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Product Development of Yogurt Drink with *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13

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ABSTRACT

Yogurt drink is a liquid yogurt with low viscosity produced through fermentation using the lactic acid bacteria *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The addition of the probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 can improve the balance of gut microbiota and have health effects. This study aimed to determine whether the probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 can be used as a co-culture in manufacturing yogurt drinks using starter cultures of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The fermentation temperatures 37°C, 39°C, and 42°C were selected to determine the optimum temperature. *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 can grow and synergize with yogurt starter culture at 37°C with a total lactic acid bacteria up to 10^9 CFU/mL at the end of the fermentation and a probiotic cell up to 10^8 CFU/mL. Cell viability, pH, total titratable acidity, viscosity, and color were also evaluated during 5 weeks of storage at 4°C. Until the end of storage, the total number of lactic acid bacteria had a value of 10^8 CFU/mL, and the number of probiotic cells had a value of 10^7 log CFU/mL. pH decreased, total titratable acid increased, viscosity changed, and the addition of probiotic did not affect the color during storage. As a result of sensory evaluation, the yogurt drink contained probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 can still produce yogurt drinks similar to yogurt drinks without probiotics. Thus, *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 could be utilized as a co-culture in making probiotic yogurt drinks.

Keywords: fermentation temperature; lactic acid bacteria; probiotic; storage time; yogurt drink

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INTRODUCTION

Yogurt is a nutritious fermented milk product that is extensively consumed due to its high nutritional content. This processed cow's milk product is fermented with lactic acid bacteria *Streptococcus thermophilus* and *Lactobacillus bulgaricus* to form the characteristic yogurt flavor (Chandan et al., 2017; Farag et al., 2022). Lactic acid bacteria can convert lactose into lactic acid, contributing to yogurt's texture and flavor (Shori, 2015). The two starters have different functions throughout fermentation. *S. thermophilus* contributes to flavor, aroma, and texture, whereas *L. bulgaricus* produces acid (Hill et al., 2017). Various forms of yogurt have been circulating, including yogurt drink. A yogurt drink is a sort of liquid yogurt consisting of a blend of sugar, flavoring, and other components homogenized in plain yogurt

(Nagaoka, 2019). In addition to their nutritional value, yogurt drink is easy to ingest due to their low viscosity. Manufacturing a yogurt drink is nearly identical to making a yogurt set, except for high-speed agitation during the final fermentation stage to break down the coagulum (Chandan et al., 2017).

Hashemi & Hosseini (2021) note that in recent year, yogurt drinks have the potential to be a suitable medium for introducing probiotics to consumers. Probiotics are live microorganisms that, when added in sufficient amounts, will provide health benefits (FAO and WHO, 2002). The addition of probiotics in products can improve consumer health if the recommended amount is between 10^6-10^9 CFU/g (Abadía-García et al., 2013). The use of probiotics as a co-culture in making yogurt can improve texture, flavor, and be beneficial to health (Lang et al., 2022). Yogurt drink containing live microorganisms can improve the health of the digestive tract function, reduce or prevent diarrhea, and strengthen the immune system (Chandan et al., 2017).

The development of local strains from Indonesia has been carried out, and various probiotic products such as yogurt, chocolate, cheese, and probiotic powder have been produced. Lactic acid bacteria were isolated from several fermented foods and have potential to be probiotic candidates (Pamungkaningtyas et al., 2018). *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 is an indigenous Indonesian probiotic isolated from dadih or fermented buffalo milk (Endang S Rahayu et al., 2019; Utami et al., 2020). This indigenous probiotic can be used as a starter culture for fermented milk (Wardani, Cahyanto, Rahayu, & Utami, 2017), and has passed a safety assessment test that this probiotic strain is safe for consumption (Endang S Rahayu et al., 2019). Based on the study of Endang Sutriswati Rahayu et al. (2016), thirty healthy adults consumed fermented milk containing *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 for 20 days and feces samples were analyzed before and after consumption. After 20 days of consuming fermented milk drinks, *L. plantarum* Dad-13 could survive and colonize the digestive tract of healthy Indonesian volunteers. After consumption was stopped, *L. plantarum* Dad-13 was still found in the feces, although the amount was reduced. In addition, the number of *Enterobacteriaceae*, *E.coli*, and non-*E.coli* coliforms in feces decreased after consuming fermented milk beverages containing *L. plantarum* Dad-13.

Starter culture plays a vital role in the manufacture of fermented milk, and numerous factors influence its growth. Fermentation temperature is one of the factors that affect the viability of probiotics. *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 has different optimum growth temperature with yogurt starter of *S. thermophilus* and *L. bulgaricus*. *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 is a mesophilic lactic acid bacteria widely used for milk fermentation and has an optimal temperature of 37°C (Wardani et al., 2017). Meanwhile, *Streptococcus thermophilus* and *Lactobacillus bulgaricus* are thermophilic lactic acid bacteria that grow at 42°C (Endang Sutriswati Rahayu & Utami, 2019). Three types of lactic acid bacteria are used in producing probiotic yogurt drinks. These lactic acid bacteria have different optimum temperatures, so the differences in fermentation temperatures of 37°C, 39°C, and 42°C were chosen to determine the optimum temperature during fermentation which has a positive impact on the growth of probiotic bacteria. This study aimed to examine whether the probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 could be used as a co-culture in the manufacture of yogurt drinks using *Streptococcus thermophilus* and *Lactobacillus bulgaricus* starter cultures. The addition of probiotics was evaluated during storage on cell viability, pH, titratable acidity, viscosity, and color. A sensory evaluation of yogurt drinks was also carried out to determine consumer acceptance.

MATERIALS AND METHODS

Material

The ingredients used in this study were fresh milk (PT Global Dairy Alami, Indonesia), starter culture Streptococcus thermophilus FNCC 0040, Lactobacillus bulgaricus FNCC 0041, and *Lactiplantibacillus plantarum subsp. plantarum* Dad-13 with a ratio of 1:1:1 were obtained from Food and Nutrition Culture Collection (FNCC) (Center for Food and Nutrition Studies, Universitas Gadjah Mada, Yogyakarta, Indonesia). Other materials used include sucrose (PT. Sugar Group Company, Indonesia), high methoxyl pectin (150 USA SAG), and mineral water (PT. AQUA Golden Mississippi). The analytical materials used were De Mann Rogosa Sharpe (MRS) (Oxid, USA), bacteriological agar (Oxoid, USA), calcium carbonate ($CaCO_3$) (Merck, Germany), sodium hydroxide (NaOH) 0,1 N, oxalic acid 01 N (Merck, Germany), and PP (Phenolphthalein) indicator. The instruments used in yogurt drink production include duran bottles (1000 ml), digital scales, water bath, incubator, and homogenizer.

Determination of fermentation temperature

Yogurt with the addition of *Streptococcus thermophilus, Lactobacillus bulgaricus,* and probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 was prepared. The preparation process for yogurt base was based on the method by Nagaoka (2019) with a few modifications. The fresh milk was pasteurized at 80°C for 10 minutes, then cooled to 37°C, and inoculated the starter culture into the milk. Afterward fermented at 37, 39, and 42°C until curd is formed to determine the optimum temperature during the fermentation process for probiotic yogurt drinks. The growth of lactic acid bacteria and the decrease in pH were analyzed every 6 hours during fermentation.

Yogurt drink production

The yogurt drink was prepared according to Nagaoka (2019) with minor modifications. Two types of yogurt drinks were prepared. The first type was made by adding *Streptococcus thermophilus* and *Lactobacillus bulgaricus* starter cultures as a control. The second type used starter *Streptococcus thermophilus*, *Lactobacillus bulgaricus,* and probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13. After the yogurt base was formed, a sugar solution with 37% water consisting of 8% sugar and 0.5% pectin was added and heated to 80°C. After the sugar solution cooled, it was mixed with the yogurt base (55%) and homogenized for 15 minutes. Then it was put into bottles (80 ml) and stored at 4°C for 5 weeks to evaluate viability, pH, total titratable acidity, viscosity, and color.

Cell Viability

Microbiological analysis of yogurt samples included counting the colonies of lactic acid bacteria (LAB) using MRS media. The amount of lactic acid bacteria was measured using the serial dilution and pour plate method using MRS agar containing 0.5% $CaCO_3$ (Wardani et al., 2017). Enumeration of probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 in mixed culture was carried out using the spread plate method on *Lactobacillus plantarum* selective medium (LPSM) agar. The samples were incubated at 37ºC for 48 h and expressed in colony-forming units (log CFU/mL). LAB and number of cell of probiotic were counted in triplicate (Bujalance, Jiménez-Valera, Moreno, & Ruiz-Bravo, 2006).

pH and titratable acidity

The pH of the samples was determined using a digital pH meter (Zentest pH60S-Z Smart Spear pH Tester, Europe). Titratable acidity was measured by adding 0,1 N NaOH solution and using phenolphthalein (PP) as an indicator (Bai et al., 2020).

Viscosity

The viscosity was measured using a Brookfield viscometer (Model DV2T, Brookfield Engineering Laboratories Inc., Middleboro, MA, USA). Spindle number 61 was performed at a rotation of 60 rpm for all the samples.

Color

Color analysis of the yogurt drink samples was evaluated using a colorimeter (Konica Minolta, Chroma Meter, CR400, Japan) was used to measure lightness (L*) values indicated ranged from 0−100 (brightness black to white), a* values indicated as green (-a*) to red (+a*), and b* as blue (-b*) to yellow (+b*) and the instrument was standardized using standard white plates (Narayana et al., 2022).

Sensory evaluation

In the hedonic test, three samples were to be served to panelists such as a yogurt drink, a yogurt drink probiotic, and a yogurt drink commercial. Participant were instructed to eat cracker and drink water for each change of yogurt drink sample. Sensory attributes include aroma, sweetness, viscosity, sourness, color, and overall taste. The test values used are between 1 and 7, i.e., 1 (strongly disliked), 2 (moderately disliked), 3 (slightly disliked), 4 (normal), 5 (slightly liked), 6 (moderately liked), and 7 (strongly liked).

Statistical analysis

All the statistical analysis was performed using R and RStudio statistics software, version 2021.09.0 Build 351, for assessing the experimental data. The determination of fermentation temperature was analyzed using the non-parametric Kruskal-Wallis rank-sum test, the difference between yogurt drink and yogurt drink probiotic was analyzed using a two-way t-test, and sensory evaluation was determined using way ANOVA to determine if there was a difference, the post hoc Tukey HSD test was continued. All experiments were done in triplicate, and the results were expressed as the mean value ± the standard deviation at the significant difference $p<0.05$.

RESULTS AND DISCUSSION

Determining fermentation temperature

To determine the optimal temperature, the yogurt fermentation was carried out at 37, 39, and 42°C. The initial number of cells added before fermentation was 10^7 CFU/mL. The number of starters used for fermentation is between 10^{6-7} CFU/mL. During fermentation, cells increase so the final number reaches 10^8 CFU/mL or more (Endang Sutriswati Rahayu & Utami, 2019). When the bacteria grow, lactic acid is formed, and specific flavors are added to the final product. Figures 1 and 2 show the total lactic acid bacteria and the number of probiotic cells produced by different cells during different fermentation times.

Yogurt with the addition of probiotic at various temperatures showed significant differences ($p<0.05$) at 36-hour fermentation. During fermentation, the total lactic acid bacteria and probiotic cell counts resulted in different cell counts at three temperatures. Total lactic acid bacteria increased up to 12 hours of fermentation, while the number of probiotic cells increased at 6 hours. Amongst the three temperatures applied, only 37°C gradually increased the number of total lactic acid bacteria and probiotic cells. Figure 1 shows the total number of lactic acid bacteria steadily increased in the number up to 10^9 CFU/mL at the end of the fermentation, and the same cell growth was also observed in the total number of probiotic cells up to 10^8 CFU/mL, as shown in Figure 2. This is in accordance with the research of Wardani, Cahyanto, Rahayu, & Utami (2017) that *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 can grow optimally at 37°C, but very slow at 40°C. *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 is mesophilic lactic acid bacteria, while *Streptococcus thermophilus* and *Lactobacillus bulgaricus* yogurt starter cultures belong to thermophilic lactic acid bacteria, which likely grow at high temperatures around 42°C (Endang S Rahayu et al., 2019; Wardani et al., 2017). The incubation temperature of 37°C is the optimum temperature for probiotic growth. It positively affects the synergistic correlation between probiotics and *L. bulgaricus* and produces the highest number of probiotic cells (Mortazavian et al., 2006). The study also conducted a study using 3 different incubation temperatures of 37, 40 and 44°C in producing probiotic yogurt. Among the three temperatures, 37°C showed the highest cell count of *L. acidophilus*. Temperatures higher than 45°C have a negative impact on probiotic growth and viability (Calinoiu et al., 2016).

During the fermentation process, lactic acid production was increased which caused the pH to decline (Figure 3). Lactose produces a sour taste and turns liquid milk into solid curd (Vedamuthu, 2006). At the end of the fermentation, the three temperatures had pH values between 4.13-4.22 which had a compact curd texture and a change in taste to sour. The decrease in the pH of yogurt is caused by the activity of lactic acid bacteria when hydrolyzing lactose into lactic acid (Jannah et al., & Al-baarri, 2014). According to (Winarno & Fernandez, 2007), lactic acid produced from carbohydrate metabolism is responsible for the decrease in pH value and contributes to the formation of a sour taste.

At 37°C *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 could grow optimally, while *Streptococcus thermophilus* and *Lactobacillus bulgaricus* were slow because they were not grown at the optimum temperature. This also resulted in a 36-hour fermentation period during which the pH reached approximately 4.13. In the production of yogurt using *S. thermophilus*, *L. bulgaricus*, *L. casei* NRRL B-1922 and *S. thermophilus*, *L. bulgaricus*, *L. reuteri* NRRL B-14171 resulted in long fermentation times of 14 and 12 hours. This may be due to the inhibition of starter culture in the presence of probiotic bacteria (Mani-López, Palou, & López-Malo, 2014).

Cell viability

In product development, the viability of lactic acid bacteria and the number of probiotic cells is important because it could affect product quality. The total viability of lactic acid bacteria and the number of probiotic cells of *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 was evaluated for 5 weeks of storage at 4°C.

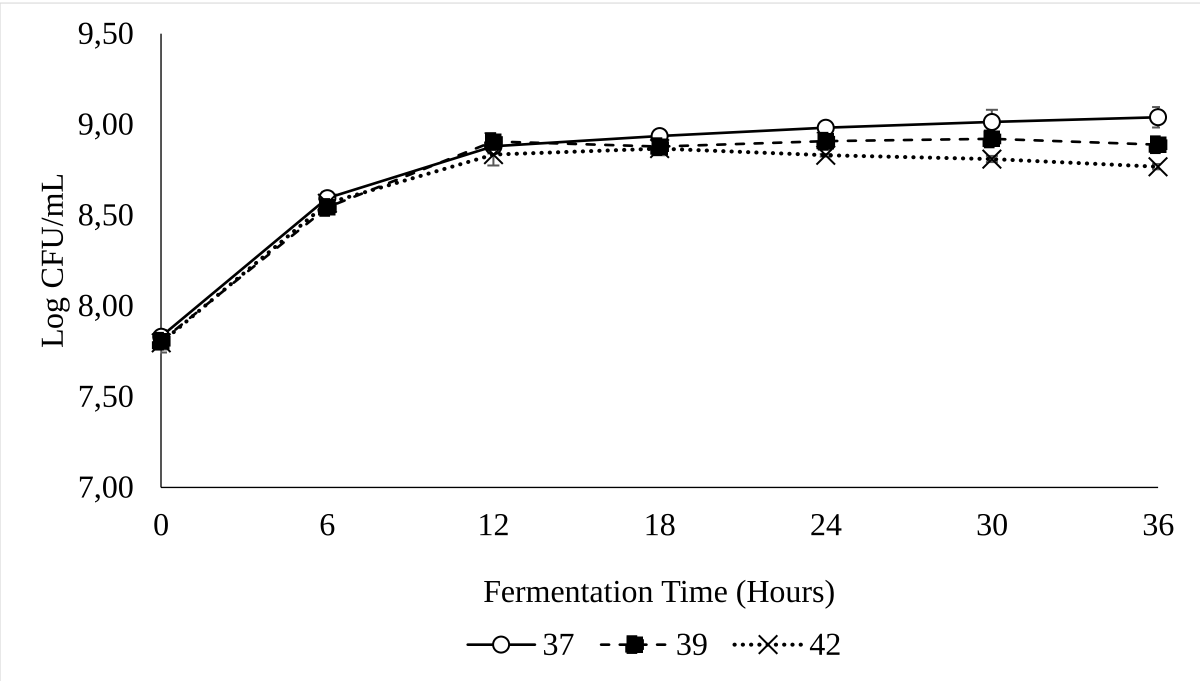

Figure 1. Growth curve of total lactic acid bacteria during fermentation

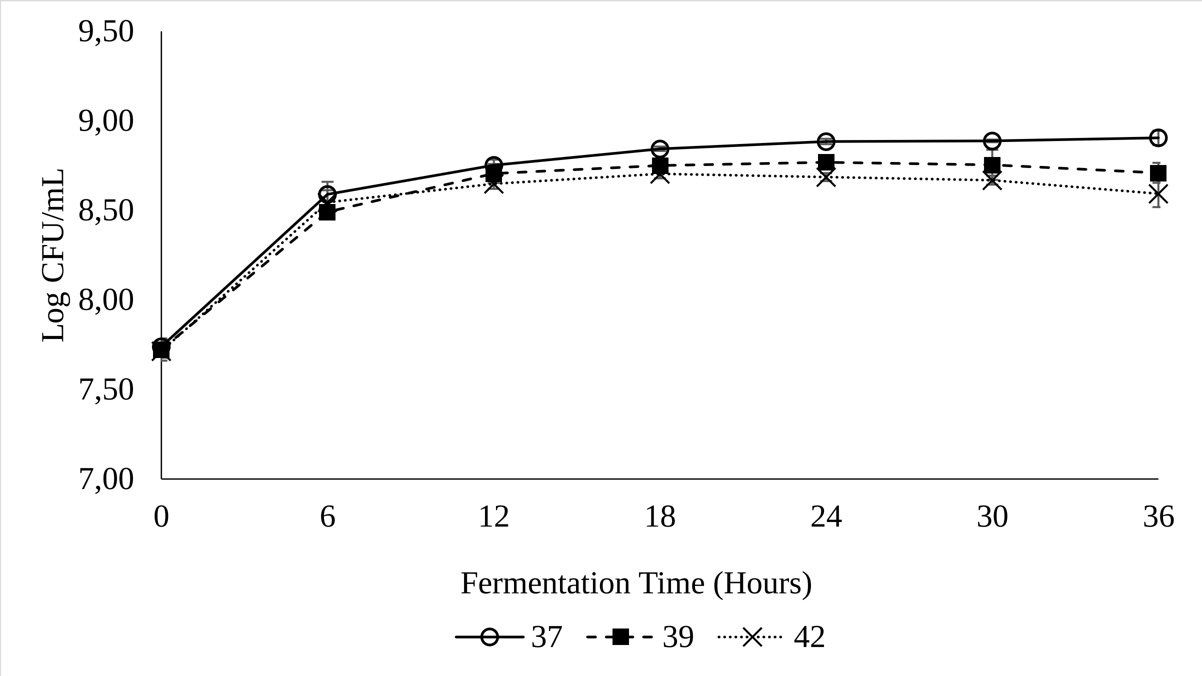

Figure 2. Growth curve of probiotic cell of *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 during fermentation

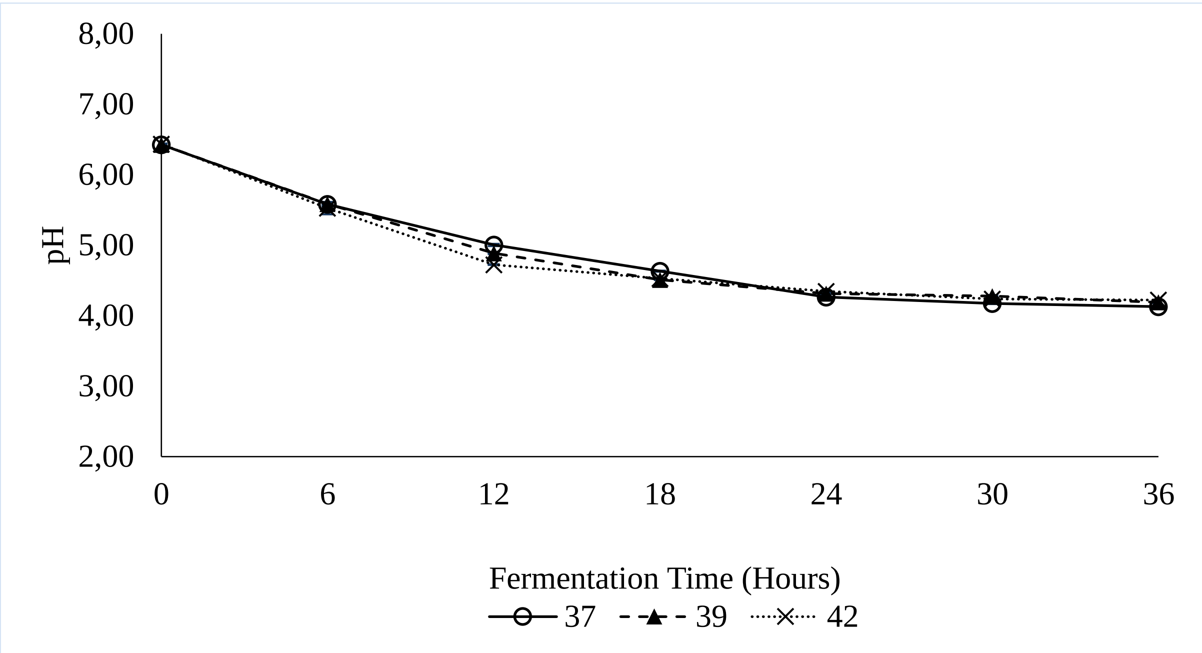

Figure 3. pH growth curve during fermentation

Based on statistical analysis, the total cell viability of lactic acid bacteria between yogurt drinks and yogurt drink probiotics showed significantly different results ($p<0.05$). Figure 4. shows that during 5 weeks of storage, the total lactic acid bacteria between yogurt drinks without of probiotics and yogurt drinks with the addition of probiotics was stable at a value of 10^8 CFU/mL. Yogurt with the addition of probiotics is a functional food product that contains of probiotic bacteria that provide health effects. Therefore, the viability of yogurt bacteria and probiotic bacteria must be maintained during the production process, storage, and survival in the intestinal tract. Total lactic acid bacteria yogurt with the addition of probiotics was stable in the range of 8.25-8.13 log CFU/mL and yogurt without the addition of probiotics was stable in the range of 8.20-8.07 log CFU/mL. The total lactic acid bacteria of the probiotic yogurt drink was higher than yogurt drink, Shori (2015) also noted adding probiotics *L. casei, L. rhamnosus* or *L. plantarum* affects the viability of *L. bulgaricus* and *S. thermophilus* in yogurt, which can increase the metabolic activity of *L. bulgaricus* and *S. thermophilus*.

Figure 5. shows the number of probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 cells, which was also stable at a value of 10^7 CFU/mL in the range of 7.96-7.81 log CFU/mL during 5 weeks of storage so it is considered a probiotic food product because it can maintain a cell count of 10^{7-9} CFU/mL (Endang et al., 2019). The number of cells in plain yogurt using the starter culture *L. plantarum* Dad-13 and *S. thermophilus* Dad-11 was relatively stable during storage until 6 weeks of storage with a number of probiotic cells of 10^7 CFU/mL (Utami et al., 2020). In the last 3 weeks, the viability of probiotics *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 has decreased, this is caused by the cessation of metabolic activity of the bacteria due to long storage (Mani-López et al., 2014). Arena et al. (2015) also noted the viability of probiotic *L. plantarum* WCFS1 and *L. plantarum* CECT 8328 decreased after 28 days of storage. According to Meybodi, Nasab, Khorshidian, & Mortazavian (2021), there are several factors that affect the viability of probiotic cells in yogurt including total titratable acid, pH, oxygen during fermentation and storage, type of probiotics used, starter culture and yogurt composition.

pH and titratable acidity (TTA)

pH and titratable acidity are the primary indicators to assessing the acidity of yogurt. Results are shown in figure 6 and figure 7, the pH and titratable acidity between yogurt drink and yogurt drink probiotics showed significantly different result ($p<0.05$). During storage, the yogurt drink pH declined but the total titrated acid exhibited the opposite trend. At the end of storage, the yogurt drink probiotic had a lower pH with a value of 3.91 compared the yogurt drink without probiotic with a value of 3.94. According to Arena et al. (2015), the yogurt with the addition of probiotic *L. plantarum* WCFS1 and *L. plantarum* CECT 8328 presented pH values after 1 and 14 days of storage significantly different from yogurt control (without probiotic).

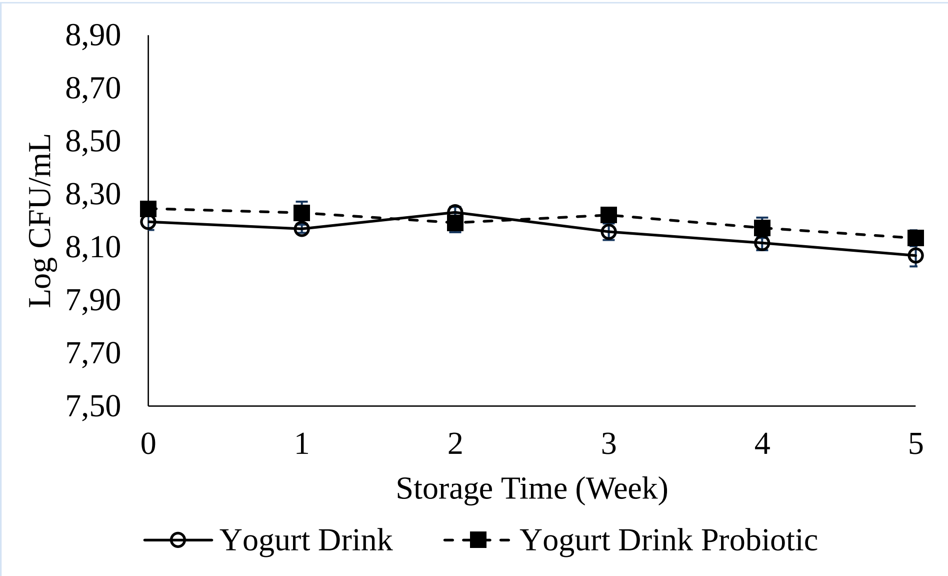

Figure 4. Viability cell of lactic acid bacteria yogurt drink and yogurt drink probiotic during storage

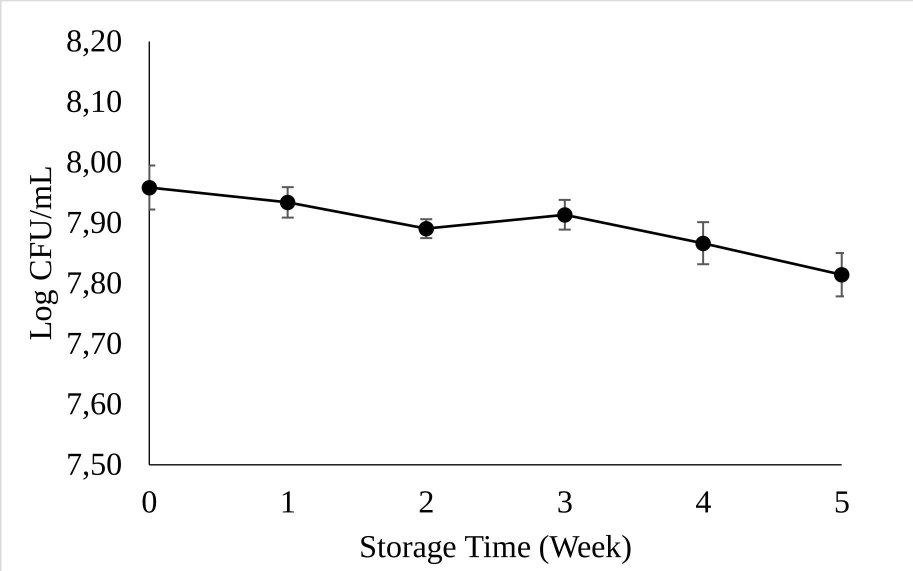

Figure 5. Viability cell of probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 during storage

However, only yogurt with addition probiotic *L. plantarum* WCFS1 had a significantly lower pH after 28 days of storage. The total titratable acidity of yogurt drink probiotic at a value of 1.29% and yogurt drink without probiotic at a value of 1.22% at the end storage. Total titratable acidity of yogurt probiotic with *L. rhamnosus* ATCC 53103, *L. casei* ATCC 393, *L. plantarum* ATCC 14917 and control yogurt (*S. thermophilus* St1342, *L. delbrueckii* ssp. *lactic* ATCC 7830) increased during 21 days storage (Shori, 2015). After storage, yogurt's decreased pH and increased acidity result from post-acidification caused by metabolic activity that generates lactic acid (Deshwal et al., 2021). Compared to yogurt without probiotics, yogurt drinks with additional probiotics produced the lowest pH, followed by total titratable acidity, which had the highest value after 5 weeks of storage. Due to the high population of lactic acid bacteria found in yogurt, overall titratable acidity levels increased during storage (Alirezalu et al., 2019).

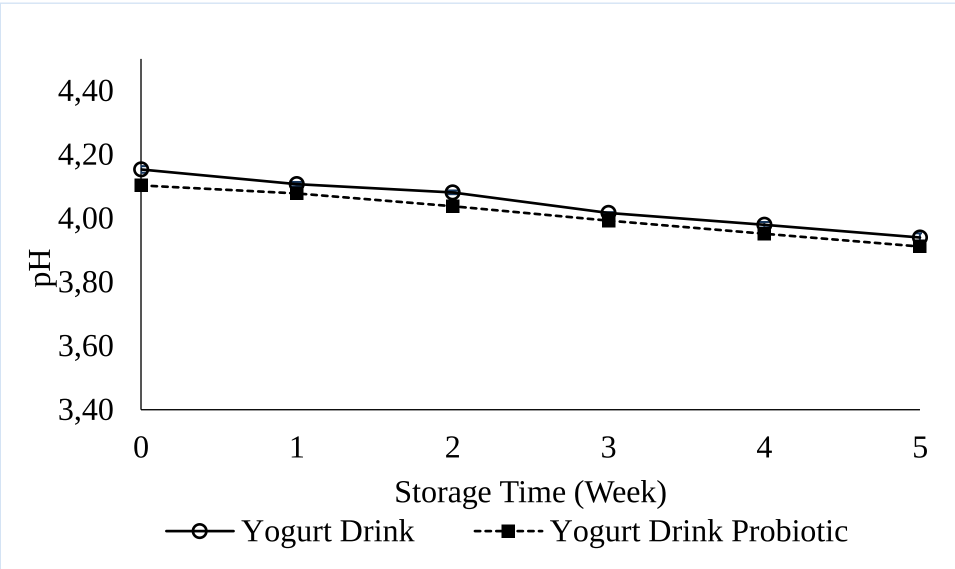

Figure 6. pH of yogurt drink and yogurt drink probiotic during storage

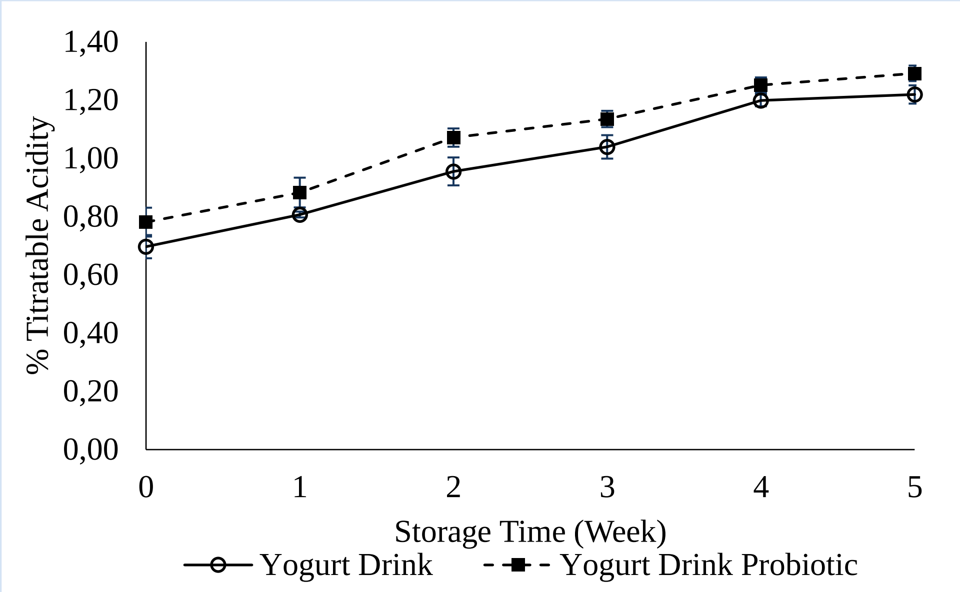

Figure 7. % Titratable acidity of yogurt drink and yogurt drink probiotic during storage

Viscosity

Viscosity stability during storage is an important indicator in fermented products (Stijepić, Glušac, Durdević-milošević, & Pešić-Mikulec, 2013). Viscosity is also related to protein content, especially casein, and viscosity during storage generally increases (Celik & Temiz, 2022). Figure 8 shows that yogurt drinks without the addition of probiotics and yogurt drink with the addition of probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 had significantly different viscosity values ($p<0.05$). The viscosity of yogurt drinks with probiotic reached the highest value of 52.23 cP compared to yogurt drinks without probiotics at a value of 51.00 cP at the end of storage. This result is in accordance with the research of Soni et al. (2020), which mentioned that the addition of probiotics, especially *Lactobacillus plantarum* (LP) (NCDC-20), produced higher viscosity than yogurt using *Lactobacillus acidophilus* (LA) (NCDC-13), *Bifidobacterium bifidum* (BB) (NCDC-229), *Lactobacillus casei* (LC) (NCDC-17), and control starter cultures due to the production of exopolysaccharide (EPS). In addition, decreased pH during storage affects viscosity. The pH value can reduce the solubility of casein, resulting in hydrophobic interactions between casein micelles to form the structure and consistency of the yogurt drink, which causes the yogurt drink to become thicker so that the viscosity increases (Setianto, Pramono, & Mulyani, 2014). The adjustment of viscosity value is due to the activity of lactic acid bacteria during the fermentation process, which can affect the viscosity of milk. The fermentation of lactose would produce lactic acid initiated by lactase enzyme and later affect the viscosity (Wibawanti & Rinawidiastuti, 2018). The final yogurt drinks viscosity was not affected by adding 0.5% pectin. In one of the previous studies, adding 0.2% and 0.4% pectin did not alter the viscosity at the end of the product (Sobhay, A., Hassan, & El-Batawy, 2019). Thun, Yan, Tan, & Effendi (2022) reported the addition of 0.3% or 0.6% pectin had no effect on the viscosity of the produced yogurt drink. A low dosage level of high methoxy pectin might not coat all casein particles and produce enough electrostatic and steric repulsions to set the dispersion.

Color

Color is important in consumer acceptance, quality, flavor, freshness, and commercial value of yogurt (Yilmaz-Ersan & Topcuoglu, 2022). During 5 weeks of storage, the L*, a*, and b* values of the two yogurt drink samples were not significantly different (p>0.05). Table 1 shows the highest L* values and the lowest a* and b* values, followed by yogurt drinks and yogurt drinks probiotics. Parameter a* values confirm that the green tone dominates the red in all samples, even with all negative measurements. Parameter b* values show that the yellow coloration dominates over the blue coloration, which was positive for all yogurt drink samples. Cui, Chang, & Nannapaneni (2021) reported during 28 days of storage, cow's milk yogurt and yogurt probiotic with *L. rhamnosus* (LGG), *Bifidobacterium animalis* subsp. *lactis* BB-12 (BB) and *L. acidophilus* La-5 (LA) did not affect the three color values. The cow's milk yogurt with and without probiotics had a whiter color. The brightness of yogurts is related to the particle size of fat globules and protein, affecting their light reflectance and scattering ability. The size of these molecules is strongly influenced by choice of unit operations and processing parameters (e.g., homogenization) (Tamime & Robinson, 1999; Ciron et al., 2012).

Sensory evaluation

In addition to providing health benefits, probiotics addition to yogurt resulting better flavor. Figure 9 shows three yogurt drink samples presented to the panelists, including yogurt drink, yogurt drink with probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13, and commercial yogurt drink produced by the dairy company. Based on the one-way ANOVA statistical analysis results, there was no significant difference (p>0.05) between the yogurt drink and the probiotic yogurt drink. The parameters of aroma, color, viscosity, sour taste, sweet taste, and overall acceptance have almost the same value on a scale of 5 (neutral).

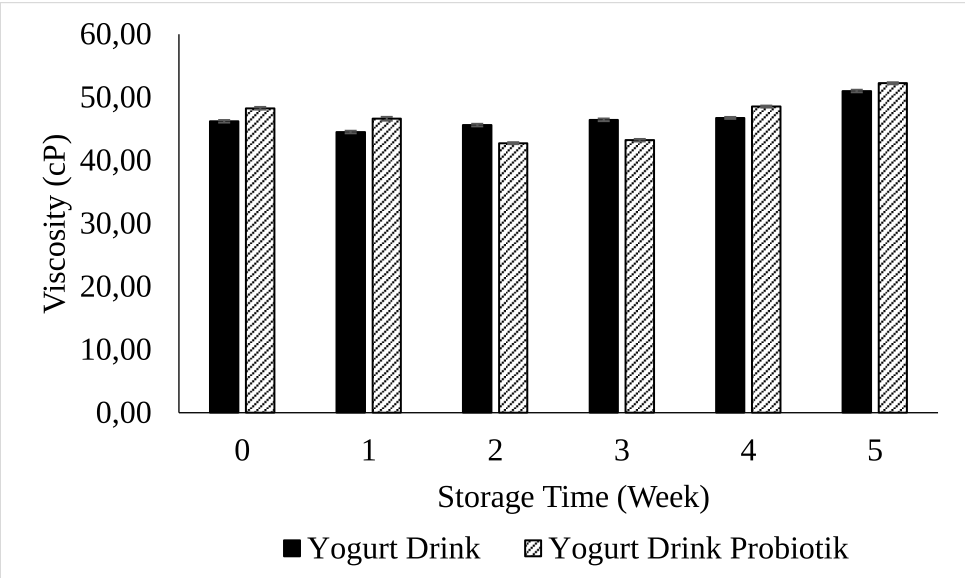

Figure 8. The viscosity of yogurt drink and yogurt drink probiotic during storage

Table 1. The color of yogurt drink and yogurt drink probiotic during storage

Week	Yogurt Drink			Yogurt Drink Probiotic		
	L*	a*	b*	L*	a*	b*
0	79.60±0.03	-5.62±0.05	9.73±0.02	79.66±0.06	-5.68±0.07	9.75±0.03
1	79.32±0.05	-5.76±0.04	9.94±0.04	79.28±0.04	-5.67±0.06	9.91±0.02
2	78.68±0.03	-4.69±0.02	9.21±0.04	78.71±0.05	-4.72±0.03	9.22±0.05
3	78.12±0.04	-2.33±0.07	8.98±0.05	78.06±0.05	-2.29±0.06	8.92±0.03
4	78.34±0.05	-3.74±0.02	9.15±0.02	78.40±0.07	-3.77±0.04	9.17±0.04
5	77.20±0.02	-2.47±0.04	8.67±0.03	77.25±0.03	-2.52±0.03	8.71±0.02

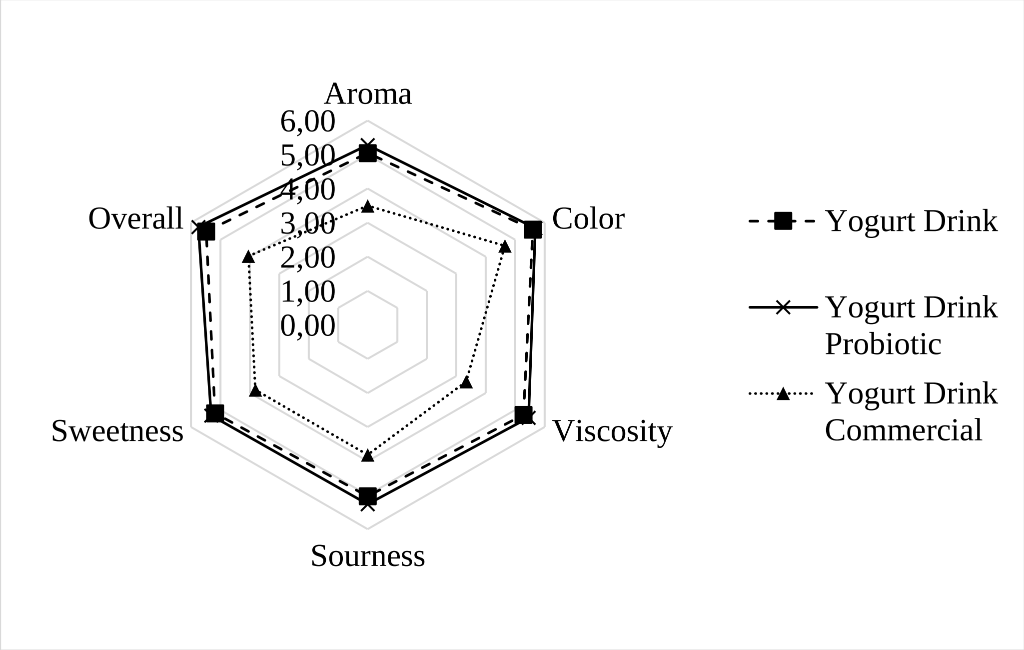

Figure 9. Hedonic sensory attributes

The addition of probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 can still produce yogurt drinks similar to yogurt drinks without probiotics because they do not have significantly different values. Overall, panelists preferred yogurt drinks with probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 with a score of 5.75. The *Lactobacillus* group can produce a stronger flavor (Endang Sutriswati Rahayu & Utami, 2019). Previous studies reported that adding probiotic *L. plantarum* A3 can enhance the sensory of the yogurt, especially components like vanilla (vanillin), leucine, $C_{18:3n6}$ (Lang et al., 2022).

CONCLUSION

A combination of *Streptococcus thermophilus*, *Lactobacillus bulgaricus*, and probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 could be used as a starter culture for producing probiotic yogurt drinks with an optimal temperature of 37°C. Probiotic yogurt drink stored for 5 weeks has a total lactic acid bacteria of 10^8 CFU/mL and probiotic *L. plantarum* cell count of 10^7 CFU/mL so that it can be categorized as a probiotic food product. During storage, the yogurt drink pH declined but the total titrated acid exhibited the opposite trend. The viscosity of yogurt drinks with probiotic reached the highest value compared to yogurt drinks without probiotics and the L*, a*, and b* values of the two yogurt drink samples were not significantly different at the end of storage. The addition of probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13 can still produce yogurt drinks similar to yogurt drinks without probiotics because they do not have significantly different values. This research might help the dairy industry develop new probiotic products using the indigenous probiotic *Lactiplantibacillus plantarum* subsp. *plantarum* Dad-13.

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