*Journal of Applied Agricultural Science and Technology*
*7(4): 365-376(2023)*
*E-ISSN: 2621-2528*
*ISSN:2621-4709*

# CHARACTERISTICS OF GANDARIA (*Bouea macrophylla* Griff) FRUIT WINE FROM PRIMARY FERMENTATION AND 14 DAYS AGING WITH DIFFERENT COMMERCIAL YEAST TYPES AND CONCENTRATIONS

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***Abstract***. *Gandaria fruit wine, however, is still made using a straightforward fermentation procedure, hence the final product is murky. The correct variables for judging fruit wine quality still require a number of optimization procedures to be carried out. The purpose of this research was, therefore, to compare the primary fermentation and aging effects of different commercial yeast types on the physicochemical properties of gandaria fruit wine. Aging for 14 days caused a significant decrease in the characteristics of gandaria wine produced with different commercial yeast types and concentrations compared to the freshly fermented wine. Total sugar, total acidity, vitamin C, total soluble solids, and turbidity were among the characteristics that decreased. Whereas with aging, the alcohol content and pH values increased. The gandaria wine produced with commercial yeast Pakmaya at a 2.5% concentration was found to be the best due to the alcohol content that complied with the standard for fruit wine and had the clearest resulting wine both for the primary fermentation and the 14-day aging.*
***Keywords:*** *aging; characteristics; gandaria wine; primary fermentation*

## 1. Introduction

In recent years, global economic expansion has centered on the use of resources for production and consumption, which creates environmental deterioration and is unsustainable. Therefore, a new method, the green economy, is required to foster inclusive, sustainable economic development and preserve the environment from destructive exploitation operations. Indonesia adopts a green economy initiative in an effort to change its economic structure into one that emits less greenhouse gases and sustains high economic growth.

By increasing the added value of commodities that give economic worth without creating environmental degradation, the development of food products through the utilization of local resources can contribute to the economic growth of the community. Gandaria fruit (*Bouea macrophylla* Griff.) is one of the indigenous commodities that can be exploited to boost added value and economic worth. Gandaria is one of the Maluku-native exotic annual fruit plants that must be cultivated due to its economic and ecological value (Papilaya, 2016; Sumanik *et al*., 2017; Taihuttu, 2013a; Taihuttu, 2013b). Due to their dense and compact crown form and well-developed and robus troots, Gandaria plants are frequently employed as conservation plants to avoid soil erosion. Gandaria's population is diminishing because it is being cleared for residential and



*Received May 10, 2023; Accepted August 22, 2023; Published November 24, 2023*
***https://doi.org/10.55043/jaast.v7i4.171***

commercial development. This must be averted by cultivating gandaria, which will be successful if the added value of gandaria fruit can be increased effectively. Its added value and economic value rise, and more people cultivate the plant.

Because gandaria fruit is easily damaged an d cannot be stored for an extended period of time after harvest, its added value and economic value can be increased by processing it into a variety of processed products. Fruit wine is an example of a processed fruit that can be used with gandaria. Wine made from fruits other than grapes is known as "fruit wine" (Onofri, 2022). The production of fruit wine is increasing steadily, and the market potential is substantial and closely tied to the development of functional products. To reduce post-harvest losses, fruit wine production is an integral part of the fruit processing industry. Fruit wine is a value-added product that contains numerous important components, including minerals, antioxidants, and phytonutrients, such as carotenoids (carotene and lutein), phenolic compounds (anthocyanins, flavonols, phenolic acids), and aromatic compounds derived from the fruit used (Velic *et al*., 2018; Velić *et al*., 2018). Fruits such as apples, strawberries, and peaches are also utilized in the production of fruit wine. Also, tropical fruit varieties, such as mango (Pino & Queris, 2011), banana (Isitua & Ibeh, 2010), and lychee (Alves *et al*., 2011), have been transformed into increasingly popular fruit wines. Thus, gandaria, a Maluku-native exotic tropical fruit, can be used as the primary ingredient in fruit wine.

Gandaria fruit wine, however, is still made using a straight forward fermentation procedure, hence the final product is cloudy. The correct variables for judging fruit wine quality still require a number of optimization procedures to be carried out (Reboredo-Rodríguez*et al*., 2015). One of the important processes in wine making to produce high quality wine is aging (Tao *et al*., 2014; Ugliano, 2013). Only in Maluku can gandaria fruit wine be sourced in sufficient quantities to allow for its production into a high-quality beverage that can boost the local economy, contribute to environmental sustainability, and serve as a draw for tourists, especially those from abroad.

The purpose of this research was, therefore, to compare the primary fermentation and aging effects of different commercial yeast types on the physicochemical properties of gandaria fruit wine.

## 2. Methods

### 2.1. Materials

Gandaria fruit was harvested in Hutumuri Village, Ambon, Indonesia, in March 2022. Only fruits with a good appearance (without physical damage, rot, or obvious contamination) were chosen from the ripe fruits after they had been cleaned in clean water to remove residue. The fruits' pulps were removed after they had been peeled. The pulps were then kept at -20 °C in the 1 kg plastic bags. Other materials used were commercial yeast (baker's yeast, Fermipan and Pakmaya), sugar, citric acid, and chemicals.

## 2.2. Gandaria Wine Production

To prepare the fermenting must, gandaria pulp was defrosted at room temperature and 1 part of the pulp was crushed and blended with 2 parts of water. Based on the final volume of the must, 40% sucrose was added. The must was then pasteurized at 80 °C for 30 minutes, then cooled to 30 °C, before the pH of the must was adjusted to 4.7 using citric acid. Four fermentation batches were performed: two of them were inoculated with commercial baker's yeast Fermipan (2.5% and 5.0%), and the other two were inoculated with Pakmaya (2.5% and 5.0%). Each one of the fermentative processes was conducted in duplicate.

Fermentations were carried out in a 1.5-litre (500 ml of must) bottle with a fermentative air lock for 2 weeks. After 2 weeks, the fermentation was considered complete when no bubbles appeared in the air lock. The wines were racked to a container at the end of fermentation to promote sedimentation of solid material from the gandaria pulp. The wine was then stored for 14 days at room temperature prior to analysis. The fresh wine from the primary fermentation and the 14-day wine were subjected to the analysis for alcohol content, total acidity, total sugar, vitamin C, pH, total soluble solids, and turbidity.

### a. Alcohol content

Alcohol content is determined using qualitative techniques. A 100 mL sample was placed in a distilling vessel and then distilled. The results of distillation were accommodated to a line mark using a pycnometer. After 15 minutes of cooling at 25°C, the pycnometer was weighed. The weight of an unfilled pycnometer and the weight of water at 25°C were calculated for comparison. The sample's ethyl alcohol concentration was depicted in the table depicting the relationship between alcohol concentration and specific gravity at different temperatures.

### b. Total sugar

10 g of ingredients were weighed and combined with 50 mLof distilled water in a 100-mL measuring vial. Pb-acetate (Merck, Germany) was introduced drop by drop until the reagent no longer caused cloudiness, after which distilled water was added and filtered to the marked line. Utilising a 200-mL measuring vial, the filtrate was contained. To remove excess Pb, sufficient anhydrous $Na_2CO_3$ (Merck, Germany) was added, followed by the addition of distilled water to the marked line, vortexing, and filtration. When Pb-free filtrate was added to anhydrous $Na_2CO_3$, the filtrate remained transparent. In an Erlenmeyer flask, 25 mLof Pb-free filtrate was pipetted, and 25 mL of Luff-Schoorl solution (Merck, Germany) was added. In addition, 25 mL of Luff-Schoorl solution and 25 mL of water were used to produce blanks. After attaching the Erlenmeyer

flask to a reverse cooler and adding a few grains of boiling stone, the vessel was heated to a boil. For ten minutes, the solution was heated to a simmer. Next, 15 mL of KI 20% (Merck, Germany) and 25 mL of $H_2SO_4$ 26.5% (Merck, Germany) were added with care. Afterwards, the liberated iodine was titrated with a 0.1 N sodium thiosulfate solution (Sigma-Aldric, New Zealand) using a 2–3 mL starch indicator. To clarify the colour change at the conclusion of the titration, starch should be added near the end of the procedure.

**c. Total acidity**

A 10 g sample was deposited in a 100 mL measuring flask, water was added to the line, and the flask was shaken and filtered with standard filter paper. The results of the filter were collected in upto 50 mL, dripped with pp indicator (Merck, Germany), and titrated with NaOH 0.1 N (Merck, Germany). Total acidity was determined according to the method described in Formula (1) (AOAC, 2019).

$$\text{Total acidity (\%)} = \text{mL NaOH} \times \text{N NaOH} \times \text{sample weight} \times 100 \quad (1)$$

**d. Vitamin C**

A 10 mL sample was added to a 100 mL measuring vial until the line was reached. 25 mL of filtrate was poured into 1 mL of amylum (Merck, Germany) and 0.1 N KI (Merck, Germany) was added until a colour change occurred. Vitamin C was computed using the following Formula (2) (AOAC, 2019).

$$\text{Vitamin C (mg/100g)} = mL\ KI \times 0.88 \times \text{dilution factor} \times \text{sample weight} \times 100 \quad (2)$$

**e. pH**

Samples of fruit wine gandaria, both fresh and aged, of as much as 30 mL were put into a 50 mL beaker glass, and pH was measured using a pH metre (Ezdo 5011, Taiwan), which had previously been calibrated using a pH 7 buffer solution.

**f. Total soluble solids**

Total soluble solids were determined by hand refractometer.

**g. Turbitidy**

Wine turbidity was measured by turbidimetri equipment (Hanna Instrument HII83749, USA).

## 3. Results and Discussion

### 3.1. Alcohol Content

Figure 1 depicts the alcohol content of gandaria wine after primary fermentation and 14 days of aging. The percentage of alcohol ranged from 8.77% to 18.52%. Fermipan yeast produced less alcohol than Pakmaya yeast in primary fermented wines. Each commercial yeast concentration of 2.5% resulted in a lower alcohol content than the concentration of 5.0% and was significantly different from one another. Except for the Pakmaya yeast (5.0%), both Fermipan yeasts (2.5% and 5.0%) and Pakmaya yeast (2.5%) experienced an increase in alcohol content after 14 days of aging. Fermipan's 2.5% and 5% wines had no statistically significant alcohol content, whereas Pakmaya's 2.5% and 5.0% were significantly different from each other and from Fermipan's.

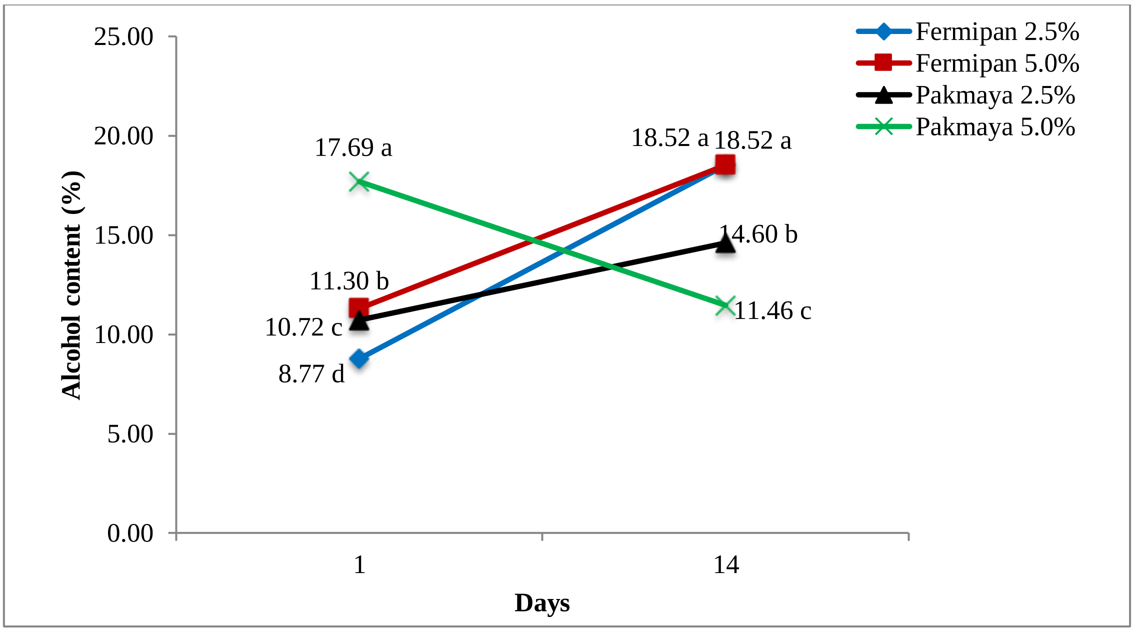


Figure 1. Alcohol content of fresh and 14-day gandaria wine from different commercial yeast types and concentration

The alcohol level after primary fermentation of Fermipan 2.5%, Fermipan 5.0%, and Pakmaya 2.5% corresponds to the typical alcohol concentration (ethanol) of grapes, which is between 8 and 15% (SNI 01-4019-1996). In contrast, Pakmaya 5.0% has exceeded the standard limit with an alcohol concentration of 17.69%. The alcohol content produced was proportional to the yeast concentration. This is because, with a larger yeast concentration, the fermentation kinetics improved dramatically (Swami *et al.*, 2014), resulting in an increase in alcohol content. 14 days after primary fermentation, there was a rise in the alcohol concentration of gandaria wine. When the pressure inside the storage container rises at high temperatures, water molecules are able to permeate out, causing the alcohol to become less liquid and its volume fraction to increase (Matei & Koseva, 2017). Both 2.5% and 5.0% of the alcohol level of Pakmaya's gandaria wine remained compliant with the standard after 14 days.

### 3.2. Total Sugar

After primary fermentation and 14 days of aging with various yeast types and concentrations, the total sugar content of gandaria wine ranged from 9.87% to 29.04%. (Figure 2). The total sugar content of wine fermented initially with Pakmaya yeast was greater than that of wine fermented initially with Fermipan yeast, and increased with increasing concentrations of both types of yeast. The total sugar of wines fermented with Pakmaya yeast decreased significantly after 14 days, while the total sugar of wines fermented with Fermipan yeast increased slightly.

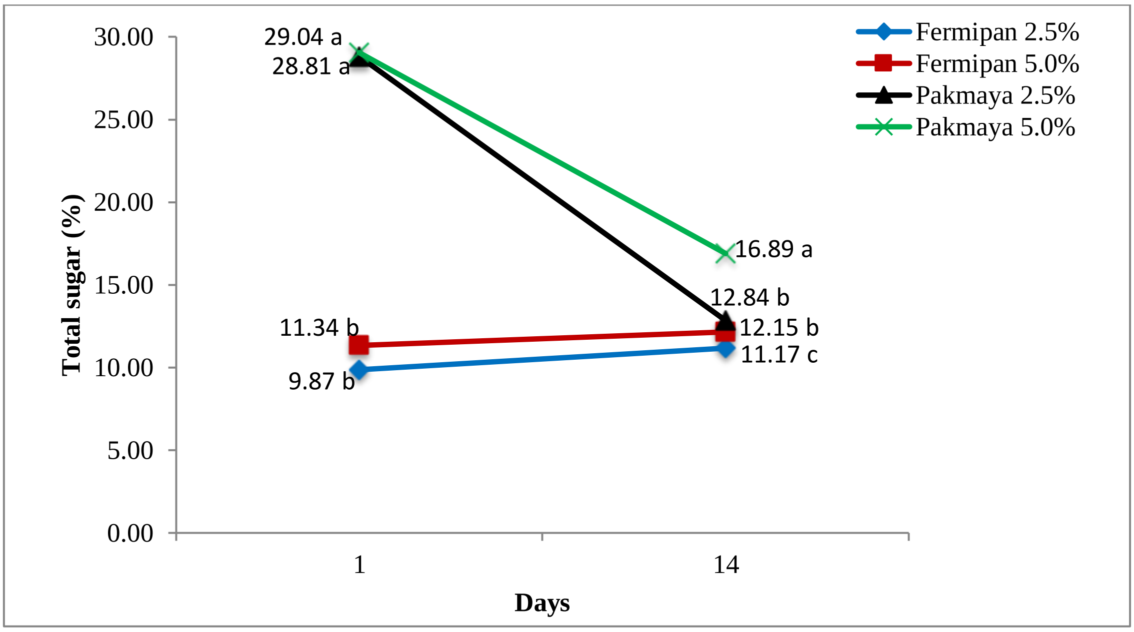


Figure 2.Total sugar of fresh and 14-day gandaria wine from different commercial yeast types and concentration

When the alcohol content reaches 11–12%, the fermentation process will encounter difficulties or even cease. Fermipan yeast converts substrates into products at a lower rate than Pakmaya yeast, as indicated by the alcohol content results. The risk of incomplete fermentation and unfermented sugar, or residual sugar, in wine is increased by an 11% alcohol content. Pakmaya's yeast with a higher alcohol content damages yeast cells and their transport system, which completely inhibits sugar consumption (Conde *et al*., 2007), resulting in Pakmaya's yeast-fermented wine having more total sugar than Fermipan yeast-fermented wine. Higher total sugar is also the result of a higher yeast concentration for the same reason that yeast concentration increases total sugar.

### 3.3. Total Acidity

Gandaria wine with different types and concentrations of yeast after primary fermentation and aging for 14 days had the total acidity ranging from 0.06%–2.30% (Figure 3). The lowest total acid produced by primary fermentation was 1.94% from 2.5% Pakmaya yeast and significantly different from Fermipan's 5.0%, but not significantly different from Fermipan's 2.5% and Pakmaya's 5.0%.

The total acidity of the wine decreased after 14 days of aging from all types and concentrations of yeast. The total acidity of wine with 5% Fermipan yeast was not significantly different from that with 2.5% Fermipan yeast, but it was significantly different with the two concentrations of Pakmaya yeast.

Even if the fruit has been fermented, the content of organic acids such as malic acid, tartaric acid, and small amounts of citric acid are usually included. Other acids found in wine, such as succinic acid, lactic acid, and acetic acid, are produced by alcoholic fermentation or malolactic fermentation. During fermentation, the yeast consumes some of the malic acid in the juice, and the malic acid content decreases during malolactic fermentation. The ideal acid content in wine is between 0.65-0.85 g/100 mL (%) (Conde *et al.*, 2007). According to SNI 01-4019-1996, the maximum total acid calculated in the acetic acid content is 0.2%. Thus, the total acidity of the primary fermented wine is still far above the standard total acid limit, whereas the wine after 14 days of aging meets the requirements for total acid in general, and those produced with Pakmaya's yeast at 2.5% and 5.0% meet the SNI requirements.

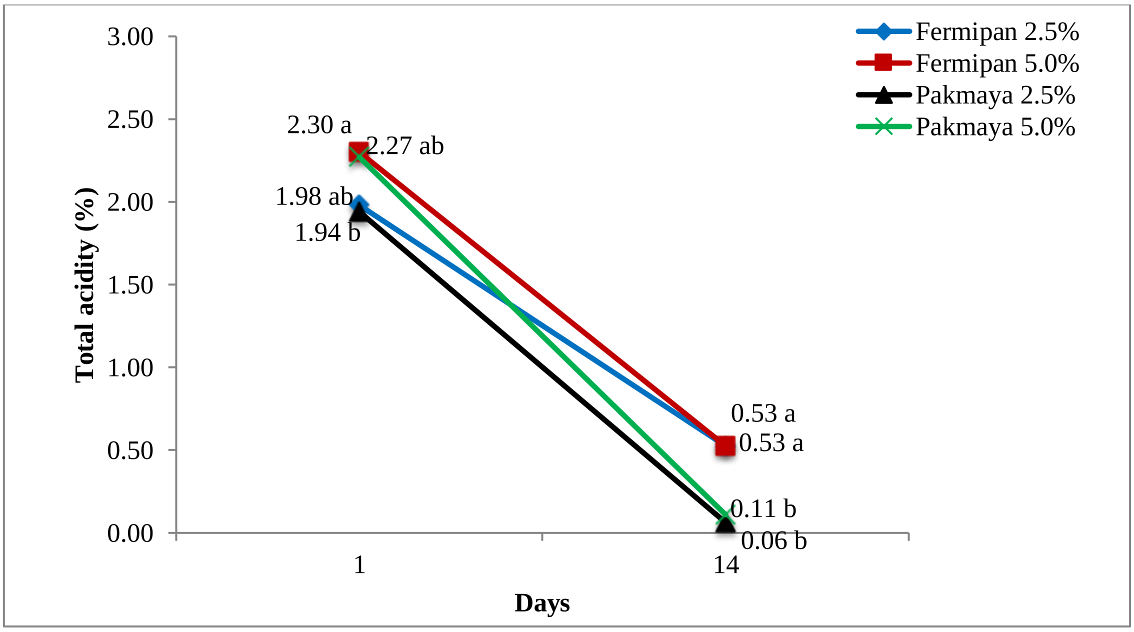


Figure 3. Total acidity of fresh and 14-day gandaria wine from different commercial yeast types and concentration

### 3.4. Vitamin C

The vitamin C content of gandaria wine was 0.88-2.90 mg/100 g after primary fermentation and 0.88-2.90 mg/100 g after 14 days of aging (Figure 4). Gandaria contains approximately 111 mg of vitamin C per 100 g. The wine's vitamin C content decreased during both primary fermentation and 14-day aging. The vitamin C content of different primary fermented wines varied significantly. Fermipan, with a concentration of 2.5%, had the highest value (2.90 mg/100 g) and was significantly different from all other treatments. It was clear that yeast at 2.5% concentration for both Fermipan and Pakmaya produced primary fermented wine with a higher vitamin C content than yeast at 5.0% concentration.

The value of the vitamin C content of wine from all types and concentrations of yeast decreased dramatically after 14 days of aging, although it did not differ significantly at that point. Vitamin C level drops off during the production of alcohol. Ascorbic acid comes into contact with dissolved oxygen when yeast is inoculated and takes over the fermentation environment. Similarly, when mixing, outside oxygen enters the fermentation environment. These factors lead to wine deterioration and a reduction in its vitamin C concentration (Cendrowski *et al.*, 2021). In the course of aging, ascorbic acid also decreased.

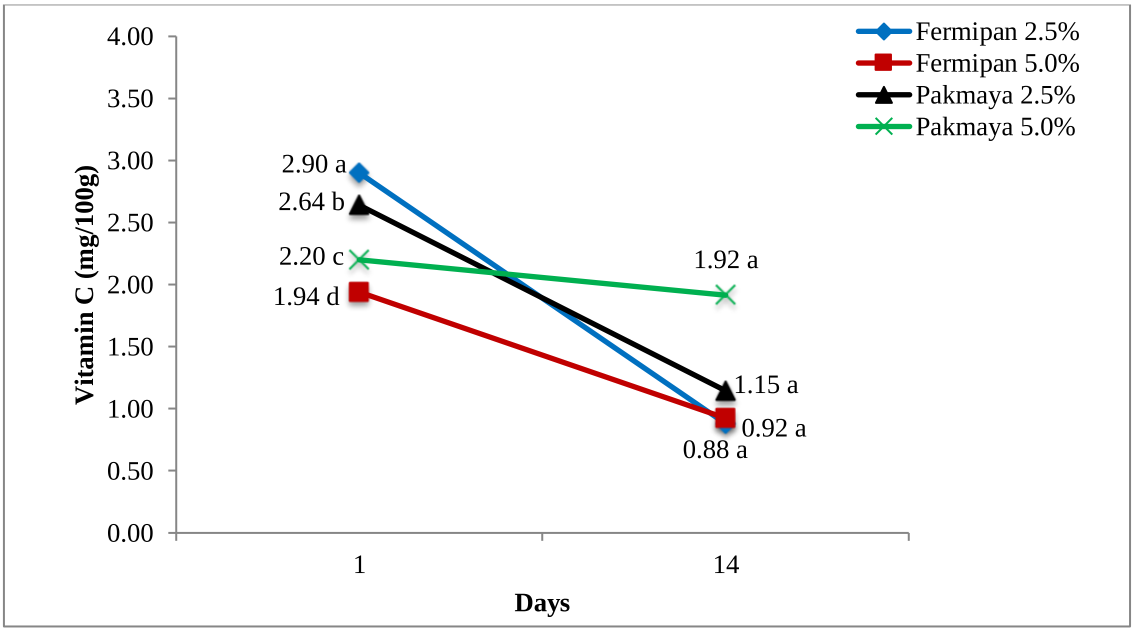

Figure 4. Vitamin C of fresh and 14-day gandaria wine from different commercial yeast types and concentration

### 3.5. pH value

Figure 5 depicts the wine's pH value, or level of acidity. All primary fermented wines, with the exception of Fermipan 2.5% and Pakmaya 2.5%, which had a pH range of 4.50–4.70, had considerably varied pH values from one another. After 14 days of aging, the pH value increased and the acidity level decreased, which is also consistent with the decline in the overall amount of acid throughout aging.

### 3.6. Total Soluble Solids

The value of the wine's total soluble solids at the end of the fermentation phase is an essential quality measure that is frequently employed as an indicator of the fermentation's stability and perfection. Figure 6 depicts the total soluble solids of primary fermented wine and after 14 days of aging. The maximum total soluble solids of primary fermented wine generated with Fermipan yeast (5%) was 22.40°Brix, which was considerably different from other treatments for which the statistics did not differ significantly. After 14 days of aging, the total value of soluble solids decreased in all yeast treatments.

The results of a study on pineapple wine revealed that the total soluble solids value decreased during fermentation and differed significantly across yeast strains and yeast concentrations (Thungbeni *et al.*, 2020). The high value of total soluble solids was due to the high sugar content, which corresponded to the total sugar yield mentioned earlier. In accordance with the aging process, the value of total soluble solids decreased as the sugar in wine was converted into aldehydes, acetals, esters, tartaric acid, and malic acid (Joshi *et al.*, 2017; Joshi *et al.*, 2015). The value of total soluble solids varied with different types of yeast and different concentrations due to variations in the ability of the yeast type or strain to convert sugar into alcohol.

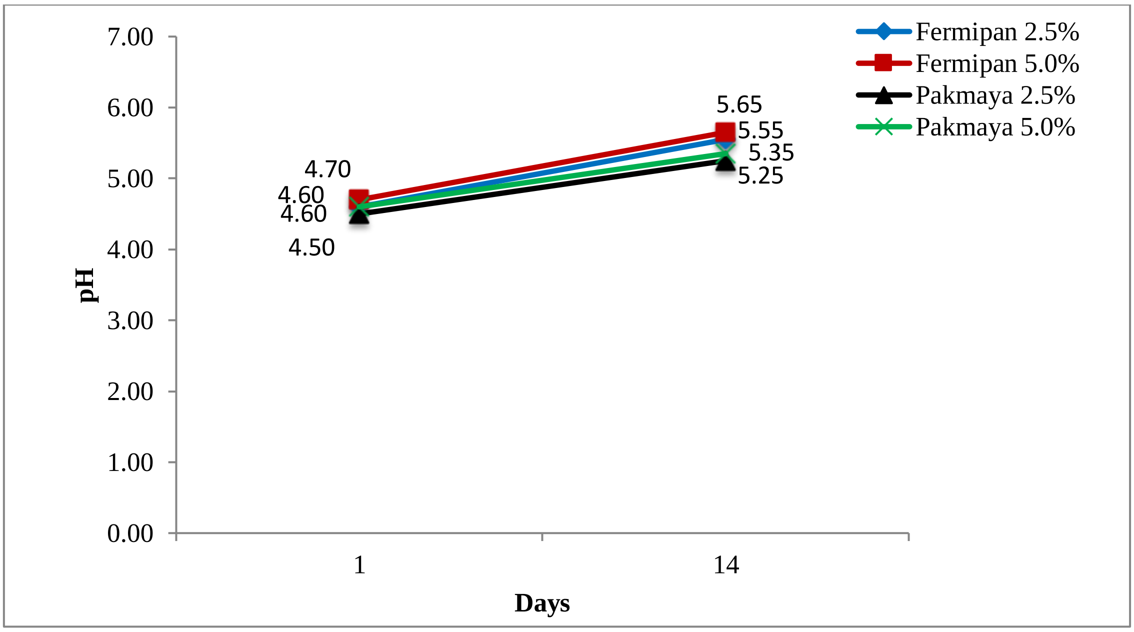


Figure 5. pH value of fresh and 14-day gandaria wine from different commercial yeast types and concentration

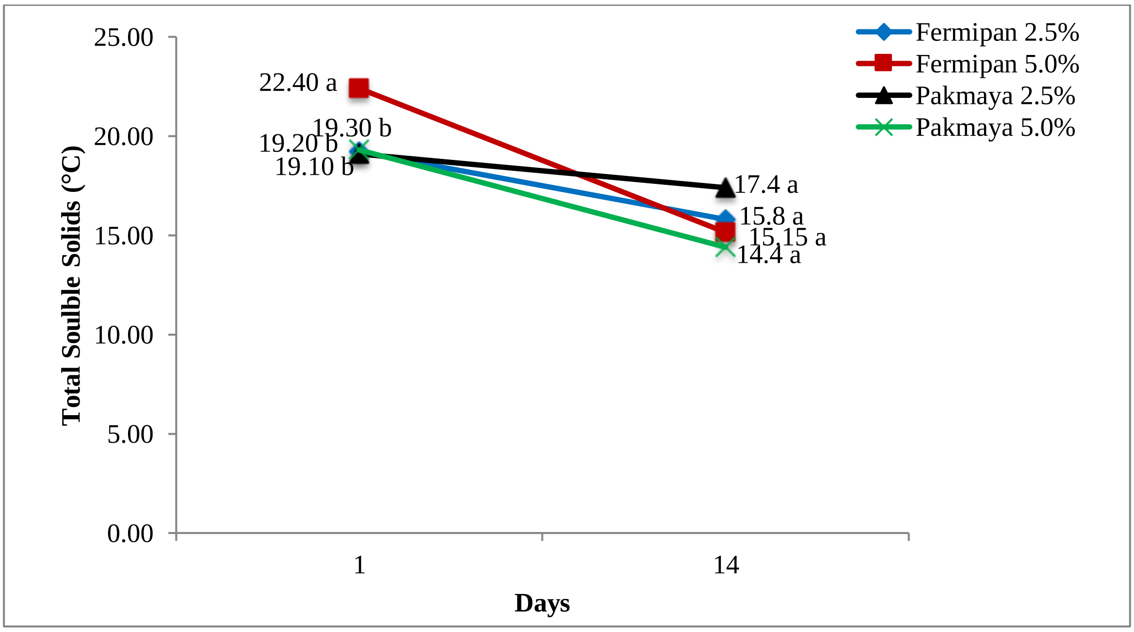


Figure 6.Total soluble solids of fresh and 14-day gandaria wine from different commercial yeast types and concentration

### 3.7. Turbidity

Figure 7 displays the differences in turbidity between freshly fermented wine and wine that has been aged for 14 days. Primary fermented wine had a turbidity range of 465-1075 NTU, while wine that had been aged for 14 days had a turbidity range of 289.45-517.50 NTU. Both Fermipan and Pakmaya yeasts had a greater turbidity value in their primary fermented wine at a concentration of 5.0%, but this difference was not statistically significant. However, the turbidity of the yeast-based wine at a concentration of 2.5% was lower for Fermipan but not for Pakmaya. The yeast from Pakmaya, when used at a concentration of 2.5% in the primary fermentation, resulted in the clearest wines or lowest turbidity value.

After 14 days of aging, there was a decrease in the turbidity value applicable to all types and concentrations of yeast. The values decreased until there was no significant difference in turbidity values. Turbidity measurements are carried out to determine the level of particulates in the wine (visual clarity) so that it is ready to be bottled. There are many potential suspensions in the wine liquid that cause turbidity, including deposits, yeast, bacteria, amorphous and crystalline materials (Bowyer *et al.*, 2012). A high yeast concentration will thus produce a wine with high turbidity because the residual yeast suspension is still high. During aging, most of the suspended matter settles, resulting in a clearer wine (Joshi *et al.*, 2017). This is the reason for the decrease in the value of wine turbidity after 14 days of aging.

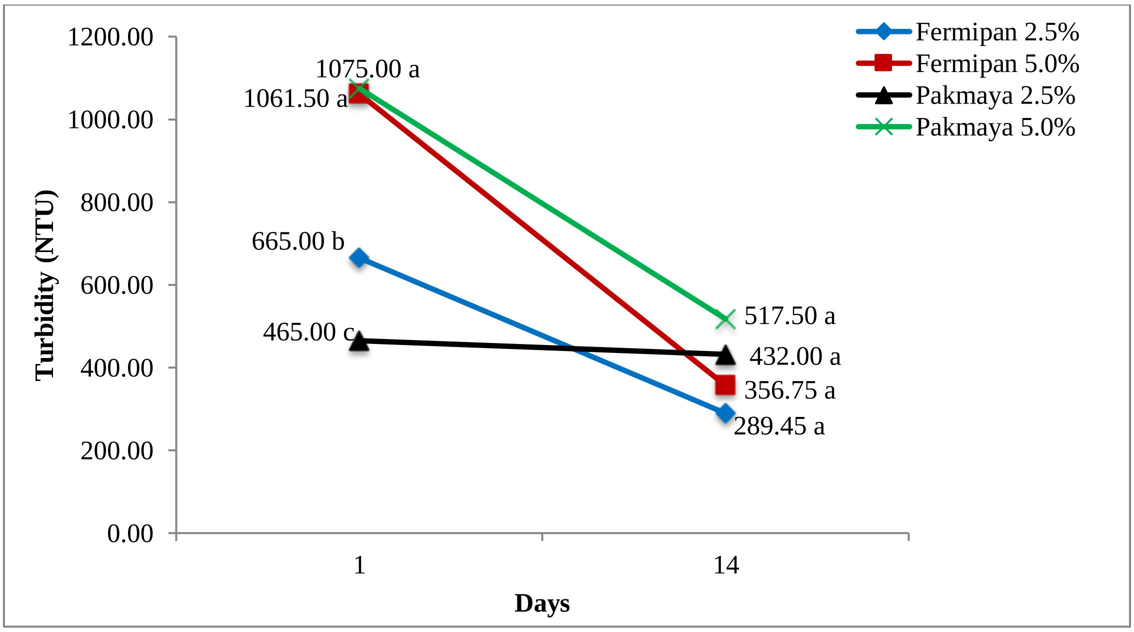

Figure 7.Turbidityof fresh and 14-day gandaria wine from different commercial yeast types and concentration

## 4. Conclusions

Aging for 14 days caused a significant decrease in the characteristics of gandaria wine produced with different commercial yeast types and concentrations compared to the freshly fermented wine. Total sugar, total acidity, vitamin C, total soluble solids, and turbidity were among the characteristics that decreased. Whereas with aging, the alcohol content and pH values increased. The gandaria wine produced with commercial yeast Pakmaya at a 2.5% concentration was found to be the best due to the alcohol content that complied with the standard for fruit wine and had the clearest resulting wine both for the primary fermentation and the 14-day aging.


## Acknowledgement

The authors acknowledge the LPPM University of Pattimura for the financial support for this specific study.


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