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RESEARCH PAPER

Physicochemical and microbiological characteristics of kefir ice cream with the addition of bengkuang (*Pachyrhizus erosus* (L.)) starch

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Abstract

The technology for fermenting milk kefir and the development in processing kefir ice cream is crucial to produce superior food products that support health. The addition of prebiotics from bengkuang (*Pachyrhizus erosus* (L.)) starch in making ice cream is the main purpose of improving the quality of kefir ice cream. This research purposed to determine the physicochemical (moisture, ash, protein, fat, phenolics, and DPPH for free radical scavenging activity) and microbiological (lactic acid bacteria, yeast, *Lactobacillus*, *Lactococcus*, *Leuconostoc*) characteristics of kefir ice cream after the addition of 3, 5, 7 and 9% (w/w) bengkuang starch. This ice cream used fresh cow's milk, skim milk, kefir, granulated sugar, whipped cream, CMC (Carboxy Methyl Cellulose), egg yolks, and varying amounts of bengkuang starch. The research showed that the best formulation for all physicochemical and microbiological characteristics was the kefir ice cream added with 9% (w/w) bengkuang starch. This product had stable viability of probiotic microbes (both lactic acid bacteria and yeast), the same protein value as the control, low fat, pH suitable for probiotics, high total phenolic content and DPPH value, and low melting rate even though the overrun value was lower compared to controls. The synergistic combination of bengkuang starch and probiotics from kefir in making ice cream has the potential to produce nutritious functional foods that are beneficial for human health.

Keywords

Bengkuang starch, Functional food, Kefir ice cream, Microbiological, Physicochemical characteristics

Introduction

Ice cream is one of the most popular semi-wet food products, as an oil-in-water emulsion containing fat, mineral salts, protein, and water (Ayar et al. 2018). The principle in making ice cream is the formation of air cavities in the mixture of ice cream ingredients so it can obtain the volume expansion, making the ice cream lighter, less dense, and soft (Guler-Akin et al. 2016). The quality of ice cream is influenced by raw materials, manufacturing, and storage processes (El-Sayed et al. 2015). Innovation in ice cream production can be done by adding probiotics and prebiotics to the constituent ingredients (Fidyasari et al. 2022). According to Aboulfazli et al. (2015), probiotics are living microorganisms added to food to promote health benefits, while prebiotics are food ingredients that stimulate the growth of probiotic bacteria. This finding was further supported by Casarotti and Penna (2015), who suggested that probiotics are usually obtained from lactic acid bacteria (LAB) because these bacteria are rarely pathogenic, while prebiotics are generally from carbohydrates in the oligosaccharides (oligofructose) and dietary fiber (inulin).

Meanwhile, kefir is a fermented milk product using kefir grains as a starter culture, containing various microorganisms species of lactic acid bacteria, acetic acid bacteria, and yeast (Van Wyk 2019). Microorganisms in kefir are believed to have the potential to act as probiotics and support human digestive health, such as *Lactobacillus kefiranofaciens*, *Lactobacillus acidophilus*, *Leuconostoc*, *Acetobacter* sp, and *Streptococcus* sp, as well as yeasts such as *Saccharomyces cerevisiae*, *Torula* (Yüksekdağ et al. 2004) *Saccharomyces marxianus*, *Candida kefyr* , *Kluyveromyces marxianus* subsp. marxianus, *Picbia fermentans*, *Kazacbastania*, *Lacbanceae meyersii*, and *Yarrowia lipolytica* (Sefidgar et al. 2014). Based on the facts above, there is a new idea to combine one of the natural prebiotic sources from *Pachyrhizus erosus* starch in making kefir ice cream.

Pachyrhizus erosus is a tuber plant known as bengkuang (in Indonesia) (Fig. 1), the plant is planted in various countries worldwide, the bengkuang originates from the American continent. Other sources confirm that bengkuang comes from central and south America, especially Mexico. From America, it spreads worldwide, especially in tropical climate areas such as South Asia, East Asia, and Asia Pacific. Initially, bengkuang plants are known as wild plants. Bengkuang is a plant that generally grows in tropical area. The bengkuang is a tuber plant that is widely cultivated in Indonesia. This plant grows to form root tubers. Root tubers are roots that grow larger because they contain food reserves (Baroroh et al. 2020). The tubers are round like a top and weigh up to 5 kg. At first glance, bengkuang tubers look like sweet potatoes. Bengkuang tubers grow single with a diameter of between 5–30 cm. The skin of bengkuang tubers is light brown or dark brown to white. The tuber flesh is white or whitish-yellow. The skin is easy to peel. Young tubers taste sweet and refreshing. This plant has excellent potential for health. Bengkuang starch is known to have complete nutritional content (Table 1), with a percentage of 2.15 ± 0.07 protein, 0.13 ± 0.10 fat, 90.02 ± 0.05 carbohydrates, 5.98 ± 0.01 crude fiber, 11.84 ± 0.08 moisture, and 0.32 ± 0.02 ash. The starch in bengkuang tubers is in the form of inulin, a polymer of fructose units. Inulin is soluble in water and cannot be digested by digestive enzymes but can be fermented by the microflora of the colon (large intestine) so that inulin functions as a prebiotic (Santoso et al. 2020). The high vitamin C content (20 mg/100 g) allows bengkuang to be a potential source of antioxidants to ward off free radical attacks that may cause cancer and other degenerative diseases (Siregar et al. 2019).

Figure 1. Photographs of the bengkuang plant (**A**) and its tuber (**B**).

This research is more specifically innovative in processing milk into kefir ice cream by adding natural prebiotic source such as bengkuang starch. The expected result is to obtain a kefir ice cream product as a functional food rich in probiotics and prebiotics.

Materials and methods

Extraction of bengkuang starch

A total of ± 1 kg of fresh bengkuang tubers obtained from Payakumbuh traditional market, West Sumatra were cleaned, grated, and squeezed. The juice was left for several hours until a precipitate forms. The precipitate was dried in an oven at 50 °C for 24 hours. Bengkuang starch powder was obtained that was then sieved with a 120 mesh sieve (Lukitaningsih 2014). The chemical composition of bengkuang starch as listed in Table 1.

Kefir preparation

Table 1. The chemical composition of bengkuang starch.

Component	Bengkuang (*Pachyrhizus erosus* (L.) starch
Moisture (%)	11.84 ± 0.08
Fat (%)	0.13 ± 0.10
Ash %	0.32 ± 0.02
Protein (%)	2.15 ± 0.07
pH	5.84 ± 0.04
DPPH (%)	59.22 ± 0.01
Total phenolics content (mg GAE/100 g)	280.16 ± 0.03
Carbohydrate (%)	90.02 ± 0.05
Crude fiber (%)	5.98 ± 0.01

Note: Values reported as mean ± standard deviation (N = 5).

A liter of cow's milk was pasteurized using the Low Temperature Long Time (LTLT) method at 62–65 °C for 30 minutes. The milk temperature was reduced to 45(±5)°C. Then, add 10% kefir grains to pasteurized cow's milk. Incubation was carried out on the samples for 24 hours under anaerobic conditions. After 24 hours, if the curd and whey separate, the kefir fermentation was successful. Then, separate the kefir and grains, then homogenize them. The kefir was matured for 12 hours at refrigerator temperature (5–8 °C). Kefir is ready to use (Ferawati et al. 2021).

Manufacture of kefir ice cream

The ingredients used in making ice cream (ice cream mix) were fresh cow's milk (28.25%), skim milk (14.125%), kefir (14.125%), granulated sugar (18%), whipped cream (25%), CMC (Carboxy Methyl Cellulose) (0.5%), egg yolks (2.5%), and various percentages of bengkuang starch addition (3, 5.7, and 9%). The process for making ice cream (modification of Akalin et al. 2018) consisted of: ICM raw materials were pasteurized at 65 °C for 30 minutes consisting of fresh cow's milk, skim milk, granulated sugar, egg yolks, and CMC except kefir and whipped cream. The ICM temperature was lowered to 40 °C, then kefir and whipped cream were added, then homogenized with a high-speed mixer for 1 minute. Randomization of the experimental units was carried out, followed by adding bengkuang starch according to the treatment and then homogenization. Incubate the ice cream mixture in an incubator at 37 °C for 3.5 hours. The aging process was carried out on ICM at a temperature of ±4 °C for 1 hour. Put the ICM into the ice cream maker and process for 30 minutes. The samples were packaged into ice cream cups and frozen in the freezer for 1 × 24 hours. After that, the laboratory analysis was carried out.

Experimental design

The experimental method with a Completely Randomized Design (CRD) with four treatments and five replications was used in this research. The treatment consisted of adding percentages of bengkuang starch (3, 5, 7, and 9%) in making kefir ice cream. This research determined the physicochemical characteristics of ice cream (moisture, ash, protein, fat, total phenolic content, free radical scavenging activity, pH, Total Titratable Acidity (TTA), overrun and melting rate) and microbiological properties (Total colonies of lactic acid bacteria, yeast, Lactococci, Lactobacilli, and Leuconostoc).

Proximate analysis

Kefir ice cream samples were analyzed for moisture, ash, protein, fat, and ash according to the method described in AOAC (2005). The pH value of samples was determined using a pH meter (HANNA). The pH meter was standardized using solutions with known pH values of 7, 4, and 10. The pH meter was dipped into a 5 mL beaker glass (pyrex) containing 3 ml of ice cream sample, and pH values were recorded (Sulmiyati et al. 2019). The determination of the total titratable acidity test was carried out based on (Purnomo et al. 2012). Acid content was determined by titration using 0.1 N NaOH for 5 mL of kefir ice cream with two drops of PP Indicator (Phenolphthalein Indicator) until the color of the sample became pink. Acid levels calculation was performed as follows:

$$\text{Total titratable acidity} = (\text{mL NaOH} \times 0.009) \times (\text{weight of milk (g)})^{-1} \times 100\%.$$

Determination of total phenolic content and free radical scavenging activity

Samples were prepared according to the method of Goraya and Bajwa (2015). As much as 2 g of the sample was dissolved in 25 mL of 80% methanol solution and left for extraction for 1 hour using Whatman filter paper no. 1 to filter the material and dilute the material with 100 mL of methanol. Evaluation of phenolic content using Folin-Ciocalteu reagent. 0.1 mL of sample extract was reacted with 1 mL of Folin-Ciocalteu reagent (1:9 parts of Folin-Ciocalteu reagent with distilled water) then wait 5 minutes, add 1 mL of sodium carbonate, and increase the volume to 10 mL with distilled water. The solution was maintained at room temperature for 90 minutes and then analyzed using a spectrophotometer at 725 nm. The standard used was gallic acid, measured in mg gallic acid equivalents (GAE) per gram of material.

The DPPH method was used to determine the % free radical scavenging activity using methanol extract (Caleja et al. 2016). The absorbance of the mixture was measured at 515 nm using a spectrophotometer (model 20D UV, Milton Roy Company, USA). The blank used was a DPPH solution without extract. Free radical scavenging activity was calculated as follows:

$$\text{DPPH radical–scavenging activity (\%)} = [(\text{Ablank} - \text{Asample}) / \text{Ablank}] \times 100.$$

Where A is the absorbance at 515 nm.

Determination of the overrun and melting rate

Overrun is calculated based on the change in each volume of ice cream sample using a standard cup (100 mL) and is calculated according to the following equation as formulated by Jimenez-Florez et al. (1993):

$$\text{Overrun} = \text{Ice cream volume (mL)} \times \text{Ice cream mix volume (mL)}^{-1} \times 100$$

Determination of the melting rate (Hanafi et al. 2022) was fifty grams of each ice cream sample were left to melt on a wire mesh screen (dimension size: 0.5 cm × 0.5 cm) at 25 ± 1 °C for 20 min. Then, the melted ice cream was weighed to determine the melting rate. The melting rate was calculated using the following equation:

$$\%\ \text{Melting rate} = \text{Weight ice cream melt} \times (\text{Initial weight})^{-1} \times 100$$

Microbiological analysis

The growing colonies of lactic acid bacteria were determined using the method (Tomar et al. 2018). The first dilution series was 1 mL of kefir ice cream sample added to 9 mL of sterile de Man Rogosa Sharpe broth (MRS-broth, Merck) with dilutions of 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} then vortexed (Schoot). Dilutions 10^{-5} and 10^{-6} were carried out with 0.1 mL de Man Rogosa Sharpe Agar (MRS-Agar, Merck) into a petri dish. Use a temperature of 37 °C for 48 hours during incubation, observe the growing colonies, and count them using a colony counter (WTW, BZG 30). Yeasts were cultured on potato dextrose agar (Merck, 1.10130) (pH 3.5) with 10% added tartaric acid (Akarca et al. 2016). The calculation was determined by selecting colonies that grew from 25–250 colonies in a petri dish and included as follows:

Colony/gram (CFU/mL)= The number of colonies × (1/ dilution factor)

Data analysis

The data were analyzed by one way analysis of variance (ANOVA) ($P \leq 0.05$) (Steel and Torrie 1991). Then, if the effect was significant, the treatment differences were tested by the Duncan's Multiple Range Test (DMRT).

Results and discussion

Physicochemical characteristics of kefir ice cream

The effect of each treatment on the physicochemical characteristics of kefir ice cream with the addition of bengkuang starch, including moisture, ash, protein, fat, phenolic content, and free radical scavenging activity can be seen in Table 2.

Based on the data in Table 2, it can be seen that the more bengkuang starch added to making kefir ice cream, the lower the moisture of the ice cream. The decrease in ice cream moisture was caused by the low moisture of added bengkuang starch as much as 11.84 ± 0.08%. It causes an increase in total solids and a decrease in moisture in the ice cream mixture. Meanwhile, the ash content in kefir ice cream slightly increased with the addition of 9% bengkuang starch, while there was no significant difference for the other treatments. The low ash content in bengkuang starch, namely 0.32% was less able to increase the ash content in ice cream. In accordance with the opinion of Jaiswal et al. (2022), the research showed that the ash content in bengkuang starch was determined by the contents of essential minerals such as calcium 15 mg, phosphorus 18 mg, and iron 0.6 mg.

Likewise, the protein content of kefir ice cream did not show significant changes in each treatment. The low percentage of bengkuang starch protein content (2.15 ± 0.07) did not affect the change in ice cream protein content even if up to 9% of bengkuang starch is added. Thus, the protein content of ice cream can be maintained at the same value as the control. This research is almost the same as research by Noman et al. (2007) that showed bengkuang tubers had a percentage of protein content (1.23 ± 0.13) and contain ten essential amino acids and seven non-essential amino acids with amounts of 12.14 and 28.84 µM/gm respectively. Protein in making ice cream functions to stabilize fat emulsions after the homogenization process, add flavor, help to foam, and increase and stabilize water holding capacity that affects the viscosity and soft texture of ice cream and increases the overrun value of ice cream (Sarwar et al. 2021). Protein can also maintain smoothness in the final product, increase overrun without forming a flaky texture and reduce total solids.

In contrast to the protein content, the percentage of fat content in kefir ice cream decreased significantly along with the increase in the percentage of added bengkuang starch. Bengkuang starch in this study had a low percentage of fat content (0.13 ± 0.10). According to Chansathirapanich et al. (2016) that the low-fat content in ice cream is caused by the crystallization of fat in the ice cream-making process that forms a fat globule structure into a three-dimensional structure that can trap water and air so that the fat content in ice cream will decrease further.

The total phenolic content in kefir ice cream with the addition of bengkuang starch experienced a significant increase. It is supported by the high total phenol content in the added bengkuang starch (280.16 ± 0.03 mg GAE/100 g). Based on Lee et al. (2017) that *Pachyrhizus erosus* tubers contain phenolic compounds in the form of

Table 2. Physicochemical characteristics (mean ± S.D., n = 5) of kefir ice cream with addition of bengkuang (*Pachyrhizus erosus* (L.)) starch.

Addition of bengkuang (*Pachyrhizus erosus* (L.)) starch	Physicochemical characteristics							
	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Phenolics (mg GAE/100 g)	% Scavenging of DPPH	pH	TTA (%)
Control	69.11 ± 0.19^{e}	0.62 ± 0.10^{a}	4.19 ± 0.54^{a}	8.20 ± 1.02^{e}	92.88 ± 0.92^{a}	30.45 ± 0.60^{a}	6.14 ± 0.07^{e}	0.11 ± 0.15^{a}
3%	68.44 ± 0.14^{d}	0.64 ± 0.13^{a}	4.25 ± 0.29^{a}	7.95 ± 0.56^{d}	110.86 ± 0.11^{b}	41.10 ± 0.75^{b}	5.82 ± 0.01^{d}	0.41 ± 0.09^{b}
5%	67.88 ± 0.28^{c}	0.61 ± 0.31^{a}	4.22 ± 0.52^{a}	7.14 ± 0.81^{c}	114.21 ± 1.08^{c}	46.12 ± 0.64^{c}	5.52 ± 0.02^{c}	0.41 ± 0.16^{b}
7%	67.14 ± 0.12^{b}	0.63 ± 0.09^{a}	4.23 ± 0.65^{a}	5.73 ± 0.73^{b}	153.74 ± 1.01^{d}	46.77 ± 0.50^{d}	5.07 ± 0.01^{b}	0.82 ± 0.21^{c}
9%	64.74 ± 0.11^{a}	0.84 ± 0.17^{b}	4.25 ± 0.71^{a}	5.16 ± 0.12^{a}	194.40 ± 1.05^{e}	52.18 ± 0.69^{e}	4.83 ± 0.01^{a}	0.88 ± 0.27^{c}

Note: ^{a,b,c,d,e}Mean with different superscript letters within a column indicate a significant difference ($P < 0.05$).

isoflavonoids, pterocarpan, and triterpenoid glycosides. Apart from that, the activity of lactic acid bacteria originating from kefir also determines the total phenols of ice cream. At the same time, lactic acid bacteria (LAB) can produce metabolites in phenolic compounds because of the activity of enzymes that form phenolic compounds. Primurdia and Kusnadi (2014) also showed that the number of LAB that will affect the total phenol value where the more LAB causes the bacteria's ability to break down glucose into primary metabolites (lactic acid) and secondary metabolites (polyphenols) that will be higher.

In direct proportion to the total phenolic content, the activity of kefir ice cream's free radical scavenging (DPPH) increased significantly along with the increase in the percentage of added bengkuang starch. The data showed the percentage of antioxidant activity in bengkuang starch is (59.22 ± 0.01). This increase was absolutely influenced by phenolic compounds in the ice cream sample with antioxidant properties. According to Shahwar et al. (2010), phenol group compounds are responsible for an essential role in antioxidant activity, where the more significant the content of phenol group compounds, the greater the antioxidant activity. Apart from that, the content of vitamins such as ascorbic acid (14 ± 0.1 mg/100 g) in bengkuang tubers also had an essential role in determining the antioxidant activity of ice cream.

The pH and Total Titratable Acidity (TTA) values in kefir ice cream samples with the addition of bengkuang with an opposite relationship. The results showed that the pH value decreased significantly along with the increased percentage of added bengkuang starch, while the TTA value experienced a significant increase. The data shows that the pH value of bengkuang starch is (5.84 ± 0.04). However, the pH value of kefir ice cream is also influenced by the activity of lactic acid bacteria originating from kefir as a component of ice cream dough. Lactic acid bacteria utilize dietary fiber (prebiotics) from bengkuang starch as an energy source for their growth. In accordance with the opinion of Ferawati et al. (2022), lactic acid bacteria with carbohydrate decomposition activity, causing an increase in acid levels in the product. Melia et al. (2019) also stated that the acid produced in kefir fermentation comes from the breakdown of carbohydrates (glucose, lactose, and sucrose) by lactic acid bacteria. Thus, the greater the amount of acid accumulates, the higher the TTA value in the tested sample. According to Rosa et al. (2017), the content of organic acids such as lactic acid, acetic acid, formic acid, succinic acid, and propionic acid determines the total acid titration in a sample.

Overrun and melting rate

Table 3. Overrun and melting rate (mean ± S.D., n = 5) of kefir ice cream with addition of bengkuang (*Pachyrhizus erosus* (L.)) starch.

Addition of bengkuang (*Pachyrhizus erosus* (L.)) starch	Overrun (%)	Melting Rate (% melted after 20 min)
Control	61.91 ± 0.21[e]	62.50 ± 0.66[d]
3%	57.29 ± 0.09[d]	58.77 ± 0.70[c]
5%	46.67 ± 0.28[c]	51.95 ± 0.23[b]
7%	31.94 ± 0.33[b]	50.66 ± 0.55[b]
9%	30.01 ± 0.51[a]	47.59 ± 0.54[a]

Note: [a,b,c,d,e]Mean with different superscript letters within a column indicate a significant difference ($P < 0.05$).

Table 3 showed that kefir ice cream had overrun and melting rate values when adding bengkuang starch. The percentage of overrun value for ice cream decreased (61.91–30.01%) as the percentage of added bengkuang starch was increased in making kefir ice cream. Overrun is the percentage increase in ice cream volume compared to the volume of the ice cream mixture. In this study, there was a decrease in the ice cream overrun value compared with the control. The decrease in ice cream moisture also determines the ice cream overrun value. The low volume of water in the ice cream mixture causes the mixture to become more compact, so the amount of air trapped in the ice cream mixture is small, and the overrun value is low. Overrun is one factor that will affect ice cream's structure. Warren and Hartel (2018) stated that thick ice cream dough may cause low overrun because the dough has difficulty expanding, and it is difficult for air to penetrate the surface of the dough. The air cavities in the ice cream mixture may cause the lower trapped air to become low that affecting the overrun value. In accordance with the opinion of Elango et al. (2018), the decreasing the volume of water in the ice cream mixture causes the denser ice cream mixture and may increase the viscosity of the ice cream mixture that may reduce the ice cream overrun value.

Meanwhile, the melting rate of kefir ice cream also decreased along with the increased percentage of added bengkuang starch in making kefir ice cream (Fig. 2). This fact proves that the addition of bengkuang starch to ice cream can prevent the ice cream from melting. The research showed that adding 9% bengkuang starch could only melt the ice cream by 47.59 ± 0.54% after 20

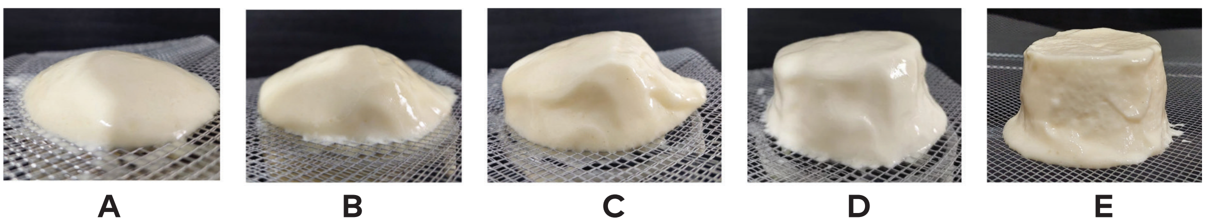

Figure 2. The melting rate of kefir ice cream with the addition of bengkuang (*Pachyrhizus erosus* (L.)) starch (**A:** control, **B:** 3%, **C:** 5%, **D:** 7%, and **E:** 9%).

Table 4. Microbiological properties (mean ± S.D., n = 5) of kefir ice cream with addition of bengkuang (*Pachyrhizus erosus* (L.)) starch.

Addition of bengkuang (*Pachyrhizus erosus* (L.)) starch	Microbiological properties (Log CFU/ml)				
	BAL	Yeast	Lactobacilli	Lactococci	Leuconostoc
Control	7.20 ± 1.02[a]	6.23 ± 1.31[a]	6.16 ± 0.87[a]	2.78 ± 1.18[a]	3.24 ± 1.08[a]
3%	8.29 ± 1.08[b]	7.68 ± 1.04[b]	7.20 ± 0.91[b]	2.88 ± 1.22[b]	4.09 ± 1.22[b]
5%	8.93 ± 1.04[c]	7.90 ± 1.12[c]	7.61 ± 0.77[c]	3.19 ± 1.20[c]	4.74 ± 1.08[c]
7%	8.98 ± 0.09[c]	7.86 ± 1.16[c]	7.86 ± 1.48[d]	3.42 ± 1.08[d]	4.79 ± 1.12[c]
9%	9.09 ± 1.13[d]	8.68 ± 1.27[d]	8.15 ± 1.56[e]	3.87 ± 0.91[e]	4.90 ± 1.11[d]

Note: [a,b,c,d,e]Mean with different superscript letters within a column indicate a significant difference ($P < 0.05$).

minutes. The melting rate of ice cream is determined by the characteristics of the ingredients used in making ice cream, such as protein sources, whole cream milk, and types of stabilizers. Furthermore, the melting rate of ice cream can be influenced by its fat content. Fat is responsible for maintaining ice cream's structure and density to provide good melting time (Pintor et al. 2017).

The viability of probiotics on kefir ice cream

Based on Table 4, there was an increase in the total colonies of lactic acid bacteria and yeast, along with an increase in the percentage of added bengkuang starch in making kefir ice cream. The increase in total LAB colonies was 7.20–9.09 Log CFU mL^{-1}, as the increase in yeast colonies was 6.23–8.68 Log CFU mL^{-1}. Lactic acid bacteria and yeast found in kefir were non-pathogenic microbes. Lactic acid bacteria break down carbohydrates in bengkuang starch and use them to support growth. According to the opinion of Fitri (2019), LAB will degrade carbohydrates into glucose, then glucose will be hydrolyzed into pyruvic acid, and pyruvic acid can be reduced to lactic acid. Meanwhile, yeast's life cycle will be in symbiosis with LAB. Yeast will utilize acid metabolites from LAB, while LAB will take yeast metabolites as amino acids and vitamins to support its growth. According to the opinion of Ponomarova et al. (2017) and Rosa et al. (2017), it was stated that yeast had a symbiotic relationship with LAB by stimulating the growth of lactic acid bacteria through the production of essential growth factors, especially amino acids, and vitamins, while bacterial metabolites, such as lactic acid, function as an energy source for yeast.

The total bacterial colonies of Lactobacilli, Lactococci, and Leuconostoc also increased along with increasing the percentage of added bengkuang starch in producting kefir ice cream. The highest colonies were found in kefir ice cream that added 9% bengkuang starch. Lactobacilli had the highest number of colonies (8.15 Log CFU mL^{-1}) followed by Leuconostoc (4.90 Log CFU mL^{-1}) and Lactococci (3.87 Log CFU mL^{-1}). These three genus of bacteria are dominant in kefir and have the potential to act as probiotics. According to Rattray and O'Conel (2011) kefir consists of 80% Lactococci and Leuconostoc spp., 10–15% yeasts, and 5–10% Lactobacilli.

Conclusions

The addition of bengkuang starch to kefir ice cream significantly impacts the ice cream's physicochemical and microbiological characteristics. Kefir ice cream with the addition of 9% was selected as the best percentage in this study that obtained water, ash, protein, total phenolic content, and free radical scavenging activity and it was better than the control, low fat, the highest total colonies of lactic acid bacteria and yeast, acceptable on pH value, TTA, overrun and melting rate. Kefir ice cream with the addition of 9% bengkuang starch had the highest viability of Lactobacilli, Leuconostoc, and Lactococci compared to the control group, indicating that increasing the concentration of bengkuang starch may increase the survival rate of probiotics.

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Conflict of Interest

All authors declare that there is no conflict of interest.

Author's Contributions

Ferawati designed the research concept, conducted experiments, and analyzed data. Sri Melia and El Latifa Sri Suharto composed and wrote the script. Doni Supadil did the work in the laboratory and visualized the data.

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