OPEN ACCESS
Journal of Multidisciplinary Applied Natural Science Vol. 6 No. 1 (2026) https://doi.org/10.47352/jmans.2774-3047.324

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Research Article

Physical Properties and Galactomannan Content of *Kolang Kaling* (*Arenga pinnata Merr*) Fruit Flour

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Received : May 11, 2025	Revised : June 27, 2025	Accepted : July 30, 2025	Online : November 16, 2025

Abstract
Kolang kaling is a fruit that comes from the sugar palm tree *(Arenga Pinnata Merr)* which grows abundantly in Indonesia. *Kolang kaling* is known to have several compounds that are beneficial to humans, one of which is the galactomannan compound which functions as a weight loss, controls blood sugar levels, and improves digestive health. In this study, *kolang kaling* flour was dissolved in sodium bisulfite ($NaHSO_3$) solution and citric acid ($C_6H_8O_7$) solution to analyze the surface structure, oil binding capacity (OHC), water binding capacity (WHC), swelling capacity (SP), polyphenol content and galactomannan levels. The results of the analysis are known that sugar palm flour has an OHC value of 130.72%, a WHC value of 599.46%, and a swelling power value of 938.45% in the reflux treatment. The results of the analysis also showed that sugar palm flour has a galactomannan content of 55.56% and has a polyphenol content that has antioxidant activity. The presence of such physical properties in sugar palm flour makes it potential to be used as a source of galactomannan to make modifications in the food sector.

Keywords: *Arenga Pinnata Merr,* citric acid, galactomannan, palm fruit flour*,* sodium bisulfite

1. INTRODUCTION

Indonesia, as one of the countries with the largest tropical climate in the world, is a place where sugar palm trees *(Arenga Pinnata Merr)* grow abundantly which produces *kolang kaling* [1] [2]. *Kolang kaling* fasten the body's metabolism [3]. *Kolang kaling* contains vitamin A, produced by cutting many isoprene units in β-carotene. Vitamin A benefits human vision by functioning as a coenzyme in the geometric isomerization reaction of 11-cis retinal to 11-trans retinal. *Kolang kaling* contains vitamin B_1 (thiamine), a coenzyme in converting pyruvate to acetaldehyde to enter the citric acid cycle in the glucose catabolism process [4][5]. *Kolang kaling* contains vitamin C (ascorbic acid), which functions as a coenzyme in the hydroxylation reaction of proline to 4-hydroxyproline, which causes the collagen helix structure to be stable so that bones are not easily injured, and blood vessels are not easily broken. Apart from various vitamins, *kolang kaling* also contains 4.58% galactomannan, a polysaccharide consisting of galactose and mannose chains [6]. *Kolang kaling* has a very high water content of 93.6%, so it is moist, which triggers the growth of microbes that cause rot [7]. Various drying methods to reduce the water content in *kolang kaling* require medium to high temperatures, so it will almost certainly damage the structure and eliminate the function of the vitamin content in *kolang kaling* because it is susceptible to heat. However, the *kolang kaling* flour produced still contains galactomannan compounds, which are relatively more heat-resistant.

Galactomannan is a short-chain amorphous hemicellulose that binds to the surface of cellulose microfibrils [8]. Galactomannan is a polysaccharide containing galactopyranose units with α-(1-6) bonds and mannopyranose units with β-(1-4) bonds. Breaking the chain of bonds in galactomannan is relatively complex in the metabolic process where the α-(1-6) bond in the galactopyranose unit requires the α-galactosidase enzyme and the β-(1-4) bond in the mannopyranose unit requires the cellulase enzyme. This is because galactomannan has the potential to be used as dietary fiber and has been proven to trigger the growth of good bacteria in the intestine to help the food digestion process [9].

Galactomannan is used as a biomarker because it

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Table 1. Yield of Galactomannan.

No	Time (min)	Galactomannan Yield (%)				
		0.1	0.2	0.3	0.4	0.5
1	30	40.30	38.48	39.87	35.12	34.30
2	60	32.48	44.50	39.37	37.34	41.33
3	90	41.48	28.16	31.70	38.60	39.61
4	120	40.49	37.00	36.11	45.79	41.17
5	150	43.11	31.17	33.50	45.01	41.69
6	180	41.31	42.67	35.17	44.46	41.59

is found in the cell walls and cytoplasm of the *Aspergillus fungus,* which causes asthma suffered by several workers in wheat factories [10]. Galactomannan has a structure with sugar branches with a more open cis-hydroxyl geometry, so it has a higher affinity for water molecules through hydrogen bonds or dipole-dipole forces. This is the basis for the galactomannan extraction process, which usually uses distilled water as a solution with a yield of around 3.82% [11]. Moreover, the galactomannan fruit flour of *kolang kaling* is helpful in the health sector, where it is used as an antibiotic enculpation to treat intracellular infection targets [9] and enculpation of insulin drugs from the *Chamaecostus cuspidatus plant* which inhibits the α -enzyme amylase and α-glucosidase thereby reducing carbohydrate absorption in type 2 diabetes mellitus sufferers [12]. Adding sodium bisulfite solution increases the degree of whiteness in flour, thus giving the flour a clean appearance [13].

This study aims to examine the physical properties of *kolang kaling* flour that has been produced. The tests carried out were oil holding capacity (OHC), water holding capacity (WHC), swelling power (SP), polyphenolic content and galactomannan level in *kolang kaling* flour. The OHC is the ability of proteins to bind oil and maintain oil content during the processing process. The OHC of each food ingredient has a different value based on the food ingredient's ability to retain the oil it absorbs during the process. This analysis aims to find out appropriate alternative food ingredients to reduce cholesterol levels in the food consumed [14]-[18]. The WHC is the ability of food ingredients to hold water that is absorbed during the processing process. A high WHC value in food will reduce the amount of water lost during food processing at high temperatures [3][4][19][20]. The SP is the maximum increase in volume and weight experienced by food ingredients when undergoing gelatinization. The decreasing swelling power value indicates that less water is absorbed during gelatinization so that the volume expansion rate becomes smaller [21]-[23]. Polyphenols are phenol derivatives, having antioxidant properties, are used to prevent damage due to oxidation reactions caused by free radicals in food. Food ingredients that have high levels of polyphenols show a good ability to fight free radicals. The higher the levels of polyphenols in food ingredients, the higher the antioxidant content [13]. It is important to choose food ingredients to consider what the content is and how the heating process of the food influences its quality, which, of course, has an impact on health.

2. MATERIALS AND METHODS

2.1. Materials

The main ingredient used in this research is *kolang kaling*. The *kolang kaling* obtained is cleaned by washing it with running water. After the *kolang kaling* is cleaned, it is dried using an oven at 50 to 110 °C for 8 h. After drying, the *kolang kaling* is mashed using a blender to obtain *kolang kaling* flour. After obtaining the flour, the flour is sifted through a sieve to separate the lumps.

2.2. Methods

The method used in this research is an experimental method carried out in the laboratory to determine the physical properties of *kolang kaling* flour that has been previously produced. This research was conducted to analyze the OHC, WHC, SP, polyphenolic content and galactomannan levels in *kolang kaling* flour.

2.2.1. OHC

OHC is the ability of proteins to bind oil and maintain oil content during the processing process [3][24]. The method used for OHC analysis is 0.5 g of each treatment sample was weighed as sample weight and poured into the centrifuge tube, then 3.5 g of oil was added and vortexed. The aim of the vortex treatment is to combine the oil and sample. After the vortex treatment, it is centrifuged at a speed of 2,000 rpm for 5 min, then the oil that has not settled with koro flour, then the tube and the sample sediment are weighed as weight of oil accumulated in the sample [25], see Eq. (1);

$$\text{OHC} = \frac{(c - a) - b}{b} \text{x } 100\% \quad \textbf{(1)}$$

where a = weight of empty tube, b = sample weight, and c = weight of oil accumulated in the sample.

2.2.2. WHC

WHC is the ability of food ingredients to hold water that is absorbed during the processing process [26][27]. Analisis WHC is similar to OHC. First, the weight of the empty centrifuge tube is weighed, then 0.5 g of each sample is weighed as sample weight, then poured into the centrifuge tube, and 3.5 g of distilled water is added. Vortexed, after vortex treatment, centrifuged at a speed of 2,000 rpm for 5 min; after settling, pour out the water or discard what is no longer mixed with the sample, then weigh the tube and sample sediment as weight of water accumulated in the sample [25], see Eq. (2);

$$\text{WHC} = \frac{(c - a) - b}{b} \text{x } 100\% \quad \textbf{(2)}$$

where a = weight of empty tube, b = sample weight, and c = weight of water accumulated in the sample.

2.2.3. Swelling Power

Swelling power (SP) of food ingredients, is the maximum increase in volume and weight experienced by food ingredients when undergoing gelatinization. The method used for swelling power analysis is to dissolve 0.1 g of starch with 10 mL of distilled water. Then, the solution was heated in a water bath for 30 min at 60 °C. The supernatant was separated by centrifuge at 2,500 rpm for 15 min and weighed [23]. After carrying out the swelling power test, the swelling power value can be analyzed using the Eq. (3).

$$\textit{Swelling Power} = \frac{\textit{Weight of the wet sediment })g\_}{\textit{Weight of the dry flour } (g)} x \text{ } 100\% \quad \textbf{(3)}$$

2.2.4. Polyphenolic Content

Polyphenols prevent damage from oxidation reactions caused by free radicals in food. Food ingredients with high levels of polyphenols show a good ability to fight free radicals. The higher the levels of polyphenols in food ingredients, the higher the antioxidant content [13]. The total polyphenolic content of the extract was determined using the method with slight modifications [28]. A 10 mg of gallic acid was dissolved in 10 mL of ethanol until obtained. The concentration of the stock solution is 1000 µg/mL, then the 1000 µg/mL solution is diluted to 100 µg/mL. The gallic acid solution, which contained 100 µg/mL, was then diluted to obtain concentrations of 80, 70, 60, 50, 40, 30, 20, and 10 µg/mL. Next, 0.3 mL of the standard

Table 2. Yield of Galactomannan in Citric Acid Solution.

No	Time (minutes)	Galactomannan Yield (%)				
		0.5	1	1.5	2	2.5
1	30	29.45	5.87	12.42	24.94	29.56
2	60	32.15	3.11	0.12	20.79	11.22
3	90	41.11	12.76	1.50	27.29	6.25
4	120	32.03	16.26	0.52	19.99	11.71
5	150	14.81	26.82	0.92	22.43	19.54
6	180	36.72	15.59	0.77	5.00	18.11

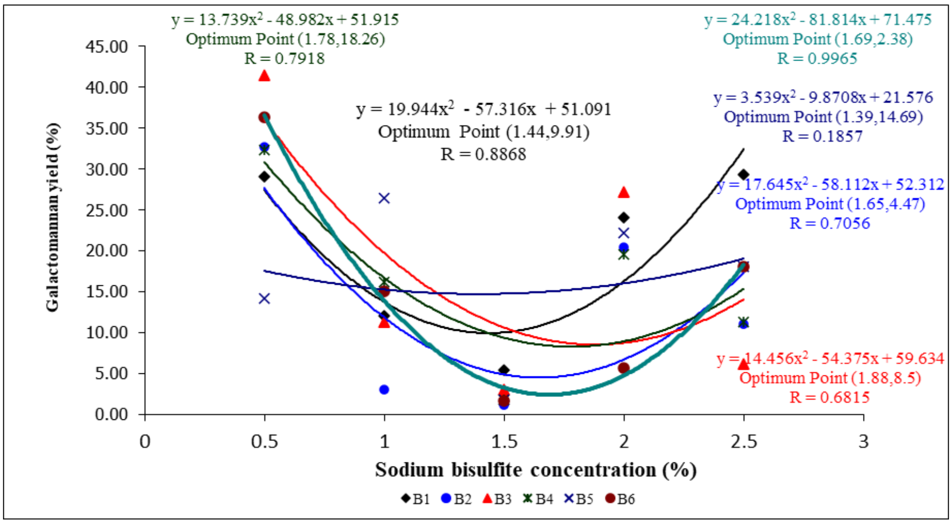

Figure 1. Relationship between sodium bisulfite concentration and galactomannan yield.

solution was added to the cuvette, along with 1.5 mL of Folin's reagent, and left for 5 min. The mixture was then added to 1.2 mL of Na_2CO_3 7.5% and left for 30 min at room temperature. Then, the absorbance was measured at a wavelength of 765 nm. A 25 mg of the extract was dissolved it in 25 mL of ethanol until a concentration of 1,000 µg/mL was obtained. Next, 0.3 mL of the sample solution was placed in the cuvette, added with 1.5 mL of Folin's reagent, and left for 5 min. The mixture was added with 1.2 mL of Na_2CO_3 7.5 % and left for 30 min at room temperature. Then, the absorbance was measured at a wavelength of 765 nm.

2.2.5. Galactomannan Levels

The 3,5-dinitro salicylic acid (DNS) reagent is prepared by combining two solutions: solution A (0.7 g phenol, 1.5 mL of 10% NaOH, 5 mL distilled water, and 0.7 g sodium bisulfite) and solution B (22.5 g sodium potassium tartrate, 30 mL of 10% NaOH, and 88 mL of 1% DNS solution). The mixed reagent is stored at room temperature in a brown bottle. A 1,000 mg/L glucose stock solution is prepared and diluted to create standard solutions. Each standard is mixed with 1.5 mL of DNS reagent, heated for 15 min, cooled, diluted to 25 mL, and measured at 550 nm [8]. For sample analysis, 0.1 g of the sample is hydrolyzed with 5 mL of 25% HCl in 50 mL distilled water at 100 °C for 3 h, then neutralized with 25% NaOH to pH 7, diluted to 100 mL, and filtered before measurement.

Galactomannan analysis using the reflux method by Азимова et al. (2019) was carried out by storing the sample for 24 h in a desiccator . A 1 g of sample flour was added with 50 mL of 2% HCl solution and boiled in a reflux condenser for 3 h until the solubility level was stable, then cooled and filtered. The resulting filtrate was then neutralized with NaOH and added with activated charcoal and filtered again. Furthermore, the filtrate was distilled until its volume reached 10 mL and 0.4 g of phenylhydrazine chloride and 0.65 g of Na-acetate in 5 mL of distilled water were added. This mixture was then stored in the refrigerator for 24 h until mannose phenylhydrazone crystals were formed. These crystals were separated by filtering and then weighed so that the galactomannan content could be calculated [29].

A total of 2 mL of sample was put into a test tube, and 1.5 mL of DNS solution was added and then homogenized. After homogenizing, the mixture was heated and cooled in a water bath for 15 min. Next, it was transferred into a 25 mL measuring flask, and distilled water was added until the mark. Absorbance was measured at 550 nm [6]. The testing process in this study was carried out using several variations in the concentration of ingredients to determine the effect of concentration on galactomannan content. The variation of sodium bisulfite solution concentration was 0.1, 0.2, 0.3, 0.4, and 0.5. The variation of citric acid concentration is 0.5, 1.0, 1.5, and 2.5. The preparation of the glucose standard calibration curve was carried out by means of a standard glucose stock solution taken 0.2, 0.4, 0.8, 1.2, 1.6 mL entered into a test tube [29]. Then added distilled water until each volume is 2 mL and added 1.5 mL of 3.5 DNS solution to each test tube and then homogenized. After being homogenized, the mixture was heated in a water bath for 15 min and cooled. Next, it was transferred into a 25 mL volumetric flask and distilled water was added up to the mark. The absorbance was measured at 550 nm [30].

2.2.6. Data Analysis

The measurement data were analyzed using Microsoft Excel. The analysis carried out was on the analysis of galactomannan results, OHC values, WHC, swelling power, polyphenol levels, and galactomannan levels using the equations explained above.

3. RESULTS AND DISCUSSIONS

This study was conducted to analyze galactomannan levels in *kolang kaling* flour. *Kolang kaling* flour that has been obtained from the previous process through the process of drying and pulverized. In this study, the analysis of *kolang kaling* flour was carried out using two different solutions, namely sodium bisulfite and citric acid to test galactomannan levels with the best yield, scanning electron microscopy (SME), WHC, OHC, polyphenol content, and swelling power.

3.1. Galactomannan Yield

The yield of galactomannan was analyzed by comparing the mass of the extract obtained with the mass of the initial sample. Analysis of the yield of galactomannan was carried out using a solution of sodium bisulfite and citric acid with varying concentrations to determine the effect of solution concentration on the yield of galactomannan produced. Factors that can influence differences in yield values for the resulting compounds include temperature, type of solution, extraction time, and dosage of ingredients [14][31]. The result of the analysis from the experiments is shown in Table 1.

Table 1 shows data on galactomannan yield in samples dissolved in sodium bisulfite solution. Sodium bisulfite can affect the polysaccharide content in sugar palm flour. The role of sodium bisulfite is to modify the chemical properties and improve the quality of food products and affect the galactomannan levels [32][33]. Table 1 does not show consistent galactomannan yields from the treatments given but it shows that at a sodium bisulfite concentration of 0.1 it shows consistent galactomannan levels with the highest levels obtained at a time of 150 min. The effectiveness of sodium bisulfite can be caused by thermal factors, initial degradation, or variations in reagent interactions [17]. Scaman et al. (2006) explains that sodium bisulfite inhibits lysozyme glycation with galactomannan at pH 8.5 and temperatures above 40 °C, which shows that sodium bisulfite can interfere with the chemical modification process involving galactomannan [34].

Table 2 shows data on galactomannan yield in samples dissolved in a citric acid solution. The analysis results do not show consistent

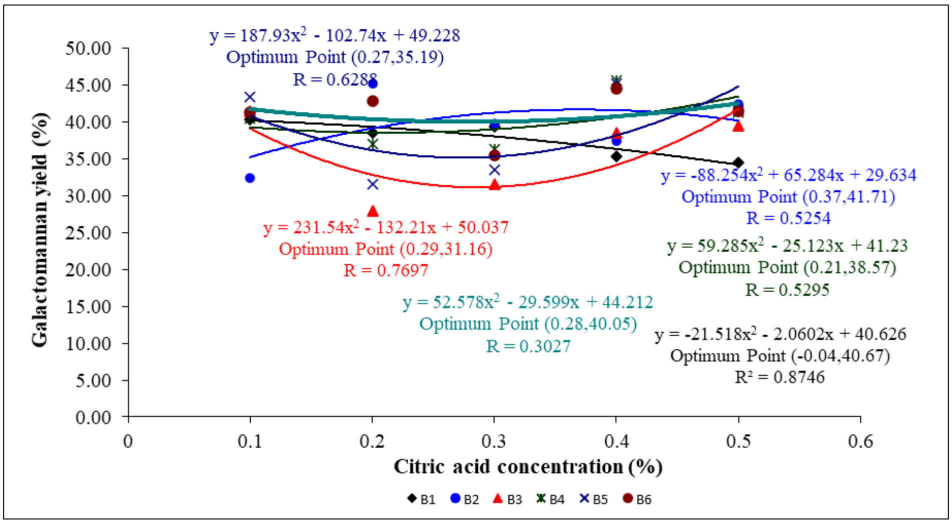

Figure 2. Relationship between citric acid concentration and galactomannan yield.

Table 3. Results of Analysis of Galactomannan Levels.

Sample	Test	Sample mass (mg)	Absorbance [y]	Cons. Measurable (mg/L) [x]	Galactomannan Content (%)	Average (%)
Sodium Bisulfite	1	3031.9	0.686	1684.389	55.5556	55.56
	2	3031.9	0.681	1684.389	55.5556	
Citric Acid	1	3040.4	0.699	1689.111	55.5556	55.56
	2	3040.4	0.721	1689.111	55.5556	
Reflux	1	3044.0	0.668	1691.111	55.5556	55.56
	2	3044.0	0.680	1691.111	55.5556	

galactomannan levels in each experiment but show that in the variation of 0.5 citric acid concentration, the average galactomannan yield is higher than the other concentrations. von Borries-Medrano et al. (2018) reported that citric acid concentration significantly affects the physicochemical properties of galactomannan starch blends [35]. The concentration of citric acid which ranged from 0 to 2.5% affected the crystallinity and formation of V-type amorphous structures in the extrudate. After obtaining the galactomannan yield data, the data was then analyzed using linear regression analysis, as shown in Figure 1.

Figure 1 shows a graph of the results of linear regression analysis on the analysis of the relationship between sodium bisulfite solution concentration and drying time and galactomannan yield in the experiments that have been carried out. The graph above shows that the R^2 value for all treatments is squared. Based on the data, it is known that the highest yield of galactomannan in *kolang kaling* is at a sodium bisulfite concentration of 0.4% and at a drying time of 120 min, which produces a galactomannan yield value of 45.79% with the equation y = 10.15x + 37.067 and R^2 = 0.174. Meanwhile, the lowest galactomannan yield was in the treatment with a sodium bisulfite concentration of 0.2% and a drying time of 90 min with a galactomannan yield value of 28.16%, which had the equation y = 6.70x + 33.900 and a value of R^2 = 0.0346.

Figure 2 shows a graph of the results of linear regression analysis in the analysis of the relationship between the concentration of citric acid solution and drying time and the yield of galactomannan in the experiments that have been carried out. The graph above shows that the R^2 value for all treatments is squared. Based on the data above, it is known that the highest galactomannan yield in *kolang kaling* is at a citric acid concentration of 0.5% and a drying time of 90 min, which produces a galactomannan yield value of 41.11% with the equation y = -5.519x + 34.339 and R^2 = 0.2879. Meanwhile, the lowest galactomannan yield was in the treatment with a citric acid concentration of 1.5% and a drying time of 60 min with a galactomannan yield value of 0.12%, which had the equation y = -2.418x + 20.732 and a value of R^2 = 0.0844.

3.2. Galactomannan Levels

Galactomannan is a short-chain amorphous hemicellulose that binds to the surface of cellulose microfibrils [8]. Galactomannan is a polysaccharide containing galactopyranose units with α-(1-6) bonds and mannopyranose units with β-(1-4) bonds. Breaking the chain of bonds in galactomannan is relatively complex in the metabolic process where the α-(1-6) bond in the galactopyranose unit requires the α-galactosidase enzyme and the β-(1-4) bond in the mannopyranose unit requires the cellulase enzyme. Three methods were used to measure the levels of galactomannan in *kolang kaling* flour, that is sodium bisulfite solution, citric acid solution, and reflux treatment.

Table 3 shows the data from analyzing galactomannan levels in *kolang kaling* flour. Experiments were conducted with a variety of treatments. As for each treatment, twice trials were carried out with the aim of ensuring accuracy so as to minimize errors [36]. The experiments conducted used the same dilution factor (DF) of 100 and sample volume of 10 mL, which was used to correct the absorbance value after dilution of the sample. This experiment used the same DF value to ensure consistent and controlled dilutions. Based on the data above, the average galactomannan content in the addition of citric acid, sodium bisulfite, and in the reflux treatment, it was 55.56%. The addition of sodium bisulfite solution to the sample provides benefits such as in the study conducted by Jiang et al. (2024) showing that sodium bisulfite is effective in preventing browning and can increase stability in various formulations [37]. Then the addition of citric acid has an effect on galactomannan such as research by Hu et al. (2017), which explains that citric acid increases the inhibition and stability of the crust and has the potential to be beneficial for galactomannan [38]. And in the reflux treatment in the study by Tobey et al. (2007), it can affect esophageal function and has the potential to worsen certain conditions [39].

Although the galactomannan results obtained in Tables 1 and 2 are varied, when analyzed using SEM, they show the same galactomannan content value of around 55.56%. This may occur due to inherent differences in measurement techniques, sample preparation, detection sensitivity, and calibration methods used in chemical and SEM analysis [9][40]. The chemical analysis carried out uses variations in solvent concentration and time. Then in analysis Table 3 uses the same sample mass with a difference in absorbance, thus making it produce different results. The comparison graph between absorbance and galactomannan levels can be seen in Table 3.

Table 3 shows a graph of the relationship between galactomannan levels and absorbance. The galactomannan levels are independent of the absorbance value. In contrast, the galactomannan content in flour tends to remain the same with differences in absorbance. Research by Rahmi et al. (2021) which tested galactomannan in wet porang flour showed that the galactomannan content was not far from the galactomannan content in commercial flour and even had a higher viscosity

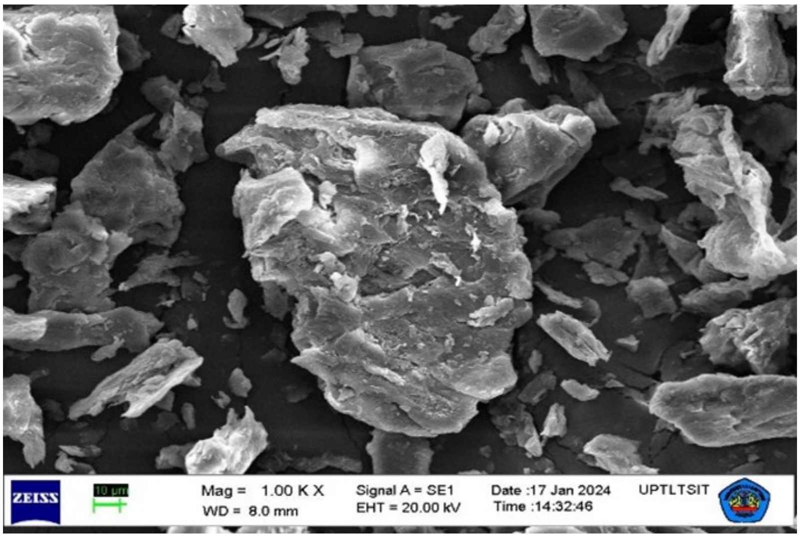

Figure 3. Surface structure of *kolang kaling* flour with sodium bisulfite solution.

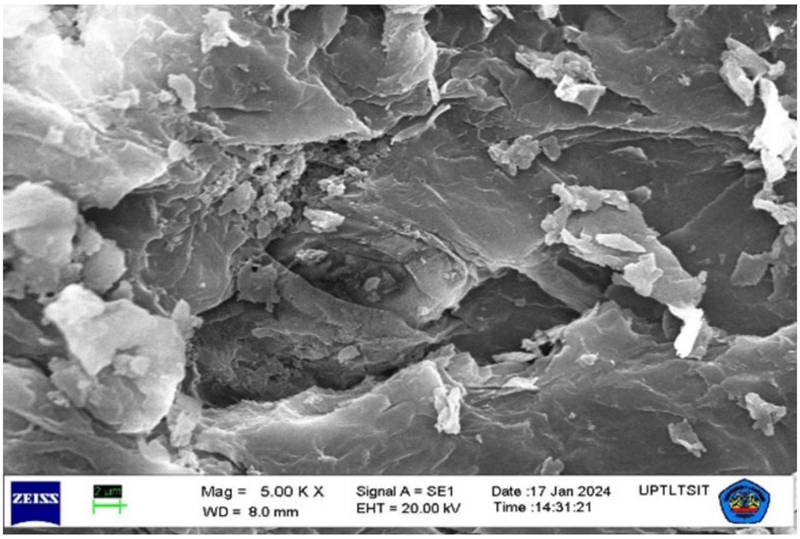

Figure 4. Surface structure of *kolang kaling* flour with citric acid as a solution.

[41].

3.3. SEM

The surface structure of palm fruit flour can be observed using an electron microscope. SEM works by detecting high-energy electrons emitted from the surface of a sample after being exposed to a highly focused electron beam in an electron gun. This electron beam is focused onto a small point on the sample surface using the SEM objective lens [42]. Figure 3 shows that the structure of the sample treated using sodium bisulfite solution has a larger size and density. This is because the swelling power in the sample is more significant compared to the sample treated with citric acid solution, as seen in the Figure 4. Figure 4 shows the results of SEM analysis on *kolang kaling* flour, which was given treatment, namely extraction with citric acid solution. The image above shows that the surface structure of the sample treated with citric acid is whiter; this indicates that citric acid can prevent oxidation reactions that cause browning in flour. This is because citric acid contains antioxidants that can prevent browning reactions in fruit [17][19].

3.4. OHC

OHC is the ability of proteins to bind oil and maintain oil content during the processing process [14]-[18]. Table 4 shows the results of the analysis of OHC in this study. The OHC value increases as different treatments are given. When given the sodium bisulfite solution, the average OHC value was 91.52%; when the citric acid solution was added, the average OHC value was 97.47%, and when treated with reflux, the average OHC value was 130.72%. These OHC values show the ability of food ingredients to bind oil or fat. Based on the data above, *kolang kaling* flour, which is treated with reflux, has the highest OHC content, so its ability to bind oil or fat is the best. Research by Sosa et al. (2020) explained that OHC in cashew flour increased in reflux treatment at pressures of 400 and 600 MPa [43]. Another study conducted by Puyed & Prakash (2006) on soybean flour showed that heat treatment with reflux can reduce oil absorption related to OHC [44].

3.5. WHC

Water Holding Capacity (WHC) is the ability of food ingredients to hold absorbed water [3][4][19][20]. The results of the WHC analysis are presented in Table 5. Based on the data in Table 5, it is known that each treatment given results in a different WHC value. When given sodium bisulfite solution, it was found that the average WHC value was 578.59%; giving citric acid solution made the average WHC value 537.76%. With reflux treatment, the average WHC value was 599.46%. The higher the WHC value, the higher the ability of the food ingredient to bind water. Reflux treatment results in the highest WHC value, namely 599.46%, so the water absorption capacity of palm fruit flour is the best for reflux treatment. Research conducted by van Steertegem et al. (2013) stated that wheat flour explained that heat treatment can significantly increase air retention capacity caused by protein cross-linking and changes in starch properties that affect the hydration behavior of flour [45].

3.6. Swelling Power

Swelling power (SP) is the maximum increase in volume and weight experienced by starch when it undergoes gelatinization [21]-[23]. The decreasing SP value indicates that less water is absorbed during gelatinization, so the volume expansion rate becomes smaller. Amylopectin plays a significant role in swelling power, while amylose acts as an inhibitor. The compactness of the granule structure is influenced by amylose content and is inversely proportional to swelling power [46]. The SP results analysis in the experiments is presented in Table 6. After being given sodium bisulfite solution, the average swelling power value was 891.84%. In contrast, when using citric acid solution, the average swelling power value was 844.20%, and when treated with reflux, the swelling power value was 938.45%. The greater the swelling power value indicates that the ability of the food ingredient to swell when heated increases; this is due to the low water content in the flour. Based on the data above, it is known that flour with reflux treatment has the highest average swelling power value, so its ability to expand when heated is the best. The study conducted by Kim et al. (2021) showed that heat treatment such as excessive steam can significantly affect the swelling power of flour [47]. Rice flour processed with hot steam showed more swelling power than unprocessed flour due to partial gelatinization.

3.7. Polyphenolic content

The function of polyphenols in food ingredients is to act as an antioxidant, which helps prevent cell damage caused by free radicals [13]. The results of the analysis of polyphenolic content in the experiments that have been carried out can be seen in Table 7. The results of the analysis using sodium bisulfite solution had an average polyphenolic content of 19.803%; by adding citric acid solution, the polyphenolic content was 19.607%, and in the reflux treatment, the average polyphenolic content was 19.820%. This analysis shows that *kolang kaling* flour has an average polyphenolic content of 19%. In addition, the analysis shows the phenolic content in units of mg GAE/g and mg GAE/100g

Table 4. OHC Analysis Results.

Sample	Test	Empty Tube Weight (a)	Sample Weight (b)	Sediment Weight (c)	OHC Value (%)	Average (%)
Sodium Bisulfite	1	5.1493	0.5200	6.1478	92.02	91.52
	2	5.1635	0.5016	6.1217	91.03	
Citric Acid	1	5.1639	0.5035	6.1565	97.14	97.47
	2	5.1647	0.5108	6.1751	97.81	
Reflux	1	5.1238	0.5041	6.3097	135.25	130.72
	2	5.1536	0.5325	6.3581	126.20	

Table 5. WHC Analysis Results.

Sample	Test	Empty Tube Weight (a)	Sample Weight (b)	Sediment Weight (c)	WHC Value (%)	Average (%)
Sodium Bisulfite	1	5,1859	0.5123	8.6490	575.99	578.59
	2	5.1778	0.5115	8.6621	581.19	
Citric Acid	1	5.0696	0.5143	8.3599	539.76	537.76
	2	5.1803	0.5007	8.3635	535.75	
Reflux	1	5,1903	0.5114	8.7575	597.54	599.46
	2	5.1281	0.5034	8.6589	601.39	

Table 6. Results of Swelling Power Analysis.

Sample	Test	Empty Tube Weight (a)	Sample Weight (b)	Sediment Weight (c)	SP Value (%)	Average (%)
Sodium Bisulfite	1	5.1366	0.1084	6.1056	893.91	891.84
	2	5.0678	0.1231	6.1631	889.76	
Citric Acid	1	5,1843	0.1164	6.1510	830.50	844.20
	2	5.1641	0.1119	6.1241	857.91	
Reflux	1	5.2584	0.1151	6.3243	926.06	938.45
	2	5.2967	0.1131	6.3721	950.84	

Table 7. Results of Analysis of Polyphenolic content.

Sample	Test	Sample Weight (g)	Absorbance [y]	Measured Concentration [x] (µg/mL)	Polyphenolic Content (mg GAE/g)	Polyphenolic C/ontent (mg GAE/100g)	Information
Sodium Bisulfite	1	0.0255	0.196	0.005667	192.1569	19.2157	Detected
	2	0.0255	0.208	0.005667	203.9216	20.3922	
Citric Acid	1	0.0255	0.199	0.005667	195.0980	19.5098	Detected
	2	0.0255	0.201	0.005667	197.0588	19.7059	
Reflux	1	0.0251	0.196	0.005578	195.2191	19.5219	Detected
	2	0.0251	0.202	0.005578	201.1952	20.1195	

which indicate the mass of gallic acid present in each gram and per 100 g. A comparison between absorption and polyphenol content can be seen in Table 7.

Table 7 shows the relationship between Polyphenolic content and absorbance based on data analysis. The graph shows that *kolang kaling* flour has the highest polyphenol content when treated with the addition of sodium bisulfite solution. This shows that *kolang kaling* flour contains polyphenolics which have antioxidant activity. This antioxidant activity can help ward off free radicals in the body. This related with study conducted by Richana et al. (2018), which explains that analysis using *Dioscorea alata* treatment with sodium bisulfite can increase the phenolic, plavonoid, and antioxidant activity content in flour, which shows that treatment using sodium bisulfite can play a role in increasing the polyphenol content in flour [48].

4. CONCLUSIONS

The results of the analysis are known that sugar palm flour has an OHC value of 130.72%, a WHC value of 599.46%, and a swelling power value of 938.45% in the reflux treatment. The results of the analysis also showed that sugar palm flour has a galactomannan content of 55.56% and has a polyphenol content that shows antioxidant activity. The presence of such physical properties in sugar palm flour makes it potential to be used as a source of galactomannan to make modifications in the food sector. This study is still limited on measuring the galactomannan content roughly in sugar palm fruit flour and has not confirmed the galactomannan structure using more representative tools such as FTIR and NMR. Research on galactomannan in sugar palm fruit flour can be continued with trials as an antibiotic incubation for intracellular infections and insulin drug incubation for type 2 diabetes mellitus sufferers.

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Conflicts of Interest

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

This research was supported by the Universitas Lampung and Universitas Nahdlatul Ulama Lampung , which provided funding for the completion of the research.

DECLARATION OF GENERATIVE AI

Not applicable.

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