

Effects of Fermentation Time and Brix on the Physicochemical Characteristics of Red Ginger Enriched Pineapple Honey Fermentate

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ABSTRACT

Pineapple is a local Indonesian fruit with limited processing applications. Developing a fermented herbal from pineapple with red ginger represent a potential product innovation to increase its value. This study aimed to determine the best formulation of pineapple-honey herbal fermentation with the addition of red ginger at different °Brix levels (20 and 30) and fermentation durations (2 and 4 weeks). Physicochemical and organoleptic characteristics were evaluated, including turbidity, °Brix, pH, ethanol content, vitamin C, and total soluble solids. Data were analyzed using one-way ANOVA and the Kruskal–Wallis test. The results showed that the addition of red ginger significantly affected turbidity, °Brix, vitamin C, and total soluble solids, but did not significantly affect pH and ethanol content. The best formulation based on organoleptic evaluation was obtained in samples fermented for 4 weeks at 30 °Brix. Overall, this study indicates that red ginger enrichment and fermentation parameters play an important role in improving the quality and sensory acceptability of pineapple-honey herbal fermentate.

Keywords: Honey Pineapple, Red Ginger, Fermentation, Physicochemical, Organoleptic



INTRODUCTION

Indonesia is rich in various tropical fruits that have great potential for processing into value-added products. Pineapple (*Ananas comosus*) is one of the leading tropical fruits widely cultivated in Indonesia, with a production increase from 1.39 million tons in 2016 to 1.79 million tons in 2017 (BPS, 2017). However, a large proportion of pineapples are often damaged or overripe before being consumed, resulting in significant post-harvest losses for farmers (Karamina et al., 2021). Therefore, developing processing methods that can minimize waste and extend shelf life while increasing the economic value of pineapple is essential. One promising approach is the production of herbal fermented beverages using pineapple as the main raw material (Samuri, 2017).

Fermentation is an effective bioprocessing method that can enhance flavor, nutritional quality, and stability while utilizing fruits with high sugar content as substrates (Hawusiwa et al., 2015). Incorporating herbal ingredients such as red ginger (*Zingiber officinale* var. *rubrum*) into fruit fermentates can further improve the functional and sensory properties of the final product. (Ismunanto, 2020). Red ginger not only enhances aroma, color, and flavor but also contributes bioactive compounds such as gingerol, shogaol, and zingerone, which exhibit antioxidant and antimicrobial activities beneficial for health (Wu et al., 2020).

Despite these potentials, previous studies on pineapple-based herbal fermentates have generally been limited to fixed fermentation parameters, particularly using the same °Brix level and fermentation duration, resulting in relatively similar physicochemical and organoleptic characteristics (Hutapea & Yulianto, 2025). There remains a lack of empirical studies exploring the combined effect of °Brix variation and fermentation time on the quality and acceptability of pineapple-honey fermentate with red ginger addition.

Therefore, this study was conducted to determine the best formulation of pineapple honey herbal fermentate with red ginger addition at different °Brix levels (20 and 30) and fermentation durations (2 and 4 weeks). The research specifically aimed to analyze how these variations influence the physicochemical characteristics and organoleptic properties of the resulting herbal fermentate. This approach is expected to contribute to the optimization of local fruit processing innovations and support the development of functional fermented beverages with enhanced sensory and nutritional quality.

METHODS

Equipment used in the fermented making process includes a turbidimeter (Eutech TN-100), a hand-held refractometer (Atago N-1 made in Japan), a Hanna digital refractometer (HI96800), a pH meter (SD 20 Organic Kit), a gas chromatograph (GC1290 made in China), a 400-mesh fermented filter, an alcohol thermometer, and a digital scale (Mettler Toledo Analytical Balance ME204).

The ingredients used to make fruit fermentate include ripe honey pineapple obtained from honey pineapple farmers in the Pemalang area of Central Java, red ginger from traditional markets, granulated sugar, *Saccharomyces cerevisiae* yeast (Fermipan brand), 70 % alcohol, iodine, distilled water, starch pro-analysis, KIO_3 pro-analysis, $\text{Na}_2\text{S}_2\text{O}_3$ pro-analysis.

This research method used a randomized block design grouped by °Brix and fermentation time. Red ginger 2 g.L⁻¹ 20 °Brix with fermentation time of 2 weeks and 4 weeks, and 30 °Brix with fermentation time of 2 weeks and 4 weeks. Simultaneously there were two samples of 20 °Brix and 30 °Brix which served as controls without the addition of herbs. The experiment was conducted at room temperature of 30-34 °C with 6 fermentate samples from 2 groups of °Brix and fermentation time. Physicochemical tests in the study included turbidity, °Brix, pH, ethanol content, and vitamin C levels. The results of the physicochemical tests were analyzed using the One Way ANOVA method and continued with Duncan analysis. While the organoleptic test included color, taste, aroma and aftertaste and then tested using the Kruskal-Wallis test.

RESULTS

The results of the physicochemical analysis of honey pineapple herbal fermentate with red ginger demonstrated notable variations among treatments. Turbidity values ranged from 86 to 225.5 NTU, with samples S1 and S6 showing the highest and lowest readings, respectively. This indicates a higher concentration of suspended solids in S1 compared to S6, which became clearer due to longer fermentation and sedimentation processes. °Brix values varied between 9.13 and 24.87, corresponding to differences in sugar concentration among treatments. Sample S2 exhibited the highest Brix value 24.87 °Brix, while S5 had the lowest 9.13 °Brix, suggesting more extensive sugar conversion in the latter due to prolonged fermentation. pH levels ranged from 3.62 to 4.24, with S1 exhibiting the highest pH 4.24 and S6 the lowest 3.62. The decrease in pH during fermentation indicates increased organic acid formation, consistent with typical yeast fermentation behavior. Ethanol content varied between 2.13 % and 4.34 %, with S5 containing the highest ethanol concentration and S2 the lowest. Notably, no methanol was detected in any of the samples, confirming the safety of the fermentation process. Vitamin C levels ranged from 8.78 to 12.69 mg/100 mL, with the highest value observed in S5 and the lowest in S4. This variation suggests that longer fermentation may lead to partial degradation of vitamin C, while moderate fermentation durations help retain its content. Finally, total dissolved solids (TDS) values ranged from 9.77 to 24.89, with S6 and S1 showing the highest and lowest readings, respectively. Comparatively, the higher TDS value in S6 indicates a greater accumulation of soluble compounds during fermentation, likely resulting from cell wall degradation and metabolite release.



Figure 1. Herbal Pineapple Fermented Products (Personal Document)

Table 1. Organoleptic Test Results of Herbal Fermentate

Ifn	Sample Test						
	pH	Turbidity (NTU)	°Brix	Ethanol %	Vitamin C mg/100mL	Total Dissolved Solids	
S1	4,24 ±0,049 ^b	225,75 ± 0,353 ^e	9,23 ± 0,014 ^a	4,06 ± 0,070 ^c	9,27 ± 0,692 ^a	9,77 ± 0,070 ^a	
S2	3,60 ± 0,042 ^a	135 ± 1,41 ^b	24,87 ± 0,028 ^c	2,13 ± 0,141 ^a	10,74 ± 0,000 ^b	24,59 ± 0,063 ^c	
S3	4,19 ± 0,035 ^b	156,50 ± 2,121 ^c	9,16 ± 0,056 ^a	4,16 ± 0,056 ^{cd}	11,71 ± 0,000 ^b	9,81 ± 0,049 ^{ab}	
S4	3,62 ± 0,021 ^a	133 ± 1,41 ^b	24,43 ± 0,063 ^b	2,21 ± 0,063 ^{ab}	8,78 ± 0,000 ^a	24,86 ± 0,0707 ^d	
S5	4,21 ± 0,028 ^b	174,50 ± 2,121 ^d	9,13 ± 0,021 ^a	4,34 ± 0,063 ^d	12,69 ± 0,000 ^c	9,93 ± 0,035 ^b	
S6	3,62 ± 0,028 ^a	86 ± 2,828 ^a	24,36 ± 0,049 ^b	2,34 ± 0,042 ^b	11,225 ± 0,685 ^b	24,89 ± 0,056 ^d	

Description:

- S1 = Control 20
- S2 = Control 30
- S3 = 2-week curing, 20 °Brix
- S4 = 2-week curing, 30 °Brix
- S5 = 4-week curing, 20 °Brix
- S6 = 4-week curing, 30 °Brix
- Based on Duncan's test with a 95 % confidence level ($p < 0.05$), the data shown are the mean ± standard deviation. Different superscript letters indicate significant differences.

Table 2. Organoleptic Test Results of Herbal Fermentate

Sample Group	Organoleptic Analysis			
	Color	Aroma	Taste	Aftertaste
K1	16.50	23.80	10.50	21.00
K2	24.50	12.50	35.50	26.05
S1	32.50	36.00	22.50	30.05
S2	34.50	38.95	41.50	39.85
S3	33.50	36.85	24.50	26.25
S4	41.50	34.90	48.50	39.80

Description:

- K1 = Control 20
- K2 = Control 30
- S1 = 2-week fermentation, 20 °Brix

- S2 = 2-week fermentation, 30 °Brix
- S3 = 4-week fermentation, 20 °Brix
- S4 = 4-week fermentation, 30 °Brix
- Data displayed are mean $\pm$ rank
- Organoleptic testing was conducted on 10 panelists

DISCUSSION

1. Turbidity Analysis

Based on data obtained from the turbidity test, five samples showed significant differences and one sample showed no significant difference. This decrease in dissolved solids was due to the fermentation process being suboptimally filtered, resulting in turbidity. This turbidity was caused by yeast metabolic activity. The high total solids content was caused by residual sugar and other solids that could not be fermented, which was caused by the inhibition of yeast activity at high alcohol concentrations, resulting in a cloudy solution (Nugroho, 2020). During the fermentation and aging process, the total dissolved solids in the honey pineapple fermentate sample, measured as turbidity, decreased. This decrease in turbidity was triggered by the yeast's metabolic process, which consumes glucose and produces CO₂ and alcohol (by products). The sugar content of the herbal fermentate was reduced by yeast metabolism, resulting in a decrease in turbidity. This theory is supported by a very strong and positive correlation between the decrease in sugar content and the reduction in turbidity (Wida Renata, 2020). The addition of red ginger also affects the turbidity level. The fermentate is greatly influenced by the material from the red ginger, which combines with the fermentate. Therefore, shaking the bottom of the bottle will affect the turbidity results (Vernhet et al., 2016).

2. pH Analysis

Fermentate typically has a pH between 3.6 and 3.1. This is due to the organic acids in pineapple, such as citric acid, malic acid, and oxalic acid, which affect the pH of the fermentate (Ismunanto, 2020). The increase in pH is due to the lactic acid produced by malic acid during the fermentation process, which increases the pH and reduces the acidity. This results in a lighter, smoother, and softer taste, improving the fermentate's organoleptic quality. The two significantly different sample groups were the 20 °Brix and 30 °Brix groups. In the pH test, sample S2 had the lowest pH value at 3.60, and sample S1 had the highest at 4.24. This aligns with the theory that increasing sugar content can affect yeast activity due to the high osmotic pressure in the fermenter tank (Pratiwi et al., 2019). The addition of sugar to the honey pineapple herbal fermentate aims to stimulate the performance of yeast in producing higher alcohol. With the higher alcohol content formed, the activity of acid-forming bacteria will inhibit the growth of the yeast, resulting in a more alkaline pH, this is in accordance with the theory (Gunam & Wrasati, 2009). However, the red ginger added is not more than 1 % of the total ingredients so it does not significantly affect the pH level (Lee et al., 2014).



3. Brix Analysis

Sugar is a key component in fruit fermentate production; various types of fruit contain 15-18 % sugar. *Saccharomyces* yeast is highly dependent on sugar as it provides nutrients for yeast growth. *Saccharomyces* yeast has a tolerance of 40 % sugar. Therefore, the sugar content in fruit fermentate significantly impacts the product. Too little will result in suboptimal results, while too much will inhibit yeast growth (Wida Renata, 2020). The sugar-derived substrate is used by yeast for the fermentation process, where the sugar is broken down into ethanol, carbon dioxide, and energy (Hartina et al., 2014). The sugar content in honey pineapple juice before the fermentation process is 30 °Brix and 20 °Brix, while after fermentation and ripening, the sugar content decreases to 24.36 for 30 °Brix and 9.13 for 20 °Brix. This decrease in sugar content is caused by fermentation activity by the yeast *Saccharomyces cerevisiae*. From the data obtained, 3 groups of data were significantly different, namely groups S1, S3, and S5 were significantly different from groups S4 and S5 while S2 was significantly different from the five groups of data. This is because during the process of adding fermented sugar with a high °Brix content, it will cause osmotic pressure in the tank so that the yeast in the tank will be inhibited (Pratiwi et al., 2019). The appropriate °Brix level for fermentation is in the range of 20-24 °Brix according to the theory put forward by (Hutkins, 2006). Sample S2 had a high °Brix content because it was a control sample that did not undergo fermentation and also had a relatively high °Brix content at the start of fermentation. The filtration used on the other samples used a macrofiltration method, which allows yeast to escape during fermentation, allowing fermentation to continue, albeit slowly (C. Patria, 2018).

4. Ethanol Content Analysis

Ethanol is the result of the fermentation of honey pineapple herbs in addition to CO₂ and lactic acid, the breakdown of sugar into smaller parts such as monosaccharides by the invertase enzyme produces ethanol where the quality of the fermentate is greatly influenced by ethanol because the reaction of organic acids that form ester compounds so that it affects the smell of fermented e (D Aprilianto, 2014). Several factors that affect the concentration of ethanol include the type and number of yeast strains used, the conditions of the fermentation environment and the nutrients in pineapple juice (Wida Renata, 2020). From the research data obtained 4 samples that were significantly different and 2 samples that were not significantly different from each treatment the highest ethanol content was obtained in sample S5 at 4.34 % and the lowest sample S2 2.13 % the results of ethanol content are directly proportional to the decrease in sugar content in the fermentate, where the fermentate content, which is low has a high alcohol content this is in accordance with the theory (Pratiwi et al., 2019). SNI 01-4019-1996 standards in fermentate, fruit for ethanol content of less than 15 %. Therefore, the results of this study comply with SNI (Hutapea et al., 2024).

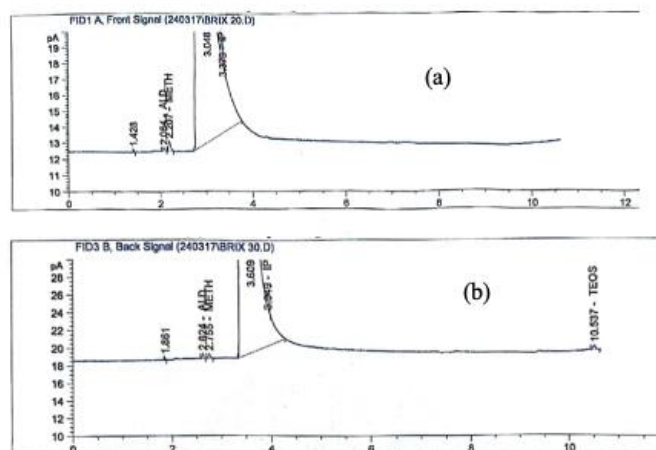


Figure 2. GC Chromatogram of Herbal Fermentate (fermentation (a). 20 °Brix; (b). 30 °Brix)

5. Total Dissolved Solids

Based on the dissolved solids test on the fermentate samples, the results showed that three samples were significantly different and three samples were not significantly different. S1 was not significantly different from S3 and S5, while S2 was significantly different from all five samples. S4 and S6 were not significantly different but significantly different from the other five samples. In the total dissolved solids test, the highest value was found in sample S6 with a value of 24.89, and the lowest value was found in sample S1 with a value of 9.77. Total dissolved solids in a beverage include several components such as fiber, protein, fat, and carbohydrates, with sugar accounting for 85 % of the total dissolved solids in fermented. The significant change in dissolved solids in beverages is due to sugar, so changes in total sugar result in changes in dissolved solids (Ovihapsany et al., 2018). The increase in total dissolved solids in honey pineapple fermentate samples is directly proportional to the decrease in sugar content in each fermentate sample and also the increase in total solids will affect the turbidity value in the fermentate (Wida Renata, 2020). Sample S1 has a low dissolved solids value compared to sample S6. This is caused by the imperfect process of degradation of complex compounds into simple compounds, in this case sucrose (Ovihapsany et al., 2018). And the fermentation process in sample S6 resulted in an increase in the total solids value compared to samples that did not undergo the fermentation process.

6. Vitamin C Level Analysis

Based on the results of the vitamin C test, the results of the significant difference test showed three samples that were significantly different and three samples that were not significantly different. A significant difference indicates a statistically significant difference, while a non-significant difference indicates insufficient evidence to declare the difference significant. Samples S1 and S4 were significantly different from samples S2, S3, S5, and S6. Samples S2, S3, and S6 were not significantly different but significantly different from samples S1, S4, and S5. Sample S5 was significantly different from all samples. Of the six samples, the levels were 9.27 mg/100 mL for S1, 10.74 mg/100 mL for S2, 11.71 mg/100 mL for S3, 8.78 mg/100 mL for S4, 12.69 mg/100 mL for S5, and



11.22 mg/100 mL for S6. The highest vitamin C content was found in sample S5 and the lowest was found in S4. The low vitamin C content was due to the pre-fermentation process. Pasteurization of honey pineapples can eliminate the vitamin C content in the honey pineapple juice (Tan, 2013). Furthermore, poor ripening processes, where oxygen and sunlight can damage the vitamin C itself, can lead to low levels (Thuraidah et al., 2015).

7. Organoleptic Analysis

The findings revealed that fermentation duration and °Brix level significantly influenced the physicochemical and organoleptic properties of honey pineapple fermentate with red ginger addition (Jackson, 2008). The optimal treatment was observed in the 30 °Brix sample fermented for four weeks (S4), which demonstrated high clarity, appealing color, and a balanced sweet-sour-spicy flavor profile (Wida Renata, 2020). Longer fermentation periods enhanced physicochemical stability and reduced turbidity, while red ginger contributed distinctive aroma and flavor through its oleoresin, gingerol, and shogaol compounds (Sabi et al., 2023; Srikandi et al., 2020; Iskandar et al., 2023). The combination of controlled °Brix concentration and fermentation duration with red ginger addition has the potential to produce a functional fermented beverage with added economic value, supporting the sustainable development of local agro-industries (Rajaguguk YV et al., 2018; Zoecklein et al., 2013; Makalew et al., 2016; Tritanti et al., 2019).

CONCLUSIONS

The results of the physicochemical analysis indicated that the addition of red ginger significantly affected the physicochemical characteristics of the fermentate, particularly in terms of turbidity, °Brix value, vitamin C content, and total dissolved solids. Based on organoleptic evaluation, the best formulation was obtained from the treatment fermented for 4 weeks at 30 °Brix with the addition of 2 g.L⁻¹ red ginger. These findings suggest that variations in °Brix concentration and fermentation duration play a crucial role in determining the quality of herbal fermentates. Practically, this study highlights the potential for developing functional fermented beverages with distinctive sensory qualities while enhancing the economic value of local pineapple production through value-added product innovation.

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