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Shelf Life of Homogenized Pasteurized Milk Under Refrigerated Storage: A Study on Chemical Quality

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Abstract
Milk is an important source of nutrition rich in protein, fat, carbohydrates, minerals, and vitamins, so it requires proper handling through the pasteurization process to kill harmful bacteria and homogenization to prevent the formation of a cream layer. This study aims to: 1) To analyze the effect of cold temperature storage time on the chemical characteristics (pH, Fat, Protein, SNF) of homogenized pasteurized milk. 2) To determine the effect of milk type (goat, sheep and cow) on the chemical characteristics (pH, Fat, SNF and Protein) of homogenized pasteurized milk 3) To determine the combination of interactions between storage time and milk type (cow, goat and sheep) on the chemical characteristics (pH, Fat, SNF and Protein) of homogenized pasteurized milk. This study was conducted on November 8-18, 2024 at the Batu Agricultural Extension Center and the Polbangtan Malang Quality Testing Laboratory. The milk samples used came from Boerja sheep farmers, Encus Goat dairy goat farmers, and cow milk from the large ruminant division of Polbangtan Malang. This study used a Factorial Completely Randomized Design with 6 treatments (0, 2, 4, 6, 8, 10 days), 3 replications, and 3 types of milk. The results showed that storage time significantly affected the chemical quality of homogenized pasteurized milk, especially on fat content and SNF. Optimal storage occurred on days 2 and 4. The type of milk also significantly affected fat content, SNF, and pH, where sheep milk showed the best chemical quality.

INTRODUCTION

Milk is a rich source of essential nutrients for humans, including proteins, fats, carbohydrates, minerals, vitamins, and other factors. Additionally, milk serves as a medium for various microorganisms that can influence its chemical composition during storage (Resnawati, H. 2020). Pasteurization is a process aimed at eliminating harmful bacteria that can compromise milk quality. It also extends the shelf life of milk, thereby preserving its quality for a certain period (Dinata, F. S., et al. 2024).

However, pasteurization alone is insufficient to produce a stable milk product over extended storage periods; homogenization is also required. Homogenization is a crucial step in milk processing. Without this process, fresh milk will form a cream layer when left to stand and stored for extended periods (Febriyanti, A. D., et al. 2023).

In Indonesia, the shelf life of pasteurized milk typically ranges from 5 to 7 days. Therefore, it is essential to understand how long pasteurized milk can be stored at higher heating temperatures, which are expected not to significantly alter the nutritional content of the milk while providing a longer shelf life (Kristanti, N. D. 2017). Hardiwiwoto, as cited in Ida D., et al. (2019), states that pasteurized milk, when packaged and stored at a cold temperature (approximately 4°C), can last for seven days without deterioration. Storage temperature significantly affects bacterial growth and numbers in pasteurized milk. Bacteria grow best at 25°C. Harmful bacteria include mesophilic bacteria that thrive at room temperatures between 20–40°C. Therefore, to inhibit bacterial growth, storage at temperatures of 4–5°C is implemented.

RESEARCH METHODOLOGY

This study was conducted from November 8 to 18, 2024, at the Batu Agricultural Extension Center and the Quality Testing Laboratory of the Malang Agricultural Development Polytechnic. The materials used were cow milk from the Large Ruminant Division of Polbangtan Malang, sheep milk from Boerja Farm, and goat milk from Encus Goat Farm in Jabung.

The equipment utilized included a homogenizer, pasteurization pan, pH meter, and Lactoscan. An experimental study was designed using a 3 × 6 factorial completely randomized design (CRD), involving three types of milk (cow, goat, and sheep) with three replications and six storage durations (0, 2, 4, 6, 8, and 10 days).

The parameters observed were fat content, protein content, solid-not-fat (SNF), and pH levels. Data were analyzed using one-way ANOVA followed by Duncan's multiple range test at $P < 0.05$. Statistical analysis was performed using IBM SPSS Statistics 27 software.

RESULT AND DISCUSSION

Fat Content

The fat content in milk varies depending on the source and livestock composition (Miarsono Sigit et al., 2021). This study indicates that fat content is a primary indicator of fresh milk quality, which is crucial for homogenized pasteurized products (Suhendra et al., 2020).

Analysis revealed significant differences in fat content among the three types of milk and over the storage period. Sheep milk had the highest average fat content (6.227%), followed by cow milk (4.900%) and goat milk (4.790%). However, slight decreases and increases in fat content were observed during storage, particularly in cow and goat milk, while sheep milk maintained relatively stable fat levels. Overall, fat content decreased periodically with increased storage duration.

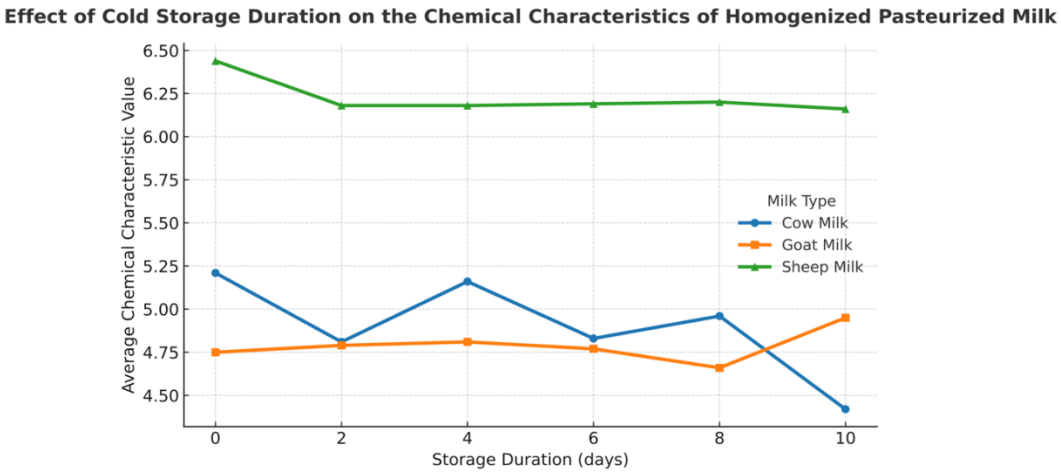

Figure 1. Effect of cold storage duration on the chemical character

Solid-Not-Fat (SNF) Content

The chemical quality of homogenized pasteurized milk can be assessed not only by its fat content but also by its Solid-Not-Fat (SNF) content, which encompasses all non-fat solids, including minerals, proteins, and lactose. Subagyo et al. (2023) stated that the total solids (including SNF) in fresh milk correlate closely with fat, lactose, and protein content. This underscores the importance of SNF levels as indicators of milk quality. The overall quality of milk, including its nutritional and functional profile, can be assessed not only by its fat content but also by its Solid-Not-Fat (SNF) content, which encompasses all non-fat solids such as minerals, proteins, and lactose.

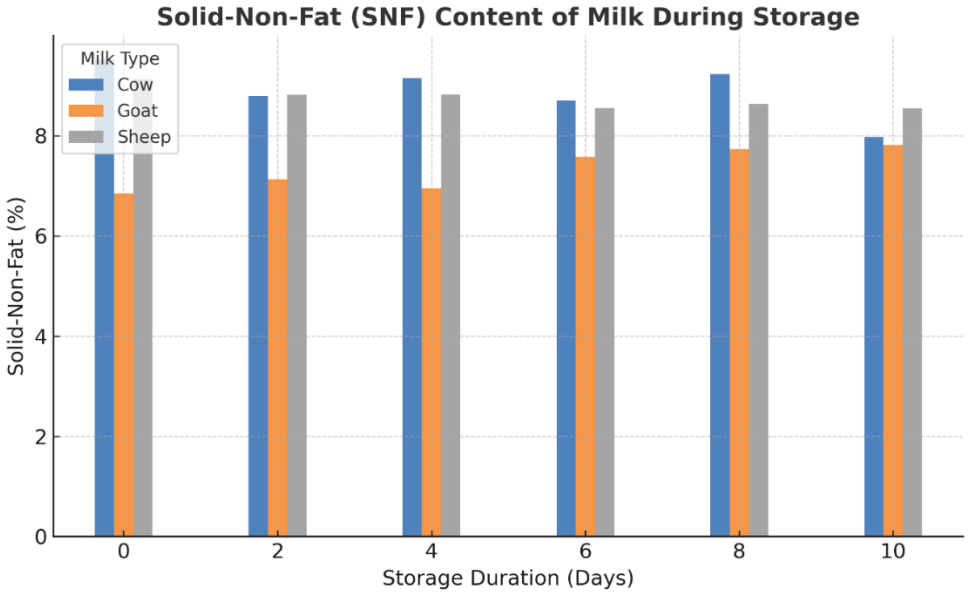

Figure 2. Solid Non Fat (SNF) content of milk during storage

According to R. W. Setianingtyas et al. (2014), variability in SNF in raw milk exists prior to processing. This indicates that SNF content is an inherent characteristic of the milk and may vary among different milk sources. Monitoring SNF levels during storage is crucial for managing the quality of dairy products. Cow milk exhibited a significant decrease in SNF content from Day 0 (9.520%) to Day 10 (7.970%), suggesting that SNF components undergo changes or degradation during refrigerated storage. In contrast, goat and sheep milk maintained relatively stable SNF levels throughout the storage period. Goat milk showed the lowest

average SNF content (7.343%), with slight fluctuations observed during storage, while sheep milk had a consistently low average SNF content.

pH Content

The pH level, which indicates the acidity or alkalinity of milk, is a critical indicator of the chemical quality of milk. Permadi et al. (2022) stated that the pH of pasteurized goat milk without the addition of ginger extract tends to decrease during cold storage. However, with the addition of ginger extract, the pH remains stable. Danah, I. et al. (2019) reported that bacterial growth can increase, and the pH of pasteurized milk in packaging may decrease, reaching the threshold of acceptable consumption.

The pH stability across different milk types changed significantly during 10 days of storage. Cow milk exhibited a very stable pH, remaining around 5.7. This stability suggests that the natural buffering system of cow milk is effective under proper storage conditions, and the degradation of components that produce acid (such as lactose turning into lactic acid) occurs slowly. Goat and sheep milk, in contrast, exhibited greater pH variation. Goat milk had the highest average pH, showing a noticeable increase in pH early in storage, but it declined towards the end of storage, which may result from various biological or chemical activities. However, the pH pattern of sheep milk was different: it started at a certain value, peaked on the second day, and then remained relatively stable around 5.9, albeit with a higher average value. These variations indicate that each type of milk has distinct inherent characteristics, and how farmers handle processing and storage affects these outcomes.

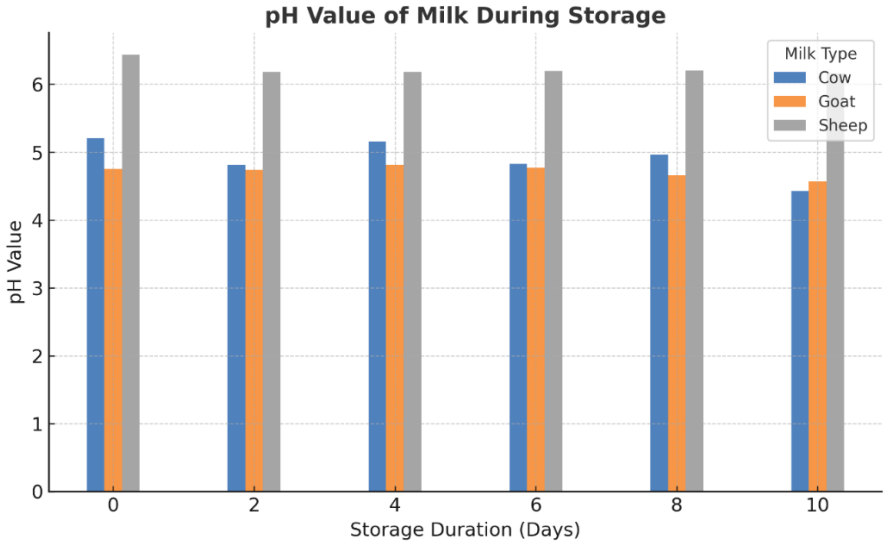

Figure 3. Ph value of milk during storage

Protein content

Efforts to maintain the quality and shelf life of pasteurized milk involve preserving the stability of its chemical components during refrigerated storage. Protein content is a critical indicator of milk quality, as it reflects the nutritional value and functional properties of the milk. Adding Cinnamon Extract to Pasteurized Cow Milk (Ismiarti & Sumarmono, 2023).

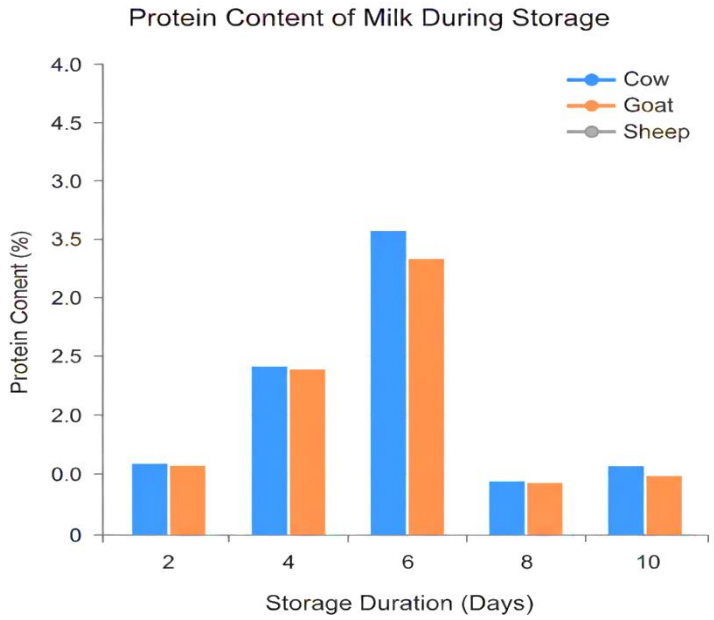

Figure 5. Protein content of milk during storage

During refrigerated storage, milk undergoes various quality changes, including alterations in pH and bacterial counts, which can affect the overall integrity of the milk and indirectly influence protein stability. Therefore, to maintain the nutritional quality and shelf life of pasteurized milk, it is crucial to employ methods that minimize protein degradation during storage (Sosiawati, E. S. H., & Rahmawati, N., 2024).

Based on the data presented above, goat milk exhibited the highest protein content on the first day (3.903%) and an average protein content of 3.517% throughout the storage period, suggesting that goat milk may be superior in protein nutrition compared to cow and sheep milk. However, over time, all milk types experienced a decline in protein content, with cow milk showing the most significant decrease on day 10 (2.983%). This reduction indicates that protein degradation occurred during cold storage

CONCLUSIONS AND SUGGESTION

The study concludes that the duration of refrigerated storage significantly decreases the chemical quality (fat, SNF, pH, and protein) of homogenized pasteurized milk from cows, goats, and sheep, with cow milk showing the most drastic decline. Additionally, the type of milk greatly influences chemical characteristics: sheep milk excels in fat, SNF, and pH; cow milk in SNF; and goat milk in protein content. Combining these factors indicates that while chemical quality tends to decline over storage time, the rate of decline varies among milk types, with the best quality generally found at the beginning of storage.

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