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Quality Evaluation of Refrigerated Salted Butter Made with Goat and Cow Milk

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ABSTRACT

Butter is a dairy product that is susceptible to oxidation, which causes a rancid taste and a short shelf life. The quality of the butter depends on the quality of the milk. The aim of the study is to determine the quality of butter made from goat and cow reared by small-scale farmers in Yogyakarta with the traditional manufacturing process. Saanen-Peranakan Ettawa (Sapera) goats' milk and Fresian Holstein were taken from farmers in the Sleman district of Yogyakarta, Indonesia. Butter was sampled after 0, 15, and 30 d of storage. This study used the Nested Design method, namely the nested quality of butter in the type of milk. The result showed that butter made from cow milk produced a higher fat content than goat milk butter ($p<0.05$), namely 85.29 ± 0.04% and 80.10 ± 0.27%. Both of the butter's acid value and pH increased during storage ($p<0.05$). There was no increase in peroxide value in cow butter, but there was an increase in goat butter from day 0 to day 15 ($p<0.05$). It can be concluded that the goat and cow milk reared by small-scale farmers in Yogyakarta are of good quality, so it produced good-quality butter, which is still good for consumption until 30 d of storage in the refrigerator.

Keywords: Salted butter, Oxidation, Sapera, Friesian Holstein, Refrigerator storage

Introduction

The increase in dairy product consumption is an opportunity that can be exploited in developing dairy products to create business opportunities in the dairy industry. According to the United States Department of Agriculture (2022), the Indonesian retail and foodservice dairy market grew steadily by 4 percent in 2021 and is expected to increase by 6 percent in 2022 and 2023 respectively. Also butter export activity increased from the January-July 2021 to January-July 2022 period by 1320 metric tons. Therefore, the development of the butter industry in Indonesia needs to be developed.

Yogyakarta is one of the provinces in Indonesia where most dairy cattle are Fresian Holstein breed, while dairy goats that are widely raised by farmers are the Ettawa crossbread, Saanen and Saanen-Peranakan Ettawa crossbreed or Sapera (Suranindyah *et al.,* 2018 and Widyobroto *et al.,* 2018). Yogyakarta had the 4th largest population of dairy cows in 2022, 3516 heads, while the population of goats was 418439 heads (Statistics Indonesia, 2023a; Statistics Indonesia, 2023b), with the majority reared by small-scale farmers (Guntoro *et al.,* 2016).

In general, about 60% of dairy products are consumed by Indonesians in the form of pasteurized milk, UHT milk, flavored or fermented milk, and evaporated or condensed milk and the remaining 40% is in the form of powdered milk, cheese, food service, confectionary goods, bakery, and pharmaceutical uses (United States Department of Agriculture, 2022). There is not much variation of goat milk products in the market, so the industry can potentially explore it to obtain added value from its business activities. Dairy products besides cows with good quality and taste need to be developed.

Whole milk can be made into various kinds of products. The separation of milk into cream and skim milk components is an example of physical treatment in product diversification (Figure 1), which can provide added value to the industry. One of the cream-based dairy products is butter. Butter is a dairy product with a high fat content. Butter is a water-in-fat emulsion with a minimum fat content of 80%, a maximum water content of 16%, and a maximum solid fat content of 2% (FAO, 2022). Butter is susceptible to oxidative degradation, leading to rancid flavor, off-odors, and reduced shelf life. The quality of butter is dependent on the quality of milk. Understanding the milk quality of small-scale farmers is important for the dairy industry overview.

The objective of the present study was to analyze the quality of butter made from goat and cow milk with a homemade process by understanding the quality of milk from small-scale farmers.

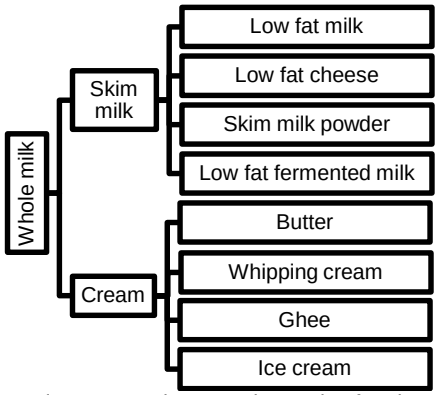

Figure 1. Products can be made after the milk separation process.

Materials and Methods

Source of materials. Fresh goat and cow milk as raw material is taken from small-scale farmers in Turi and Pakem sub-districts, Sleman district, Yogyakarta, Indonesia. Goat milk from the Saanen-Peranakan Ettawa crossbreed (Sapera) was used in this research, while cow milk is from the Fresian Holstein breed. The milk used for butter production is 30 L/batch, milked in the morning.

Manufacturing. Cow and goat butter was produced according to the method of Murti *et al*. (2020) with the addition of 1% salt (w/w). Butter is produced using a traditional process, from hand mixer to churning process, then washing and working manually. The butter process is shown in Figure 2. The sample is packed into a plastic cup of as much as 120 g tightly closed with plastic wrap, and stored in the refrigerator.

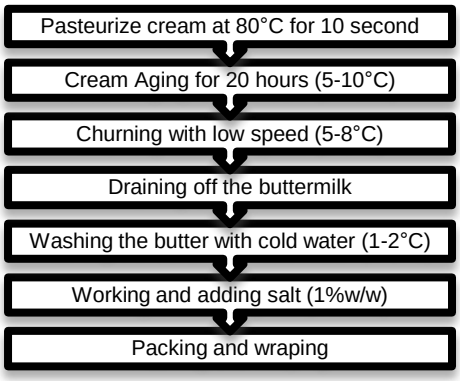

Figure 2. Flow chart of butter manufacturing.

Chemical data. Moisture content, fat content, acid value, and peroxide value were analyzed according to the method of Sudarmadji *et al*. (1976). Analysis of lactic acid and acetic acid concentration using HPLC instruments according to Mannheim (1984) with modifications. HPLC sample was prepared by weight of 2.5 g of butter and diluted with 25 mL water, then heated at 60°C for 20 min using a water bath. The sample is cooled to room temperature and then put in the refrigerator for 20 min. Filtration was performed using Whattman no. 1 and filtered with a 0.2 µM millipore. The sample was collected in an Eppendorf container and then degassed for 20 min before being injected. 20 µL of the sample was injected into a reverse phase HPLC device with an amine column type HPX 87H with UV-Vis detector. The oven temperature setting is 40°C, flow rate of 0.4 mL/min, maximum pressure of 200 kg/cm^2 with a wavelength of 275 nm. The pH value was analyzed according to the SNI (1998) method using a digital pH meter EUTECH model PC 700.

Experimental design. Friesian Hostein milk was obtained from Mr. Supriyono at Kemiri RT 03 RW 08, Purwobinangun, Pakem, Sleman, D.I Yogyakarta, and Sapera milk was obtained from CV. Umskey at Kemirikebo, Turi, Sleman, D.I Yogyakarta. This study used the Nested design method, namely the nested quality of butter in the type of milk. The butter was kept in the refrigerator at 5°C, and quality was observed at 0, 15, and 30 d. The butter quality observed included acid value, peroxide value, pH value, lactic acid, and acetic acid concentration with 3 replications.

Statistical analysis. Quality and composition of fresh milk analysis using a t-test. The acid value, peroxide value, and pH value of butter were analyzed by one-way ANOVA, and the organic acid was analyzed descriptively.

Results and Discussion

Quality of milk

The quality of milk produced by the small-scale farmers is shown in Table 1. Cow and goat milk showed negative results (no precipitate formed) in the ethanol stability test and had a normal pH value. The ethanol stability standards used to measure the freshness of cow milk are 70% (SNI, 2011), while goat milk is between 45-65% (Guoa *et al.,* 1998; Ljutovac *et al.,* 2007; Prajapati *et al.,* 2017). A lower pH value influences lower ethanol stability (Fagnani *et al.,* 2016; Ibáñez *et al.,* 2019), which could indicate–that bacteria have begun to grow in the milk.

Table 1. Quality of cow and goat milk

Parameters	Cow milk	Goat milk
Ethanol 70%	Negatif	n.a
Ethanol 65%	n.a	Negatif
pH	6.54±0.02^a	6.41±0.01^b
Specific gravity	1.0285±0.00^a	1.0303±0.00^b
Fat (%)	3.36±0.20^a	4.03±0.09^b
Moisture (%)	88.21±0.07^b	86.01±0.1^a
Crude Protein (%)	2.77±0.04^a	3.58±0.14^b

n.a = not applied.
^{a,b} Different superscripts on the same row indicate differences ($p<0.05$).

Cow milk has a specific gravity of 1.028 ± 0.00, while goat milk has a specific gravity of 1.030 ± 0.00. Murti (2016) explained that the specific gravity of cow milk ranges from 1.023 to 1.032. Park *et al.* (2007) also explained that the specific gravity of goat milk is generally higher than that of cow's milk, with a range of 1.0231 to 1.0398.

The fat content of cow milk was lower than that of goat milk ($p<0.05$) at 3.36±0.20% and 4.03±0.09%, respectively. SNI (2011) explains that

the minimum fat content of cow milk is 3%. Kanwal *et al.* (2004) reported that the fat content of goat milk ranged from 3.9 to 5.7% with an average of 4.73%. also. Thai Agricultural Standard (2008) explains that the fat of goat milk that has standard quality is 3.1-3.4%.

The water content of cow milk was higher than goat milk ($p<0.05$), at 88.21 ± 0.07 and 86.01 ± 0.1%, respectively. Dandare *et al.* (2014) explain that the water content of cow milk ranges from 84.8 to 87.42%. Suranindyah *et al.* (2018) explained that the Ettawa Peranakan goat milk had a water content of 84.58%, while the Sapera goat had a water content of 86.41%. Based on the results of testing the composition and quality of cow and goat milk reared by small farmers, it can be concluded that the milk has good quality.

Composition of cream and butter

The composition of both butters was analyzed after production. Fat content, solid non-fat, moisture, and total solid are presented in Table 2. Cow milk produces a higher fat content butter than cow butter ($p<0.05$). The total solids of cow butter were higher than those of goat butter and lower in SNF and moisture ($p<0.05$). Both butters have fulfilled the requirements of the Codex Alimentarius standard for butter with a minimum of 80% fat and a maximum of 16% moisture.

Table 2. Composition of cream and butter of cow and goat milk

Parameter (%)	Cow butter	Goat butter
Fat content	85.29±0.04[b]	80.10±0.27[a]
Solid non-fat	2.17±0.03[a]	3.68±0.70[b]
Moisture	12.54±0.06[a]	16.21±0.45[b]
Total solid	87.46±0.06[b]	83.78±0.44[a]

[a,b] Different superscripts on the same column indicate differences ($p<0.05$).

Differences in fat content and moisture of butter can be caused by the churning process, which is not optimum and causes buttermilk not to be optimally released, and it can be affected by moisture and solids non-fat in the butter becoming high. The churning process can be affected by the size of milk fat globules; the cream's temperature and aging time also affect the churning process. The aging treatment of cow and goat cream in this study was the same. The lower fat content in goat butter compared to cow butter is due to the smaller size of fat globules present in goat milk. Murti *et al.* (2020) explain that cow milk has a greater number of medium-sized milk fat globules (60.2%), whereas goat milk has a greater number of smaller size milk fat globules (56.7%). These smaller globules can pass through the churning process and dissolve more easily in the buttermilk, reducing the fat content in butter. Deosarkar *et al*. (2016) also noted that smaller fat globules are more resistant to breaking during churning than larger milk fat globules.

Oxidation of butter during storage

The quality of butter during storage is shown in Table 3. The analysis showed that cow and goat butter's acid value significantly increased ($p<0.05$) during storage on day 30 compared to 0 and 15 d. An increase in the acid value in the product is an early indication of the occurrence of a rancidity process. This increased process occurs due to the hydrolysis of triglycerides into fatty acids by lipase (Koczon *et al.,* 2008). Milk lipase usually comes from endogenous factors and is produced by psychrophilic microbes (Widodo, 2003). Park *et al.* (2014) explained that the maximum limit for the acid value of butter is 2.8 mg KOH/gr fat, so it can be concluded that both kinds of butter still have good quality during 30 d of storage. The increase in acid value in both types of butter was not sharp; this could be due to good quality milk from farmers, in terms of good alcohol stability tests, the heating factor in the cream pasteurization process, and storage in cold temperatures, which could inhibit lipase activity. The stirring process in making butter can also potentially break the fat globule membrane, increasing the risk of lipolysis (Widodo, 2003). In their research, Murti *et al.* (2020) explained that the size of milk fat globules in cows is larger than in goat milk. These large fat globules are more easily damaged when stirring in the churning process, making easier lipolysis in cow milk fat possible.

The peroxide value of cow butter showed a non-significant increase ($p>0.05$) during 30 d of storage in the refrigerator, while goat butter showed a significant increase ($p<0.05$) during storage on the 15th and 30th d. Kong *et al.* (2011) explained that the peroxide value of a food product should not be more than 10 meq/kg of fat.

Fat oxidation can be affected by levels of unsaturated fatty acids, light exposure, temperature, and the presence of antioxidants (El-Safety *et al.,* 2017). The rate of auto-oxidation of fat can increase if there is an increase in temperature. Heating causes a transfer of copper from the milk plasma to the fat globules, thereby spurring oxidation. Heating can also denature metalloproteins and increase the availability of various metals to catalyze oxidation, but the pasteurization process of cream above 80°C can stabilize milk against possible oxidation induced by copper and light (Widodo, 2003).

Table 3. Quality of butter during storage

Parameters	Milk type	Days storage			p Value
		0	15	30	
Acid value (mg KOH/g)	Cow	0.88±0.03[a]	0.87±0.04[a]	1.00±0.04[b]	<0.00
	Goat	0.74±0.03[a]	0.74±0.02[a]	0.79±0.03[b]	<0.00
Peroxide value (meq/kg)	Cow	2.18±0.13[a]	2.26±0.07[a]	2.28±0.02[a]	0.09
	Goat	2.19±0.04[a]	2.31±0.03[b]	2.30±0.04[b]	<0.00
pH	Cow	6.46±0.13[a]	6.39±0.05[a]	6.29±0.07[b]	0.02
	Goat	6.39±0.07[a]	6.36±0.05[a]	6.31±0.02[b]	0.02

[a,b] Different superscripts on the same row indicate differences ($p<0.05$).

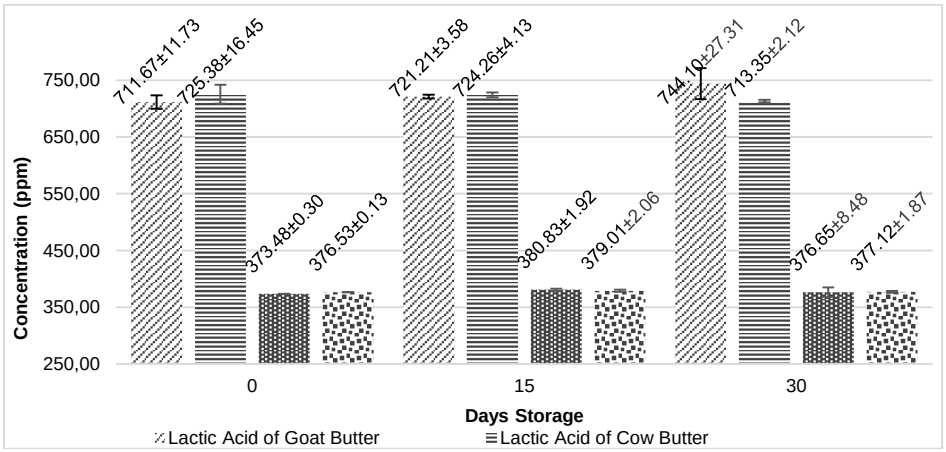

Figure 3. Graphic of lactic acid and acetic acid of butter during storage.

The pH value of goat and cow butter, which were stored for 30 d, showed a significant change ($P<0.05$). In this study, the pH value was slightly decreased. It might be the effect of increasing acid value and lactic acid on goat and cow butter. Goat butter tends to have a lower pH value because it produces more lactic acid during storage (Figure 3). Organic acids are natural constituents of all dairy products, including butter. Schripsema (2008) explained that acetic acid was present in all salted butter, and the levels varied from 6 to 271 µg/g. also, lactic acid was not found in every sample with varying 0-1788 µg/g. Riel *et al.* (1956) explained that the pH of sweet butter ranged from 6.4 to 7.2. A decrease in the pH value can occur due to increased triglyceride hydrolysis activity, thus increasing the levels of free fatty acids present in the product.

The decrease in pH is also caused by the formation of lactic acid and acetic acid as a result of fermentation by bacteria. Schripsema (2008) explained that bacteria convert lactose into lactic acid and citric acid into acetic acid. Presenting high lactose in butter products might increase bacteria activity. In an incomplete washing process in butter, it is possible that there is still lactose, which can increase the possibility of lactic acid bacteria growing. It can be prevented by a complete washing process to remove buttermilk, which contains lactose, and continuing with the working process to remove water optimally.

Conclusion

It can be concluded that the goat and cow milk reared by small-scale farmers in Yogyakarta have good quality, so it can produce good quality butter, which is still good for consumption during 30 d of storage in the refrigerator. The cow butter in this research tends to have a longer shelf life.

Conflict of interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Author's contribution

The first author contributed to collecting data, performing the analysis, and drafting the manuscript. The second author contributed to directing the research process, writing the manuscript, and checking the data analysis results.

Ethics approval

This study did not involve human and intervention to animals as an object for the research, thus we did not use ethical declaration approved by any ethical committee.

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