Study of Physical and Chemical Characteristics of Cow’s Milk Evaporated by Climbing Film Evaporator Method

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Study of Physical and Chemical Characteristics of Cow's Milk Evaporated by Climbing Film Evaporator Method

Kajian Karakteristik Fisik dan Kimia Susu Sapi Evaporasi metode Climbing Film Evaporator

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Abstract

Cow's milk is one of the livestock commodities that are in demand among the public as a complement to nutritional needs. Milk has various components both macro and micro that support daily nutritional needs. One of the methods to increase nutrients contained in milk is through the evaporation method. The purpose of this study was to analyze the physical and chemical characteristics of milk that undergo the evaporation process using climbing film evaporator. This study used an experimental method with a descriptive approach, which described the physical and chemical characteristics of cow's milk before (control) and after evaporation. Analysis of physical and chemical properties used paired sample t-test at the 5% level (0.05) to determine the difference in milk quality before and after the evaporation process. The temperature of the steam passing through the evaporator ranged from 132 - 176^{0}C with evaporation process of 25 minutes. The results showed that there were significant differences ($p<0.05$) in the parameters of freezing point, moisture content, fat, protein, lactose, minerals, and solid non-fat between fresh and evaporated milk. Density and pH showed no significant difference. Evaporation of cow's milk could enhance the nutritional content of milk (protein, fat, lactose, and minerals).

Keywords: Climbing film evaporator, physical and chemical characteristics, nutrients, evaporated cow's milk

Abstrak

Susu sapi merupakan salah satu komoditas peternakan yang diminati di kalangan masyarakat sebagai salah satu pelengkap kebutuhan gizi. Susu memiliki berbagai komponen baik makro maupun mikro yang dapat menunjang kebutuhan nutrisi harian yang dibutuhkan. Salah satu upaya yang dilakukan untuk meningkatkan kadar nutrisi yang terdapat pada susu yakni melalui metode evaporasi. Evaporasi susu merupakan proses pengurangan kadar air di dalam susu melalui proses pemanasan. Tujuan dari penelitian ini adalah untuk menganalisa karakteristik fisik dan kimia dari susu yang mengalami proses evaporasi menggunakan *climbing film evaporator*. Penelitian ini menggunakan metode eksperimen dengan pendekatan deskriptif, yaitu mendeskripsikan karakteristik fisik dan kimia susu sapi sebelum (kontrol) dan sesudah dievaporasi. Analisis data uji fisik dan kimia menggunakan paired sample t-test pada taraf 5% (0,05) untuk mengetahui adanya perbedaan kualitas susu sebelum dan sesudah proses evaporasi. Hasil analisis menunjukkan bahwa terdapat perbedaan yang signifikan ($p<0.05$) pada parameter titik beku, kadar air, lemak, protein, laktosa, mineral, dan solid non-fat antara susu segar dan susu evaporasi. Sedangkan densitas dan pH tidak menunjukkan perbedaan yang signifikan. Evaporasi susu sapi dapat meningkatkan kandungan nutrisi yang terdapat pada susu (protein, lemak, laktosa dan mineral).

Kata Kunci: Climbing film evaporator, karakteristik fisik dan kimia, nutrisi, susu sapi evaporasi

Introduction

Dairy milk is one of the livestock commodities in Indonesia with an increasing amount of consumption among the public. Data from the Directorate General of Animal Husbandry and Animal Health shows that the participation rate of milk consumption in 2021 was 44.23%, while in 2022 it increased to 45.12% (Direktorat Jendral Peternakan dan Kesehatan Hewan, 2023). However, this figure is still quite low when compared to other countries in the world.

In 2022, the total milk consumption in Indonesia is only 989,154 tons, while India, which is the country with the largest milk consumption in the world, has a total milk consumption of 85,000,000 tons in 2022, followed by the United States and China (Pusat Data dan Sistem Informasi Pertanian, 2022). In Indonesia, the increasing public consumption of cow's milk is in line with economic progress as shown by an increase in the per capita income of the Indonesian people (Hidayat & Anggraeni, 2021). In addition, the emergence of public awareness of consuming milk as a complement to nutritional needs also contributes to the level of milk consumption (Hendriyanto et al., 2021).

Milk has various components both macro and micro that can support the daily nutritional needs required by the body. Macro components consist of water, fat, protein, and lactose. In comparison, micro components include vitamins, enzymes, minerals, lipids, and dissolved gases which will also determine the physical, chemical, and biological characteristics of milk (Lambrini et al., 2020).

The composition of macro and micro components contained in milk is influenced by several factors including cow age, reproduction, milking stage and conditions, temperature, and health conditions of the cow (Sigit et al., 2021). Water content is the macro component in milk that has the highest composition. Based on data on the composition of food ingredients Indonesian Ministry of Health (2021), the value of water content in milk is 88.3 grams per 100 grams of milk. One of the attempts made to increase the level of nutrients contained in milk is through a concentrating process using the evaporation method. Evaporated milk is produced by reducing the water in the milk by about 60% to achieve a certain level of concentration to increase the viscosity of the milk and enhance the nutritional value (Nouh et al., 2017; Silveira et al., 2013).

The evaporation process is a thermal process where the solvent separates from the solution due to the heat applied. The amount of heat applied during the process will affect the quality of the evaporated product. Several studies reported that the conventional evaporation process on food affected the nutritional and sensory characteristics (Julai et al., 2023). Nutrient content such as protein will denature at high temperature of heating. In addition, the taste, smell, and color of milk can also change due to heating (Hariono et al., 2021). Therefore, to maintain the nutritional content of milk, the evaporation process is carried out under vacuum conditions, using a pressure below atmospheric pressure (1 atm) thus the temperature applied can also be reduced and does not harm the components contained in the milk (Istiyati & Sari, 2020; Susilo et al., 2021). Research conducted by Julai et al (2023) and Syakdani et al (2019) showed that evaporation at low temperatures through a vacuum process produced products with better nutritional content.

Currently, consumer demand for evaporated milk is growing. In Sabah, Malaysia, the average consumption of evaporated milk per household during Covid-19 was 1018 g and fresh milk was 1425 mL (Seriger et al., 2022). Whereas in Peru, evaporated milk is the most preferred milk by Peruvians' besides UHT milk (Mónago & Tavera, 2018). During the second half of the twentieth century, Chile started to increase the import of evaporated milk to meet consumer demand (Llorca-Jaña et al., 2020). In Indonesia, evaporated milk has begun to be used as an alternative to coconut milk in making typical Makassar desserts with consideration of the nutritional content of evaporated milk. The research conducted by Sara et al., (2022)showed that products with evaporated milk substitutes were preferred by consumers compared to products with coconut milk ingredients.

One type of vacuum evaporator that can be applied to milk evaporation is the climbing film evaporator. The climbing film evaporator was chosen as a tool in the vacuum evaporation process because of the short contact time with the liquid and the use of low temperatures in heating, to avoid damage to the material (Hasan & Ali, 2011). The short contact time on the material occurs due to the rapid heat transfer rate in the evaporator (Ahmad et al., 2018; Yang et al., 2010). Ahmad et al. (2018) stated that most sugar factories in the Pakistan region use climbing film evaporators to obtain cane sugar syrup with more optimal process. The selection of an evaporator is one of the important variables in improving the quality of the product produced.

We find it crucial to conduct further research on evaporated milk to improve the quality of evaporated milk from both physical and chemical characteristics. A large amount of cow's milk production in Indonesia in 2023, namely 837.22 thousand tons (Direktorat Jendral Peternakan dan Kesehatan Hewan, 2023), can be a supporting factor in producing dairy products in the form of evaporated milk. However, there is no information regarding the production of evaporated milk using a climbing film evaporator. Therefore, the research conducted aimed to make evaporated milk using climbing film evaporator, as well as the physical and chemical characteristics.

Method

The research was conducted in the Food Engineering Laboratory and Livestock Production Laboratory of Politeknik Negeri Jember on July 12-14, 2023. The cow's milk used came from the PFH (Peranakan Friesian Holstein) dairy farm managed by the Department of Animal Husbandry of Politeknik Negeri Jember. Cow's milk was obtained from 1 cow aged 3 years. The process of feeding the cow was done once with three times distribution processes at 08.30 AM, 09.00 AM, and 09.30 AM for each cage and drinking adlibitum. Sampling was done during milking in the morning at 07.00 AM and the cow was in good health. The instrument used for the evaporation process was climbing film evaporator (Armfield, UK), and the milk analysis process used LactoStar (Funke Gerber, Germany). Lacto Star has advantages in analyzing milk over other methods, as it is more efficient in terms of time and cost (Hariono et al., 2021). Determination of pH using a digital pH meter (Schott).

This research used an experimental method with a descriptive approach in describing the physical and chemical characteristics of cow's milk before and after evaporation. Milk samples used in the control and treatment were the same milk samples, which were obtained from PFH cattle farms managed by the Department of Animal Husbandry, Politeknik Negeri Jember. Milk samples were divided into two, the control (without treatment) and the evaporated milk samples using climbing film evaporator. A certificate of ethical feasibility was issued by the Research Ethics Commission Politeknik Negeri Jember with number: 1096/PL17.4/PG/2023

Evaporated milk production

The milk evaporation process was carried out by placing 1000 mL of milk in the chamber. The steam source (steamer) used is set at a pressure of 2 bar with an adjusted steam flow rate. Hot vapor from the steamer flowed through the faucet integrated into the evaporator.

The temperature of the steam used in the evaporation process ranged from 132 - 176^{0}C. The time required in the evaporation process refers to research conducted by Ahmad et al. (2018) with a total evaporation process time of 25 minutes with details of 5 minutes was the time when the appliance was switched on until the boiler steam temperature reached 132^{0}C, 15 minutes of heat exposure time and 5 minutes for cooling the device. Giving heat for 15 minutes to the milk sample is the best time needed in the heat transfer process using a climbing film evaporator. The pressure used during the evaporation process was controlled in the range of 0.5 - 1 bar. The milk concentrate formed as much as 250 mL was automatically collected in the evaporator vessel to be analyzed for physical and chemical properties. Physical analysis included density and freezing point, while chemical analysis included moisture, protein, fat, lactose, SNF (Solid non-fat), pH, and mineral content.

Physical (density, freezing point,) and chemical (protein, fat, lactose, mineral content, solid non-fat) properties testing

The analysis of protein, fat, lactose, total non-fat solids (SNF), freezing point, density, and milk mineral content was done using a LactoStar milk analyzer. Before the test was conducted, the milk analyzer was cleaned using acid and alkaline solution and rinsed with distilled water. A total of 25ml samples were taken in sample tubes and put in the sample holder. The device was switched on by pressing the power button. Next the enter button was pressed and the type of cow's milk sample was selected on the screen.

The scanning process lasted for ±4 minutes and the results of milk quality readings were displayed on the screen including density, freezing point, solid non-fat, fat, protein, lactose, and mineral content (Shaker et al., 2015).

pH testing

The pH was tested referred to AOAC 1998 using a digital pH meter that had previously been calibrated using pH 4 and pH 7 buffer solutions. The electrodes on the pH meter were washed before being immersed in the milk. The pH value of the milk would appear on the screen.

Moisture content analysis

Determination of milk moisture contentused oven method (SNI 01-2891-1992). A total of 1-2 ml of milk was placed into a cup that has known its initial weight. Then the cup that had been filled with the sample was put into the oven at 105^0 C for 24 hours. After 24 hours, the cup was placed into a desiccator before finally being weighed again to determine the weight of the sample after being evaporated. The calculation of water content can be seen in the equation below:

$$\text{Moisture content} = \frac{W}{W_1}\ x\ 100\%$$

where,

W = weight of sample before drying (g)

W_1 = weight of sample after drying (g)

The data of physical and chemical characteristics obtained were then carried out statistical analysis using paired sample t-test at the 5% level (0.05) to determine the difference in milk quality before and after the evaporation process. If the p-value was <0.05, there was a significant difference between the physical and chemical characteristics of milk before and after evaporation. Data were analyzed using IBM SPSS Statistics 20.

Result and Discussion

Evaporation is the process of reducing the amount of solvent contained in the solution. The evaporation process is different from the drying process because in evaporation the final result of the process is a thick liquid, not a solid as in drying (Wijaya et al., 2019). Evaporated milk is milk where the moisture content has been reduced to as much as 60% (Nouh et al., 2017). This causes changes in the composition of the nutritional content of milk. This change is due to the loss of one component of milk in a large enough amount to affect the levels of other components. In the research that was conducted, the milk evaporation process used a climbing film evaporator.

Climbing film evaporator is a type of evaporator with easy maintenance compared to other evaporators. In addition, the high heat transfer rate at low evaporation temperatures causes the contact time with the material to be faster. The heat transfer coefficient in the vertical tube can reach 6000 W/m^{2}K (Yang et al., 2010). The higher the heat transfer coefficient, the evaporation process in the evaporator and condensation in the condenser can take place effectively and the quality of the evaporated product will be more optimal (Kusumadewi et al., 2018). The rapid contact time with the material causes the nutrients in the heat-sensitive milk to be preserved and the evaporation process can take place better (Yang et al., 2010). Therefore, climbing film evaporators can be an option in the milk evaporation process to obtain more optimal nutritional value with a more efficient process.

Physical characteristics of evaporated milk

Evaporated milk is a food product in liquid form with a higher viscosity than fresh milk due to the reduction of water content in it (Nieuwenhuijse, 2021). Some of the physical characteristics analyzed in this study are density andfreezing pointas listed in Table 1. The test results of the physical characteristics of evaporated milk were also compared with fresh milk to see the effect of

the evaporation process on the physical characteristics of milk.

Table 1. Test results of physical parameters of evaporated milk and fresh milk

Parameter	Fresh milk*	Evaporated milk*	p-value
Density (g/ml)	1,028 ±0.113	1,051±0.199	0.202[a]
Freezing point (⁰C)	(-) 0,511 ±0.019	(-) 0,829±0.031	0.004[a]

*data presented as mean ± deviation
[a] Paired sample t-test (significant p<0.05)

Based on Table 1, the value of each physical parameter of evaporated milk is higher than fresh milk. Density is the measurement of mass per unit volume of a substance (Abdurrojaq et al., 2021). The higher density value indicates that the number of components (carbohydrates, fats, proteins, vitamins, and minerals) contained is greater (Christi et al., 2022) therefore, the nutrient content in evaporated milk is also higher. The statistical test results showed that the p-value was 0.202 so there was no significant difference in the density of fresh milk and evaporated milk (p>0.05). However, the evaporation process was able to increase the density of milk by 2%. The evaporation process will cause water loss in milk resulting in reduced milk volume (Syakdani et al., 2019). This causes an increase in density value from fresh milk to evaporated milk. Fresh milk still has a high enough water content so that the volume of the liquid larger. The water content in fresh milk is in the range of 87.87 - 89.13% (Hariono et al., 2018). This is in line with research conducted by Istianah (2017) who studied evaporation using a falling film evaporator to produce pineapple concentrate. The process produced pineapple concentrate with a density increase of 1% when the pineapple has undergone an evaporation process.

Milk has a lower freezing point compared to the freezing point of water. This is because milk has components such as carbohydrates, proteins, fats, vitamins, and minerals that interact with each other to affect the freezing point of milk (Bouisfi & Chaoui, 2018). The freezing point of milk can also be used as a parameter to determine the quality of milk because the freezing point is strongly influenced by the composition of the components in the milk (Christi et al., 2022). Based on Table 1. it can be seen that evaporated milk has a lower freezing point compared to fresh milk. From statistical test results, the p-value obtained was 0.004 and showed that there was a significant difference (p<0.05) in the freezing point parameter between fresh milk and evaporated milk. Freezing point is related to the interaction between molecules and ions contained in milk. When the evaporation process is carried out, the water contained between casein micelles (inter micellar water) and within casein micelles (intra micellar water) will be evaporated. Inter-micellar water is more volatile than intra-micellar water, so when this condition is reached the distance between casein micelles will be closer because the water between the micelles has been evaporated. The absence of water between micelles causes agglomeration between micelles so that the size of the micelles is getting bigger (Holt et al., 2013; D. Z. Liu et al., 2012). The larger the micelle size, the stronger the hydrophobic interaction that occurs, which causes the freezing point of evaporated milk to be lower than fresh milk (Yazdi et al., 2014). This is in line with research conducted by Jayawardena et al., (2017) showed that sucrose solutions with high brix values would have a lower freezing point.

The higher the density value of milk and the lower the freezing point of milk indicates that the number of components contained in milk is greater and thus the nutritional content of milk is also increasing (Cais-Sokolińska et al., 2018). The viscosity profoundly connected with tactile thickness when slurping is utilized as an implies of evaluation as compared to mouth feeling or gulping (Ismail et al., 2022). The greater the number of solute particles, the closer the distance between molecules, which causes stronger interactions between particles and affects the viscosity of the solution (Sutariya et al., 2017). This is in line with the research conducted by Bista et al., (2020) which showed that samples with high concentrations had greater viscosity. Therefore, physical characteristics (density and freezing point) would also affect consumer acceptance.

Chemical characteristics of evaporated milk

The quality of evaporated milk is also determined through chemical analysis. The analysis included analysis of moisture content, fat, protein, lactose, solid non-fat, and mineral content. In addition, pH value was also one of the parameters analyzed at this stage. The chemical characteristics of evaporated milk can be seen in Table 2, the results of which are also compared with the values found in fresh milk.

Table 2: Test results of chemical parameters of evaporated milk and fresh milk

Parameter	Fresh Milk*	Evaporated Milk*	**p-value**	**% Change**
Moisture content (%)	88,08±0.93	72,93±0.67	0.007[a]	-17.2 ▼
Fat (%)	2,91±0.13	6,04±0.05	0.001[a]	107.56 ▲
Protein (%)	3,36±0.24	5,88±0.11	0.003[a]	75 ▲
Lactose (%)	4,92±0.09	8,61±0.25	0.008[a]	75 ▲
Mineral (%)	0,73±0.03	1,05±0.04	0.028[a]	43.84 ▲
Solid non-fat (SNF) (%)	9.10±0.81	15.84±0.12	0.001[a]	74.06 ▲
pH	6,32±0.15	6,14±0.03	0.393[a]	-2.85 ▼

Data presented as mean ± deviation
[a] Paired sample t-test (significant p<0.05)
▲ Increase
▼ Decrease

Based on the analysis results in Table 2, the moisture content of evaporated milk is lower than fresh milk. The evaporation process used a climbing film evaporator that lasted for 25 minutes was able to reduce the moisture content of milk by 17.2%. Based on statistical analysis, the p-value of moisture content was 0.007, indicating that there was a significant difference in moisture content (p<0.05) between fresh and evaporated milk. The reduction of moisture content in evaporated milk is influenced by several factors including temperature, pressure, and evaporation rate (Syakdani et al., 2019). The evaporation process in milk will reduce the moisture content which causes an increase in osmotic pressure in the milk. The high osmotic pressure will affect microbial growth in milk (Wood, 2015). This is in line with research conducted by Y. Liu et al., (2021), the higher concentration of the solution caused a decrease in microbial growth due to the greater osmotic pressure. If the number of microbes decreased, the shelf life of evaporated milk could also increase compared to fresh milk if stored at the same place (Hwang et al., 2007).

The concentration is the ratio between the component to be measured to the volume of the component as a whole (mixture). If there is a reduction in one of the components due to the evaporation process, the volume of the mixture will also decrease. Therefore, the content of each component in the milk will also increase. Therefore, the fat, protein, lactose, and mineral content of evaporated milk will higher than fresh milk (Prestes et al., 2022). This is in line with research conducted by Braga & Palhares, (2007) which showed that the evaporation process of breast milk with a 30% reduction in water content could increase the levels of sodium, potassium, calcium, phosphorus, magnesium, protein, fat, and lactose up to 38%. The statistical test results showed that the p-values obtained of fat, protein, lactose, and mineral content were 0.001; 0.003; 0.008; and 0.028, respectively. This indicated that there was a significant difference (p<0.05) in the chemical parameters tested. The significant difference in the chemical characteristics of evaporated milk compared to fresh milk affects the texture and flavor of the milk (Suhendra et al., 2020). Lactose and fat are components that contribute significantly to the texture and flavor of milk. Lactose is a group of disaccharides composed of D-glucose and D-galactose and connected through glycosidic bonds that contribute to the sweet taste of milk (Mutaqin et al., 2020) However, lactose has a fairly low sweetness level compared to sucrose, which is only 20-40% (Dominici et al., 2022) thus the sweetness in milk is not too strong. By adding lactose concentration up to 3.3 times, the sweetness level equivalent to sucrose will be obtained (Shendurse & Khedkar, 2015). Besides lactose, fat is a component that plays an important role in the characteristics of milk

produced from the aspects of aroma, flavor, and texture (McCarthy et al., 2017). Research conducted by Chojnicka-Paszun et al., (2012) showed that the higher fat content in milk gives a creamy texture and savory taste to the milk produced. Thus, evaporated milk has a creamier texture, more savoury taste, and slightly sweeter than fresh milk.

Total solid non-fat (SNF) consists of protein, lactose, vitamins, and minerals. The value of total solid non-fat in evaporated milk obtained was below the standard set by the Food and Drug Administration (FDA), which is a minimum value of 16.5% (FDA, 2023). In the research studied, the total solid non-fat value obtained was 15.84%. SNF levels in evaporated milk below the FDA value can be caused by chemical changes in lactose and protein in milk. When the temperature is too high, lactose isomerizes and degrades into lactulose and organic acids, which causes reduction in milk lactose content and affects the SNF content. In addition, high temperature also denatures whey protein to produce insoluble protein. The changes in lactose and protein levels cause the SNF content of evaporated milk not to be optimal due to the high heating temperature (Mandal et al., 2019). However, the SNF value of evaporated milk had a significant difference with fresh milk ($p<0.05$). This is due to the reduced amount of solvent in the milk so that the ratio of total solid non-fat to total liquid increases.

Therefore, to improve the quality of evaporated milk, temperature control during the process needs to be maintained so that no components are damaged during the process. So that the lactose and protein levels in evaporated milk can reach more optimal values. The value of total solid non-fat in milk is influenced by lactose and protein levels, if the lactose and milk protein levels are high, the SNF value will also increase. Protein in milk is influenced by the type of feed consumed by livestock (Astuti et al., 2020) . Hence, the SNF value in milk can also vary due to diverse animal feeding. The addition of protein source feed can increase milk SNF levels. This is in line with the research of Nouh et al. (2017) who conducted milk evaporation on various brands and produced SNF values that were quite diverse and met the standards set by the FDA.

Based on Table 2, evaporated milk has a lower pH value than fresh milk which is 6.14. However, the pH value of evaporated milk has not been regulated in the Indonesian National Standard (SNI) 01.2780.1992. The decrease in pH value in evaporated milk is caused by changes in ion equilibrium the milk due to heating. Heating causes the amount of calcium and phosphate ions in the milk to decrease due to molecular aggregation. Ions that is originally in the dissolved phase turn into a colloidal phase. The change in equilibrium in the milk causes an increase in the concentration of H^+ ions in the milk. Therefore, pH value of evaporated milk is lower (Prestes et al., 2022; Singh, 2007) . The aggregation of calcium ions and phosphate ions occurs based on the following reaction equation $Ca^{2+} + H_2PO_4^- \rightarrow CaHPO_4 + H^+$, where the reaction shows that the heating process will lead to an increase in the formation of $CaHPO_4$, which is the aggregate of the calcium and phosphate ion reaction. In addition, the reaction also shows that if the number of aggregates produced is greater, the number of H^+ ions produced is also increased. The higher the H^+ ion content of the milk, the lower the pH of the milk (Anema, 2009)Click or tap here to enter text.. Research conducted by Nouh et al. (2017) showed that the average pH value of evaporated milk from various brands was 6.2.

The decrease in pH observed in evaporated milk affects the microbial activity within the milk. This will affect the food safety of the milk itself. Based on the results of the study, the pH value of evaporated milk is 6.14. This value is suitable for the growth of molds and yeasts as well as spore-forming bacteria because they can live and perform metabolic activities in the pH range of 4-7 (Maynou et al., 2017). However, with the heating process, microbial cells can undergo denaturation and damage to enzymes that play a role in the metabolic process. Therefore, the evaporated milk produced is safe for consumption (Chawla et al., 2021). The decrease in pH value in evaporated milk also affects the flavor of the milk produced. Based on research conducted by Sayel et al., (2023), evaporated milk had the lowest score on the flavor aspect compared to fresh milk and condensed milk. This is due to the low pH found in producing milk with

a slightly sour flavor, thus reducing consumer preference.

Both calcium and phosphate are contributors to the determination of pH. Milk processing greatly influences the concentration of calcium and phosphate, which has an impact on pH. In addition, processing can also affect other components such as proteins that are unstable at high temperatures. Therefore, it is necessary to control the processing process, which includes temperature and heating time, to enhance the quality of the milk produced.

Conclusion

The evaporation process of cow's milk using Climbing Film Evaporator produced evaporated milk with higher physical characteristics than fresh milk. There was a significant difference in the freezing point of evaporated milk compared to fresh milk, but no significant difference in density. In the chemical characteristics, there were significant differences in the moisture content, fat, protein, lactose, minerals and solid non-fat While there was no significant difference in pH between evaporated milk and fresh milk.

Recommendations for further research are experimental studies related to evaporation conditions including temperature, pressure, and evaporation time using climbing film evaporators. These parameters can be studied further to improve the quality of evaporated milk produced.

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