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Inhibition of *Maillard* Reaction of Kepok Banana Flour with Citric Acid

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Abstract. Bananas are a type of climateric fruit that undergoes post-harvest ripening, so bananas are easily damaged and have a short shelf life. Kepok banana flour is one of the food diversification products that can increase add value of kepok bananas. The production of kepok banana flour produces brown flour, so the appearance of flour is less attractive. Research aimed to improve the quality of kepok banana flour using citric acid. The experimental design used was a Completely Randomized Design (CRD) with 5 treatments and 4 replications. The treatments given were citric acid concentrations of 0%, 0.2%, 0.4%, 0.6%, and 0.8%(w/v). The results obtained were whiteness index values of 75.07%-78.20%, water content of 3.05%-3.55%, reducing sugar of 0.03%-0.012%, color of 1.76-2.16, aroma of 2.00-2.80, and overalls of 2.68-2.92. An increase in the citric acid concentration may increase the reduced sugar, whiteness index, and water content kepok banana flour. The best treatment in the study was a concentration of 0.8% among others.

Keywords: banana kepok**,** citric acid, flour, reducing sugar, whiteness index

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1. Introduction

Banana is one type of plant that can grow throughout the year in Indonesia which has a tropical climate. Kepok banana which is harvested approximately 90 days after flowering can be used as raw material for making banana flour. The amount of banana production in Indonesia based on data from the Badan Pusat Statistik (BPS) in 2020 reached 8.18 million tons and increased by 6.85% in 2021 to 8.74 million tons. Along with the increase in banana production, the amount of banana consumption in Indonesia has also increased. Based on BPS in 2021, banana consumption in Indonesia reached 2.39 million tons and increased by 33.81% from 2020. Pisang kepok is a type of banana that grows spread in various regions of Indonesia, so banana kepok is easy to find [1]. Kepok bananas contain starch of 22 – 23% and fructooligosaccharide (FOS) of 0.3% [2]. Starch in kepok bananas will break down into glucose, fructose, and sucrose when ripening or

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maturation [3]. The high starch content of kepok banana has the potential to be processed into banana flour.

Banana flour can be used as a substitute for wheat flour in food product processing and can reduce gluten levels [4]. Kepok banana flour has the advantage of being gluten-free [5]. Kepok banana flour is deficient flour color, which tends to be brown due to enzymatic and non-enzymatic *browning* reactions, so the appearance is less attractive [6]. Enzymatic browning of banana flour can be prevented by the use of citric acid [7]. Citric acid can inhibit *the Maillard* reaction by lowering the pH [8]. The aim of this study was to determine the effect of soaking banana kepok with different concentrations of citric acid.

2. Materials and Methods

The primary material for making kepok banana flour was yellow kepok banana which were taken from Semarang with raw conditions, citric acid (Gajah, Indonesia), water, aquades, Nelson A and B reagents, Arsenomolybdate, and anhydrous glucose. The tools used are sieves, cabinet dryers (Maksindo, Indonesia), Colorimeters CS-10 (CHN spec, China), oven (Memmert, German), desiccator (Duran, German), and spectrophotometer UV-Vis (Biobase BK-UV 1900, Indonesia.

2.1. Research Design

The research was carried out using a Completely Randomized Design (CRD), parameter assessment was caried out on study was carried out on kepok banana flour treated with citric acid (w/v) 0% as control, 0.2%, 0.4%, 0.6%, and 0.8%. The assessment consists of reducing sugar, whiteness index, water content, and organoleptic.

2.2. Making Kepok Banana Flour

The production of kepok banana flour has been adopted from Rosalina *et al.* [9] with modifications. The steps for making banana kepok flour starts with sorting and washing of kepok banana. The banana kepok is then peeled and sliced to a of ± 2 mm. The banana kepok were divided into 5 parts and was soaked with 1500 ml water and adding citric acid according to the treatment (w/v) 0% as control, 0.2%, 0.4%, 0.6%, and 0.8% for 3 minutes. The banana pieces are dried using a *cabinet dryer* at 60°C for 6 hours. The dried bananas are crushed and sived thorough 80 mesh.

2.3. Parameter Testing

Whiteness index testing on kepok banana flour was carried out with a Colorimeter tool that produced L*, a*, and b* values [10]. The results of the analysis are calculated using the *Whiteness Index* (WI) formula:

$$\text{WI}\ (\%) = 100 - \sqrt{(100 - \text{L}*)^2 + a*^2 + b*^2} \quad (1)$$

Water content testing was carried out by oven drying method has been adopted [11]. The results of the analysis are calculated using the water content formula:

$$\% \text{ Water Content} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100\ \% \quad (2)$$

Reducing sugar testing with Nelson-Somogyi method was carried out by Febriani et al. [12]. anhydrous glucose of 0.1 g was added to 100 ml of distilled water. Standard glucose solution was diluted 0, 2, 4, 6, 8, and 10 mg/100 ml. Sample 0.5 g diluted by 50 ml distilled water and then filtered. The sample filtrate was diluted at a dilution of 10^{-1} and homogenized. Then, 1 ml of Glucose solution and sample put into tube, then adding 1 ml Nelson A:B (25:1) reagents. Heat for 20 minutes at 100ºC, then cool to 27ºC. Add 1 ml of Arsenomolybdate reagent and 7 ml of distilled water. The solution was homogenized, then the absorbance was measured with a UV-Vis spectrophotometer wavelength of 540 nm and the results of glucose solutionwas made into a linear regression curve. The absorbance value of the sample is entered into the linear regression curve equation standard solution and obtained the results of the reducing sugar content of each sample in mg/ml (x). The results of the analysis are calculated using the reducting sugar formula:

$$\% \text{ Reducing Sugar} = \frac{\text{x} \times \text{Dilution factor}}{\text{Sample weight (mg)}} \times 100\ \% \quad (3)$$

Organoleptic testing was carried out by the scoring method with the help of 25 semi-trained panelists to assess the physical quality of banana flour which includes color, aroma, and overall. The score is 1-4, lowest value indicates undesirable quality while the highest value indicates desirable organoleptic quality.

2.4. Data Analysis

Data analysis was performed using the SPSS *for windows* 26.0 application. Parametric data with *Analysis of Variance* (ANOVA) and *Duncan Multiple Range Test* (DMRT). Non-parametric data with *Kruskal-Wallis* and *Mann-Whitney*.

3. Results and Discussion

Parametric data from the study of kepok banana flour with different citric acid concentrations had a significant effect ($p<0.05$) on reducing sugar and a non-significant effect ($p>0.05$) on whiteness index and water content. Parametric test results can be seen in Table 1. Testing organoleptic resulted in color and aroma parameters having a significant effect ($p<0.05$), while *overall* parameter non-significant effect ($p>0.05$). Non-parametric test results can be seen in Table 2.

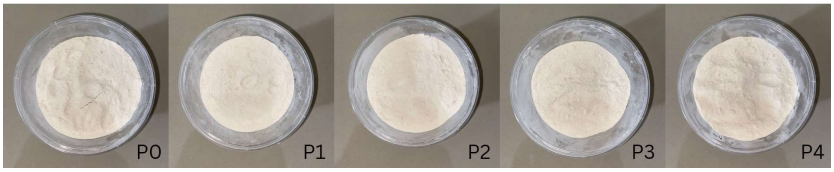

Figure 1. The Result of Kepok Banana Flour

Table 1. Parametric Test Result of Banan Kepok Flour

Treatment	Reducing sugar (%)	Whiteness index (%)	Water content (%)
P0 = 0%	0.03 ± 0.01^{c}	75.07 ± 1.25	3.04 ± 0.38
P1 = 0.2%	0.05 ± 0.02^{bc}	75.74 ± 3.10	3.44 ± 0.35
P2 = 0.4%	0.08 ± 0.03^{ab}	76.58 ± 2.57	3.24 ± 0.39
P3 = 0.6%	0.09 ± 0.04^{ab}	77.33 ± 2.44	3.28 ± 0.73
P4 = 0.8%	0.12 ± 0.03^{a}	78.20 ± 1.61	3.55 ± 0.53

Table 2. Parametric Test Result of Banan Kepok Flour

Treatment	Organoleptic		
	Color	Aroma	Overall
P0 = 0%	1.76 ± 0.83^{a}	2.72 ± 1.02^{cd}	2.68 ± 0.75
P1 = 0.2%	2.40 ± 0.91^{b}	2.80 ± 0.87^{d}	2.92 ± 0.70
P2 = 0.4%	1.76 ± 0.83^{a}	2.24 ± 0.93^{abc}	2.72 ± 0.79
P3 = 0.6%	1.96 ± 0.79^{ab}	2.32 ± 0.85^{abc}	2.80 ± 0.87
P4 = 0.8%	2.16 ± 0.75^{ab}	2.00 ± 0.87^{ab}	2.72 ± 0.84

3.1. Reducing Sugar Content

Based on the data in Table 1, it can be seen that the addition of citric acid at concentrations of 0%, 0.2%, 0.4%, 0.6%, and 0.8% had a significant effect ($p < 0.05$) on yellow Kepok banana flour. The average reducing sugar content of Kepok banana flour is 0.03% – 0.12%. The higher concentration of citric acid can increase the reducing sugar content of banana flour due to the conversion of sucrose into glucose and fructose. Glucose and fructose contain reducing sugars, so the reducing sugar content will increase. The increase in reducing sugars is consistent with the addition of more citric acid, as more sucrose hydrolysis occurs during heating [13].

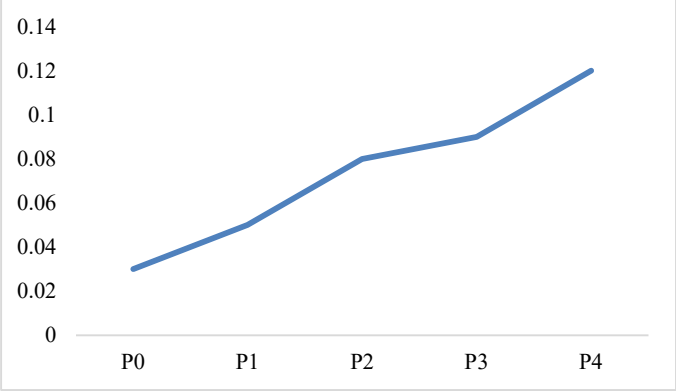

Figure 2. Reducing Sugar in Kepok Banana Flour

An increase in reducing sugars can occur if the *Maillard* reaction is inhibited during heating. This can occur because citric acid causes the atmosphere become acidic and not optimal for the *Maillard* reaction to occur. The *Maillard* reaction can be inhibited by citric acid, which plays a role in lowering the pH [14]. The *Maillard* reaction is optimal in an alkaline situation [15].

3.2. Whiteness Index

Based on the data in Table 1 shows that the addition of citric acid with concentrations of 0%, 0.2%, 0.4%, 0.6%, and 0.8% had a non significant effect ($p>0.05$) on yellow kepok banana flour. The average whiteness index of kepok banana flour is 75.07 – 78.20%. The higher concentration of citric acid can increase the whiteness index of banana flour caused by the inhibition of the browning reaction, so that the brightness level of banana flour increases. The higher whiteness index value it means that the color is lighter [16].

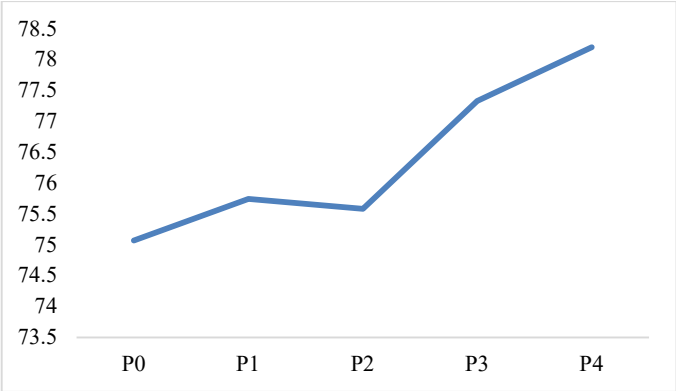

Figure 3. Whiteness Index in Kepok Banana Flour

Citric acid added in the soaking process decreases the pH in bananas, causing the browning reaction to be inhibited. Citric acid is a weak organic acid that can function to lower pH [17]. Citric acid can lower the pH to below the optimum pH of the enzyme so that citric acid can cause the enzyme to denature and the browning reaction can be inhibited [18]. The enzymatic browning reaction in fruits can be inhibited by soaking with citric acid, as citric acid is an organic acid that can complex copper ions [19]. The sequestration or metal-binding properties of citric acid can inhibit the adverse effects of metals on food [20].

The degree of whiteness index may also be affected by non-enzymatic browning reactions that can occur during banana drying. Yellow kepok bananas contain reducing sugars and amino acids that can undergo the *Maillard* reaction when heated. The *Maillard* reaction is less optimal in the acidic state, so citric acid can inhibit the browning reaction [21].

3.3. Water Content

Based on the data in Table 1 shows that the addition of citric acid with a concentration of 0%, 0.2%, 0.4%, 0.6%, and 0.8% had non significant effect ($p>0.05$) on yellow kepok banana flour. The average water content of kepok bananas is 3.04 – 3.55%. The water content of yellow kepok banana flour in all treatments has met the requirements of SNI 01-3841-1995, which is a maximum of 12%. The quality of banana flour can be seen from water content. The quality of flour can be determined through water content which can affect the shelf life of foodstuffs [22].

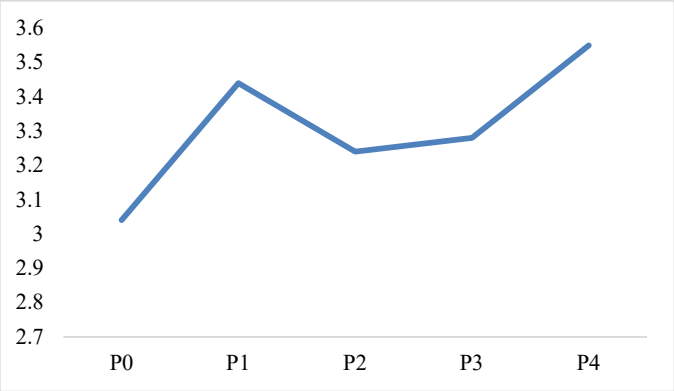

Figure 4. Water Content in Kepok Banana Flour

The water content of banana flour comes from the ingredients, soaking process, and drying of bananas. Based on the results of research by Ruhdiana and Sandi [23] the water content of yellow kepok bananas in 100g reaches 65.54%. According to Rizkika *et al.* [24] The sap contained in fresh bananas can be absorbed by citric acid during the soaking process and causes the water content of banana flour to decrease compared to fresh bananas. The drying process of bananas also causes the water content in bananas to evaporate. Drying using heat energy can cause the water content of food loss so that the water content in the material decreases [25].

The different concentrations of citric acid added during soaking show a non significant difference in the water content of banana flour. The process of soaking kepok bananas with a higher concentration of citric acid results in the water content of the banana flour also being higher. That is caused by citric acid has hygroscopic properties [26]. Hygroscopic is the ability of materials to absorb water vapor from the environment [27].

3.4. Organoleptic Properties

Based on the results of the *Kruskal-Wallis* test in Table 2, it can be seen that different citric acid concentrations had a significant effect ($p<0.05$) on color and aroma parameters, while there is non significant ($p>0.05$) in overall parameters. Color variation in banana flour can be caused by browning reactions during the banana flour processing. Enzymatic and non-enzymatic browning reactions in the production of banana flour can affect the resulting color [6].

The aroma score of yellow kepok banana flour in all treatments decreased. Bananas contain ester compounds such as butyrate, acetic acid (amyl and isoamyl esters), and propionate that cause the characteristic aroma of bananas [26]. The decrease in the characteristic aroma of bananas in banana flour can be caused by the soaking of citric acid. The higher the concentration of citric acid added in the processing will cause the distinctive aroma of the product to decrease [27].

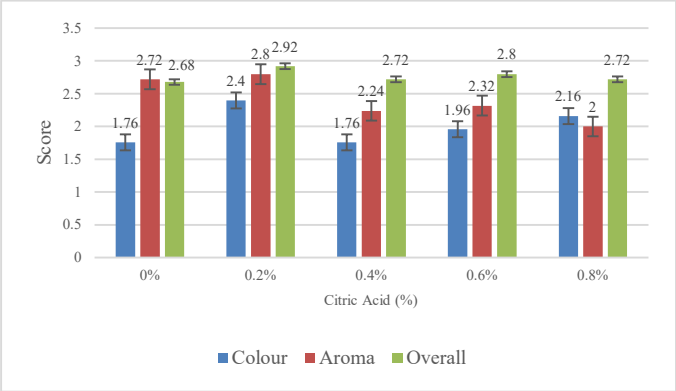

Figure 5. The Result of the Organoleptic Test

Based on the panelists' assessment, the highest overall score was 2.92 at a citric acid concentration of 0.2%. The highest overall score showed that panelists liked banana kepok flour the most with the addition of 0.2% citric acid concentration to the resulting color and aroma parameters. The treatment with the highest score value is the best treatment acceptable to the panelists [28].

4. Conclusion and Recommendation

The addition of citric acid increases the whiteness index, reducing sugar, and producing water content according to SNI. The best treatment is the addition of citric acid with a concentration of 0.8%. Further research needs to reduce the amount of reducing sugar content of kepok banana flour. Further research can be conducted related to the use of banana flour in the manufacture of food products to determine the effectiveness of citric acid in inhibiting browning reactions.

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