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# Development of low-alcohol durian wine

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**Abstract** The unusual durian has undergone fermentation to produce a low-alcohol wine. *Saccharomyces cerevisiae* is used to ferment the low-alcohol wine durian. Research findings indicated that a 1:7 durian pulp-to-water ratio and 1.50% w/v yeast cultures were chosen based on their high ($p \leq 0.05$) generation of ethyl alcohol content. The 25 °Brix low-alcohol durian wine was then selected to meet the necessary criteria to get a significantly ($p \leq 0.05$) high preference score in terms of aroma, taste, and overall acceptability, which were 6.70 ± 0.50, 7.30 ± 0.55, and 7.15±0.60, respectively. The ethyl alcohol concentration, total soluble solids, and pH of the resulting wine were 8.30±0.11%, 11.80±0.18°Brix, and 4.19±0.02, respectively. Interestingly, the findings of this study suggested that an innovative beverage could be created, combining the unique flavor of durian with reduced alcohol content and minimizing waste pollution for environmental preservation.

**Keywords:** Low-alcohol, Wine, Durian, Fermentation

## Introduction

Durian (*Durio zibethinus* L.) is a popular and expensive tropical fruit which grown Southeast Asia including Malaysia, Thailand, Indonesia, the Philippines and Viatnam (Aziz and Jalil, 2019). Duo to durian is rich in nutritional component, creamy texture, sweet-bitter taste, unique taste and aroma, and its superlative flesh, so, it's called the "king of tropical fruits" (Aziz and Jalil, 2019; Zhu *et al*., 2015). Moreover, it has been showed high bioactive qualities and nutrient richness, durian pulp has become more popular both historically and currently (Haruenkit *et al*., 2007). Furthermore, durian fruit pulp has been superbly revitalized as a good source of protein (1.47%), fats (5.33%), fiber (3.10%), and carbohydrates (27.00%) (Devalaraja *et al.,* 2011). The main unsaturated fatty acid in durian is linoleic acid, while the main saturated fatty acids are stearic, palmitic, myristic, capric, and arachidic acids (Haruenkit *et al*., 2010). A larger percentage of η-3 fatty acid (polyunsaturated fatty acid) can be

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beneficial and may be associated with a reduction in inflammation, platelet aggregation, blood pressure, and plasma triacylglycerols (Caterina, 2011).

On the other hand, in order to an excess of the fruit during durian season and other fruits, the price of durian has dropped significantly. As a result, there have been numerous obvious attempts to increase the durian fruit crop's worth. Making fruit wines from it is one way to address these issues. Due to its distinct and potent flavor and widespread use in Southeast Asian nations, durian wine is an intriguing choice (Lu *et al*., 2017a). Furthermore, fermentation is the best method for reducing volatile sulfur compounds particularly thiols and disulfides, which some people find undesirable (Lu *et al*., 2018).

Currently, based on the driving policies and health benefits, the low-alcohol beverages (range from <0.5 to 10.5%vol) have become more acceptable in the marketplace and estimates assume a continual growth (Nikolaou *et al*., 2023). According to Bucher *et al.* (2020), the first reason why consumers desire to cut back on their alcohol intake is because they want to be able to drive when intoxicated or because alcohol usage, in general, may be socially unacceptable. A second reason could be that consumers view low-alcohol beverages as a reaction to the rise in dietary-related illnesses. All alcoholic beverages contain ethanol, which is linked to positive changes in a number of cardiovascular biomarkers, including decreased concentrations of fibrinogen and other hemostatic components and increased levels of adiponectin and high density lipoprotein cholesterol (Brien *et al.*, 2011). In addition, wine producers also want to avoid excessive alcohol taxes and try to satisfy shifting customer demands brought on by growing social and health consciousness (Bucher *et al.*, 2018).

For low-alcohol wine fermentation, pre-fermentation, microbiological techniques, and processing technologies have been employed. According to earlier studies, Gill *et al.* (2009) assessed low-alcoholic plum wine preserved with heat treatment. The wine's germs were completely eradicated by the heat treatment, thus it can be used to preserve low-alcohol wines. Additionally, the impact of various finishing fermentation processes on the microbiological stability and quality of low-alcohol sweet white wine is examined by Cui *et al.* (2011). According to the results, combined ultrasonic treatment was the optimum method for finishing fermentation. It had a higher overall fatal rate of *S. cerevisiae*, and the resulting wines had appealing smells and a rich flavor typical of the Italian Riesling grape variety.

For durian wine fermentation, Lu *et al*. (2017b) assessed the chemical effects of co-inoculating three commercial strains of *Oenococcus oeni* with *Torulaspora delbrueckii* in the fermentation of durian wine. The excessive amounts of ethyl acetate (>80 mg/L) in wines co-fermented with the corresponding latter two oenococci were anticipated to have a negative impact on wine fragrance. They also resulted in a marked increase in the formation of lactic and acetic acids. Then, the effects of successive inoculation (Seq-I) of yeast *Williopsis saturnus* with *Bifidobacterium animalis* subsp. *Lactis* (*Lactobacillus casei*) on the fermentation of durian pulp were examined by Lu *et al.* (2018). While the sulfur-containing compounds that were originally present in durian were reduced to trace levels, the addition of *W. saturnus* improved the viability of *L. casei* L26 and produced a variety of volatile compounds (alcohols, esters, and aldehydes) that may improve the aroma profiles of the fermented durian pulp. Utilizing *W. saturnus* in conjunction with the appropriate probiotic combination may be a novel approach to creating probiotic products based on durian. Moreover, Dinata *et al.* (2021) evaluated the impact of adding durian pulp on the properties of Gayo wine coffee. They demonstrated how adding durian pulp considerably changed the amount of ash and caffeine present, but had no discernible influence on the amount of water. Moreover, the sensory score was reduced in terms of over-fermentation by the 30 days of fermentation in the Gayo wine coffee wine combined durian flesh.

Other fruit low-alcohol wine production, higher quantities of aromatic esters and alcohols were found in Zaosu pear wine by Yang *et al.* (2022) using a mixed inoculation of *M. pulcherrima* 346 and *S. cerevisiae* ES488 compared to pure *S. cerevisiae* culture. By employing mixed fermentation with *M. pulcherrima* 346 and *S. cerevisiae* ES488 and adding apple juice. They reported that the accumulation of aromatic esters, higher alcohols, and terpenoids could enhance the bland flavor of pear wine. The initial pH of 3.7, the inoculation ratio of *M. pulcherrima* 346 and *S. cerevisiae* ES488 of 1.5:1, the sequential inoculation time of 45 hours, and the fermentation temperature of 18 ◦C were the optimized mixed fermentation parameters that improved the aroma and taste of pear apple wine with a highlighted novel and distinctively complex flavor. Furthermore, according to Nikolaou *et al.* (2023), essential oils (*Citrus medica*) and low alcohol (~6% vol) wines were made and their qualities were assessed using immobilized kefir cultures on fruit pieces. The relative amounts of terpenes, alcohols, and carbonyl compounds were found to be important in differentiating low-alcohol wine products using principal component analysis (PCA). Besides, the combined effects of lactic acid bacteria (LAB) and yeast on the taste attributes of navel orange wine were investigated by Xiong *et al.* in 2024. Along with increased levels of total phenol and flavonoids, the co-fermentation with the three strains greatly increased the number and variety of volatile compounds in the navel orange wine. The free radical scavenging activity also showed a noticeable improvement.

However, there is currently no research on the manufacturing of durian wine with low alcohol content. Thus, the aim of this study was to examine how the proportion of water to durian pulp affects the fermentation of wine. The optimum treatment was then chosen in order to assess the effect of the yeast starter concentration and the sugar concentration on wine production. Finally, durian wine was determined by sensory evaluation by using a 9-point hedonic scale method.

## Materials and methods

### *Materials*

From previously observation, durian (Mongtong cultivar) was chosen to determination in this research. Durian was purchased from a local farmer in Chanthaburi province, Thailand. Its were then transported to the laboratory and kept in the refrigerator at -20 °C before experiment. *Saccharomyces cerevisiae* in Active Instant Dry Yeast (Proma) was purchased from Thongpitak Trading Limited Partnership, Thailand.

### *Effect of the ratio between durian pulp and water on wine fermentation*

Four ratios of durian pulp and water including 1:5, 1:6, 1:7 and 1:8 were prepared in 15 litter bottles. The solutions were pasteurized at 60 °C for 30 min. Then, 0.5% w/v the active dry yeast was mixed and the solution were then incubated at 37 °C for 6 days. Some chemical and microbiological properties were investigated every 2 days until 6 days. Including, viable cell count, ethyl alcohol content, pH, total soluble solid, phenolic compound and DPPH antioxidant activity were analyzed. For viable cell count determination, total viable count was performed with YPD (Yeast Extract Peptone Dextrose) medium for 48 h inoculation at 37ºC and then reported as log CFU/ml. For chemical properties determination such as ethyl alcohol content, pH, total soluble solids were analyzed by using Ebulliometer (Dujardin-Salleron, France), pH meter (Republic of Singapore) and hand refractometer (Atago, Japan); respectively.

For the total phenolic component content determination, the method of Iqbal *et al.* (2005) was used to examine with few modifications. After extracting about 3 ml of the solution with 30 ml of 80% ethanol, the mixture was agitated for 24 hours. Whatman No. 1 was used to filter the resultant solution. Next, 950 ul of distilled water, 1.60 ml of 7.50% $NaCO_3$, 2 ml of folin-ciocalteu phenol reagent, and 50 ul of filtrated were combined. For 2 hours, the mixture was incubated at 37ºC. At 760 nm, the absorbance was measured. Lastly, the gallic acid standard curve was used to determine the concentration of the phenolic compound.

The capacity to decrease the free radical 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH, Sigma), was the DPPH radical scavenging activity. The Gulcin *et al.* (2003) assay method was adapted to measure the DPPH radical scavenging activity. To summarize, 2 ml of the sample solution were combined with 2 ml of 0.16 mM DPPH in methanol, and the reaction was allowed to finish for half an hour at room temperature in the dark. Next, 2 ml of 80% v/v methanol and 2 ml of 0.16 mM DPPH were combined. Every sample extract was stored at room temperature and in the dark. At 517 nm, the absorbance was measured. The following formula was used to determine the DPPH free radicals' scavenging effect:

DPPH scavenging activity (%) = [(Acontrol – Asample)/Acontrol] x 100

Where Acontrol is the absorbance of the control reaction and Asample is the absorbance of the samples.

### *Effect of the yeast starter concentration on wine fermentation*

In terms of significantly highest ethyl alcohol content production, the best solution from previously section was chosen to evaluate. All samples were pasteurized at 60 °C for 30 min. Four concentrations of Active Instant Dry Yeast (Proma) including 0.50,1.00, 1.50 and 2.00 % (w/v) were added and the solution were then fermented at 37 °C for 6 days. Some chemical and microbiological properties were determined every 2 days until 6 days. Viable cell count, ethyl alcohol content, pH, total soluble solid, phenolic compound and DPPH antioxidant activity were analyzed as mention previously.

### *Effect of the sugar concentration on wine production*

Also, in terms of significantly highest ethyl alcohol content production, the best starter concentration was selected to investigate in this section. First of all, all samples were also pasteurized at 60 °C for 30 min. Four concentrations of sugar such as 10,15, 20 and 25 °Brix were mixed and the solution were then fermented at 37 °C for 4 days. Some chemical and microbiological properties were examined every 2 days until 4 days. Viable cell count, ethyl alcohol content, pH, total soluble solid, phenolic compound and DPPH antioxidant activity were also investigated as mention formally. Lastly, a 9-point hedonic scale was used to evaluate the sensory qualities of those durian wines, including color, aroma, taste, texture, and overall like (Watts *et al.,* 1989) featuring 30 inexperienced panelists from the Food Innovation and Business department's faculty and students (Faculty of Agro-industrial Technology, Rajamangala University of Technology Tawan-Ok, Chanthaburi Campus, Chanthaburi, Thailand).

*Statistical analysis*

Three duplicates of each experiment were conducted using various batches of durian wine. Data were subjected to analysis of variance (ANOVA) ($p < 0.05$). Using computer software, Duncan's multiple range test (DMRT) was used to distinguish significant differences between means within each experiment at a significance threshold of $\alpha = 0.05$ (Helge, 2009).

**Results**

The effect of the ratio between durian pulp and water on wine fermentation, change for ethyl alcohol content, total soluble solid, viable cell count, pH, phenolic compound and antioxidant activity of durian wine samples during fermentation are illustrated in Figures 1,2 and 3. The levels of ethyl alcohol content of four ratio between durian pulp and water tended to be sharply increased at 6 days fermentation. Significantly ($p \leq 0.05$) highest of the amount of ethyl alcohol was exhibited in the ratio for 1:7 which changed the number from 0.00 to 8.07±0.10 for 0 and 6 days fermentation, respectively. In contrast, during the course of six days of fermentation, the amounts of total soluble solids in all treatments continued to progressively decrease. Significantly ($p \leq 0.05$), the ratio of 1:8 had the highest quantity of total soluble solid, dropping from an initial 18.00 °Brix to 8.00 °Brix for 0 and 6 days of fermentation, respectively (Figure 1).

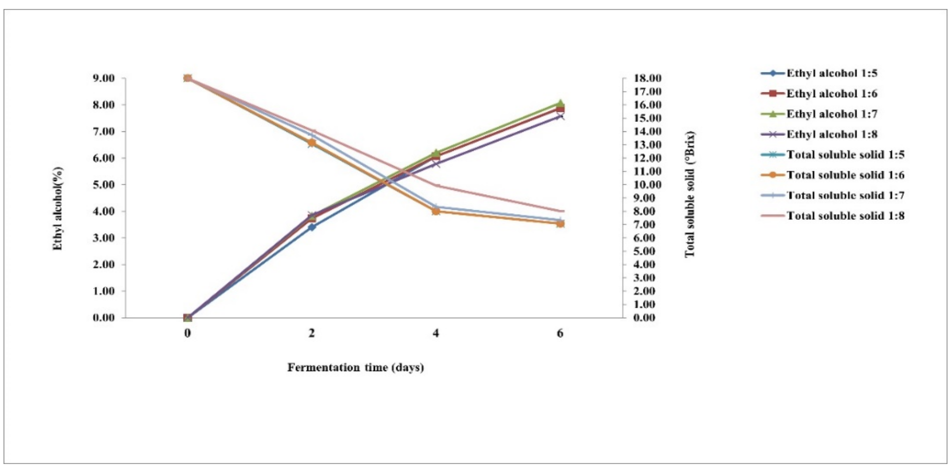


**Figure 1.** Effect of ratio between durian pulp and water on ethyl alcohol and total soluble solid in durian wine fermentation by *S. cerevisiae* during various times

The numbers of viable cell counts tended to increase during fermentation (Figure 2). It was found significantly highest in the ratio 1:7, which was the number from 3.21 ± 3.21 3.21±0.04 to 0.05 log CFU/ml for 0 and 6 days of fermentation, respectively. Nevertheless, the levels of pH of all treatments were still similarly between 4.13 and 4.29.

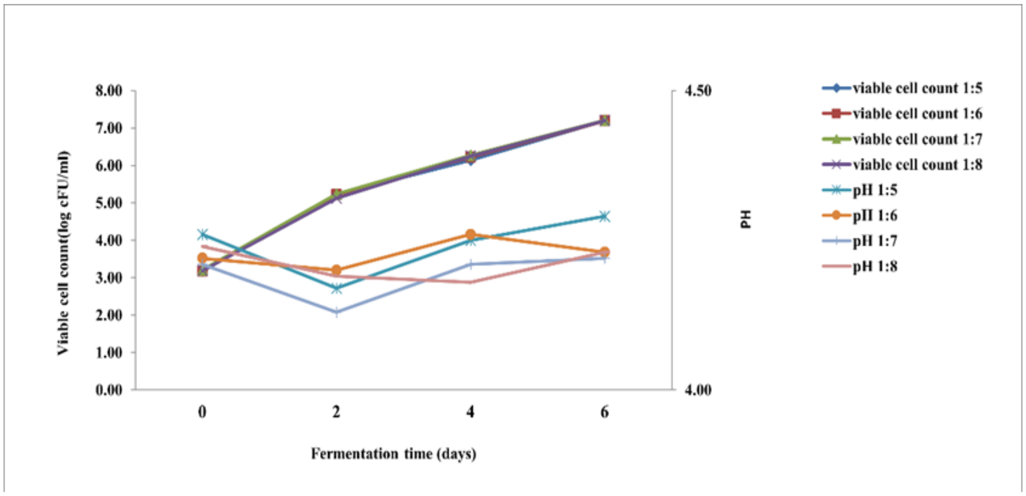


**Figure 2.** Effect of ratio between durian pulp and water on viable cell count and pH in durian wine fermentation by *S. cerevisiae* during various times

The amount of durian pulp increased for both phenolic compounds and antioxidant activity, following the same trend. The highest phenolic compound was exhibited in the ratio 1:5 which was the values from 1.52±0.04 to 1.55±0.02 mg/ml for 0 and 6 days of fermentation, respectively. The antioxidant activity (DPPH) was significantly highest in the ratio 1:5 which was the values from 5.03± 0.03 to 5.39±0.10 % for 0 and 6 days of fermentation, respectively. Furthermore, the antioxidant of all treatments exhibited slightly increased which depended on the time fermentation and then significantly ($p\leq 0.05$) highest at 6 days fermentation (Figure 3).

Subsequently, based on the significantly higher ethyl alcohol content, the ratio of durian pulp to water of 1:7 was chosen to continue to determine the effect of yeast starter concentration on wine fermentation. Four concentrations of yeast starters, including 0.50, 1.00, 1.50, and 2.00% (w/v), were observed. The numbers of ethyl alcohol of all concentrations were also increased, while the total soluble solids dropped at 6 days of fermentation. Significantly ($p \leq 0.05$), the highest alcohol content was shown in the 1.5% w/v yeast concentration, with the number 8.80±0.18 % at 6 days of fermentation. For the level of pH and viable cell count were exhibited in the same trend as previous results. The viable cell was increased, whereas the pH had similar values in all of the treatments (Figure 5).

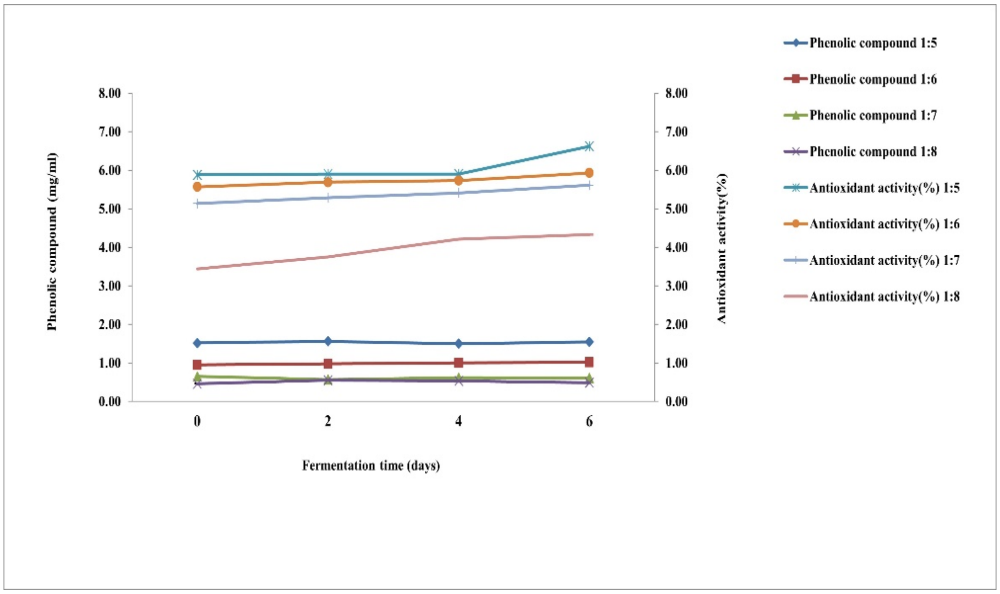


**Figure 3.** Effect of ratio between durian pulp and water on phenolic compound and antioxidant activity in durian wine fermentation by *S. cerevisiae* during various times

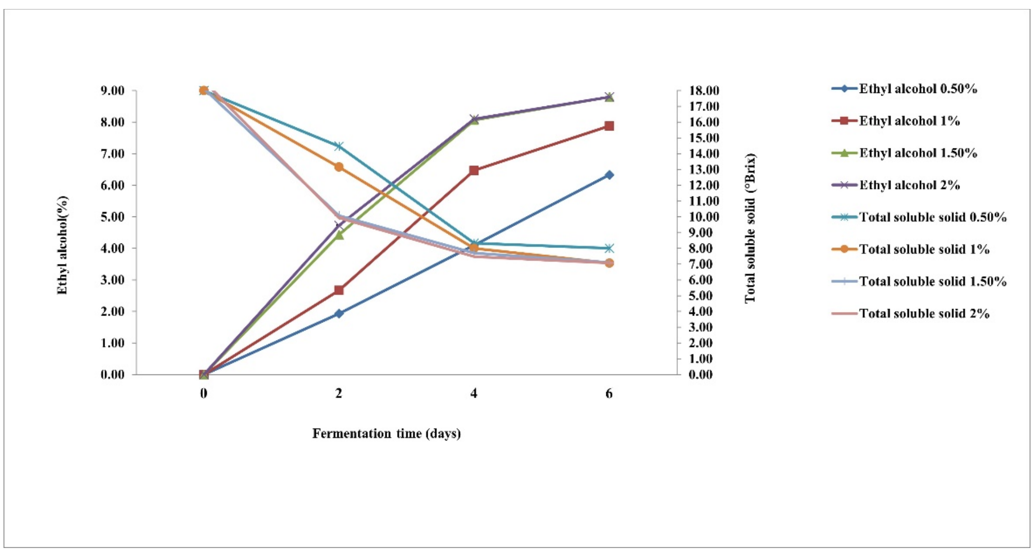


**Figure 4.** Effect of yeast stater concentration on ethyl alcohol and total soluble solid in durian wine fermentation by *S. cerevisiae* during various times

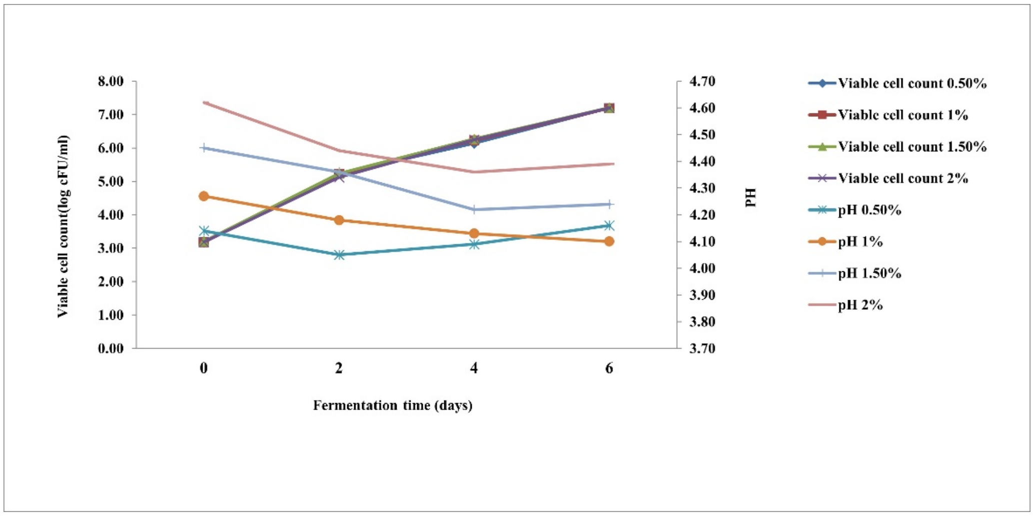


**Figure 5.** Effect of yeast stater concentration on viable cell count and pH in durian wine fermentation by *S. cerevisiae* during various times

The high concentrations of yeast were found to increase phenolic compounds (Figure 6). Moreover, the phenolic compound and antioxidant activity also showed the same results. Significantly ($p \leq 0.05$), the highest phenolic compound content was exhibited in 2% yeast concentration, which was the numbers from 0.69 ± 0.06 to 0.72 ± 0.07 mg/ml for 0 and 6 days of fermentation, respectively.

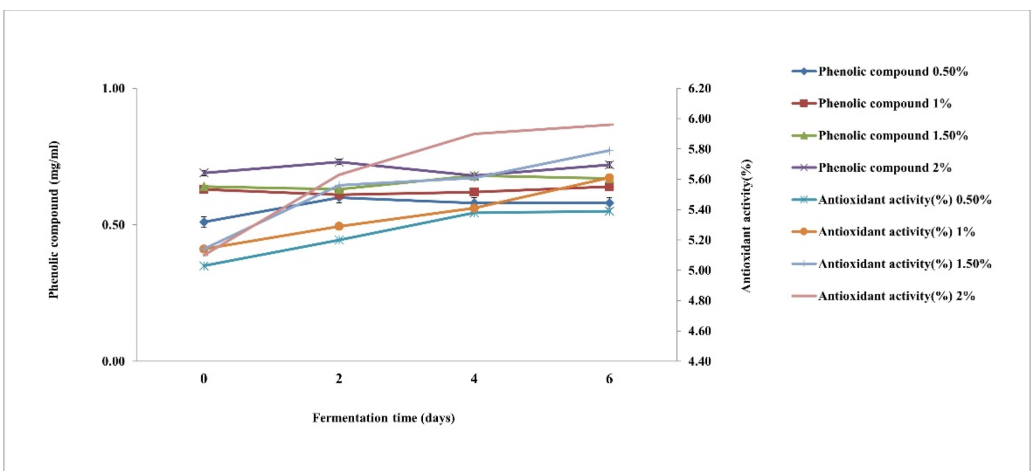


**Figure 6.** Effect of yeast stater concentration on phenolic compound and antioxidant activity in durian wine fermentation by *S. cerevisiae* during various times

Ethyl alcohol production 1.50% w/v was significanty high to investigate the effect of sugar concentrations on wine fermentation. Four sugar concentrations, such as 10, 15, 20, and 25°Brix, were performed which. changed in the levels of ethyl alcohol, total soluble solids, pH, viable cell count, phenolic compounds, and antioxidant activity were found in the same trends (Figures 7, 8, and 9).

Due to producing low-alcohol durian wine, the fermentation time was changed to 4 days. During fermentation, the values of ethyl alcohol content of four sugar concentrations also tended to increase, while the levels of total soluble solids of all treatments decreased. The amount of ethyl alcohol was significantly highest in 25 °Brix, which changed the numbers from 0.00±0.00 to 8.30±0.11 for 0 and 4 days of fermentation. On the other hand, the total soluble solid was significantly highest in 25 ° Brix, which changed the values from 25.13±0.21 to 11.80±0.18 °Brix for 0 and 4 days of fermentation (Figure 7).

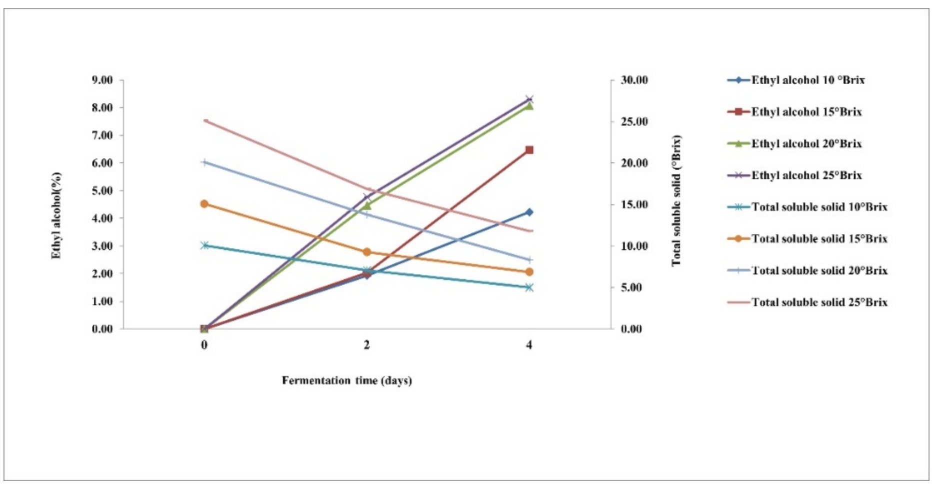


**Figure 7.** Effect of sugar concentration on ethyl alcohol and total soluble solid in durian wine fermentation by *S. cerevisiae* during various times

The levels of viable cell counts still tended to increase during fermentation (Figure 8). The most significant increase was exhibited at 25° Brix, which was the numbers from 3.38±0.02 to 6.28±0.01 log CFU/ml for 0 and 4 days of fermentation. For pH, the values of pH of all treatments were also found at 25 °Brix, which were the numbers 4.24±0.01 and 4.19±0.02 for 0 and 4 days of fermentation.

Based on phenolic compounds, the sugar durian wine showed a high amount, while the antioxidant activity was found in opposite levels. The antioxidant activity tended to increase during fermentation. The significantly highest phenolic compound was exhibited at 10° Brix, whereas the significantly lowest was shown at 25° Brix, which were the numbers of 0.77±0.04 to 0.56±0.06 mg/ml for 4 days of fermentation. In contrast, for antioxidant activity, the significantly highest was shown in 25 °Brix and the lowest was found in 10 ° Brix, which were the levels of 5.60 5.60±0.08 and 5.24±0.04 % for 4 days of fermentation (Figure 9).

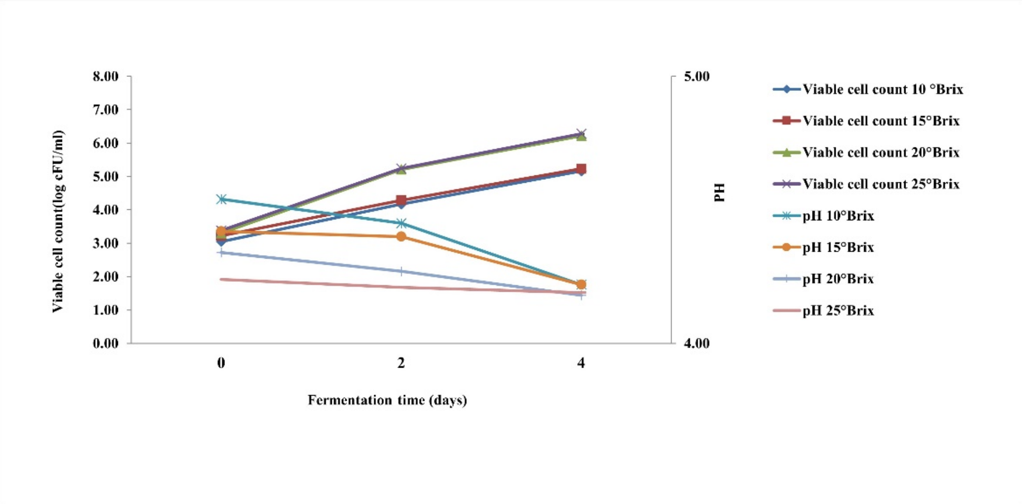


**Figure 8.** Effect of sugar concentration on viable cell count and pH in durian wine fermentation by *S. cerevisiae* during various times

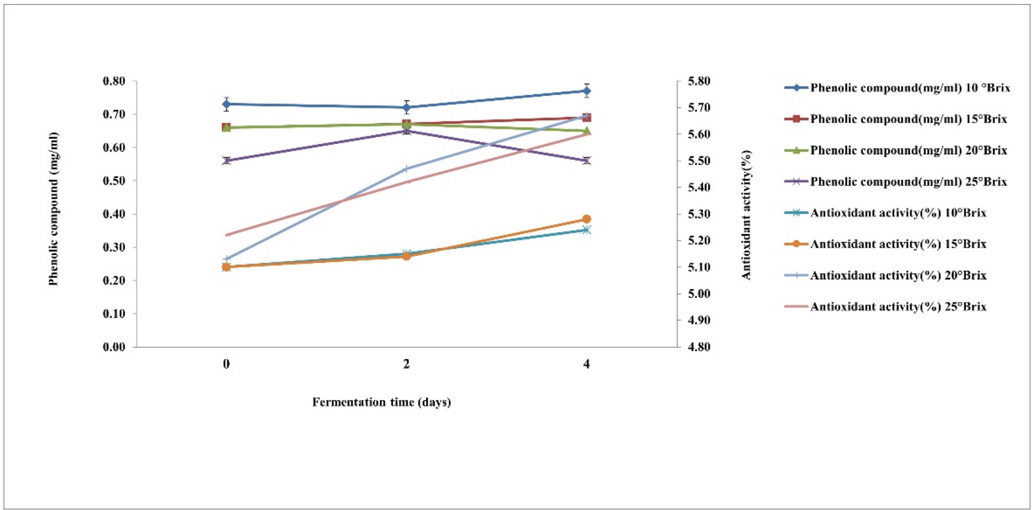


**Figure 9.** Effect of sugar concentration on phenolic compound and antioxidant activity in durian wine fermentation by *S. cerevisiae* during various times

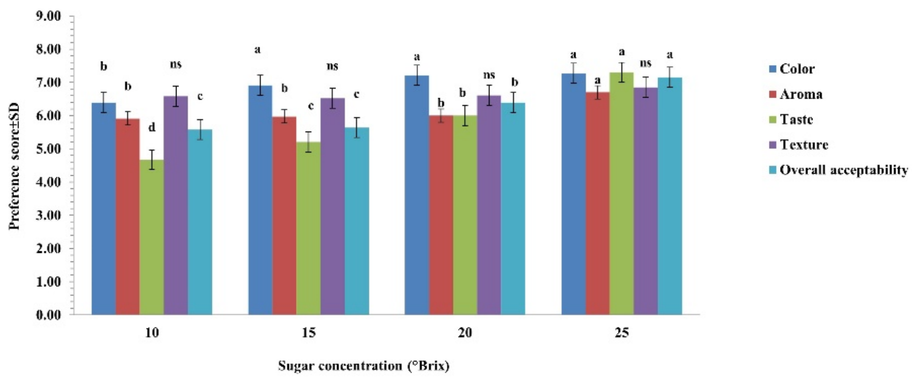


**Figure 10.** Sensory evaluation of durian wine with various concentrations of sugar

Then, four low-alcohol durian wines were sensory evaluations with 9-point hedonic scaling. Results found that the increasing of the preference score of overall acceptability depended on the amount of sugar added. The preference scores were significantly highest for aroma, taste, and overall liking which exhibited in 25 °Brix durian wine, which scored 6.70 ± 0.50, 7.30 ± 0.55, and 7.15 ± 0.60, respectively. In addition, the preference score of 25 °Brix durian wine for texture was not significantly differed (Figure 10). Then, the obtained wine had an ethyl alcohol concentration, total soluble solids, and pH of 8.30±0.11%, 11.80±0.18, and 4.19±0.02, respectively.

## Discussion

From the estimation effect of ratio between durian pulp and water on wine for 6 days fermentation, alcohol content, total soluble solid, viable cell count, pH, phenolic component, and antioxidant activity of durian wine samples were impact of the ratio of durian pulp to water on wine fermentation. At six days of fermentation, the ethyl alcohol concentration of the four ratios of durian pulp to water showed a significant increase. The ratio for 1:7 showed the highest amount of ethyl alcohol. However, during six days of fermentation, the amounts of total soluble solids in all treatments continued to progressively decrease in the same manner. Significantly ($p \leq 0.05$), the ratio of 1:8 had the highest quantity of total soluble solid. The number of viable cell counts tended to be increase during fermentation, wherease, the levels of pH of all treatments were still similarly. It's possible that *S. cerevisiae* used the sugar in durian wine to produce ethyl alcohol and synthesize cells without the need for pH correction or nutrient supplements (Fleet, 2003). Consequently, this study made it clear that the total soluble solids and alcohol concentration were the increasing and decreasing trends discovered in this observation. Furthermore, our findings agree with those of Lu *et al.* (2017b) and Lu *et al.* (2018), who reported that the total soluble solids decreased during fermentation, with the °Brix value rapidly dropping, and that the amount of sucrose dropped significantly when fermented with certain probiotics and yeast.

The amount of durian pulp increased for both antioxidant activity and phenolic substances in the same direction. This could be durian pulp contains various phenolic compounds, including hydroxycinnamic acids (e.g., caffeic, p-coumaric, ferulic acids) and hydroxybenzoic acids (e.g., gallic acid), which are known for their antioxidant properties (Aziz and Jalil, 2019). In addition, the antioxidant capacity of durian pulp is often assessed using assays like DPPH (1,1-diphenyl-2-picrylhydrazyl), which evaluate the ability of the pulp to scavenge free radicals or reduce metal ions. Therefore, higher concentrations of phenolic compounds in the pulp enhance its performance in these assays (Charoenphun and Klangbud, 2022). Furthermore, the antioxidant of all treatments showed a rise with the duration of fermentation, reaching its greatest level at 6 days.

Based on the significantly highest ethyl alcohol content. the durian pulp to water ratio of 1:7 was selected to investigate for yeast starter concentration on wine fermentation. Yeast starter concentrations for instance 0.50, 1.00, 1.50, and 2.00 percent (w/v) were observed. At six days of fermentation, the amount of ethyl alcohol in all concentrations also rose, wherease the amount of total soluble solids decreased. At 6 days of fermentation, the 1.5% w/v yeast with the greatest alcohol content ($p \leq 0.05$) had a number of 8.80±0.18%. In addition, both the pH level and the number of viable cells showed the same pattern as earlier findings. While, the pH remained constant across all treatments, the number of viable cells increased depending the time fermentation. The high concentrations of yeast effected to increase phenolic compound. *S. cerevisiae* produces enzymes such as β-glucosidases that can hydrolyze glycosidic bonds in phenolic glycosides, releasing free phenolic compounds. So, at higher yeast concentrations, the increased enzymatic activity can enhance the release of these compounds, leading to higher concentrations in the fermented product. This process is often observed in fruit-based fermentations, where the yeast's enzymatic action contributes to the development of the beverage's flavor and antioxidant properties (Swiegers *et al*., 2005).

The impact of sugar concentrations on wine fermentation to further investigation, 1.50 % w/v was chosen due to the ethyl alcohol production being significantly high ($p \leq 0.05$). Four different sugar concentrations such as 10,15, 20, and 25 Brix were performed. Similar patterns to those previously described, the changes in ethyl alcohol, total soluble solids, pH, viable cell count, phenolic compound, and antioxidant activity were seen. Four low-alcohol durian wines were then subjected to sensory evaluations using a nine-point hedonic scale. According to our findings, 25 °Brix durian wine had the greatest preference scores for aroma, taste and overall linking ($p \leq 0.05$). This could be sweetness perception can also enhance the intensity of aroma. Studies have shown that the presence of sweetness can amplify the perception of certain volatile compounds, leading to a more pronounced aroma. This interaction suggested that higher sugar concentrations in durian wine could enhance its aromatic profile, so, the higher preference scores observed in this observation (Zhang *et al*., 2023).

In conclusion, the findings of the study indicated that the optimal combination for producing low-alcohol durian wine was a 1:7 durian pulp and water, 1.5% (w/v) starter culture, followed by a 25 °Brix sugar. The produced durian wine has a distinct durian scent and is a clear yellow tint. The results of this study enhanced the value of durian and decreased waste pollution in terms of environmental protection. Additionally, by combining the unique flavor of durian with a lower alcohol content, low-alcohol durian wine is a novel beverage that appeals to a larger spectrum of consumers. However, further research is required on the production process, curing time, yeast strains, and other relevant topics in order to preserve quality and flavor while lowering the alcohol concentration.

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## Conflicts of interest

The authors declare no conflict of interest.

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