Effect of Ganyong (Canna discolor) Starch Addition as a Prebiotic on the Quality of Acidophilus Fermented Goat Milk

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Abstract. Ganyong (*Canna discolor*) belongs to the family *Cannaceae* and is one of the tuber crops containing 88.2% carbohydrates, with potential as a prebiotic due to its high inulin content. Ganyong tuber has a higher inulin content compared to other tubers, where 100 g of ganyong tuber contains 23.63% inulin. This study aimed to determine the effect of adding ganyong starch to goat milk fermented with *Lactobacillus acidophilus* on the quality of the fermented milk. The experimental design used was a Completely Randomized Design (CRD) consisting of five treatments: 0% (P1), 1% (P2), 2% (P3), 3% (P4), and 4% (P5) ganyong starch, with four replications for each treatment, resulting in 20 experimental units. The observed parameters were acidity (pH), lactic acid levels, and syneresis. The data obtained were statistically analyzed using Analysis of Variance (ANOVA), followed by Duncan Multiple Range Test (DMRT) if significant differences were found. The results showed that the addition of ganyong starch had a highly significant effect on pH and lactic acid levels ($P<0.01$), and a significant effect ($P<0.05$) on syneresis. Among the treatments, the addition of 2% ganyong starch produced fermented goat milk with lower acidity, the highest lactic acid levels, and reduced syneresis. In conclusion, ganyong starch in fermented goat milk can be effectively used as a source of inulin to support the growth of lactic acid bacteria, particularly *Lactobacillus acidophilus*. These findings highlight its potential as a natural ingredient for fermented milk products that are suitable for consumption and meet the Indonesian National Standard (SNI 2981:2009)

Keywords: acidophilus milk, ganyong, pH, syneresis, lactic acid levels, fermented goat milk

1 Introduction

Fermented milk is milk processed using lactic acid bacteria, characterized by a sour taste and aroma. The benefits of fermented milk include providing health effects for the body, particularly for the digestive tract. *Lactobacillus acidophilus* is a Gram-positive, homofermentative, rod-shaped microorganism that produces bacteriocins and has potential

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as a probiotic. *Lactobacillus acidophilus* can be found in various environments, ranging from milk to the human gastrointestinal tract. This bacterium is generally Gram-positive, non-motile, non-spore-forming, rod-shaped, and produces lactic acid as the end product of fermentation metabolism [1]. Probiotics require nutrient-rich substrates for growth, one of which is carbohydrates belonging to soluble dietary fiber [2]. The presence of prebiotics supports the growth of probiotics by serving as a nutrient source. Prebiotics have beneficial effects on lactic acid bacteria, functioning as an energy source for bacterial viability, aiding digestion, and producing short-chain fatty acids. One potential prebiotic source is the ganyong tuber. Ganyong tuber has a higher inulin content compared to other tubers, with 100 g of ganyong tuber flour containing 23.63% inulin [3]. Although various starch sources have been evaluated as prebiotic ingredients, studies on the potential use of ganyong starch as a functional prebiotic substrate and its role in supporting the growth performance of probiotic bacteria, particularly *Lactobacillus acidophilus* in fermented goat milk, have not yet been reported. Therefore, the purpose of this study was to determine the effect of adding ganyong starch as a prebiotic to goat milk fermented with *Lactobacillus acidophilus* on the quality of fermented milk. Specifically, this study examines the physicochemical properties of fermented milk, including pH, lactic acid levels, and syneresis, in accordance with the Indonesian National Standard (SNI 2981:2009).

2 Materials and methods

2.1 Materials

The goat milk used as research material came from local farms around Banda Aceh, and *Lactobacillus acidophilus* ATCC 4356 came from the Dairy Processing Science and Technology Laboratory of Syiah Kuala University in Banda Aceh.

2.2 Sample preparation

In sample preparation, fresh PE goat milk was first pasteurized at 72°C for 15 seconds. Then the samples were prepared according to the treatment by adding ganyong starch with a percentage of 0, 1, 2, 3, and 4% respectively and by adding *Lactobacillus acidophilus* starter at 5% each. Furthermore, it was incubated at 37°C for 18 hours

2.3 pH measurement

The pH measurement follows the procedure of [4]. Before measurement, the pH meter was calibrated first with pH 6.8 and pH 4.0 buffers. The electrode was washed with distilled water and dried using tissue, then the pH of the sample was measured by dipping the pH meter electrode into 20 ml of sample and the number indicated on the pH meter was recorded.

2.4 Lactic acid levels

Lactic acid levels was measured by following the Mann's Acid Test method [5]. A total of 18 ml of sample was put into Erlenmeyer, then added phenolphetalin solution as an indicator as much as 3-4 drops of sample titrated with 0.1 N NaOH, until a stable pink color was formed. Lactic acid levels was calculated using the following equation.

$$\text{Lactic acid} = \frac{ml\ NaOH\ x\ 0{,}1\ N\ x\ 90}{Sample\ weight\ x\ 1000} x\ 100\ \% \qquad (1)$$

2.5 Syneresis

The syneresis test used the method of [6]. A total of 10 grams of fermented goat milk was weighed and put in a syneresis tube then stored in a refrigerator at 5°C for 1 hour. Next, it was centrifuged for 10 minutes at 3000 rpm. The supernatant (whey liquid) was weighed and calculated using the formula.

$$\text{Syneresis} = \frac{Supernatant\ weight}{Initial\ weight}\ x\ 100\ \% \qquad (2)$$

2.6 Data analysis

This study used a complete randomized design (CRD) consisting of 5 treatments and 4 replicates. The research treatment given was the addition of ganyong starch flour with different percentages P1 (0% ganyong starch flour) = control, P2 (1% ganyong starch flour), P3 (2% ganyong starch flour), P4 (3% ganyong starch flour), and P5 (4% ganyong starch flour). The addition of *Lactobacillus acidophilus* 5% as starter in each treatment. The data obtained were analyzed using Analysis of Variance (ANOVA), if there were differences between treatments then further tests were carried out using Duncan's multiple distances.

3 Results and discussion

The results of the study on the effect of ganyong starch addition on the quality of fermented goat milk are presented in Table 1.

Table 1. Effect og ganyong starch addition on ph, lactid acid levels, and syneresis of fermented goat milk

Parameter	ganyong starch				
	P_1	P_2	P_3	P_4	P_5
pH	4.8 ± 0.12^{a}	4.58 ± 0.11^{b}	4.56 ± 0.05^{b}	4.52 ± 0.08^{b}	4.24 ± 0.12^{c}
Lactic acid level	0.90 ± 0.13^{C}	1.17 ± 0.02^{A}	1.18 ± 0.04^{A}	1.03 ± 0.04^{B}	0.98 ± 0.02^{BC}
Syneresis	$29.35\pm19.69^{b*}$	$47.40\pm5.93^{a*}$	$43.69\pm5.31^{ab*}$	$53.08\pm3.17^{a*}$	$51.93\pm2.85^{a*}$

Information : Superscript abc are significant different (P<0.01)
Superscript ABC are significantly different (P<0.01)
Superscript ab* are significantly different (P<0.05)
P1 = 0%: P2 = 1%: P3 = 2%: P4 = 3%: P5 = 4%)

Based on the analysis of variance in Table 1, it was shown that the addition of ganyong starch at different percentages had a highly significant effect (P<0.01) on pH values. The resulting pH values decreased in each treatment. The decrease in pH occurred because lactic acid bacteria, during their growth activity, utilized nutrients in the fermentation medium as an energy source. This statement is in line with the results of a study [7], which reported that the addition of 0.1% ganyong starch (T4) produced an average pH value of approximately 4.47±0.01, while the addition of 0.025% ganyong starch (T1) resulted in an average pH value of 4.55±0.01. These findings indicate that a higher level of ganyong starch addition leads to a lower pH value, suggesting that ganyong starch serves as an energy source for the metabolic activity of lactic acid bacteria. In addition, it is known that ganyong starch contains 23.63% inulin, which plays a role in lowering pH by forming short-chain fatty acids during inulin fermentation in the large intestine. This process lowers the pH in the large intestine, thereby enhancing the growth of lactic acid bacteria while inhibiting the growth of pathogenic bacteria [8].

The addition of ganyong starch at different percentages had a highly significant effect ($P<0.01$) on lactic acid levels. The results of the study showed that lactic acid levels fluctuated (increased and decreased) across treatments. This is consistent with the statement of [9], who reported that such fluctuations occur because lactic acid, as a short-chain fatty acid, is also utilized as a carbon source by *Lactobacillus acidophilus* for its growth through the β-oxidation metabolic pathway. Thus, lactic acid resulting from inulin metabolism is directly used as a nutrient source by *Lactobacillus acidophilus*. Similarly, the lactose content in milk serves as an energy source for lactic acid bacteria in producing lactic acid, thereby enhancing their activity in converting substrates into lactic acid. The increase in lactic acid levels is thought to be influenced by high total solids (including lactose, protein, fat, and minerals), which support the growth activity of lactic acid bacteria and consequently increase lactic acid production. This statement is in line with the findings of [10] who reported that the higher the milk addition, the higher the total solids produced in fermented milk. According to [11] goat milk contains 13.41% total solids; therefore, the addition of ganyong starch will increase the total solids content in the fermentation medium.

The addition of ganyong starch at different percentages had a significant effect ($P<0.05$) on syneresis. The syneresis results showed an increase in each treatment with the addition of ganyong starch compared to without the addition of ganyong starch (control treatment). The level of syneresis in fermented milk can be influenced by several factors, including acidity, pH, and water-binding capacity [12]. In this study, the syneresis observed fluctuated (both increasing and decreasing) with each treatment according to the percentage of ganyong starch added. This is in line with [13] who stated that low syneresis reflects good fermented product quality, whereas high syneresis indicates weak water retention, causing more nutrients to separate from the solids due to low gel strength. According to [14] low protein–water interaction results in precipitation, causing the protein network to release water. This leads to gel shrinkage, which promotes curd formation and whey separation. Gels that have formed can liquefy again when heated beyond their boiling point. [15] stated that gel formation involves four steps: (1) hydration of the gel-forming material, (2) mixing with other ingredients, (3) heating the mixture sol, and (4) cooling the sol in a mold so that the gel solidifies.

4 Conclusion

The concentration among treatments of pH, lactic acid levels, and syneresis resulted in the quality of fermented goat milk that met the Indonesian National Standard (SNI 2981:2009) at the 2% ganyong starch addition treatment. The addition of 2% ganyong starch was able to support the growth of lactic acid bacteria, particularly *Lactobacillus acidophilus*, in the fermentation medium by maintaining moderate acidity, increasing lactic acid levels, and minimizing syneresis. This condition can optimally support bacterial metabolism and maintain the physical stability of the fermented milk matrix.

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