrageenan, gum arabic, and carboxymethyl cellulose (CMC).

1.2. Literature Review

Flower leather is a processed food product with flowers as the main raw material. Flower leather is similar to fruit leather, but it differs in the raw materials used [1]. Good food leather has an elastic texture, allowing it to be rolled [2]. Fruit leather is a thin sheet that has a distinctive consistency and flavour depending on the type of fruit used.

Kecombrang (*Etlingera elatior*) is known by various names, including 'kincung' in North Sumatra, 'kecombrang' in Java, 'honje' in Sunda, 'bongkot' in Bali, 'sambuang' in West Sumatra, and 'bunga kantan' in Malaysia. Kecombrang plant is a type of plant from the *zingiberaceae* family that is widely used in medicine, from rhizomes, fruits, and flowers [3]. People have long used kecombrang plants traditionally in various kinds of processed food, spices, and flavour in food [4].

The bioactive compounds contained in kecombrang flowers are alkaloids, saponins, tannins, flavonoids, phenolics, triterpenoids, steroids, vitamins, minerals and glycosides that act as antimicrobials and antioxidants and are good for health [5]. Kecombrang flowers also contain anthocyanin compounds that act as antioxidants, antidiabetics, anti-inflammatory, and anti-cancer [6].

The nutritional content in 100g of kecombrang flowers consists of carbohydrates (4.4g), fat (1.0g), protein (1.3g), water (91g), dietary fibre (1.2g), calcium (32g), iron (4mg), magnesium (27mg), phosphorus (30mg), potassium (541mg), and zine (0.1mg) [7].

Hydrocolloids that can be utilised in the manufacture of flower leather include carrageenan, gum arabic, and carboxymethyl cellulose (CMC). Carrageenan is one of the hydrocolloids derived from seaweed that can form gels and can improve the texture of food products [8]. In this study, kappa-type carrageenan (κ-carrageenan) was used because it is the most commonly used type in food applications and is abundant. Kappa carrageenan can also form a stronger gel compared to the iota and lambda types of carrageenan [9].

Gum arabic is a natural polysaccharide that is widely consumed in the food industry. Gum arabic acts as a food additive that can improve the texture, viscosity, and shape of food ingredients and can maintain food flavour [10]. Carboxymethyl cellulose (CMC) is a stabilizer commonly used in food or beverage products derived from fruits. Carboxymethyl cellulose (CMC) is white flour and odourless, hygroscopic, soluble in water, and has a pH of 5. The level of CMC use in food products should be less than 1.5%, usually 0.1 - 1.4% [11].

1.3. Research Objective

The aims of this study were to analyze the effect of the type and concentration of hydrocolloids on the characteristics of flower leather and to determine the best treatment of the type and concentration of hydrocolloids that produce flower leather with the best quality.

2. MATERIALS AND METHODS

2.1. Material

The materials used for this study are kecombrang flower, kappa carrageenan, arabic gum, carboxymethyl cellulose granulated sugar, and citric acid. The materials used for analysis were NaOH, H_2SO_4, Na_2CO_3, Iodine, amylum solution, and aquades.

2.2. Research Procedures

This research was conducted experimentally using a completely randomized design (CRD) factorial pattern consisting of 2 factors. Factor I is the types of hydrocolloids (carrageenan, arabic gum, CMC), and Factor II is the concentration of hydrocolloids (0,3%, 0,6%, 0,9%). The data obtained were analyzed by ANOVA to determine the effect of treatment with 2 replications. If there is a significant difference, further testing is carried out using the DMRT (Duncan Multiple Range Test) method at a level of 5%.

2.3. Making Puree of Kecombrang

The preparation of kecombrang flower puree begins with cutting the base of the petals to reveal the young red flowers of kecombrang. The flowers are then separated from the stalk and washed using running water. The washed flowers are then drained and weighed. The weighed kecombrang flowers are then put into a blender and water is added to the ratio of flowers: water (1:2), then the kecombrang flowers are blended until smooth.

2.4. Making Flower Leather

Puree of kecombrang (60 g) was mixed with the addition of each hydrocolloid (carrageenan, gum arabic, CMC) and concentration (0.3%, 0.6%, and 0.9%). Other ingredients are sugar 40%, and citric acid 0.2 g. The dough was cooked for 5 minutes to boil. The dough was poured into a baking tray with a thickness of 2-3 mm. Then, they were dried in a food dehydrator for 6 hours at 80˚C.

3. RESULT AND DISCUSSION

3.1. Physicochemical Characteristics of Flower Leather

Table 1. Analysis result of water content, water activity, and pH of flower leather

Samples	Colour	Aroma	Taste	Texture
A1B1	2,84	3,08	2,84	2,68
A1B2	4,08	3,60	3,24	3,56
A1B3	4.20	3.40	3.08	3.44
A2B1	4.00	3.44	3.08	3.32
A2B2	3.44	3.36	3.40	2.76
A2B3	4.16	3.64	3.24	3.36
A3B1	4.32	3.60	3.16	3.60
A3B2	4.20	3.76	3.68	3.80
A3B3	3.48	3.52	3.72	3.32

The results of water content showed that as the concentration of hydrocolloids increased, the water content decreased. Carrageenan can form a gel with polymer chains, forming a continuous three-dimensional mesh; then this mesh will bind or mobilise water in it and will form a strong and rigid structure as

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the concentration of carrageenan increases [12]. CMC has polar groups that will bind water molecules with hydrogen bonds which can cause water molecules to be trapped [13]. CMC can absorb water because it has a high enough stabilizer and has hygroscopic properties that can bind water. This shows that hydrocolloids act as gelling agents and water binders, so that they can reduce the water content of food products [14].

The treatment of hydrocolloid concentration showed significant differences ($p \geq 0.05$) on the water activity of kecombrang flower leather. Hydrocolloids can reduce the free water content in food ingredients [15]. Increasing hydrocolloid concentration will reduce the water activity of the material, thus preserving flower leather because microorganisms need high water activity to multiply. The chain structure that contains many hydroxyl groups causes hydrocolloids to absorb water more easily.

Changes in pH value can also be affected by the addition of ingredients used in the manufacture of flower leather, such as sugar and citric acid. The higher concentration of carrageenan will increase the pH of flower leather. This is because carrageenan is the result of seaweed extraction with an alkaline solution, so carrageenan is alkaline. Carrageenan is derived from seaweed sap extracted with alkaline solutions, so it tends to have an alkaline pH [16]. The addition of CMC also affects the pH value of flower leather. The higher concentration of CMC will increase the carboxyl groups that are hydrolyzed and increase the pH value [17]. The addition of gum arabic to flower leather kecombrang will also increase the pH value. This is because the addition of gum arabic can reduce the total acid in the product [18].

Table 2. Analysis result of yield, crude fibre, and tensile strength of flower leather

Samples	Yield (%)	Crude fibre (%)	Tensile strength (N)
A1B1	25.41	2.07	1.49
A1B2	26.39	2.15	1.99
A1B3	27.05	2.32	2.78
A2B1	24.92	2.01	1.40
A2B2	25.19	2.06	1.46
A2B3	25.85	2.47	1.51
A3B1	25.39	1.87	1.48
A3B2	26.73	1.93	1.69
A3B3	27,54	2,02	2,11

The yield of flower leather is influenced by the water content of the raw materials and the processing process. If the water content of an ingredient is low, the mass yield will be higher [19]. The ability of each hydrocolloid to bind water also affects the yield of flower leather produced. CMC is one type of polysaccharide other than starch that can bind water. High fibre content will increase the ability of a hydrocolloid to absorb water. The insoluble dietary fiber content in CMC has a high ability to absorb water, so the product becomes heavier and affects the yield. The higher concentration of hydrocolloids will result in more bound water, which will cause the yield to be high. The water that is present and bound in the flower leather dough will evaporate during drying, so the yield produced is small when only a small amount of hydrocolloids are added.

The value of crude fibre content in the product tends to increase, this is due to the addition of hydrocolloids used in the manufacture of flower leather. The increasing concentration of CMC increased the crude fibre content of flower leather. Carboxymethyl cellulose (CMC) is a cellulose derivative that has an important role and is useful as an emulsifying agent, suspending agent, and as binding agent. This is because CMC is an insoluble fibre, so its use in the manufacturing process will increase the crude fibre content of flower leather. The addition of higher concentrations of gum arabic will increase the crude fibre content of the product. Gum arabic has a polysaccharide unit component that belongs to the indigestible fibre group [20]. Arabic gum is a mixture of polysaccharides and glycoproteins that can bind to the components contained in the material (including fibre), so that the fibre content will increase [21].

The addition of higher concentrations will result in greater tensile strength values. The addition of carrageenan-type hydrocolloid with increasing concentration will produce a greater tensile strength value. This is because carrageenan contains 3,6-anhydrogalactose groups, which play a role in the formation of a double helix matrix structure. Three-dimensional crosslinks with a sturdy structure and resistance to force and pressure will be formed when carrageenan is heated and allowed to cool. Carrageenan can form a gel in water, melt when heated, and re-gel when cooled [22]. Arabic gum added in the manufacture of flower leather can also increase the tensile strength value, so that a higher concentration of gum arabic will produce a higher tensile strength value. This is thought to be due to the increase in gelling components contained in gum arabic so that the interaction force between the molecular matrix contained in the product will be stronger, increasing the tensile strength value of the resulting flower leather product. The addition of gum arabic helps to increase the density of the fibres in forming the gel. Gum arabic is a type of hydrocolloid that plays an important role in forming texture in food ingredients.

The addition of CMC to flower leather showed that as the concentration of CMC increased, the tensile strength value also increased. The increase in tensile strength is due to the influence of the addition of CMC, which is related to its ability to combine the cross-linking of polymer chains to form a mesh that can immobilise water and form a strong structure (Herawati, 2018). The addition of CMC with a higher concentration will also affect the tensile strength because CMC is classified as a polysaccharide that makes flower leather more compact. The more constituent polysaccharides will increase the stretching strength so that the ability to stretch is greater and resistant to breaking.

3.2. *Sensory Characteristics of Flower Leather*

Sensory test results showed that the treatment of hydrocolloid type and concentration had a significant effect ($p \geq 0.05$) on the colour of flower leather produced. It can be seen that the level of panelists' liking for the colour of kecombrang flower leather obtained an average result between 2.84 and 4.32. The treatment of CMC hydrocolloid type with a concentration of 0.3% produced an average value of 4.32, which was classified in the ‘like’ assessment category according to the panellists. The dark red colour of kecombrang flower leather is due to the influence of anthocyanin pigments derived from kecombrang flowers (Table 3).

Sensory test results showed that the treatment of hydrocolloid type and concentration had no significant effect ($p \leq 0.05$) on the aroma of flower leather produced. It can be seen that the level of panellist preference for the aroma of kecombrang flower leather obtained the average number between 3.08-3.76. The treatment of the CMC hydrocolloid type with a concentration of 0.6% resulted in an average value of 3.64, classified in the ‘neutral’ assessment category according to the panellists. The aroma of kecombrang flower leather is caused by the distinctive aroma of kecombrang flowers. The aroma of the hydrocolloid type and concentration treatments did not show a significant difference, this is because the hydrocolloids used (carrageenan, gum arabic, and CMC) have no aroma.

Table 3. Sensory test result of flower leather

Samples	Colour	Aroma	Taste	Texture
A1B1	2,84	3,08	2,84	2,68
A1B2	4,08	3,60	3,24	3,56
A1B3	4.20	3.40	3.08	3.44
A2B1	4.00	3.44	3.08	3.32
A2B2	3.44	3.36	3.40	2.76
A2B3	4.16	3.64	3.24	3.36
A3B1	4.32	3.60	3.16	3.60
A3B2	4.20	3.76	3.68	3.80
A3B3	3.48	3.52	3.72	3.32

It can be seen that the treatment of hydrocolloid type and concentration had no significant effect ($p \leq 0.05$) on the flavour of flower leather produced. The test results showed the level of panellist preference for the flavour of kecombrang flower leather obtained an average result between 2.84 - 3.72. The treatment of CMC hydrocolloid type with a concentration of 0.9% produced the highest average according to the panellists of 3.72. This treatment received an average score of 3.72 which was classified as ‘neutral’ according to the panellists. Flower leather of kecombrang gives a sour and sweet flavour. The sweet flavour produced is due to the addition of sucrose at 40% in the manufacture of flower leather.

It can be seen that the treatment of hydrocolloid type and concentration has a significant effect ($p \geq 0.05$) on the texture of flower leather produced. Sensory test results showed the level of panellist preference for the texture of kecombrang flower leather obtained the number of rankings between 2.68 - 3.80. The treatment of CMC hydrocolloid type with a concentration of 0.6% produced an average value of 3.80 classified in the ‘neutral’ assessment category according to the panellists. The treatment of different types of hydrocolloids with different concentrations had a significant effect on the texture parameters of kecombrang flower leather. This is due to the different gel-forming ability of each type of hydrocolloid used.

4. CONCLUSION

The treatment of hydrocolloid type and concentration had a significant effect ($p \leq 0.05$) on the treatment of pH content, crude fibre content, tensile strength, colour, and texture scores of flower leather. However, it did not provide a significant effect ($p \leq 0.05$) on water content, water activity, yield of flower leather, taste, and aroma scores of flower leather.Flower leather with the addition of 0,9% carrageenan was the best treatment that produced flower leather with a moisture content of 7.99%, water activity of 0.5, yield of 27.05%, pH level of 4.84, crude fibre of 2.32, and tensile strength of 2.781 N. The organoleptic characteristics of colour 4.2 (liked), aroma 3.4 (somewhat liked), taste 3.08 (somewhat liked), and texture 3.44 (somewhat liked).

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