

CHARACTERISTICS OF PROBIOTIC DRINKS FROM PINEAPPLE PEEL AND RED WATERMELON JUICE USING *Lactocaseibacillus paracasei* RN2-53 STARTER

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ABSTRACT

Probiotic drinks are beverages containing lactic acid bacteria (LAB) that are beneficial to the digestive tract because they can provide health benefits. The addition of red watermelon juice is a material that can be used to make probiotic drinks because it contains high levels of antioxidants. This study aims to determine the appropriate ratio of pineapple peel juice and red watermelon juice to the characteristics of the probiotic drink produced. The study was conducted experimentally using a completely randomized design (CRD) with four treatments and four replicates. The treatments in this study were the ratios of pineapple peel juice and red watermelon juice, namely S1 (100:0), S2 (75:25), S3 (50:50), and S4 (25:75). The results showed that different fruit juice ratios had a significant effect on the acidity level (pH), total lactic acid, total vitamin C, total BAL, and antioxidant activity of the probiotic beverage. The selected treatment was S3 (50:50), which met the quality standards (SNI) with a pH value of 3.67, total lactic acid of 0.42%, total vitamin C of 4.22 mg/100 g, antioxidant activity of 16.97 ppm, and total BAL of 8.99 log CFU/ml. The descriptive sensory characteristics were slightly red in color, with a distinctive fermentation aroma and slightly sour taste. The hedonic sensory evaluation showed that the color was liked by the panelists, while the aroma, taste, and overall evaluation were somewhat liked by the panelists.

Keywords: fruit juice ratio, *Lactocaseibacillus paracasei*, pineapple peel juice, probiotic drink, watermelon juice

INTRODUCTION

Probiotic beverages are drinks that contain microorganisms such as lactic acid bacteria (LAB), which are beneficial to the digestive tract because they provide health benefits. Some types of LAB commonly used in the production of probiotic fermented beverages include *Bifidobacterium longum*, *Lactocaseibacillus casei*, *Lactocaseibacillus paracasei*, and *Lactiplantibacillus plantarum*.

Beverage can be classified as a probiotic drink if it contains live microorganisms at the time of consumption and meets the minimum probiotic concentration requirement of 10⁶ CFU/ml (Aritonang et al., 2019). The use of fruit juice in the production of probiotic beverages is an alternative to cow's milk, which is relatively expensive; furthermore, fruit juice serves as a nutrient source for probiotic bacteria because it contains sugars, minerals, and vitamins essential for their growth. Several previous studies have used various types of fruit in the production of probiotic beverages, such as guava fermented using *Lactocaseibacillus paracasei* (Agustina et al., 2021) and watermelon using *L. casei* strain Shirota (Sari & Catarina, 2020). Another type of fruit that can also be used in the production of probiotic beverages is pineapple.

Pineapples are one of the horticultural commodities with significant economic value that are thriving in Riau Province. The main pineapple production center in Riau Province is located in Tambang Subdistrict, Kampar Regency. According to the Badan Pusat Statistik Provinsi Riau (2024), pineapple production in Tambang Subdistrict in 2023 reached 235,600 metric tons. Fresh pineapples consist of 40% edible flesh, while the remaining 60% is waste, comprising 40% outer peel, 16% crown, and 4% core (Murni et al., 2008). Pineapple peel is a discarded part that has not yet been optimally utilized.

Pineapple peel contains nutrients and sugars. According to Sitiroha et al. (2013), the glucose content of pineapple peel is 2.18%. The sugar and carbohydrate content of pineapple peel can be utilized as a carbon source for microbes during the fermentation process. Pineapple peel extract has a relatively low pH of 4.74, and based on sensory evaluation, a probiotic beverage made from pineapple peel extract without added sucrose tastes sour (Elsaputra et al., 2016). Adding other ingredients, such as watermelon, can enhance the nutritional content specifically the antioxidants in pineapple peel extract.

Watermelon is a very popular fruit that is widely enjoyed by the public due to its sweet taste; it has a very high water content of 92% and a sugar content of 6% (Mahmud et al., 2018). Lycopene can help prevent degenerative diseases such as diabetes, heart disease, and cancer (Jitmau et al., 2010). Fermented water kefir made from watermelon, using an optimal mesocarp concentration of 20%, yields a beverage with a total bacterial count of 7.96 log CFU/ml, total lactic acid of 0.82%, an alcohol content of 2.22%, total yeast of 7.22 log CFU/ml, and antioxidants of 26.2 ppm (Syalom et al., 2020).

Sultan et al. (2022) developed a probiotic beverage combining pineapple and papaya juices using 5% *L. casei*; the optimal ratio of 50:50 resulted in a pH of 3.96, a total bacterial load of 9.06 log CFU/ml, and a total lactic acid content of 2.41%. Oyeleke et al. (2013) also prepared a mixed juice of watermelon and pineapple with an optimal ratio of 70:30; their study found that the pineapple juice had a pH of 3.80, and after adding 70% watermelon juice, the pH increased to 4.40. Based on these findings, a study entitled “Characteristics of a Probiotic Beverage formulated with Pineapple Peel and Red Watermelon Juice Using *Lactocaseibacillus paracasei* RN2-53 as the Starter Culture” was conducted.

METHODS

Material and Equipment

The ingredients used in the preparation of probiotic beverages are pineapple, watermelon, the *Lactocaseibacillus paracasei* RN2-53 bacterial isolate, and sucrose or granulated sugar (Gulaku). The materials used in the analysis were deMan Rogosa Sharpe Broth (MRSB), deMan Rogosa Sharpe Agar (MRSA), NaCl (saline), 70% and 96% alcohol, newspaper, filter paper, aluminum foil, rubber, plastic, glass, alcohol, pH 4 and 7 buffer solutions, 0.01 N iodine solution, 1% starch indicator, 0.1 N NaOH, 1% phenolphthalein indicator, and distilled water. The equipment used in the preparation of the pineapple peel juice probiotic drink includes a knife, cutting board, juicer, mixing bowl, digital scale, glass jars, pot, stove, thermometer, blender, and strainer. The equipment used for sensory testing includes cups, trays, plastic spoons, writing utensils, documentation tools, questionnaire forms, and booths.

Experimental Design

The study was conducted experimentally using a Completely Randomized Design (CRD) with a single factor. The ratio of pineapple peel extract to watermelon extract, modified from Sultan et al. (2022). The treatment consisted of four levels (S1, S2, S3, and S4) with four replications, yielding 16 experimental units. ratios for the combination of pineapple peel extract and red watermelon were based on namely:

S1 = Pineapple peel extract (100:0)

S2 = Pineapple peel extract : watermelon extract (75:25)

S3 = Pineapple peel extract : watermelon extract (50:50)

S4 = Pineapple peel extract : watermelon extract (25:75)

Research Implementation

Preparation of raw materials and starter culture

The preparation of pineapple peel extract was based on Rizal et al. (2020): the pineapple peels were washed with clean water, then blanched at 80°C for 5 minutes. The pineapple peels were blended with water in a 1:1 ratio, and the mixture was then filtered to obtain the pineapple peel extract.

The process of making watermelon juice is based on Effendi & Wardatun (2017). The watermelon is cut open, and the flesh is removed. The seeds are separated from the flesh, and the flesh is pureed using a juicer. The watermelon juice is collected in a jar.

The preparation of the starter culture was based on Yusmarini et al. (2021). The starter culture was prepared in stages: first, an MRSB solution was prepared and sterilized at 121°C and 1 atm for 15 minutes. Once the medium reached the appropriate temperature (43–45°C), the MRSB solution was inoculated with a *Lc. paracasei* RN2-53 culture equivalent to 2% of the MRSB solution volume, then incubated at 37°C for 18 hours. Next, a second medium was prepared consisting of 75% MRSB solution and 25% pineapple peel extract and treated the same as the first medium, except that the bacteria used were those from the first medium. This process was repeated for media consisting of 50% MRSB and 50% pineapple peel extract, 25% MRSB and 75% pineapple peel extract, and finally, the bacteria were grown in a medium consisting of 100% pineapple peel extract.

Probiotic beverage production

The production of the probiotic beverage from pineapple peel juice was carried out based on a modified method of Fajri et al. (2021). Pineapple peel juice and red watermelon juice were combined according to the predetermined treatment ratios and transferred into Erlenmeyer flasks. Subsequently, 4 g of sucrose was added to each treatment, and the mixture was pasteurized at approximately 70°C for 10–15 minutes. After pasteurization, the fruit juice mixture was cooled to 30°C, followed by the addition of 5 g of *Lc. paracasei* RN2-53 starter culture to each treatment. The inoculated mixture was then incubated at 37°C for 18 hours.

Observation parameters and data analysis

Acidity analysis, as specified by AOAC (2005), was determined using a pH meter. The determination of total lactic acid was based on AOAC (2005). Total lactic acid was calculated by alkalimetric titration using 0.1 N NaOH. The total lactic acid bacteria count was determined using the method employed by, specifically the spread plate technique. A 1 ml sample of the probiotic beverage made from pineapple peel extract was collected using a micropipette and added to 9 ml of 0.85% physiological saline solution to achieve a 10^{-1} dilution. Serial dilutions were then performed up to the 10^{-7} level. The inoculation process was carried out in a sterile environment, specifically a laminar airflow cabinet. The inoculated Petri dishes were subsequently incubated for 24 hours at 37°C in an inverted position to prevent water condensation on the inner surface of the lid from dripping onto the culture medium. The determination of total vitamin C was based on Sudarmadji et al. (1997) using a titration method with an iodine solution and an amylose indicator. A 25-ml sample was placed in a 100-ml volumetric flask, distilled water was added to the mark, and the mixture was filtered through filter paper to separate the filtrate. The antioxidant analysis was conducted according to Gumansalangi & Djarkasi (2019) using the DPPH method.

The sensory evaluation of probiotic beverages made from pineapple peel and watermelon juice was based on Setyaningsih et al. (2010). The sensory evaluation consisted of descriptive and hedonic tests. The descriptive test aimed to identify the characteristics of the probiotic beverages made from pineapple peel and watermelon juice in each treatment, specifically the tributes of color, aroma, and taste, where the samples were placed in clean containers that had previously been assigned random code numbers. The hedonic test aimed to determine the panelists level of preference, covering color, aroma, taste, and overall evaluation, with a rating scale ranging from “like very much” to “dislike very much.” The testing of the pineapple peel and watermelon juice probiotic beverage samples was conducted by 30 semi-trained panelists for the descriptive test and 80 untrained panelists for the hedonic test.

The data obtained from the observations were then statistically analyzed using analysis of variance (ANOVA) in SPSS version 23. If the calculated F-value is equal to or greater than the table F-value, the analysis proceeds to the DMRT test at the 5% significance level.

RESULTS AND DISCUSSION

The results of the analysis of variance regarding pH, total lactic acid, and vitamin C of the probiotic beverage formulated from pineapple peel juice and red watermelon juice are presented in Table 1.

Table 1. Chemical characteristic of probiotic beverages pineapple peel and red watermelon juice

Chemical Characteristics	Treatment			
	S1 (100:0)	S2 (75:25)	S3 (50:50)	S4 (25:75)
Degree of acidity (pH)	3.76 ^c	3.75 ^c	3.67 ^b	3.43 ^a
Total lactic acid	0.32 ^a	0.32 ^b	0.42 ^c	0.49 ^d
Vitamin C	7.04 ^d	5.63 ^c	4.22 ^b	2.82 ^a
Antioxidant activity	29.41 ^c	14.40 ^{ab}	16.97 ^b	11.07 ^a

Note: Values followed by different lowercase letters indicate significant differences based on DMRT results at the 5% significance level. IC50 value of less than 50 ppm (very strong), an IC50 value of 50 ppm to 100 ppm (strong) an IC50 value of 100 ppm to 159 ppm (moderate), and an IC50 value of 160 ppm to 200 ppm (weak). Numbers followed by different lowercase letters indicate statistically significant differences according to the DMRT test at the 5% level.

Degree of Acidity (pH)

Degree of acidity (pH) of the probiotic beverages made from pineapple peel and red watermelon juice in treatment S4 differed significantly from the pH values of the other treatments. Treatment S1 showed results that did not differ significantly from S2 but differed significantly from S3 and S4. The pH value of the probiotic beverage based on pineapple peel and red watermelon juice tended to decrease as the proportion of added red watermelon juice increased. This is because red watermelon juice contains natural sugars, namely 9.4% fructose, 4.4% glucose, and 3.4% sucrose (Shanely et al., 2016), while pineapple peel juice contains natural sugars such as fructose (2.04%), glucose (2.18%), and sucrose (3.87%) (Sitiroha et al., 2013). The content of simple sugars in watermelon is higher than that in pineapple. The higher the sugar content, the faster the rate of carbohydrate metabolism, resulting in higher levels of organic acids, which in turn lowers the beverage's pH. Hutchinson et al. (2024) state that glucose and fructose can directly enter the glycolysis pathway after being phosphorylated or oxidized by enzymes without polymeric breakdown, where they are converted into pyruvate and subsequently into various organic acids.

Decrease in the pH of probiotic beverages is influenced by the growth and activity of lactic acid bacteria (LAB), which can break down carbohydrates into lactic acid. The carbohydrates in pineapple peel extract and red watermelon fruit serve as substrates for the growth of *Lactocaseibacillus paracasei* RN2-53. According to Corsetti & Valmorri (2011), *Lactobacillus* spp. is a group of lactic acid bacteria capable of breaking down carbohydrates into simpler compounds, with the end products being organic acids, including lactic acid. The lactic acid produced can lower the pH of the probiotic beverages made from pineapple peel and red watermelon juice, thereby creating an acidic environment. Sunaryanto et al. (2014) added that *Lactobacillus paracasei* is a type of heterofermentative bacterium that can produce organic acids such as lactic acid, ethanol, and carbon dioxide as end products.

Total Lactic Acid

Total lactic acid was determined using acid-base titration. Total lactic acid content in the probiotic beverages made from pineapple peel and red watermelon juice in treatment S1 was not significantly different from that in treatment S2, but was significantly different from that in treatments S3 and S4. The

highest total lactic acid content was found in treatment S4. This is because the high use of red watermelon juice increases the carbohydrate content. The carbohydrates in watermelon juice contain natural sugars such as fructose (9.4%), glucose (4.4%), and sucrose (3.4%) (Shanely et al., 2016). The higher the amount of carbohydrates available to *Lactobacillus acidophilus*, the more of them are converted into lactic acid (Legowo et al., 2009).

Total lactic acid content of probiotic beverages is inversely proportional to the pH value. The total lactic acid content makes the environment of probiotic beverages made from pineapple peel and red watermelon juice acidic, resulting in a low pH in the probiotic beverages. Carbohydrates are utilized by *Lc. paracasei* for growth, reproduction, and acid production. The more carbohydrates available, the higher the total lactic acid content will be. Fajri et al. (2021) added 5% *Lc. plantarum* 1 RN2-12112 during the production of a synbiotic beverage made from jicama and red dragon fruit juice, resulting in a total lactic acid content of 1.18%.

Total lactic acid content in the product is the result of fermentation by *Lc. paracasei* RN2-53, a heterofermentative lactic acid bacterium that produces lactic acid as one of the fermentation products of glucose, in addition to ethanol, acetic acid, and CO₂. The total lactic acid in this study ranged from 0.32–0.49%, which is lower than the results reported by Rahayu et al. (2021), who used a 4% starter culture in a probiotic pineapple peel juice beverage with varying fermentation durations, yielding total lactic acid levels between 0.90–2.34%. The high lactic acid content in Rahayu's study was due to a longer fermentation process 72 hours compared to the 18-hour duration in this study, allowing the BAL to have more time to convert glucose into lactic acid.

Total Vitamin C

Vitamin C is an essential nutrient that is vital for the human body and acts as an antioxidant that protects the body from damage caused by free radicals. The results of the analysis of variance indicate that the ratio of pineapple peel extract to red watermelon extract has a significant effect on the total vitamin C content of the probiotic beverage. The average total vitamin C values for the probiotic beverages made with pineapple peel extract and red watermelon extract are shown in Table 1.

Total vitamin C content of the probiotic beverages made from pineapple peel juice and red watermelon juice differed significantly across all treatments. The vitamin C content of the probiotic beverages decreased as the ratio of red watermelon juice increased. This is because the vitamin C content in red watermelon is relatively lower than that in pineapple peel juice. According to Feladita et al. (2018), red watermelon juice contains 1.4313 mg/100 g of vitamin C, whereas pineapple peel juice has a higher vitamin C content of 84.48 mg/100 g (Destiana & Rahayu, 2021). This difference indicates that the organic acids present in pineapple peel juice also help create a pH environment that supports the stability of ascorbic acid, resulting in consistently high measured vitamin C levels in treatments with higher concentrations of pineapple peel juice.

Changes in total vitamin C content are also influenced by several factors, namely temperature, light, and oxygen. Vitamin C, or ascorbic acid, is the simplest vitamin; it is unstable and prone to change due to oxidation, and it is easily damaged and degraded during storage. Vitamin C is more stable under acidic pH conditions but is prone to oxidation at higher temperatures or under alkaline pH conditions. In this study, the probiotic beverage was stored or fermented at 37°C, and the vitamin C content decreased from 7.04 to 2.82 mg/100g, indicating the oxidation of ascorbic acid. This is consistent with the study by Nocianitri et al. (2025) on fermented Dutch eggplant juice stored at cold temperatures, where the vitamin C content on day 0 (32.1%) decreased to 31.1% on day 30.

Antioxidant Activity

Antioxidant activity is the ability of a compound to neutralize free radicals, which can be measured using the inhibitory concentration (IC₅₀) parameter that is, the minimum concentration of an antioxidant compound required to neutralize 50% of DPPH free radical activity. IC₅₀ antioxidant activity of the probiotic beverages made from pineapple peel and red watermelon juice in treatment S4 was not significantly different from that in treatment S2, but was significantly different from that in the other treatments. A lower IC₅₀ value indicates stronger antioxidant activity in the probiotic beverage, and conversely, a higher IC₅₀ value indicates weaker antioxidant activity. The more red watermelon juice used, the lower the IC₅₀ value obtained in this study. This is because red watermelon juice contains phenolic compounds and flavonoids. Neglo et al. (2021) stated that phenolic compounds such as carotenoids specifically lycopene and beta-carotene which function as antioxidants and anti-inflammatory agents, are also found in watermelon.

Antioxidants are compounds that can inhibit oxidation reactions by binding to free radicals and highly reactive molecules. Red watermelon juice contains lycopene, vitamin C, and flavonoids, which act as antioxidants. Flavonoids are temperature-sensitive compounds that degrade at higher temperatures during storage. Flavonoids have the ability to mitigate or reduce the risks posed by free radicals and can also be used as free-radical scavengers.

The IC₅₀ values for antioxidant activity in this study ranged from 11.07 to 29.41 ppm. The IC₅₀ values in this study were lower than those reported by Nnennani et al. (2022), who investigated the phytonutrients and antioxidant activity of watermelon juice and found an IC₅₀ value of 40 ppm. Several parameters that can influence the concentration of antioxidants in probiotic beverages include the type of raw materials used, fermentation duration, fermentation temperature, inoculum amount, and type of starter culture.

Total Lactic Acid Bacteria

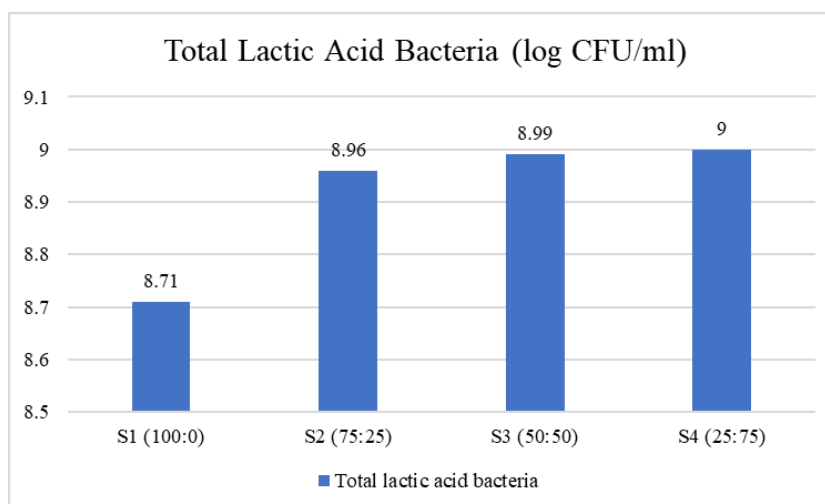


Figure 1. Bar chart of total lactic acid bacteria

Total lactic acid bacteria analysis is the process of calculating the total amount of lactic acid bacteria in a fermented product. This analysis is important for determining quality and serves as a key indicator of a product's suitability as a probiotic beverage. The analysis of variance results show that the ratio of pineapple peel extract to red watermelon fruit extract has a significant effect on the total lactic acid bacteria

of the probiotic beverage. The average total lactic acid bacteria values for the probiotic beverages made from pineapple peel extract and red watermelon fruit extract are shown in Figure 1.

Total lactic acid bacteria values of the probiotic beverages made from pineapple peel extract and red watermelon juice in treatment S1 differed significantly from the total lactic acid bacteria values in treatments S2, S3, and S4. The total lactic acid bacteria values of the probiotic beverages increased with the addition of red watermelon juice. This is because red watermelon juice contains more simple sugars than pineapple juice. Shanely et al. (2016) stated that watermelon juice contains 9.4% fructose, 4.4% glucose, and 3.4% sucrose, whereas pineapple peel juice contains natural sugars such as 2.04% fructose, 2.18% glucose, and 3.87% sucrose (Sitiroha et al., 2013). The higher the carbohydrate or natural sugar content in red watermelon juice, the more nutrients lactic acid bacteria can utilize for growth and development.

Lactic acid bacteria utilize nutrients in fruit juice during the fermentation process to grow. This is consistent with the study by Syalom et al. (2020), in which water kefir made from watermelon had total lactic acid bacteria values ranging from 7.21 to 7.96 log CFU/ml when mesocarp concentrations of 0–20% were added. A higher proportion of red watermelon juice can provide additional nutrients for bacterial growth, resulting in greater bacterial proliferation. The total lactic acid bacteria count obtained in this study was 8.71–9.00 log CFU/ml. This value was lower than that of the pineapple and papaya fruit juice probiotic beverages studied by Sultan et al. (2022), which ranged from 9.06 to 9.25 log CFU/ml. This is because pineapple and papaya are richer in nutrients and bioactive compounds, which can support the growth of lactic acid bacteria. The total lactic acid bacteria values in this study met the requirements of SNI 01-7552-2009 regarding flavored fermented milk beverages, which stipulate a minimum colony count of 7 log CFU/ml (Badan Standardisasi Nasional, 2009).

Organoleptic Analysis

Organoleptic analysis in this study comprised intensity assessment tests and hedonic tests. The intensity assessment evaluated several sensory attributes, including color, aroma, and taste, while the hedonic test assessed panelists' preferences regarding color, aroma, taste, and overall acceptability. The results of the analysis of variance for the organoleptic analysis of the probiotic beverage formulated from pineapple peel extract and red watermelon juice are presented in Table 2.

Table 2. Recapitulation of organoleptic analysis

Parameter	Treatment			
	S1 (100:0)	S2 (75:25)	S3 (50:50)	S4 (25:75)
Intensity rating test				
- Color	1.00 ^a	2.63 ^a	3.50 ^b	4.30 ^b
- Aroma	1.60 ^a	2.70 ^b	3.60 ^c	3.90 ^c
- Taste	1.50 ^a	2.53 ^b	3.16 ^c	3.53 ^c
Hedonic test				
- Color	3.38 ^b	3.08 ^a	3.76 ^c	3.80 ^c
- Aroma	3.16 ^c	2.72 ^a	2.75 ^{ab}	2.98 ^b
- Taste	3.37 ^b	3.08 ^{ab}	3.12 ^{ab}	2.92 ^a
- Overall acceptance	3.52 ^b	2.91 ^b	3.27 ^c	3.10 ^a

Note: Color descriptive scores: 1: yellow; 2: slightly yellow; 3: orange; 4: slightly red; 5: red. Aroma descriptive scores: 1: very weak characteristic fermentation aroma; 2: no characteristic fermentation aroma; 3: weak characteristic fermentation aroma; 4: characteristic fermentation aroma; 5: very strong characteristic fermentation aroma. Taste descriptive scores: 1: very sweet; 2: sweet; 3: slightly sour; 4: sour; 5: very sour. Hedonic scores: 1: dislike very much; 2: dislike; 3: somewhat like; 4: like; 5: like very much.

Color

Color is one of the parameters used to assess the quality and appeal of a product as perceived through the sense of sight. Color influences the panelists' first impression, which is a crucial aspect in their acceptance of the product. Table 2 shows that the average descriptive color scores for the probiotic beverages made from pineapple peel and red watermelon juice ranged from 1.00 to 4.30, corresponding to colors ranging from yellow to slightly red. The statistical results indicate that the colors of the probiotic beverages made from pineapple peel and red watermelon juice differed significantly across treatments. The color of probiotic beverages is due to the presence of pigments in the fruit juice. Pigments play a crucial role in determining the visual quality and appeal of fruit juice. According to Azhari et al. (2021), pineapples contain carotenoid pigments, including β -carotene and xanthophylls, which give the juice its yellow color. Red watermelons have red flesh derived from the pigment lycopene. Both lycopene and β -carotene are carotenoid compounds. Carotenoids are natural pigments widely recognized for their colors, particularly yellow, orange, and red. The colors of the probiotic beverages made from pineapple peel and red watermelon juice are shown in Figure 2.

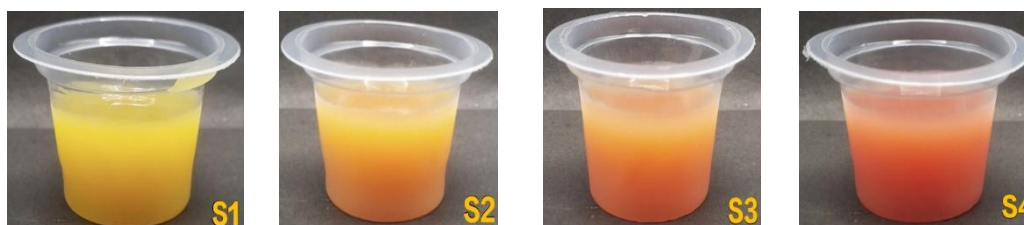


Figure 2. Probiotic drink made from pineapple peel extract and red watermelon juice

The color of fruit juice products is influenced by pigments. Pigments in fruit juice are sensitive to pH. According to Bell et al. (2016), under neutral to slightly alkaline conditions (pH 7–8), carotenoid pigments in juice decrease by 26%, whereas under acidic conditions (pH 3–6), carotenoid content tends to be higher. In this study, the pH values were in the acidic range, specifically 3.43–3.76, resulting in a red color as perceived by the senses. This indicates that acidic conditions help maintain carotenoid stability, whereas faster degradation occurs at higher pH levels. At low pH, anthocyanins exist in the form of a stable flavilium cation and are bright red in color. As the pH rises toward neutral, the chemical structure of anthocyanins changes to a quinone acid and then to a colorless chalcone. A low pH protects the color molecules from being easily oxidized or degraded by light and heat.

The hedonic ratings for the color of probiotic beverages made from pineapple peel and red watermelon ranged from 3.08 to 3.80, indicating “somewhat like” to “like.” Statistical results show that treatment S3 was not significantly different from treatment S4, but was significantly different from treatments S2 and S1. The highest hedonic rating score for the color of the probiotic beverage was observed in treatment S4, indicating that it was liked by the panelists. Panelists preferred beverages with a slightly red color. According to Spence (2015), the color red creates positive expectations regarding the beverage's taste even before panelists taste it. According to Suparman et al. (2019), consumers prefer bright and natural fruit juice colors, as these are associated with fresh and healthy products. This is also consistent with Sari & Catarina (2020), who found that the type of watermelon most preferred by panelists for watermelon probiotic beverages was red watermelon, with a color preference score of 4.19 (like).

Aroma

Aroma is one of the key aspects of sensory evaluation that contributes to flavor and influences the quality of food products. Aroma testing is conducted by smelling volatile compounds inhaled through the nose. The descriptive aroma scores for the probiotic beverages made from pineapple peel and red watermelon juice ranged from 1.60 to 3.90, indicating a spectrum from no distinct fermented aroma to a distinct fermented aroma. Statistical results show that treatment S3 was not significantly different from treatment S4, but was significantly different from treatments S1 and S2. The characteristic fermented aroma in probiotic beverages made from pineapple peel and red watermelon juice is caused by microorganisms producing organic acids and volatile compounds with a characteristic fermented aroma during the fermentation process. The characteristic fermentation aroma in probiotic beverages increases with the higher carbohydrate content in the red watermelon juice. This is because red watermelon juice contains 7.55% carbohydrates, consisting of 6.2% sugar and 0.4% fiber. Red watermelon juice contains natural sugars, namely 9.4% fructose, 4.4% glucose, and 3.4% sucrose (Shanely et al., 2016). The available natural sugars are broken down to produce organic acids, specifically lactic acid, which has a characteristic fermented aroma.

Table 7 shows that the hedonic aroma scores for the probiotic beverages made from pineapple peel and red watermelon ranged from 2.72 to 3.61, indicating “somewhat like” to “like.” Statistical results indicate that the highest hedonic score was found in treatment S1, which differed significantly from the other treatments. The hedonic scores for the aroma of the probiotic beverages in treatment S1 were preferred by the panelists because they preferred fruit juice beverages without a distinct fermented aroma. This is because acidic probiotic beverages have a pungent aroma that some consumers dislike. An overly strong fermentation aroma in probiotic beverages can reduce panelists’ liking scores. Sari & Catarina (2020) reported that the mean hedonic score for the aroma of a probiotic beverage formulated with red watermelon was 3.25, which was classified as “fairly liked” by the panelists.

Taste

Taste is a very important quality assessment parameter that is evaluated through the sense of taste and is influenced by raw materials, additives, and the processing methods used. The analysis of variance results indicate that different ratios of pineapple peel and red watermelon juice have a significant effect on the descriptive and hedonic taste of the probiotic beverages. Table 2 shows that the descriptive taste scores for the probiotic beverages made from pineapple peel and red watermelon juice ranged from 1.50 to 3.53, indicating a taste ranging from sweet to sour. The statistical results indicate that treatment S3 was not significantly different from treatment S4, but was significantly different from treatments S1 and S2. The more red watermelon juice used, the more sour the resulting probiotic beverage tasted. This is because during the fermentation process, microorganisms utilize nutrients from the pineapple peel and red watermelon juice, as well as the added sucrose, to produce various organic acids as metabolites, which cause the sour taste in the probiotic beverage. According to Ray & Joshi (2014), the breakdown of sugars by lactic acid bacteria (LAB) produces energy for the activity of probiotic bacteria, resulting in lactic acid production that can lower the pH and impart a sour taste to the final product. According to Pratiwi et al. (2018), during the fermentation process, LAB convert nutrients in the medium into lactic acid. The sour taste develops and intensifies as total LAB and total titratable acidity increase.

The hedonic sensory evaluation of the taste of probiotic beverages made from pineapple peel and red watermelon juice ranged from 2.92 to 3.37, indicating “somewhat liked.” Statistical results show that the hedonic ratings for treatment S1 were not significantly different from those of treatments S2 and S3, but were significantly different from those of treatment S4. The more acidic the probiotic beverage, the lower the panelists’ liking scores, as the sour taste in fruit juice-based probiotic beverages can influence panelists’ perceptions of their quality and freshness, even though probiotic beverages are known for their sour taste.

In addition, some panelists may not have understood that the sour taste in probiotic beverages is normal and results from the fermentation process. The hedonic score for treatment S1 indicated a sweet taste. The sweet taste in pineapple juice comes from its natural sugar content, while the sour taste is caused by compounds such as citric acid and malic acid (Mardiyah, 2016). According to Setiawan (2019), the most decisive factor in a product's acceptance is its taste, which influences consumers' final decision to accept or reject a food product.

Overall Evaluation

The overall evaluation is a hedonic assessment of probiotic beverages based on the panelists' level of preference for color, aroma, and taste. Table 2 shows that the overall hedonic evaluation scores for the probiotic beverages made from pineapple peel and red watermelon ranged from 2.91 to 3.52, indicating "somewhat like" to "like." Treatment S1 was not significantly different from treatment S3. Panelists preferred the probiotic beverage in treatment S1 because it had a brighter color, lacked the characteristic fermented aroma, and tasted sweet. According to the results of a study by Elsaputra et al. (2016), probiotic beverages made from pineapple peel ranging from those without added sucrose to those with 12% added sucrose received overall hedonic ratings ranging from 3.03 to 3.67, which corresponds to "somewhat like" to "like." The overall hedonic ratings of probiotic beverages made from pineapple peel and red watermelon juice indicated "like" ratings in terms of color, aroma, and taste.

CONCLUSION

The results of the study showed that different fruit juice ratios had a significant effect on the acidity (pH), total lactic acid, total vitamin C, total BAL, and antioxidant activity of the probiotic beverages made from pineapple peel and red watermelon juice. Different fruit juice ratios also had a significant effect on sensory descriptive and hedonic evaluations. The probiotic beverage made from pineapple peel and red watermelon juice in the selected treatment, namely S3 with a pineapple peel juice:red watermelon juice ratio of 50:50, met the quality standards of SNI 01-7552-2009 for flavored fermented milk beverages, with a pH of 3.67, total lactic acid of 0.42%, total vitamin C of 4.22 mg/100 g, antioxidant activity of 16.97 ppm, and total bacterial count (BAL) of 8.99 log CFU/ml. Descriptive sensory characteristics included a slightly reddish color, a distinctive fermented aroma, and a slightly sour taste; in the hedonic sensory evaluation, the color was well-liked by the panelists, while the aroma, taste, and overall rating were moderately liked by the panelists.

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