Effect of temperature and duration of thermal pasteurization on polyphenol oxidase (PPO) enzyme activity, total plate count (TPC), physicochemical and organoleptic properties of Cavendish banana fruit juice (Musa cavendishii)

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ABSTRACT
This research aims to determine the effect of temperature and duration of thermal pasteurization process in Cavendish banana juice. Cavendish banana is an abundant cultivated banana that has not been used properly, which is a climacteric fruit that has increased ethylene production after harvesting. Cavendish bananas have great potential as fruit juice. Pasteurization was carried out at temperatures of 55, 60, 65, 70 and 75 °C for 5, 10, and 15 minutes. Pasteurization with higher temperature and time can increase the total dissolved sugar and viscosity as well as decrease the pH value and PPO enzyme activity. The reducing sugar content of Cavendish banana juice was determined using the DNSA method with the greatest value at 55 °C for 5 minutes, which is 9.53%. Meanwhile, the content of phenol and flavonoid was determined using the Krishnan and Sinija method. The highest value of phenol and flavonoid content at 60 °C for 5 minutes, was 0.1728 mg GAE/g and 0.1583 mg QE/g sample. Antioxidant activity was determined using the DPPH method and the greatest percentage of inhibition at 60 °C for 5 minutes, which is 61.60%. Vitamin C levels were identified by the UV-Vis spectrophotometry method with the greatest value at 55 °C for 5 minutes, which is 1.1409 mg/100 g. The Total Plate Count (TPC) of Cavendish banana juice decreased after pasteurization with the smallest total number of bacteria at 75 °C for 15 minutes, with a value of 3.2×10³ CFU/ml. Pasteurization process at 75 °C for 15 minutes can reduce the activity of PPO enzyme as much as 97%. In the organoleptic test, preferred level of Cavendish banana juice to all attributes of the average hedonic scale with the category of the likes.

Introduction
Harvesting Indonesia is a tropical country that is rich in plantation products in the form of fruits and vegetables. Cavendish banana (Musa cavendishii) is one of the original cultivated bananas from Indonesia which has become a national superior fruit. Cavendish bananas have a lot of nutritional content and have the potential to be used as ingredients for making drinks (Alkharkhi et al., 2009).

Cavendish bananas have a sweet taste, high in carbohydrates, minerals, vitamin B6 and vitamin C. The mineral and vitamin content in Cavendish bananas is important for the body to help treat stomach ulcers, accelerate metabolism, reduce hypertension (high blood pressure), overcome muscle fatigue because it has simple and complex carbohydrates as an energy source (Siriwardana et al., 2019). Cavendish bananas can be consumed in various ways, including by eating the fruit directly and can also be drunk in the form of fruit juice.

Nowadays consumer interest in packaged fruit juice drinks is increasing because it is very practical, easy to consume and contains high nutrition. In the manufacture of packaged fruit juice drinks, the pasteurization process is carried out before being packaged. It aims to kill pathogenic microbes (disease-causing) and spoilage microbes (fungi and bacteria) found in fruit juice drinks. In addition, pasteurization also aims to inactivate enzymes that cause natural browning reactions in fruit juice drinks so that they are safer to consume and last longer before the packaging is opened.

The pasteurization process of Cavendish banana juice is carried out by heating which will improve the nutritional quality, color and taste of Cavendish
banana juice. The heating temperature is too high and the heating time is too long can reduce the nutrients contained in Cavendish banana juice. On the other hand, if the heating temperature is too low and the heating time is too short, it is feared that the total number of microbes contained in the fruit juice is still quite high. Cavendish banana juice contains enough sugar to grow mycobacteria. Thus, if the pasteurization process is not carried out and packaged properly, it is very easy to be contaminated by microbes. The purpose of this study was to determine the effect of temperature and duration of pasteurization on the quality of Cavendish banana juice to obtain fruit juice with high nutritional content and in accordance with the quality requirements of fruit juice drinks based on National Standardization Agency of Indonesia (SNI).

Research Methods

Materials

The research material used in this study is the Cavendish banana (Musa cavendishii) fresh and ripe obtained from Nongkojajar, Pasuruan (East Java, Indonesia), CMC food grade, phosphate buffer solution, NaCl pH 7.5, phosphate buffer solution pH 7, phosphate buffer solution 0.05 M pH 7.5, ammonium sulfate, catechol, bovine serum albumin, Lowry's reagent, distilled water, filter paper and ps methanol, potassium tartrate, dinitrosalicylic acid, glucose, ascorbic acid, ammonium molybdate, oxalic acid, sulfuric acid (H₂SO₄), ferric(III) chloride (FeCl₃), folin-ciocalteu, sodium carbonate (Na₂CO₃), sodium nitrite (NaNO₂), aluminum chloride (AlCl₃), sodium hydroxide (NaOH), DPPH solution, buffer peptone water (BPW), plate count agar media (PCA). The tools used in the process of making Cavendish banana juice were blender, double jacket pasteurizer with PID control, knife, bottle container and scale. The tools used in the analysis include pH meter, refractometer, viscometer, centrifugator, UV-Vis spectrophotometer, incubator, autoclave, vortex, shaker, electric stove, analytical balance, color reader and dialysis bag.

Methods

Making Cavendish Banana Fruit Juice.

The manufacture of Cavendish banana juice begins with peeling and cutting the Cavendish banana fruit, then 0.5% CMC stabilizer was added and mixed evenly. After that the juice was made using a blender. Cavendish banana juice was added with water in a ratio of 2:1. Then the pasteurization process was carried out at temperatures 55, 60, 65, 70 and 75 °C for 5, 10 and 15 minutes with three times replication. Cavendish banana juice was stored in a black glass bottle and placed in the refrigerator at −18 °C temperature.

Total Plate Count

Samples of Cavendish banana juice was diluted 10⁻² and 10⁻³ were taken 1 mL and put in a sterile petri dish. Then 15 mL of PCA was added in a petri dish. After that, the sample was carefully shaken to form a number eight. Then the mixture was allowed to solidify and then put in an incubator at 37 °C for 24 hours. When finished, the number of colonies that grow in each cup containing 25-250 colonies.

Total Dissolve Solid (TDS)

Analysis of total dissolved solids in this study was using a refractometer. Before use, the prism was cleaned first with distilled water and then calibrated with 2-3 drops of distilled water on the prism, the light was directed and adjusted to the line of intersection. The TDS value will be displayed on the screen with units of °Brix.

Viscosity Test

Viscosity testing was using a Vibro viscometer, first calibrated with distilled water, then poured a sample of Cavendish banana juice into a 35-45 mL Fontaine. The lever was then lifted until the sensor plate was submerged by the sample, pressed the start and stop buttons to take viscosity readings in mPa.

pH Test

Testing pH was using a pH meter, the first step was calibrated with a buffer solution of pH 4, 7, and 9 until stable. Then the electrode is rinsed with distilled water and wiped with a tissue, the electrode is dipped into the sample until it is stable. Then the value of pH sample can be read.

Color Test

Color testing uses the Hunter method using a color reader. The first step is calibration of the tool with distilled water, then the sample is placed into a container and the lens is placed on standard porcelain perpendicularly, the target button is pressed. After that the values of L, a*, b* can be read.

Estimation of Reducing Sugar

The reducing sugar content was calculated using the 3.5 dinitrosalicylic acid method according to Garriga et al. (2017), where 1 mL sample of Cavendish banana juice 10 mg/mL was put in a test tube that had been covered with aluminum foil, then 1 mL of reagent was added and heated for 5 minutes in boiling water. Then, the sample was cooled at room temperature, then added 8 mL of distilled water.
and vortexed. After that the absorbance of each sample was measured at a wavelength of 540 nm using UV-spectrophotometry.

**Estimation of Vitamin C**
Vitamin C content was calculated using the UV-Vis spectrophotometric method according to Kapur et al. (2012), where 1 mL sample of Cavendish banana juice 500 mg/mL was put in a test tube that had been covered with aluminum oil. Then, 4 mL of 5% H$_2$SO$_4$ solution and 5 mL of 5% ammonium molybdate reagent was added. Then it was vortexed and incubated for 30 minutes. Then the absorbance of each sample was measured at a wavelength of 754.7 nm using UV-spectrophotometry.

**Identification of Phenolic and Flavonoid**
Phenol compounds were identified qualitatively using FeCl$_3$ according to Lolaen et al. (2013), where 5 mL of Cavendish banana juice was added with 20 drops of FeCl$_3$ 1%. Meanwhile, flavonoid compounds were identified qualitatively through a color change test with NaOH according to Sapiun et al. (2020), where 5 mL of Cavendish banana juice was taken and mixed with 50 mL of water, then boiled and 1 mL was taken to be tested with 10 drops of NaOH 10%.

**Estimation of Total Phenol Content.**
The phenol content was calculated using the colorimetric method (Krishnan and Sinija, 2016). One mL sample of 500 mg/mL Cavendish banana juice was put in a test tube that had been covered with black duct tape, then 5 mL of folin-ciocalteu 10% was added, vortexed and incubated at room temperature for 4 minutes. Then, 4 mL of Na$_2$CO$_3$, 7.5% was added, vortexed and incubated at room temperature for 15 minutes. Then, the absorbance of each sample was measured at a wavelength of 754.7 nm using UV-spectrophotometry.

**Estimation of Total Flavonoid Content**
The flavonoid content was calculated using the colorimetric method (Krishnan and Sinija, 2016). Where 2.5 mL of the 500 mg/mL Cavendish banana juice sample was put in a test tube which had been covered with black duct tape. Then, 0.5 mL of distilled water, 0.3 mL of NaNO$_2$ 5%, 0.3 mL of AlCl$_3$, 10% was added, vortexed and incubated at room temperature for 5 minutes. After that, 4 mL of 1M NaOH and 2.4 mL of distilled water were added. Then the absorbance of each sample was measured at a wavelength of 489.9 nm using UV-spectrophotometry.

**Antioxidant Activity Test**
Antioxidant activity was determined using the DPPH method, where 1 mL of Cavendish banana juice sample 100 mg/mL was put in a test tube which had been closed with black duct tape. Then, 1 mL of 0.2 mM DPPH and 3.5 mL methanol were added. Then it was vortexed and incubated at room temperature for 30 minutes. After that, the absorbance of each sample was measured at a wavelength of 517 nm using UV-spectrophotometry and the % inhibition was measured.

**Polyphenol Oxidase (PPO) Enzyme Purification**
PPO enzyme purification was analysed using method described in Bora et al. (2004). The Cavendish banana juice sample was added with 2 mL of 0.2 M phosphate buffer pH 7.5 (0.5 M NaCl) and homogenized at high speed for 3 minutes. Then, ammonium sulfate to 80% and homogenized were added, deposited at a temperature of 4 °C for 24 hours. The process is continued with centrifugation at a speed of 4300 rpm and a temperature of 5 °C for 20 minutes. The enzyme extract precipitate was added with 0.05M phosphate buffer pH 7 to a volume of 10 ml. After that, 3 ml was put into a dialysis bag, soaked in distilled water at 4 °C for 24 hours, and the soaking water was changed once. Then the rope of the dialysis bag is removed so that the pure enzyme extract has been obtained and poured into the test tube for further processing.

**Polyphenol Oxidase Enzyme Activity Test**
PPO enzyme activity was analyzed using 0.2 mL of enzyme extract, 2 mL of 0.01M catechol and 1.8 mL of phosphate buffer pH 7.5. Then, it was measured using a UV-VIS spectrophotometer with a wavelength of 420 nm (Gordon et al., 2013).

**Protein Determination**
Determination of protein was conducted using the Lowry method, by using 2.5 ml of Lowry D reagent and 1 mL of enzyme extract. Then, it was vortexed and left at room temperature for 10 minutes. After that, 0.25 mL of folin-ciochitel was vortexed and left at room temperature for 30 minutes. Then measured using a UV-VIS spectrophotometer with a wavelength of 750 nm. The value obtained is then calculated using a regression equation to determine the value of the specific activity of the PPO enzyme (Gordon et al., 2013).
Organoleptic Test
Organoleptic testing is testing based on the sensing process. Organoleptic tests were performed on samples of Cavendish banana juice which included color, flavor, taste and texture. Testing using a hedonic scale consisting of 5 scales with 5 statements: 1 = very dislike; 2 = somewhat dislike; 3 = regular or neutral; 4 = like and 5 = very like. Testing is performed by giving 16 random samples that have each been given different codes to 15 rather trained panelists. Panelists are required to provide an assessment of the questionnaire that has been provided by charging in accordance with the existing hedonic code and scale.

Results and Discussion
Total Plate Count
Determination of the total number of bacteria in this study used PCA (Plate Count Agar) which contains nutrients as an energy source for microorganisms to support the growth of bacteria. The relationship between pasteurization time and the total number of bacteria in Cavendish banana juice at various temperatures is presented in Figure 1.

In Figure 1, it can be seen that the total number of bacteria in Cavendish banana juice decreases with increasing temperature and the time of pasteurization because bacteria will stop reproducing at high temperatures. At the same heating time, if the heating temperature is higher, the total number of bacteria will decrease. The total number of bacteria in the Cavendish banana juice was initially $2.67 \times 10^2$ CFU/mL. After pasteurization, the total number of bacteria in Cavendish banana juice decreased with the best result at 75 °C for 15 minutes with a value of $3.2\times10^1$ CFU/mL. The results of statistical analysis showed that pasteurization temperature and time had a significant effect on the total number of bacteria in Cavendish banana juice, and this result is in accordance with Yang et al. (2019).

Total Dissolved Solid (TDS)
The total dissolved solids (TDS) of Cavendish banana juice increased along with the treatment duration of pasteurization and the high temperature, as shown in Figure 2. The highest total dissolved solids of banana juice were 15.800 °Brix which was found at a temperature treatment of 75 °C, with a pasteurization duration of 15 minutes. Meanwhile, the lowest total dissolved solids were 13.300 °Brix, which is without any pasteurization treatment. The results of statistical analysis showed that pasteurization temperature and time had a significant effect on the total dissolved solid in Cavendish banana juice. The increase is because longer pasteurization makes the water content in the fruit evaporate. Evaporation of water can increase the solids component due to reduced water content in the fruit so that the dissolved solids content also increases. The evaporation of water during heating causes the water content to decrease, and the solids concentration increases. The total dissolved solids increased along with the increase in the total sugar of the fruit juice (Lawalata et al., 2020).
Figure 2. Total dissolved solid of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements

Figure 3. Viscosity of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements

Viscosity
In Figure 3, it can be observed that the viscosity content of Cavendish banana juice increased with increasing treatment time and heating temperature. The initial viscosity value of Cavendish banana juice was 0.3970 Pa.s. After pasteurization, the viscosity of Cavendish banana juice increased, where the highest viscosity content was found at a temperature treatment of 75 °C with duration of 15 minutes, where the value is 2.2833 Pa.s. The result of statistical analysis showed that pasteurization temperature and time had a significant effect on the viscosity of bacteria in Cavendish banana juice. That is following research Rabie et al. (2009), which states that the longer the pasteurization process, the higher the viscosity of the fruit juice product.

pH
Cavendish banana juice changes in pH during the pasteurization process, which can be seen in Figure 4. It can be seen that with the pasteurization process, the pH of Cavendish banana juice tends to decrease. At the initial conditions, the pH of Cavendish banana juice was 5.3233. After pasteurized, the lowest pH was 4.7900 at the treatment temperature of 65 °C for
10 minutes. The pH value is related to the acid content contained in the fruit juice. The more acid contained in the fruit juice, the lower the pH of the fruit juice. The acid content in Cavendish banana juice is due to the presence of citric acid and malic acid in bananas. According to Lawalata et al. (2020), pH is the level of acidity that will affect the durability or quality of a product.

Changes in the pH value have the opposite effect on the total acid level. If the total acid level is high, the pH value is low, while if the acid level is low, the pH is high. That is in line with the results of the study namely the total acidity of Cavendish banana juice decreased, with the length of pasteurization and high temperatures. The results of the statistical analysis also showed, that the temperature and time of pasteurization had a significant effect on the degree of acidity (pH) in Cavendish banana juice.

**Figure 4.** pH of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements

![Figure 4: pH of Cavendish banana fruit juice](image)

**Figure 5.** Total color change (ΔE) of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements

![Figure 5: Total color change (ΔE)](image)

**Color**

In this study, color testing was carried out on samples of Cavendish banana juice before and after pasteurization on day 1 and 3. The test results showed the level of color values (L* brightness, (a*) redness and yellowness (b*), and total color change (ΔE). The results of the color test analysis can be seen in Table 1.

In Figure 5 it can be observed that the total color change (ΔE) of Cavendish banana juice tends to decrease with increasing temperature and
length of pasteurization time. In Table 1, it also can be observed that the sample changes color to brown or dark with increasing pasteurization temperature and time. This is following the statement that Cavendish banana juice changes color to brown (browning reaction) due to non-enzymatic browning, namely the Maillard reaction, reactions that occur between carbohydrates, especially reducing sugars with primary amine groups. The browning reaction proceeds faster with increasing temperature and duration of pasteurization, causing the Cavendish banana juice color to become browner (Sims et al., 1994).

Table 1. Color of Cavendish banana fruit juice

| Temp (°C) | Time (Minute) | ΔL*  | Δa*  | Δb*  | ΔE   |
|----------|---------------|------|------|------|------|
| 55       | 5             | 1.5867 | 0.0833 | -1.1833 | 4.5767 |
| 55       | 10            | 2.6733 | 0.2067 | -1.2633 | 3.2500 |
| 55       | 15            | 1.8900 | 0.1900 | -1.2333 | 3.0700 |
| 60       | 5             | 2.6800 | 0.2300 | -1.5433 | 3.2367 |
| 60       | 10            | 2.0533 | 0.0500 | -1.0500 | 2.7067 |
| 60       | 15            | 1.5400 | 0.0333 | -0.3667 | 1.6633 |
| 65       | 5             | 1.6533 | 0.1233 | -0.6433 | 1.8167 |
| 65       | 10            | 0.7533 | 0.0300 | -0.2367 | 1.4300 |
| 65       | 15            | 0.3567 | -0.0100 | -0.1800 | 0.6533 |
| 70       | 5             | 0.6400 | -0.1033 | -0.4033 | 0.9000 |
| 70       | 10            | 3.4100 | 0.0433 | -0.7033 | 3.6567 |
| 70       | 15            | 0.5033 | 0.0000 | -0.4800 | 0.7833 |
| 75       | 5             | -0.7700 | -0.3067 | 0.0800 | 1.4800 |
| 75       | 10            | -0.1133 | -0.1300 | -0.3667 | 3.3633 |
| 75       | 15            | -0.8767 | 0.0667 | 0.1033 | 1.5700 |
| TP       | -             | 1.3200 | 0.0933 | 1.7300 | 3.2333 |

Figure 6. Reducing sugar of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements

**Reducing Sugar**

In Figure 6, it can be seen that the reducing sugar content in Cavendish banana juice decreases with increasing temperature and duration of thermal pasteurization. The sample without pasteurization or control of Cavendish banana juice was initially 10.88%. After pasteurization, the reducing sugar content of Cavendish banana juice decreased, where the highest reducing sugar content was at 55 °C for 5 minutes with a value 9.53%, while the
lowest reducing sugar content was at 65 °C for 10 minutes with a value 5.51%. This is due to the interaction of reducing sugars (glucose and fructose) in banana juice with amino acids that produce melanoidin compounds during heating. More melanoidin or brown pigments are formed which results in reduced sugar levels (Bazaz et al., 2018). The results of statistical analysis showed that interaction of pasteurization temperature and time had a significant effect on the reducing sugar in Cavendish banana juice.

**Vitamin C**

In Figure 7, it can be seen that the vitamin C content in Cavendish banana juice decreases with increasing temperature and duration of thermal pasteurization. Samples without pasteurization or control of Cavendish banana juice initially 1.3417 mg / 100 g sample. After pasteurization, the vitamin C content of Cavendish banana juice decreased, where the highest vitamin C content was at 55 °C for 5 minutes with a value 1.1409 mg/100g sample, while the lowest vitamin C content was at 75 °C for 10 minutes with a value 0.1015 mg/100 g sample.

![Figure 7. Vitamin C of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements](image)

The decrease in vitamin C levels was due to ascorbic acid being sensitive and unstable to heat and being easily oxidized when exposed to air and high temperatures (Salih et al., 2017). The results of statistical analysis showed that interaction of pasteurization temperature and time had a significant effect on the vitamin C content in Cavendish banana juice.

**Identification Phenolic and Flavonoid**

Identification of phenolic compounds is done by using a reagent FeCl₃ 1% while flavonoid compounds use NaOH 10%. In Figure 8 it can be seen that there is a change in the color of the Cavendish banana juice sample from light brown to greenish. This shows that Cavendish banana juice contains phenolic compounds because it forms a green color (Harbone, 1987). In addition, there was a change in the color of the Cavendish banana juice sample in the identification of flavonoids from white to yellow. This shows that Cavendish banana juice contains flavonoid compounds because it forms a yellow color. As the temperature increases and the pasteurization time increases, the color changes fade which indicates a decrease in the content of phenols and flavonoids.
Total Phenol Content
In Figure 9, it can be seen that the phenol content in Cavendish banana juice decreases with increasing temperature and length of heating time. At the same heating time, if the heating temperature is higher, the phenol content will be less. The amount of phenol content in Cavendish banana juice was initially 0.1758 mg GAE/g sample. After pasteurization, the phenol content in Cavendish banana juice decreased, where the highest phenol content was at 60 °C for 5 minutes with a value of 0.1728 mg GAE/g sample. This is because the pasteurization temperature and time that are too high can destroy the phenolic compounds in the cell components (Rosas et al., 2007). The results of statistical analysis showed that interaction of pasteurization temperature and time had a significant effect on the total phenol content in Cavendish banana juice.

Total Flavonoid Content
In Figure 10, it can be seen that the flavonoid content in Cavendish banana juice decreases with increasing temperature and length of heating time. The amount of flavonoid content in Cavendish banana juice was initially 0.1691 mg QE/g sample.

After pasteurization, the flavonoid content in Cavendish banana juice decreased, where the highest flavonoid content was at 60 °C for 5 minutes with a value of 0.1583 mg QE/g sample. Flavonoids decrease due to the influence of temperature variations during the pasteurization process because
these compounds are sensitive to heat and will be degraded at temperature over 60 °C (Nayak et al., 2020). The results of statistical analysis showed that interaction of pasteurization temperature and time had a significant effect on the total flavonoid content in Cavendish banana juice.

**Antioxidant Activity**

In Figure 11, it can be seen that the antioxidant activity of Cavendish banana juice decreases with increasing temperature and length of heating time. Inhibition in Cavendish banana juice was initially 69.80 %. After pasteurization, the % inhibition in Cavendish banana juice decreased, where the largest % inhibition was pasteurized at 60 °C for 5 minutes with a value of 61.60%. This is in line with research conducted by Benattouche el al. (2019), which states that the antioxidant activity of the sample will decrease with increasing temperature and length of pasteurization time. The results of statistical analysis showed that interaction of pasteurization temperature and time had a significant effect on the antioxidant activity in Cavendish banana juice.

**Enzyme Activity of Polyphenol Oxidase**

The presence of polyphenol oxidase (PPO) enzymes in Cavendish bananas will cause enzymatic browning. This reaction will cause a change in the color of the Cavendish banana juice product, but it can also reduce the quality and shelf life of the product. So, that pasteurization is needed to inactivate the PPO enzyme activity. Identification of PPO enzyme activity in Cavendish banana juice was using dialysis bag and 80% ammonium sulfate to obtain a higher level of enzyme purity.

![Figure 11. Antioxidant activity of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements](image1)

![Figure 12. Polyphenol oxidase enzyme (POE) activity of Cavendish banana fruit juice. Error bars represented standard deviation from three measurements](image2)
In Figure 12, it can be observed that the enzyme activity tends to decrease with increasing treatment duration and heating temperature. The specific activity of the PPO enzyme is highest before pasteurization treatment with a value of 0.1096 U/mg. The value of the PPO enzyme-specific activity was lowest for the pasteurization treatment with a temperature setting of 75 °C and a duration of 15 minutes, which was 0.0032 U/mg and reduced the PPO enzyme activity by 97%. The decrease, in this case, is due to the inactivation treatment at high temperatures that will cause the protein of the enzyme to start to denature. The result of statistical analysis showed that pasteurization temperature had a significant effect on the viscosity in Cavendish banana juice. This is the following research Chaisakdanugull and Theerakulkait (2009), which states that the higher the temperature and the longer the pasteurization time, the lower the PPO enzyme activity will be.

**Organoletic Test**

**Color**

Figure 13 shows the average value of organoleptic color. The treatment sample without pasteurization or control produced a hedonic score with a value of 4 which means panelist "like". After pasteurization, the panelists preferred sample at temperature treatment and pasteurization time of 65 °C for 5 and 10 minutes with a value of 3.26 which means panelists "regular or neutral" while the lowest color organoleptic average values were obtained from the 70 °C for 5 minutes, 65 °C and 70 °C for 10 minutes with a value of 2.6 which means panelists "somewhat disliked". This is because too high pasteurization can decrease the level of panelist fondness for the color of banana juice because there is a decrease in the quality of the color of the fruit juice due to the non-enzymatic reaction of browning by amino acids, sugars, and organic acids (Ortiz et al., 2017).

![Temperature and Duration Pasteurization](image)

**Figure 13.** Average level of panelist liking for color attributes. Error bars represented standard deviation from three measurements
**Figure 14.** Average level of panelist liking for scent attributes. Error bars represented standard deviation from three measurements.

**Scent**

In Figure 14, it can be seen that the average organoleptic value of the most preferred scent of panelists was at temperature treatment and pasteurization time of 55 °C for 5 minutes with a value of 3.87 which means panelist "like". Samples without pasteurization or control had the same range of hedonic scores as the most preferred treatment, while the aroma of Cavendish banana juice was least preferred at 60 °C pasteurization treatment for 15 minutes with a value 2.67 which means panelists were "somewhat disliked". It is suspected that the degradation and evaporation of some volatile compounds in bananas so that the typical aroma of bananas is reduced (Praja et al., 2021).

**Taste**

In Figure 15, it can be seen that the average organoleptic taste value that most panelists prefer was at temperature and duration of pasteurization thermal at 55 °C for 5 minutes with a value 4 which means panelist "likes". Samples without pasteurization or control, had the same hedonic score range as the most preferred treatment, while banana Cavendish juice taste was least preferred pasteurized at 65 °C and 70 °C for 15 minutes with a value 2.40 meaning panelists were "somewhat disliked". It is thought that the typical taste of the fruit is influenced by several factors such as chemical compounds, temperature and other additives. The typical flavor-forming organic compounds of the fruit are evaporated in the heating process (Sims and Bates, 1994).

**Texture**

In Figure 16, it can be seen that the average organoleptic texture value that most panelists prefer was at temperature and time of pasteurization at 55 °C for 5 minutes with a value 4.07 which means panelist "like". The sample without pasteurization or control had the same range of hedonic scores as the most preferred treatment, while the texture of Cavendish banana juice was least preferred was pasteurized at 60 °C for 15 minutes of 2.33 which means panelists were "somewhat disliked".
Figure 15. Average level of panelist liking for taste attributes. Error bars represented standard deviation from three measurements.

Figure 16. Average level of panelist liking for texture attributes. Error bars represented standard deviation from three measurements.

This is suspected to be a decrease in the level of panelist fondness for the texture of Cavendish banana juice because the increasing temperature and heating time then there is a process of evaporation of some water in the pasteurization process so that the texture is thicker and denser.

**Conclusion**

From the Cavendish banana juice pasteurization process carried out at temperatures of 55, 60, 65, 70, and 75 °C for 5, 10, and 15 minutes, it can be concluded that the higher the temperature and the longer pasteurization time, it was found that the total number of bacteria, phenol and flavonoid content, antioxidant activity, vitamin C, reducing sugar, pH and PPO enzyme activity decreased. Meanwhile, total dissolved solids and viscosity increased with increasing temperature and length of pasteurization time. The largest content of vitamin C was at 55 °C for 5 minutes, which was 1.1409 mg /100 g. The largest content of total phenols, total flavonoids and antioxidant activity was at 60 °C for 5 minutes, with values of 0.1728 mg GAE/g, 0.1583 mg QE/g and 61.60%. The best value in the total number of bacteria and PPO enzyme activation was at a temperature of 75 °C for 15 minutes with a value of $3.2 \times 10^4$ CFU/mL and 97%. In the organoleptic test (preferred level) of Cavendish banana juice to all attributes of the average hedonic scale were with the category of the likes.

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