Effect of Goat Kefir Utilization on Physicochemical Quality and Sensory Attributes of Ice Cream Probiotic

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Abstract. Sustainable development goal no. 12, to "ensure sustainable consumption and production patterns", include a goal to reduce food waste at consumer level and food losses along the production and supply chains. For dairy, commonly referenced reasons are related to misunderstanding of spoilage before consuming products and improper storage. As a wasted food, milk can have negative environmental impacts when disposed of down the drain. This study will discuss the food waste problem, causes, and potential solution at consumer level with particular focus on goat's milk kefir (GMK) as one of dairy functional food product. GMK used in this study was 0%, 25%, 50%, and 75% of milk volume to make probiotic ice cream (PIC). The uses of GMK turn out to make PIC with significant difference ($P < 0,05$) in physicochemical properties and sensory attributes for each treatment. Physicochemical properties and sensory attributes influenced product acceptability. Hence, this study aims (1) to formulate a PIC added with GMK, (2) to determine the impact of GMK on PIC's physicochemical properties and sensory attributes, and (3) to assess the acceptance of PIC. The utilization of GMK in PIC is a potentially novel strategy for producing nutritious dessert to solve food waste problem.

Keywords: Dairy product · Frozen dessert · Probiotic food

1 Introduction

Lately, the dessert trend is toward low-fat, plant-based foods. This is due to several factors such as the presence of allergies and the aim to improve health status, one of which is the problem of lactose intolerance and functional plant foods [1]. Unfortunately, the use of plant materials to make desserts is not as good as animal ingredients when viewed from the textural properties and sensory attributes of the product [2]. Therefore, one of the possible scenarios is reducing the presence of allergies from an animal ingredient as macronutrient sources for improving health beneficial status [3]. The modification aims to minimize the occurrence of lactose intolerance and increase the ability of functional

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food. One way is to use goat's milk kefir (GMK) as the main ingredient for making probiotic ice cream (PIC). PIC can be formulated to have a good nutritional properties with careful balancing of the recipe to ensure acceptable taste and texture.

Kefir is a product of milk fermentation by grains kefir consisting of several lactic acid bacteria (LAB) such as *Lactobacillus kefiri, Leuconostoc, Lactococcus,* and *Acetobacter* as well as several yeasts such as lactose-fermenting (*Kluyveromyces marxianus*) and non-lactose-fermenting (*Saccharomyces unisporus, Saccharomyces cerevisiae*, and *Saccharomyces exiguus*) [4–6]. Fermentation is not only able to increase shelf life but is also able to form distinctive characteristics such as flavor and texture. These probiotics can hydrolyze organic matter through lipase enzymes and carry out catabolic reactions, namely changing complex compounds into simpler ones such as aldehydes, alcohols, ketones, and various ester compounds which in turn will form unique flavors and textures [7]. Some results from secondary fermentation will produce acetaldehyde and exopolysaccharide compounds [8].

The purpose of this study is to modify animal raw materials as the main source of macronutrients to develop functional food-based frozen desserts that can provide a pleasant experience for consumers. In this context, it seems that the use of GMK to produces PIC is the right choice to help overcome the problem of lactose intolerance and other health issues without reducing its physicochemical quality or sensory attributes. What's more, GMK also contains good probiotics to help the human digestive process. If PIC's acceptability is good, may be, we can reach sustainable development goal number 12 through functional food.

2 Materials and Methods

2.1 Materials

Ice cream is a frozen mixture of a combination of components, such as milk, sweeteners, stabilizers, emulsifiers, flavoring agents. In this study, any result of PIC incorporated with different concentration (ml/ml) of GMK (0; 0.25; 0.50; 0.75). The following table is a total ingredient that use to produce PIC completely:

2.2 Preparation

The ingredients of PIC consisted of milk, GMK, whipped cream, MAG, and NaCl. First, PIC was produced pasteurized ($70°C$; $2 minutes$) and then chilled until reached $40°C$. .. Then homogenized with sugar using a whipper. Next, GMK (P0 to P3), whipped cream, MAG, and NaCl was added and subjected to homogenous mixing through stirring using the table mixer for 10 min. Next, the PIC was subjected to a chilling process at $1°C$ for 24 h. After the chilling process had been completed, the PIC was transferred into a cup and frozen in an ice cream maker (GEA ICE – 1530) for 1 h to produce the ice cream. All the samples were kept in a closed cup container and stored in the freezer at $-18°C$ for physicochemical and sensory analysis. The physicochemical (overrun, melting rate, and pH) analyses were performed in triplicate except for sensory (appearance, texture, flavors, and acceptability) analyses which involved 30 panelists. This is the procedure for making PIC:

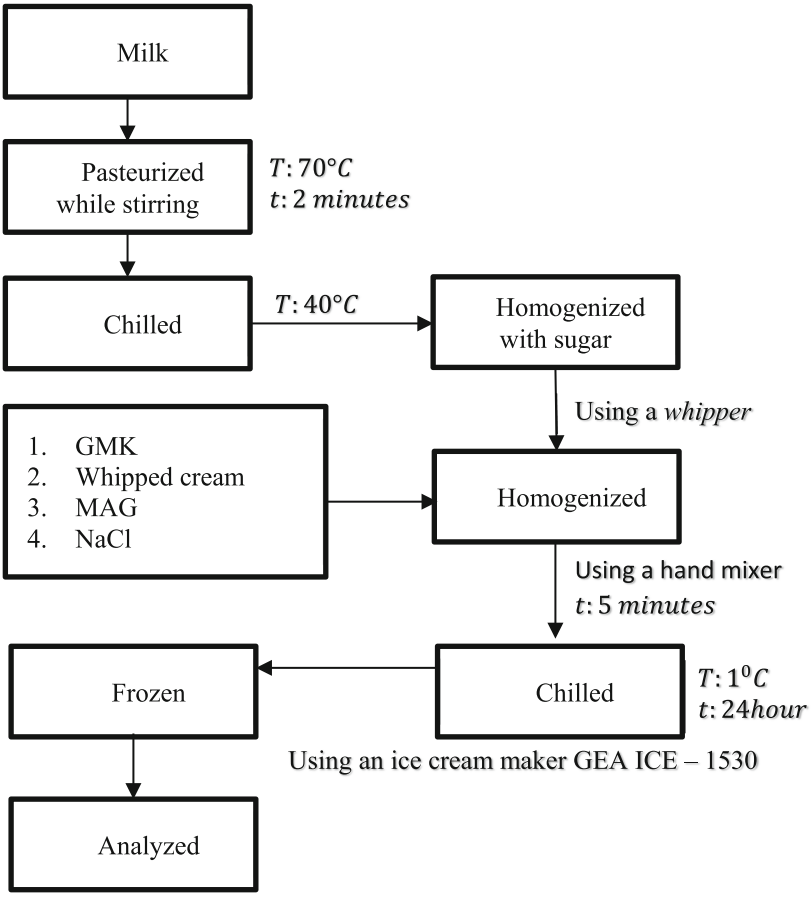

Fig. 1. Flowchart how to produce probiotic ice cream

2.3 Overrun Calculation

The overrun was calculated using following equation, as formulated by Hanafi et al. [9]:

$$\%Overrun = \frac{Volume\ of\ ice\ cream\ (mL)}{Volume\ of\ ice\ cream\ mixture\ (mL)} \times 100(1) \quad (1)$$

2.4 Melting Rate Calculation

The melting rate was calculated using following equation, as formulated by Hanafi et al. [9]:

$$\%Meltingrate = \frac{Weight\ ice\ cream\ melt}{Initial\ weight} \times 100\,(2) \quad (2)$$

Table 1. Product's ingredients

No	Ingredients	t0	t1	t2	t3	Unit
1	GMK	0	62,5	125	187,5	ml
2	Milk	250	187,5	125	62,5	ml
3	Whipped cream	150	150	150	150	gr
4	Sucrose	100	100	100	100	gr
5	Mono-acyl glyceride (MAG)	0,5	0,5	0,5	0,5	gr
6	NaCl	2	2	2	2	gr

Table 2. Guidelines for untrained panelists to di organoleptic test on probiotic ice cream based on hedonic scale

Sensory Attributes	**Scale Rating Guidelines**
1. Appearance 2. Flavor 3. Texture 4. Overall acceptability	1 = Extremely very doesn't like 2 = Very doesn't like 3 = Fairly doesn't like 4 = Doesn't like 5 = Enough 6 = Like 7 = Fairly like 8 = Very like 9 = Extremely very like

2.5 Sensory Attributes Determination

The sensory attributes of each sample were determined using an organoleptic test. Ice cream is highly accepted product by children, adolescent, and adults, as well as by the elderly public Because of it, organoleptic tests were carried out by 30 untrained panelists 15 men and 15 women. The guidelines were also provide to help panelists to do their job showed at Table 2.

2.6 pH Value Calculation

The pH of each ice cream sample was determined using a pH meter at $25 \pm {}^{o}$C.

2.7 Statistical Analysis

Data obtained from overrun, melting rate, pH, and sensory attributes were analyzed using Microsoft Office Excel. Analysis of variance and Duncan's multiple range test was performed to compare significant differences among the samples, which was significant at 0.05 ($P < 0,05$). Therefore, data were presented as mean $\pm$ standard deviation (S.D.).

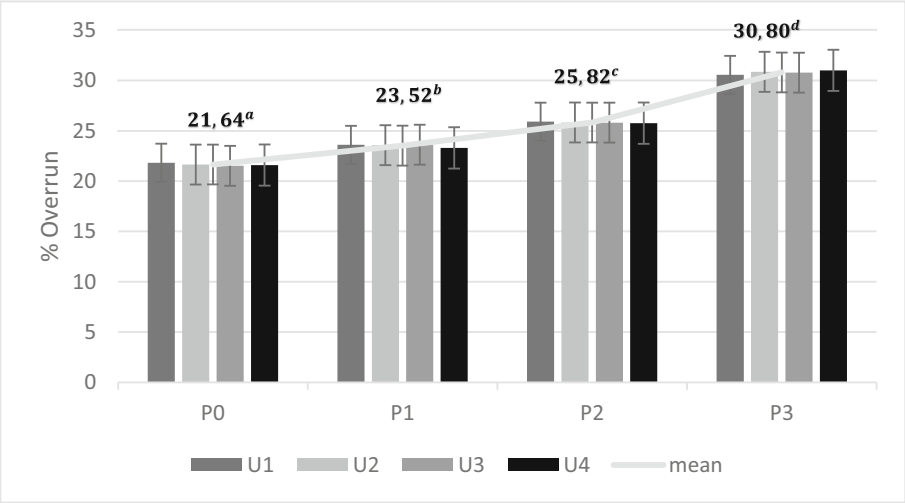

Fig. 2. Effect of using GMK on PIC's overrun. Based on DMRT the value of overrun was $(21, 64^a; 23, 52^b; 25, 82^c dan 30, 80^d \pm 0, 07)$. Each treatment is followed by a different symbol, so each treatment is different from one another. P for treatment and U for repetition. Bars with different letters (a, b, c, d) shows significant difference ($P < 0.05$)

3 Results and Discussion

3.1 Overrun

The meaning of overrun is an increasing in volume caused by the entry of air bubbles during the whipping process [10]. Figure 2 shows that the use of GMK increases PIC's overrun. The greatest increase occurred when using GMK as much as 75% of the milk volume as the main ingredient for producing PIC. The increase of overrun is because the fat globule contents in GMK have a smaller size than in normal milk. Fat globules are key players in overrun formation. The reduction in the size of the fat globules on the surface of the incoming air bubbles during the mixing and freezing process reduces their viscosity, resulting in a decrease in the aggregation of fat globules around the air bubbles. This decrease in globular aggregation causes an increase in overring due to a lot of incoming air [1].

The presence of air bubbles in product correlates with overrun value, which turns out to affect the inhibition of the heat rate so that it has an impact on the melting rate value of each type of PIC. This is because the physical quality of ice cream is influenced by the distribution of ice particles, air bubbles, and fat globules [11]. The increase in overrun reduces the melting rate, so it can be concluded that the use of GMK has the potential to make PIC more resistant to melting. The high overrun value tends to reduce the melting rate due to the presence of air cells that act as heat insulators [9]. Therefore, it can be concluded that use of GMK can increase overrun in the manufacture of PIC.

Air in PIC provides a light texture and influences the physical properties of melting rate[12]. The melting time determined in the melting rate test is related to the product structure stability after the overrun, influenced by the type of emulsifier used in

the process. This indicates the extent of stabilization and partial coalescence occurring during the product manufacture[4]. In addition, it results in the partial coalescence and destabilization of the fat present in the mixture, with the formulation of an internal lipid structure, capable of imprisoning air bubbles [13].

3.2 Melting Rate

In this study, the highest melting rate was obtained in the control treatment (P0), then decreased as the volume of GMK increased for each treatment. This is because, during the increase in the volume of GMK, there is a reduction in the size of fat globules in the ice cream. As a result, many air bubbles can enter the dough during the whipping process which causes an increase in the overrun value. Increasing the overrun value tends to reduce the melting rate [14]. Based on Fig. 3, there was a decrease in the melting rate for each increase in the volume of GMK used in the treatment. GMK has small fat globules which can form fat bonds. These bonds tend to stabilize air bubbles and foam in the ice cream structure which results in a decrease in the melting rate. Many factors affect the melting rate, such as the amount of air entering, the formation of ice crystals, and the relationship between fat globules during the ice cream production process [9].

In this study, the melting rate percentage was observed at a temperature of and it took 80 min for PIC completely melt. Following the explanation [9], the ice cream's melting rate measurement is carried out by comparing the mass of melted ice cream with the initial mass, then multiplied by 100%. Based on [11], more air in the ice cream will increase the overrun and cause a slowdown in the heat rate so it has an impact on the lowering of melting rate. The decrease in melting rate causes the PIC to not melt

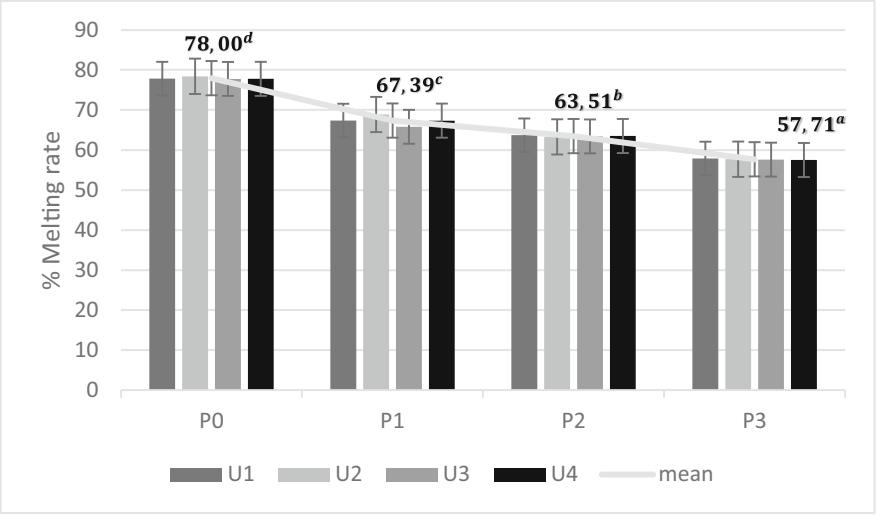

Fig. 3. Effect of using GMK on PIC's melting rate. Based on DMRT the value of melting rate was$(78, 00^d; 67, 39^c; 63, 51^b and 57, 71^a \pm 0, 33)$. Each treatment is followed by a different symbol, so each treatment is different from one another. P for treatment and U for repetition. Bars with different letters (a, b, c, d) shows significant difference ($P < 0.05$)

Table 3. Value of pH analysis ($mean \pm S.D., n = 3$) of PIC formulation incorporated with different concentration of GMK. Mean without superscript letter indicate there is no significant difference ($P < 0,05$).

GMK's Concentration (ml/ml)	pH Value
0 (control)	$7,213 \pm 0,042$
0,25	$6,900 \pm 0,040$
0,50	$5,920 \pm 0,026$
0,75	$5,813 \pm 0,022$

easily. Even so, it is known that ice itself is the heat conductor, so the more ice formed, the higher the melting rate [11]. This can be minimized by increasing the number of heat insulators such as air bubbles and fat globules in the ice cream mixture [1, 9, 11].

As a part of the challenge about the knowledge and control of ice crystallization, the choice of appropriate emulsifier such as MAGs is suitable to decrease the melting rate of PIC. Based on Fig. 3, we can see that MAGs can reduce melting rate of PIC. They can be used to stabilize ingredients, prevent separation, improve food texture, and extend product shelf life, improving emulsion stability when mixed type are used [15]. During the whipping and freezing process, some of the fat in the mix is converted into aggregates. Fat aggregates are mainly the result of three mechanism such as aggregation, partial coalescence, and coalescence [16].

3.3 Value of pH

Probiotic inform of cultures may be added to ice cream in two ways [4]. In this study, we add them directly to the pasteurized mix inform of GMK. In this study, the pH must be closely controlled during the fermentative process so that any undesirable reactions do not occur during production. In addition to the increased sensibility of probiotic microorganisms to low pH values (4.0 – 4.5), negative effects on sensory acceptance of the product may arise [4]. Because of it, one alternative in this study is to stop the fermentation at pH values around 5.813 ± 0.022.

Chemicals that can cause protein denaturation are the degree of acidity (pH). The pH value is used to express the level of acidity or alkalinity of a product. Table 3 shows the results of measuring for pH value on PIC formulation in all treatments. Based on the table, it is known that the use of GMK reduces the acidity but not significantly. This means the reduction of acidity isn't because of adding GMK. Probiotics which acts as fermentation agent can reduce the acidity level [8]. The presence of a fermenting agents in a product may give rise to a sour taste. However, the product should have relatively high pH values from 5.5 up to 6.5, which leads to an increased survival of lactic cultures during storage, also the lower acidity results in increased consumer acceptance, especially by those who prefer mild products [4].

The effect of pH on the binding of taste and aroma (flavor) by protein is related to changes in protein conformation. Flavor binding usually increases more strongly at alkaline than acidic pH. This is because the protein tends to be denatured reversibly

which has an impact on the opening of the protein structure so that the hydrophobic portion of protein is exposed. Exposure to the hydrophobic portion of the protein has the potential to increase its ability to bind flavor [17]. This is because the flavor is nonpolar so interactions with proteins occur through hydrophobic interactions.

Proteins are more stable at pH at their isoelectric point. At neutral pH, most proteins will be negatively charged. Meanwhile, at extreme pH, the proteins will swell and open. The degree of opening of the proteins structure is greater at alkaline pH than at acidic pH. Under alkaline conditions, carboxyl, phenolic, and sulfhydryl groups ionize so that the protein structure will open [18]. This aims to expose these groups to the aqueous phase to increase the potential of protein as a flavor binder. An understanding of the basic principles of binding flavor by protein is needed so that methods can be developed that can increase or decrease certain flavors and aroma according to the taste and production goals of PIC.

3.4 Sensory Attributes

Sensory attributes was a parameter that can be used as an assessment material for a food product. These qualities can be assessed using the hedonic scale based on Table 2 by conducting organoleptic tests on all samples [9]. Some of the attributes observed in this study was appearance, flavor, and texture [19]. Studies show that the addition of MAG to the PIC formulation was able to produce a good texture as well as provide a mouthfeel and creaminess sensation that was acceptable to the panelists. Besides texture, other attributes that can be measured was sweet, salty, sour, and bitter tastes [17]. The result of PIC's organoleptic test using hedonic scale showed that 30 panelists gave scores of fairly doesn't like unfermented milk-based ice cream and like for fermented milk-based ice cream. This is because there was differences in the content of various ingredients in the formulation that significantly affected the results of the panelist's assessment.

PIC was a dessert that contains fat and emulsifier. This will affect the color, texture, and flavor. Flavor is a combination of aroma and taste. The sweet taste comes from the milk lactose, while the sour taste comes from the milk fermentation process [20]. Increasing the fat content and concentration of emulsifiers in the formula significantly affects the color and texture of ice cream. Unfortunately, the result of the other studies shows that in PIC's formulation there was no needed to add emulsifiers in stages because the probiotics contained already capable of acting as swelling and gelling agents to reduce production costs [21].

The composition of raw materials can change the sensory characteristics of a food product, especially semi-solid dessert from dairy which of course has the potential to affect consumer response [20]. Studies show that fat plays an important role in the emergence of flavor as a solvent for lipophilic compounds and indirectly affects the texture of the product [17]. The use of MAG can improve texture but reduce aroma and flavor density [21]. Studies show that the use of MAG can form emulsions and significantly affect the taste of dessert [20]. The same study shows that modified food products such as PIC will be well received by consumers if their sensory qualities match their preferences such as color, aroma and taste which show the characteristics of the origin food and the texture is not much different from other similar conventional ice cream [9].

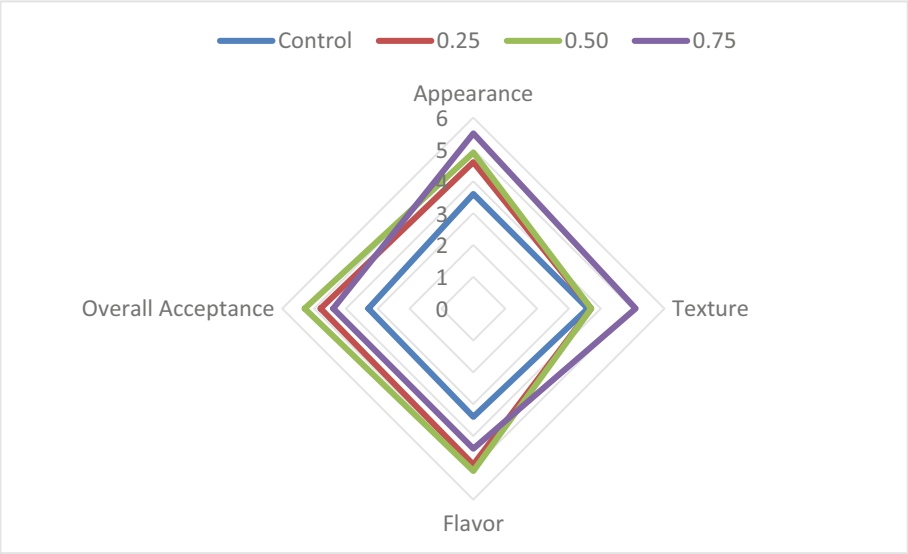

Fig. 4. Assessment of PIC sensory attributes with various levels of GMK concentrations and the addition of MAG

4 Conclusions

Increasing the concentration of GMK and the addition of MAG had a significant effect on the sensory attribute, overrun dan melting rate of probiotic ice cream. Meanwhile, all the treatment has no effect on changes of pH value significantly. Concentration of 0.50 GMK was the best treatment based on sensory attribute, overrun, and melting rate calculation compared to other treatments.

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