Characteristics of Fruit Wine from Several Types of Banana with Various Types of Yeast

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Abstract. Banana is a fruit that is ranked the highest of production in Indonesia with complete nutritional value. However, they can undergo rapid deterioration in quality with a relatively short shelf life. Fermentation is considered as an interesting and simple method of reducing post-harvest loss of highly perishable fruits such as banana. One of the products obtained from juice fermentation is fruit wine. The objective of this research are to produce wine using various types of bananas, types of yeasts, and fermentation periods. This banana wine is made from "ambon lumut banana", "raja bulu banana", and "mas banana" with yeast Saccharomyces cerevisiae, Saccharomyces bayanus, and ratio Saccharomyces cerevisiae : Saccharomyces bayanus (1:1), and fermentation time of 7, 9, 11, 13, and 15 days. The total soluble solid, pH, alcohol content, clarity, lightness, and color are analyzed for each treatment along with organoleptic test which consists of scoring and hedonic test. The best quality banana wine from this research is wine made from "pisang mas" with Saccharomyces cerevisiae yeast that has been fermented for 13 days. The banana wine has a total soluble solid of 13.25°Brix, pH of 3.21, total titratable acidity of 0.78%, an alcohol content of 8.03%, clarity of 88.23%, yellow in color with a °Hue of 122.30, total flavonoids of 7.46 µg QE/mL, total phenolic of 56.17µg GAE/mL, IC_{50} of 27.9%, and favored by panelists.

Keywords: banana, fermentation, wine, yeast

1 Introduction

Banana (*Musa sp.*) is a fruit that very popular in Indonesia because it can be easily found and available in various types such as pisang ambon lumut, pisang raja, and pisang mas. All types of bananas can be consumed directly without being processed and have a sweet taste with fragrant aroma. Based on the data from the Kementerian Pertanian [1], bananas are the most produced fruit in Indonesia with an average increase in production of 5.38% annually. But bananas are classified as plants that have a short shelf life. Storage at low temperatures is one of the common ways to extend the shelf life of fruits but bananas are easily damaged and are susceptible to chilling injuries. Therefore, one of the methods that can be done to reduce post-harvest losses and gain added value is to process them into wine [2,3].

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Wine is an alcoholic beverage made from the fermentation of grapes with a minimum alcohol content of 8% [4]. However, other fruits such as bananas, apples, and oranges can be used to make wine. Banana wine originates from East Africa but has gaines popularity all over the world because it gives some health benefit with relatively low alcohol content [5].

2 Research Methodology

2.1 Materials and Equipments

The main materials were used ambon lumut banana, raja bulu banana, and mas banana obtained from traditional markets, water, sugar, citric acid, wine yeast with two different types, that is Saccharomyces cerevisiae and Saccharomyces bayanus, also commercial banana wine "Deo Gratias".

The main equipments used in this research were stoves, steamer, stopwatch, blender, refractometer, pH meter, analytical balance, oven, UV-Visible spectrophotometer, chromameter, micropipettes, disposable petri dish.

2.2 Research Procedures

This research is an experimental consisting of preliminary research and primary research stage. The preliminary research conducted was to determine the optimum blanching time of banana fruit using catalase test. Bananas that have been peeled are cut and then steam blanched for 0, 1, 2, 3, 4, and 5 minutes. The bananas are then dripped with 3% H_2O_2 and observed if there are air bubbles. If there are air bubbles, the catalase enzyme in bananas are still active and expressed as positive. The optimum blanching time of the banana pulp is determined when the catalase enzyme in the banana is no longer active with the shortest time to inactivate the enzyme. The optimum time that has been determined is then used in blanching treatment in the production of yeast culture and banana juice.

The main research is divided into 2 stages. In the first stage of the research, the effect of using different types of bananas and yeast types to produce banana wine will be analyzed and then determine the best banana wine through chemical, physical analysis, and organoleptic tests. In the second stage of research, the effect of fermentation time on the chosen banana wine produced in the previous stage of research will be analyzed and then choose the best banana wine through chemical, physical analysis, and organoleptic tests too. The best banana wine in the second stage of the research was also further analyzed for total phenolic, total flavonoid, and antioxidant activity (IC50). In addition, the best banana wine from the second stage was also compared with the commercial banana wine “Deo Gratias”. The procedure of making banana wine can be seen in Fig.1.

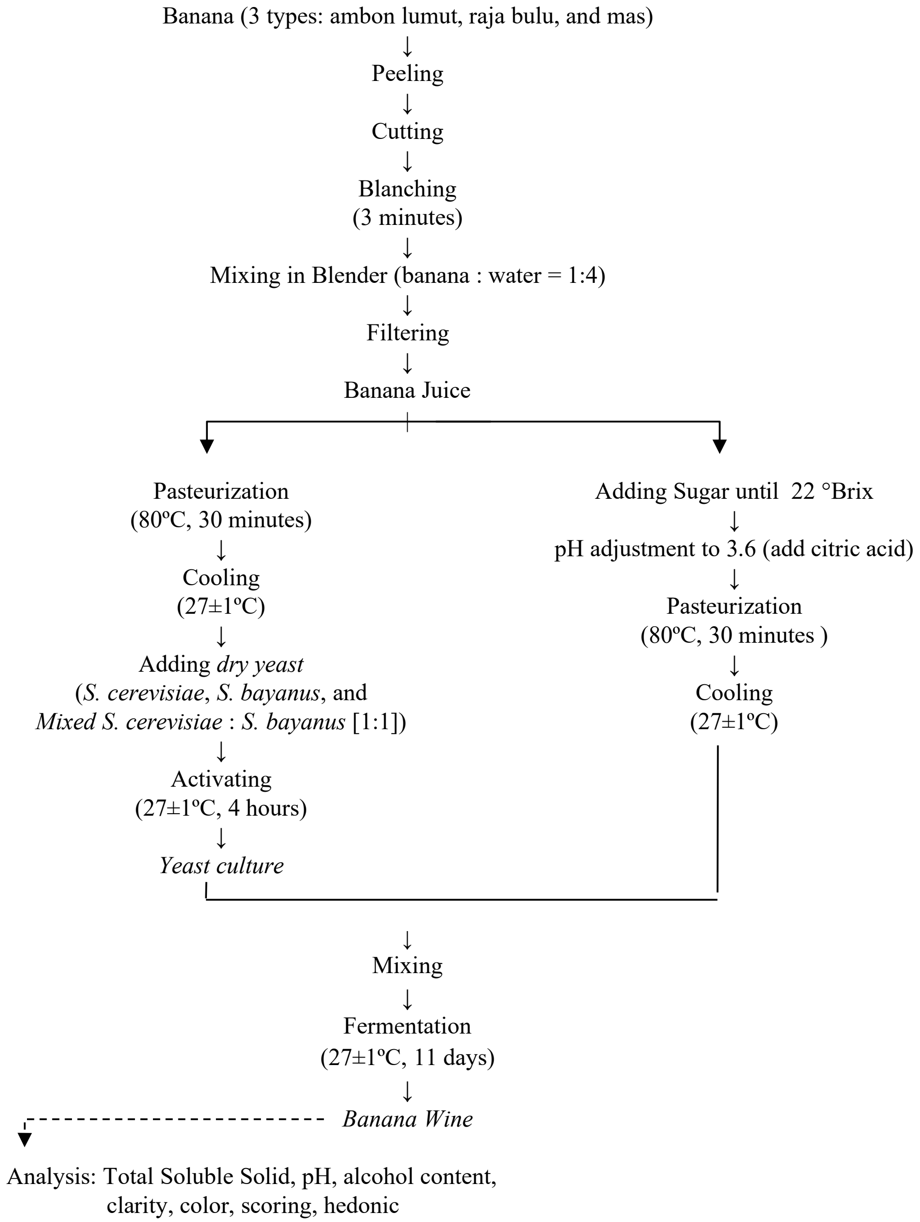


Fig. 1. Chart in Making Banana Wine [5, with modification]

2.3 Analysis

The analysis were conducted: total soluble solid [6], pH [7], total titratable acidity [8], alcohol content [6], clarity [10,8], color [11], organoleptic tests [12], total phenolics [13], total flavonoids [14], antioxidant activity [15], and alcohol content [16].

2.4 Experimental Design

The experimental design used in the stage I research was a completely randomized design (CRD) of two factors,which are type of banana and type of yeast with three replications for each treatment and in the stage II research was a completely randomized design (CRD) of one factor, which is fermentation time with four repetitions. The fermentation period specified is 7, 9, 11, 13, and 15 days. Statistical analysis in the stage I and stage II research were obtained using the Statistical Package for the Social Sciences (SPSS) program.

3 Result and Discussion

3.1 Identification of Banana Fruits

The bananas used were identified at the Lembaga Ilmu Pengetahuan Indonesia (LIPI). Based on the identification results, it is evident that the types of banana used in this study were Ambon lumut, Raja bulu, and Mas.

3.2 Determination of Optimum Blanching Time of Banana

The results of catalase tests on pisang ambon lumut, pisang raja bulu, pisang mas can be seen in Table 1.

Table 1. Catalase test result of pisang ambon lumut, pisang raja bulu, and pisang mas.

Minute-	Types of banana		
	Ambon lumut	Raja bulu	Mas
0	++++	+++	+++
1	++++	++	++
2	+	+	+
3	-	-	-
4	-	-	-
5	-	-	-

Note:
- : No air bubble
+ : Very few air bubble
++: Few air bubble
+++ : Many air bubble
++++: Very many air bubble

Based on the catalase test results in Table 1, it can be seen that bananas that are blanched for 3 minutes have no air bubbles. Based on these results, the optimum time for the specified banana fruit blanch is 3 minutes.

3.3 Effect of Different Types of Banana and Types of Yeast

Wine Total Soluble Solid (TSS). The total soluble solid of banana wine with different types of banana and types of yeast are in Fig. 2. It can be seen that wine made from pisang ambon lumut has a significantly lower total soluble solid ($p \leq 0.05$) compared to wine made from pisang raja bulu and pisang mas. TSS indicates a lower sugar content.

During the fermentation process, yeast converts sugars such as glucose, fructose, and sucrose into alcohol, carbon dioxide, and organic acids [17]. Based on Fig. 2, it can be seen that wine fermented with S. bayanus yeast tends to have a significantly lower total soluble solid ($p \leq 0.05$) compared to other yeasts. This is not in accordance with the theory which states that S. bayanus has a slower fermentation rate compared to S. cerevisiae. According to [18], there are several S. bayanus strains that ferment more slowly than other S. bayanus strains. Different yeast strains can affect the banana wine produced. Therefore, the discrepancy with the theory can be due to the strain used is the S. bayanus strain which has a fast fermentation rate so that it can break down more sugar compared to other types of yeast.

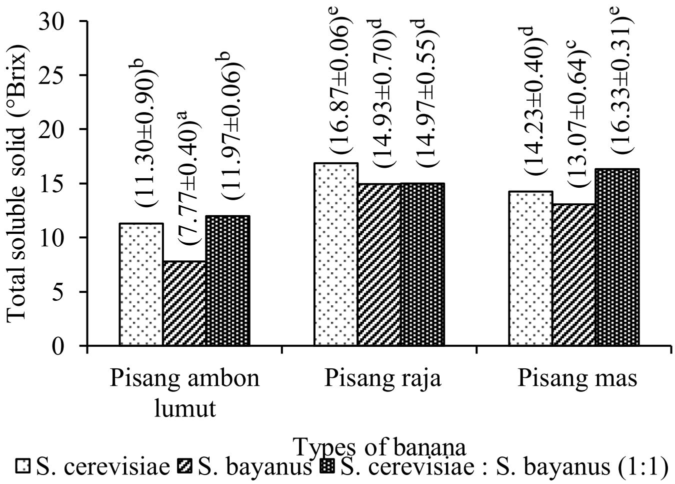
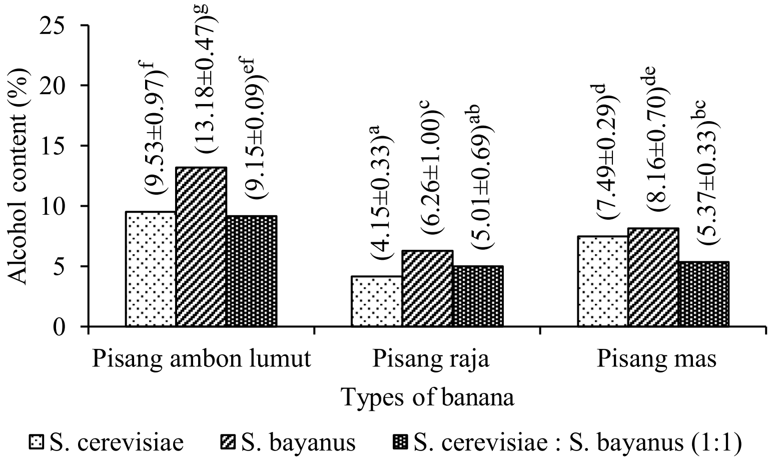


Fig. 2. Effect of different types of banana and types of yeast on wine total soluble solid

Wine Alcohol Content. The alcohol content of banana wine with different types of bananas and types of yeast can be seen in Fig. 3. It can be seen that wines made from pisang ambon lumut with *S. bayanus* yeast have significantly higher alcohol content (p

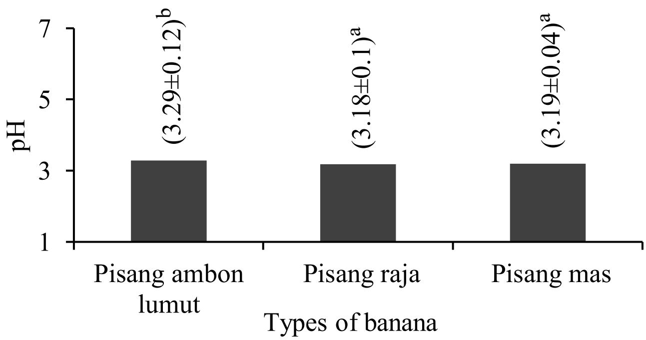
≤ 0.05) compared to other treatments. During the fermentation process, yeast converts sugar into alcohol. Hence, the greater the decrease in total soluble solid, the higher the alcohol content of the wine [19].



Note: Different letter notations indicate a significant difference (p ≤ 0.05)

Fig. 3. Effect of different types of banana and types of yeast on wine alcohol content

pH Wine. Based on statistic results, only different types of banana have an effect on pH wine. The pH of banana wine with different types of bananas can be seen in Fig. 4. The wine made from pisang ambon lumut has a significantly higher pH (p ≤ 0.05) compared to wine made from pisang raja bulu and pisang mas. This can occur because during the fermentation process, alcohol formation is more dominant than the formation of organic acids.



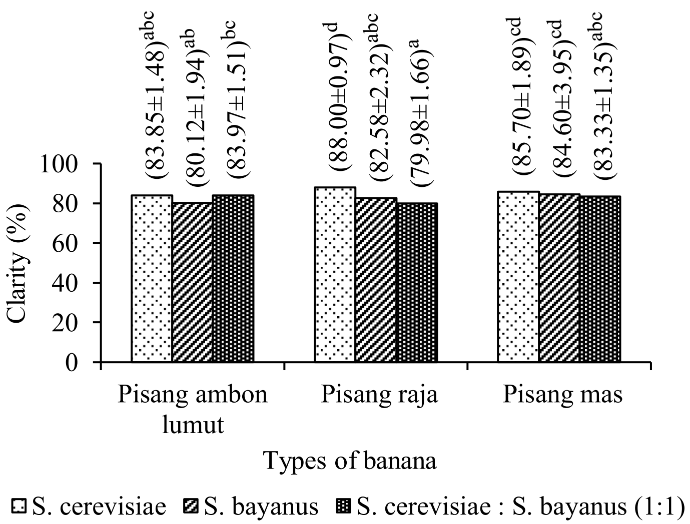
Note: Different letter notations indicate a significant difference (p ≤ 0.05)

Fig. 4. Effect of different types of banana and types of yeast on pH wine

Lightness and Color of Wine. Based on the analysis result, the types of banana and the types of yeast does not affect the lightness (L*) of the wine. The lightness of all banana wine samples is in the range of 51.09-52.08 and can be categorized as light.

Based on the analysis result, the types of banana and the types of yeast did not affect the color of the wine. °Hue of all banana wine samples is in the range of 105.59-116.40° and is categorized as yellow.

Wine Clarity. The clarity of banana wine with different types of bananas and types of yeast can be seen in Fig. 5. It can be seen that wine made from pisang raja with *S. cerevisiae* yeast and wine made from pisang mas with *S. cerevisiae* and *S. bayanus* yeast has a significantly higher level of clarity ($p \leq 0.05$) compared to other treatments. According to [20], wine clarity can be influenced by pH, where the lower the pH of the wine, the higher the clarity. The results obtained are in accordance with the theory that wines with high pH tend to have a low level of clarity.



Note: Different letter notations indicate a significant difference ($p \leq 0.05$)

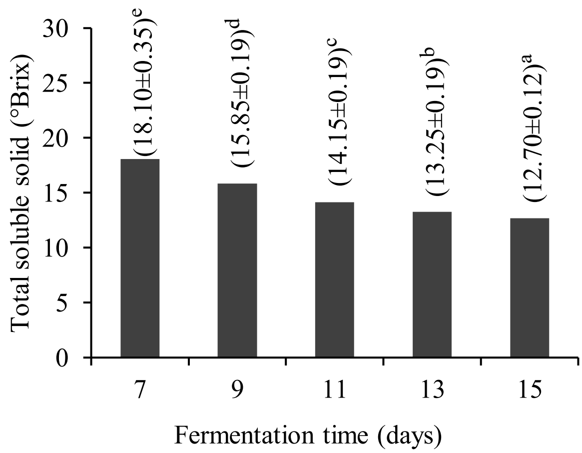
Fig. 5. Effect of different types of banana and types of yeast on wine clarity

Determination of Selected Banana Wine based on Types of Bananas and Yeasts. Based on the results of the first stage of research, the selected banana wine was determined from the alcohol content, clarity, color, and organoleptic tests. The hedonic test is the main reference in selecting the best banana wine because the banana wine produced must be liked by the panelists. Based on the hedonic test, the most preferred banana wine is wine made from plantain or mas banana with ratio yeast S. cerevisiae or S. cerevisiae : S. bayanus (1:1). Based on these results, it is necessary to look at other considerations. The physical test which is an important parameter in influencing consumer acceptance is the clarity and color of the wine. The brightness and color of banana wine from all treatments were not significantly different. However, banana wine made from plantain and mas banana with S. cerevisiae yeast has the highest level of clarity.

In addition, from the four treatments, wine made from banana mas with yeast S. cerevisiae had the highest alcohol content, which was 7.49%. Therefore, the selected banana wine is a wine made from mas banana with S. cerevisiae yeast. However, the alcohol content of the selected banana wine has not yet reached the requirements specified by SNI, which is a minimum of 8%. Therefore, it is necessary to optimize the length of fermentation to increase the alcohol content of the selected banana wine. The selected banana wine will be fermented for 7, 9, 11, 13, and 15 days.

3.4 Effect of Different Fermentation Time

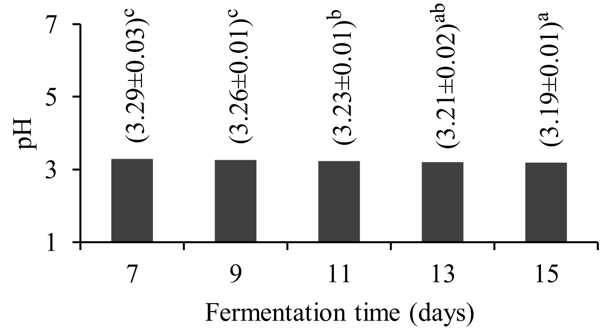
Total Soluble Solid Banana Wine. The total soluble solids of banana wine with different fermentation time can be seen in Fig. 6. Based on Fig. 6, it can be seen that all treatments experienced a decrease in total soluble solids. This can occur because during the fermentation process, yeast will convert sugars such as glucose, fructose, and sucrose into alcohol, carbon dioxide, and organic acids [17]. In addition, it can also be seen that over time, the total soluble solids that are converted are getting lower. This can occur because of a decrease in the activity of yeast in breaking down sugar molecules.



Note: Different letter notations indicate a significant difference ($p \leq 0.05$)

Fig. 6. Effect of different fermentation time on total soluble solid

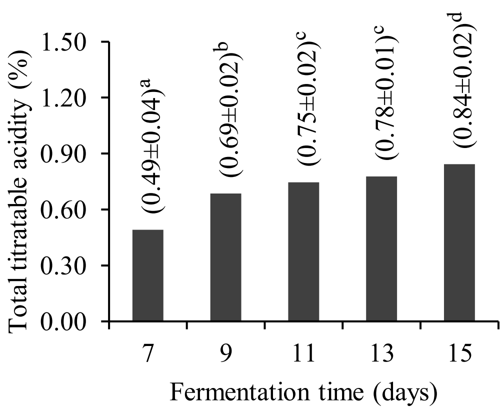
pH Banana Wine. The pH of banana wine with different fermentation time can be seen in Fig. 7. It can be seen that all treatments experience a decreased in pH. Therefore, wine will experience a decrease in pH during the fermentation process. In addition, it can also be seen that longer fermented wine has a lower pH. This can happen because the longer the fermentation process, the organic acids produced also increase. According [20], total titratable acidity is inversely proportional to the pH. Therefore, a longer fermentation period will result in wines with a lower pH because the organic acids produced are higher.



Note: Different letter notations indicate a significant difference ($p \leq 0.05$)

Fig. 7. Effect of different fermentation time on pH

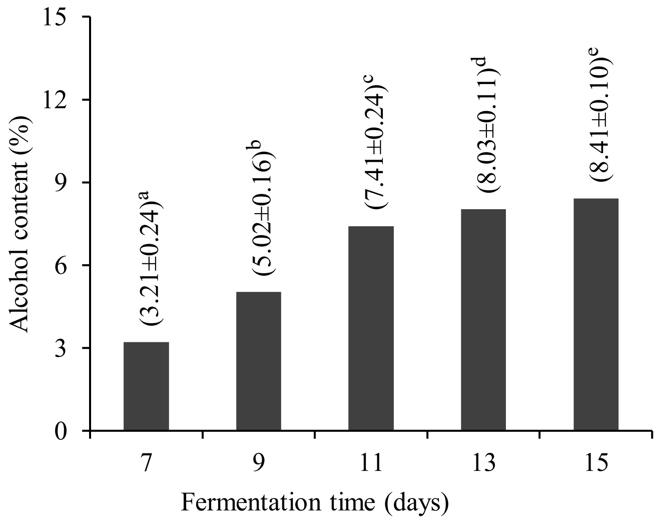
Total Titratable Acidity Banana Wine. The total titratable acidity of banana wine with different fermentation time can be seen in Fig. 8. It can be seen that the banana wine experiences an increase in total titratable acidity as the fermentation time increases. This is because the longer the fermentation process, the organic acids produced also increases. The fermentation process will produce organic acids such as acetic acid, pyruvic acid, citric acid, malic acid, and lactic acid from the breakdown of sugar molecules [21].



Note: Different letter notations indicate a significant difference ($p \leq 0.05$)

Fig. 8. Effect of different fermentation time on total titratable acidity

Alcohol Content Banana Wine. Alcohol content of banana wine with different fermentation time can be seen in Fig. 9. It can be seen that alcohol content increases with an increase in fermentation time. This is because the fermentation process will convert sugar into alcohol, and so a longer fermentation time indicates that more sugar is converted into alcohol [21]. However, the alcohol produced will not always increase with a longer fermentation time. It can be seen from Fig. 19 that the formation of alcohol of the banana wine fermented for 11 days began to decrease. This is due to the decline in yeast activity with an increase in fermentation time [22].

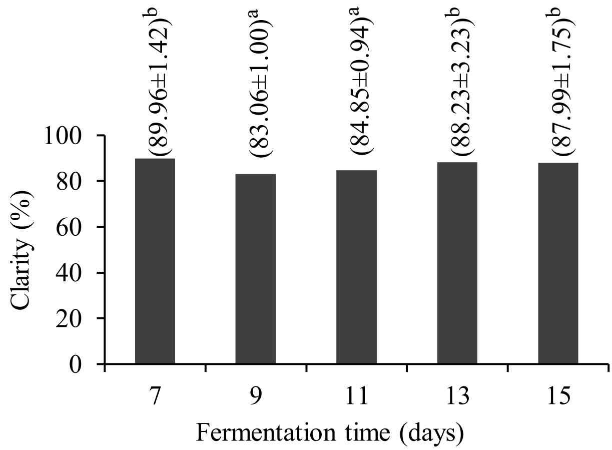


Note: Different letter notations indicate a significant difference ($p \leq 0.05$)

Fig. 9. Effect of different fermentation time on alcohol content

Lightness of Banana Wine. Based on the analysis results, fermentation time does not affect the lightness (L*) of the wine. The lightness of all banana wine samples is in the range 51.70-52.60 and can be categorized as light.

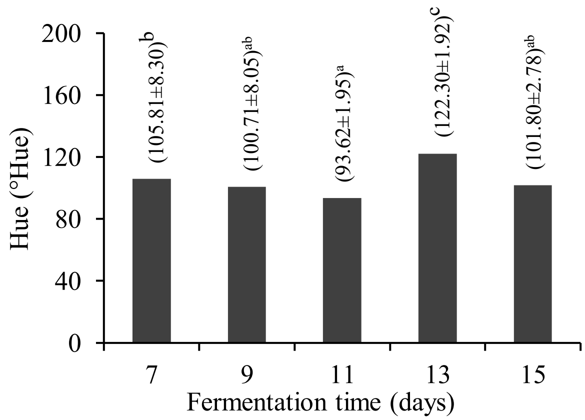
Clarity of Banana Wine. The clarity of banana wine with different fermentation times can be seen in Fig. 10. It can be seen that wine fermented for 7, 13, and 15 days has a significantly higher level of clarity ($p \leq 0.05$) compared to wine that is fermented for 9 and 11 days. According [20], pH can affect the clarity of wine where wine with lower pH, will appear clearer. The results obtained are in accordance with the theory that wines with high pH tends to have lower clarity. This can occur because a high pH will reduce the charge of the suspended particles so that the particles will be suspended longer in the solution [20].



Note: Different letter notations indicate a significant difference ($p \leq 0.05$)

Fig. 10. Effect of different fermentation time on clarity

Color of Banana Wine. The color of banana wine with different fermentation time can be seen in Fig. 11. A hue value of 54-90° indicates a yellowish-red color, a hue value of 90-126° indicates a yellow color, and a hue value of 126-162° indicates a greenish-yellow color. Based on Fig. 11, it can be seen that the fermentation time affects the color of the wine. Wine fermented for 13 days has the highest hue value significantly ($p \leq 0.05$).



Note: Different letter notations indicate a significant difference ($p \leq 0.05$)

Fig. 11. Effect of different fermentation time on color

According to [20], wines with high pH tends to have an amber color, whereas wines with low pH and high acidity tends to have a pale yellow color. However, this does not apply to wines with high sugar content where sugar can affect discoloration. The °Hue of all banana wine samples is in the range 93.62-122.30° and can be categorized as yellow.

3.5 Total Phenolics, Total Flavonoids, and Antioxidant Activity of Selected Banana Wine

Based on the results of the research, the best quality banana wine is made from Mas banana with S. cerevisiae yeast and fermented for 13 days. Analysis of total phenolics, total flavonoids, and antioxidant activity (IC_{50}) are conducted on the selected banana wine. The results can be seen in Table 2.

Table 2. Total phenolics, total flavonoids, and antioxidant activity

Parameter	Analysis result
1. Total phenolics (µg GAE/mL)	56.17±9.42
2. Total flavonoids (µg QE/mL)	7.46±0.98
3. Antioxidant activity (%)	27.96±2.5

Based on Table 2, it can be seen that the banana wine produced has a low flavonoid, phenolic content, and antioxidant activity. According to [23], samples that have an IC50 value of >100 ppm have weak antioxidant activity, whereas samples that have an IC50 value of 10-50 ppm have strong antioxidant activity.

3.6 Comparison of Selected Banana Wine with Commercial Banana Wine

The selected banana wine based on research was then compared with a commercial banana wine, "Deo Gratias", although the type of banana and yeast that is used to produce the commercial banana wine is unknown. The selected banana wine has better in stability with a higher alcohol content, clarity, and lightness compared to the commercial banana wine, but has lower total phenolics, total flavonoids, and antioxidant activity. The lower total phenolics, total flavonoids, and antioxidant activity in the selected banana wine can be due to differences in the type of banana used and the process applied [24].

4 Conclusion

The chosen banana wine from the research was made from banana type pisang mas with S. cerevisiae yeast, whereas the wine that was fermented for 13 days. Those selected banana wine has a higher alcohol content, clarity, and lightness than the commercial banana wine, so the banana wines produced can be recommended for commercial production.

The analysis result of chosen banana wine has a total soluble solid of 13.25°Brix, pH of 3.21, total titratable acidity of 0.78%, an alcohol content of 8.03%, clarity of 88.23%, yellow in color with a °Hue of 122.30, total flavonoids of 7.46µg QE/mL, total phenolic of 56.17μg GAE/mL, IC_{50} of 27.9%, and favored by panelists. The selected banana wine have lower total phenolics, total flavonoids, and antioxidant activity than the commercial banana wine.

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