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The Effect of Milking Time and Post-Harvest Handling on the Quality of Fresh Milk in People Livestock

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ABSTRACT

Milk composition is essential in determining the quality of milk produced by farmers to meet the SNI 3141.1:2011. This study aimed to analyze and assess the physical, chemical, and biological quality of fresh milk from crossbred dairy cows at different milking times and harvest-postharvest handling. The experimental was designed using 2×2 Factorial Complete Randomized design with six repetitions. The independent variables in this study were milking time, including morning (P1), and afternoon (P2). Handling methods included conventional (V1), and modern (V2). Biplot analysis, and Multi-Criteria Decision-Making (MCDM) using the Analytic Hierarchy Process (AHP) method was performed. Milking time had a significant (p<0.05) on specific gravity, pH, TS, fat content, TSNF, protein, lactose, TPC, and S. aureus, which produced the best value at P1, except fat content. Harvest-postharvest handling had a significant (p<0.05) on pH, TPC, S. aureus, and coliforms, where V2 produced the best values compared to V1. Modern harvest-postharvest handling can reduce the TPC of fresh milk by 32.73%, S. aureus by 43.33%, and coliforms by 40.97% compared to that of conventional methods. Biplot analysis showed proximity between TPC, S. aureus and coliform. AHP optimization showed that morning milking time and modern handling methods are the most optimal combinations for producing best quality of fresh milk.

1. INTRODUCTION

Most dairy farms in Indonesia are still dominated by smallholder farms, with low milk production, only around 8-13 liters per head per day. As a result, domestic fresh milk is only able to meet about 20% of national needs, while the remaining 80% must be imported (Daryanto, 2021). Most domestic fresh milk (SSDN) has not met the SNI 3141-01:2011 quality standards, especially in terms of the number of microbes (<1 million CFU/ml) and dry matter content (>11.3%) (BSN, 1011). To meet the quality and safety standards of fresh milk in accordance with SNI, dairy farmers must be given knowledge and competence regarding one of the components of milk harvest-post-harvest management, namely milking time and handling methods used.

Harvest handling starts from the preparation of milking or pre-milking to milk milked from lactating dairy cows. Post-harvest handling begins after milk is expressed, namely post-milking handling, milk storage, and pre-processing activities. Harvest and post-harvest handling greatly affects the level of damage, quality, and economic value of the fresh milk produced (Sudewa, 2020; Fekata *et al*., 2023; Amentie *et al*., 2016). The karmic loss rate of poor post-harvest management reached 2.59 % - 3.35 % (BPPP, 1997), still higher than Ethiopia's 0.28 - 0.93% (Azeze & Haji, 2016; Zegeye & Teklehaymanot, 2016). However, the aggregate overall post-harvest loss from farmers to retailers for dairy products is reported to be between 2.1 to 4.3 percent in Ethiopia (Minten *et al*., 2021). The post-harvest loss of fresh dairy products in Uganda reaches 0.10-1.25% for large-scale processors, and 0.60-1.61 for small-scale processors (Kasirye, 2003). In addition, good sanitation hygiene is also needed, including sanitation of operational equipment, cage sanitation, officer hygiene, hygiene and health of cows, as well as cleanliness of water sources used during the post-harvest process.

Currently, the majority of people's dairy farms are still handling harvest and post-harvest conventionally by hand. Apart from the limited cost, farmers also argue that mechanical harvest and post-harvest handling using machines does not produce better quality compared to manual harvest and post-harvest handling. Therefore, it is necessary to conduct a study that evaluates and analyzes the handling of harvest and mechanical and conventional post-harvest using a uniform population, combining all aspects of milk quality, as well as a simple financial feasibility analysis related to the use of the two technologies.

The objectives of this study are to: 1) Analyze and study the milking time, as well as modern and conventional post-harvest harvest handling methods; 2) Analyze the influence of modern and conventional handling on the physical, chemical, and microbiological quality aspects of fresh cow's milk produced; and 3) Determine the best handling method and milking time from the quality aspect. The results of the study are expected to be used to improve and improve the post-harvest process of fresh milk among farmers and small industries.

2. RESEARCH MATERIALS AND METHODS

The research was carried out at the Cibugary dairy farm, which was located at the DKI Livestock Complex, Pondok Ranggon, Cipayung, East Jakarta. This study used fresh milk taken from 12 Friesian Holstein lactating dairy cows, which were handled using modern and conventional methods at morning and evening milking time.

2.1. Design of Experiment

The experiment was designed according to 2×2 factorial Completely Randomized Design with six replications. Factor V is the post-harvest handling method (V1: conventional, V2: modern), while factor P is the milking time (P1: morning, P2: afternoon).

2.2. Measurement and Data Analysis

The quality indicators of fresh cow's milk are related to 3 (three) aspects, including: 1) physical quality aspect; 2) chemical quality aspects; and 3) biological quality aspects. In this study, the physical quality aspects of milk include specific gravity (BJ) and acidity level (pH). The chemical quality aspects tested include fat content, lean dry matter content, dry matter, protein, and lactose. Meanwhile, the biological aspects tested were Total Plate Count, *Staphylococcus aureus*, and coliform.

The data was analyzed using Minitab 17 software with ANOVA tests. If the results show a real difference, the analysis is followed by the Least Significant Difference (LSD) test. Biplot analysis, a multivariate method that visualizes the relationship between observation objects and variables in two dimensions, is used to describe the relationships between parameters (Leleury & Wokanubun, 2015). Data processing is also carried out with Minitab 17. In addition, an analysis was also carried out using Multi Criteria Decision Making (MCDM) with the Analytical Hierarchy Process (AHP) method to determine the best milking time and method. AHP breaks down complex problems into hierarchical structures, with tiers that include objectives, criteria, and alternatives. Data is processed using Expert Choice 11.

3. RESULTS AND DISCUSSION

In this study, observations were made on the implementation of fresh milk handling that is currently applied by dairy farms, both conventionally and modernly. The results of observations on post-harvest handling at Cibugary Dairy Farm are presented in Figure 1.

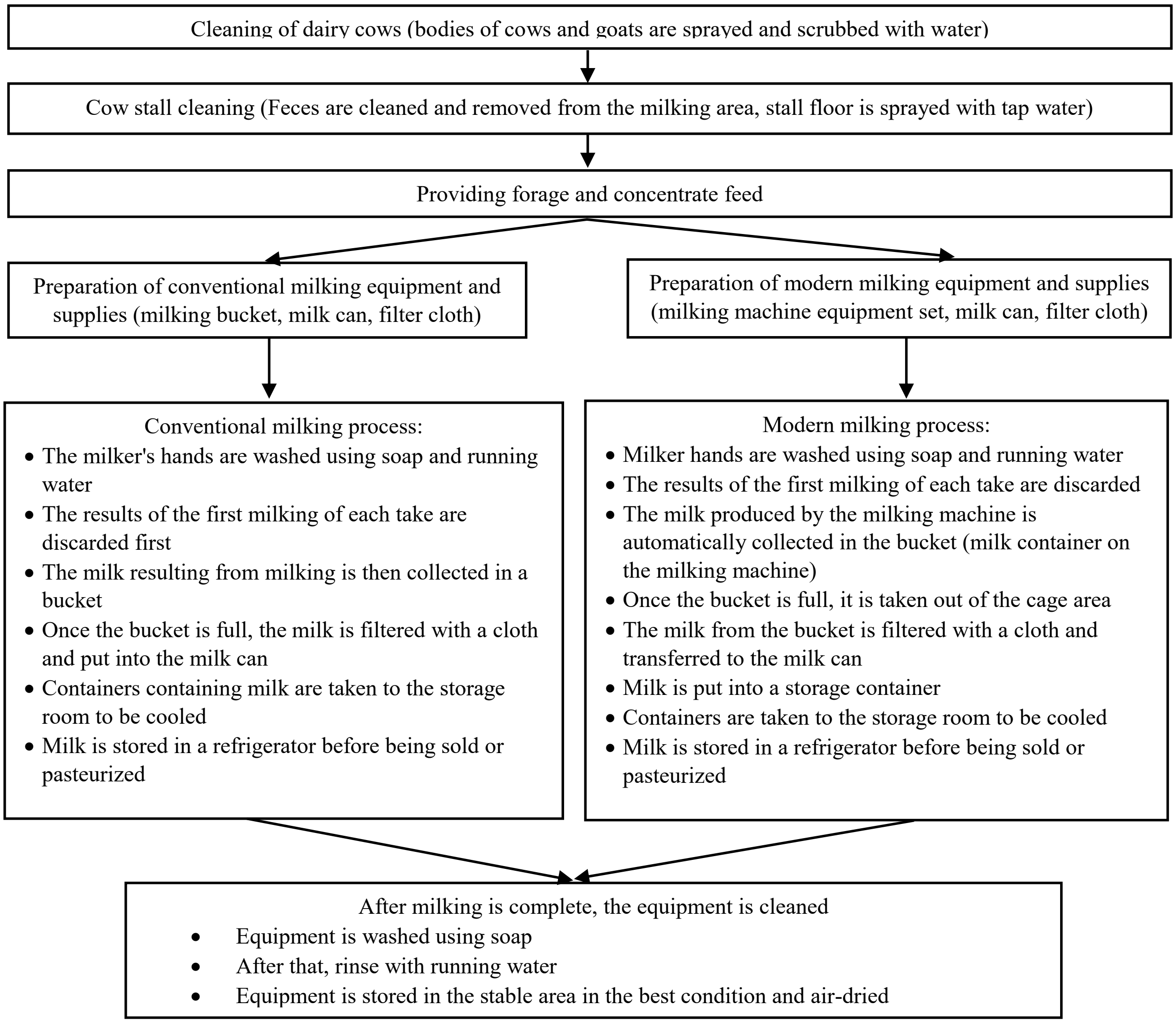


Figure 1. Implementation diagram of fresh milk handling practices

3.1. Results of Quality Testing

Tests were carried out on physical quality aspects (specific gravity, acidity), chemical quality aspects (dry matter, fat content, lean dry matter, protein, lactose), and biological quality aspects (TPC, *S. aureus*, coliform).

3.1.1. Specific Gravity

Specific gravity (BJ) is the ratio of the total solids to the moisture content of milk at the same volume and temperature. BJ was measured with a lactodensimeter at room temperature (27^{o}C). The data on the average and deviation of fresh milk quality standards are presented in Table 1. The standard BJ based on SNI is 1.027 g/ml at 27°C. Statistical tests showed that milking time had a significant effect (p = 0.000) on milk BJ, while post-harvest handling (p = 0.186) and the interaction between post-harvest handling and milking time (p = 0.932) had no significant effect on milk BJ.

BJ is affected by the fat content and lean dry matter. The relationship between BJ and fat content is inversely proportional, meaning that the higher the fat content, the lower the BJ, and the lower the fat content, the higher the BJ. BJ fat is lower than BJ, water, and other solids contained in milk. Meanwhile, BJ has a direct relationship with dry lean

Table 1. Effect of treatments on the average of specific gravity, (g/ml) of fresh milk

Component	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	1.029±0.00	1.026±0.00	1.028±0.00^{A}
V2 (Modern)	1.031±0.00	1.027±0.00	1.029±0.00^{A}
Average	1.030±0.00^{a}	1.027±0.00^{b}	

Note: Superscript with different letters on the same row or column shows a significant difference ($p < 0.05$). Lowercases for milking time (P), UPERCASES for handling methods (V)

materials. The higher the value of dry non-fat ingredients, the higher the BJ value of milk (Amrulloh, 2018). This is related to discussions related to other components of physical quality.

The BJ value in morning milking (P1) is higher than the BJ value in afternoon milking (P2). This is due to the milking interval. Vergi *et al*. (2016) stated that different milking time intervals will affect the specific gravity of milk. The milking time carried out in this study was morning milking at 05.00 and afternoon milking at 15.00, where morning milking had a time interval of 14 hours and afternoon milking had a gap of 10 hours. This is related to the duration of metabolic processes in the body of dairy cows and milk synthesis in the uterine glands. Too short milking intervals lead to high fat content and low moisture content because the specific gravity of fat is lower than the specific gravity of water. This is because dairy cows do not have enough time to form the milk components of the feed consumed (Blakely & Bade, 1998). Vidyanto *et al*. (2015) stated that the optimal milking time interval for the balance of production quantity and milk quality is 12:12. Based on the results of the research and literature, milking in the afternoon is recommended to start at 17.00 so that the quality of fresh milk produced is more optimal.

3.1.2. Acidity (pH)

The pH value was measured using potentiometric titration. The results of the statistical test can be seen in Table 2. In general V1 has a lower average pH value than V2, while P2 has a lower average pH value than P1. The interaction of the V1P2 treatment produced the lowest average pH value of 6.39, while the V2P1 treatment produced the highest average pH value of 6.83 compared to the other three treatments. The formation of lactic acid is caused by the conversion of lactose into lactic acid (Umar *et al*., 2014). The pH value was measured using potentiometric titration. Statistical tests showed that single factors milking time and post-harvest handling resulted in significant effect on the acidity (pH) of milk with $p = 0.000$ for milking time and $p = 0.025$ for post-harvest handling methods. The minimum standard for the acidity of fresh milk based on SNI 3141.1:2011 is 6.3-6.8 and if it exceeds this limit, it can be said that the milk has abnormalities or damage.

Table 2. Effect of treatments on the average of physical quality (acidity) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	6.55±0.05	6.39±0.07	6.47±0.10^{B}
V2 (Modern)	6.83±0.04	6.78±0.07	6.80±0.06^{A}
Average	6.69±0.15^{a}	6.58±0.22^{b}	

Note: Superscript with different letters on the same row or column shows a significant difference ($p < 0.05$). Lowercases for milking time (P), UPERCASES for handling methods (V)

Christi *et al*. (2022) stated that the pH value of milk is influenced by environmental factors such as temperature and humidity, sanitation of cages and equipment, cleanliness of milking officers, milking duration, milking intervals, and accuracy at the time of pH measurement. The pH value is also greatly influenced by the activity of lactic acid bacteria in fresh milk or the presence of an abnormality in dairy cows. Low pH values (acidic) can be caused by the activity of lactic acid bacteria and can lower the pH of milk to 6.2-5.9. The acidity of milk is also caused by various natural compounds in fresh milk that are acidic in nature such as citric acid compounds, amino acids and carbon dioxide that are soluble in milk. This is related to bacterial contamination in milk so that the pH becomes lower.

The interaction between the V1P2 treatments resulted in average values that tended to be lower than the other treatment interactions. This can be caused by higher ambient temperatures and humidity in the afternoon so that bacterial activity becomes faster. The results of this study are in accordance with the research of Suherman *et al.* (2013) regarding the temperature and humidity of the air in the Jakarta and Bogor areas where the air temperature in the morning is relatively suitable for FH virgin cows, but the air humidity is not suitable because it is above the normal range. The daytime temperature rises quite high and then begins to decline in the afternoon, but the humidity is very high. The environmental conditions in Pondok Rangon according to BMKG measurements are a temperature of 26ºC with a humidity of 85% at 05.00 WIB and a temperature of 33ºC with a humidity of 60% at 15.00 WIB. The temperature began to decrease at 17.00 WIB, which was at a temperature of 30ºC with a humidity of 70%.

Research conducted by Mulyati *et al.* (2018) obtained results that the number of microbes in conventional milking tends to have higher values compared to modern milking. This is mainly due to the cleanliness of the milking officers and the longer milking time so that the chance of milk to be contaminated becomes greater. Modern milking produces a smaller number of microbes due to minimal contact with milking and shorter milking times. The presence of microbes closely relates to microbiological and enzymatic activities that can cause the pH of fresh milk to be lower.

3.1.3. Dry Mater of Milk

The data from the research on dry matter presented in Table 3 show that the P1 results in dry matter of 10.87%, which is significantly higher than that of P2 by 10.73% (p = 0.039). The percentage of dry matter V2 of 10.82% tends to be higher than V1 of 10.78% but has no significant effect (p = 0.512). The dry matter standard is not regulated in SNI, but is an indicator in determining the quality and price of milk purchases.

Table 3. Effect of treatments on the average of dry mater (%) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	10.84±0.13	10.71±0.14	10.78±0.14^{A}
V2 (Modern)	10.89±0.06	10.74±0.23	10.82±0.18^{A}
Average	10.87±0.10^{a}	10.73±0.18^{b}	

Note: Superscript with different letters on the same row or column shows a significant difference (p < 0.05). Lowercases for milking time (P), UPERCASES for handling methods (P).

Nugraha *et al.* (2016) stated that the composition of nutrients such as fat, protein, lactose, vitamins, and minerals greatly affects the high total BK content of milk. The milking time interval affects the quality of milk. The milking interval is related to the length of the metabolic process in the dairy cow's body and the process of milk synthesis in the uterine glands. Cows that are milked for a long time have a greater chance of milk synthesis so that the lumen of the alveoli can be filled with milk optimally. This affects the content of the Total BK which is better in the morning milking. Ozcan *et al.* (2015) stated that the composition of milk is also influenced by environmental conditions such as temperature, humidity, solar radiation, and wind speed. The respiration ratio and body temperature of dairy cows exposed to hot air increase in response to balance their body condition with the environment. This response has a direct impact on the quantity and quality of milk, including BK.

Table 4. Effect of treatments on the average of lean dry mater (%) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	8.50±0.15	8.06±0.16	8.28±0.27^{A}
V2 (Modern)	8.47±0.16	8.28±0.25	8.37±0.22^{A}
Average	8.48±0.15^{a}	8.17±0.23^{b}	

Note: Superscript with different letters on the same row or column shows a significant difference (p < 0.05). Lowercases for milking time (P), UPERCASES for handling methods (P).

3.1.4. Lean Dry Matter

Lean dry matter (BKTL) is a component in milk other than water and fat. The BKTL content depends on the levels of protein, fat and lactose present in milk (Utari *et al*., 2012). Statistical tests showed that the average BKTL at the time of milking P1 had a value of 8.48% where the value was higher than P2 of 8.17% and the difference was significant with p = 0.001 (Table 4). The average BKTL of the V1 treatment method (8.28%) tended to be lower than that of V2

(8.37%), but the difference was not significant (p = 0.224). There was no interaction between treatments (p = 0.107). Based on the research data, it can be seen that the BKTL content of all treatments meets SNI 3141.1:2011, which is 7.80% (BSN, 2011). Morning milking has a higher BKTL value than afternoon milking. These results are in accordance with a study conducted by Cristi *et al*. (2022) where the average BKTL yield in the morning milking is higher than in the afternoon. This is influenced by the interval factor or milking distance from morning to evening.

3.1.5. Protein

Protein is the main nutrient in milk because it contains essential amino acids that are beneficial for the body. The minimum standard for fresh milk protein content based on SNI is 2.80. Statistical tests showed that milking time had a significant effect (p = 0.001) on milk protein levels. Post-harvest handling and interaction between treatments had no significant effect (p = 0.361) on milk protein levels. The protein content in the morning milking (3.13%) was higher than in the afternoon milking (2.83%), although the difference was not too significant (Table 5).

Table 5. Effect of treatments on the average of protein content (%) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	3.14±0.03	2.76±0.34	2.95±0.31^{A}
V2 (Modern)	3.11±0.05	2.91±0.12	3.02±0.14^{A}
Average	3.13±0.04^{a}	2.83±0.26^{b}	

Note: Superscript with different letters on the same row or column shows a significant difference (p < 0.05). Lowercases for milking time (P), UPERCASES for handling methods (P).

The results of this study are in line with the findings of Christi *et al*. (2022) who stated that morning milking has higher protein levels than afternoon milking. Vergi *et al*. (2016) stated that milking intervals affect milk quality where short intervals lead to high fat content. This is because the fat synthesis process is faster than other components of milk. Mardalena (2008) examined the relationship between fat content and other nutritional values in milk. The difference in fat content in each milking affects the levels of other nutrients such as protein and lactose. Each chemical nutritional value in milk is interrelated and the higher the fat content, the higher the protein and lactose levels.

Nugraha *et al*. (2016) stated that the quality of protein from morning and evening milking tends to be constant. The amount of protein in milk can be influenced by internal and external factors. Internal factors include physiological conditions, cow race, lactation rate, estrus, pregnancy, calving interval, and age. External factors are feed. The results of the post-harvest treatment in Table 5 show that the modern treatment (3.02%) produces a higher percentage of protein content than conventional (2.95%), but not significantly different to that of conventional one. Research conducted by Toušová *et al*. (2014) found that the milk protein content in modern milking using the Automatic Milking System (AMS) is higher than conventional milking using hands.

3.1.6. Lactose

Statistical tests showed that milking time had a significant effect (p = 0.000) on milk lactose levels, post-harvest handling and the interaction between post-harvest handling and different milking times had no significant effect (p = 0.279) on milk lactose levels. Table 6 shows that the average lactose level in morning milking (4.40%) is significantly better than afternoon milking (3.75%). The results of the post-harvest treatment showed that the modern treatment (4.11%) had a higher percentage of lactose content than conventional (4.04%), but had no real effect. The research of Toušová *et al*. (2014) found that lactose levels are higher than in summer milking than that of winter. It has to do with

Table 6. Effect of treatments on the average of lactose content (%) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	4.36±0.03	3.72±0.34	4.04±0.37^{A}
V2 (Modern)	4.45±0.05	3.78±0.12	4.11±0.38^{A}
Average	4.40±0.17^{a}	3.75b±0.14^{b}	

Note: Superscript with different letters on the same row or column shows a significant difference (p < 0.05). Lowercases for milking time (P), UPERCASES for handling methods (P).

air temperature and humidity. Temperature control in summer affects the metabolism of cows so that it has an effect on the quality of milk produced. It is the same with the difference in milking time where afternoon milking has a higher temperature and humidity than in the morning. The conversion of lactose to lactic acid by the activity of microorganisms and enzymatic activity can also lead to a decrease in the pH of milk. In addition, similar to protein levels, lactose levels can also be affected by milking intervals although the difference is relatively small (Mardalena 2008). Lactose is a component of milk that causes sweetness due to the influence of its constituent substance, namely glucose. The conversion of lactose to lactic acid by the activity of microorganisms and enzymatic activity can lead to a decrease or increase in the pH of milk.

3.1.7. Fat Levels

Statistical tests showed that milking time had a significant effect (p = 0.000) on milk fat content. Post-harvest handling and the interaction between post-harvest handling and different milking times had no significant effect (p = 0.554) on milk fat content (Table 7). The minimum standard for fresh milk fat content based on SNI 3141.1:2011 is 3.00%. Cows that are milked at longer intervals produce a greater amount of milk. Longer milking intervals result in optimal milk production, but the fat content is relatively low. In contrast, short milking intervals produce high-fat milk with lower milk production (Vergi *et al*. 2016). In addition to the milking interval, differences in fat content in morning and evening milking can also be caused by environmental conditions such as temperature and humidity. Ozcan *et al*. (2015) stated that protein and fat levels are higher in summer than in winter, where summer has higher temperatures and humidity than winter.

Table 7. Effect of treatments on the average of fat content (%) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	2.27±0.04	2.34±0.03	2.30±0.05^{A}
V2 (Modern)	2.28±0.03	2.31±0.02	2.29±0.03^{A}
Average	2.27±0.03^{b}	2.32±0.03^{a}	

Note: Superscript with different letters on the same row or column shows a significant difference (p < 0.05). Lowercases for milking time (P), UPERCASES for handling methods (P).

Table 8. Effect of treatments on the average of Total Plate Count (log CFU/ml) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	6.03±0.03	6.07±0.02	6.05±0.03^{A}
V2 (Modern)	5.86±0.07	5.92±0.06	5.89±0.07^{B}
Average	5.95±0.10^{b}	6.01±0.09^{a}	

Note: Superscript with different letters on the same row or column shows a significant difference (p < 0.05). Lowercases for milking time (P), UPERCASES for handling methods (P).

3.1.8. Total Plate Count

The results of the study in Table 8 showed that handling and milking time each had a significant effect on TPC with p = 0.000 for post handling and p = 0.018 for milking time. While, the interaction between handling and milking time had no significant effect (p = 0.865). Conventional handling (V1) results in TPC that does not meet the SNI limit, which is 6.05 log CFU/ml (1.1×10^6 CFU/ml). In contrast, modern handling interactions in morning milking (V2P1) showed the best TPC, which was 5.86 log CFU/ml (0.7×10^6 CFU/ml), although this difference was not significant. Modern treatment capable to reduce TPC by 32.73%.

TPC closely relates to hygiene and sanitation. In modern post-harvest handling, milk that has been expressed using a machine is filtered and transferred to a milk container in the milk storage room. In contrast to conventional handling, milk from milk cans is directly filtered at the milking site and stored in plastic. This activity is carried out in the cowshed area so that it opens up a greater opportunity for contamination from the air. In addition, conventional milking processes that take longer than modern milking allow for greater air contamination. The filter cloth used by farmers can be a source of contamination because it is not sterilized and not dried properly. After the filtration is complete, the filter cloth is washed with plain water and soap, then dried. The cloth is not rinsed with hot water or disinfectant liquid, so there may still be microbes or dirt. The officer cleanliness factor also needs to be considered, considering that after cleaning the cowshed, the officer does not change his clothes so there is a possibility that dirt is still attached to the officer's body. The cause of high TPC in general can also be caused by not dyeing the nipples before milking. This is in accordance with the statement of Cahyono, (2013) that TPC can be prevented by carefully dipping the nipples of dairy cows so that it can reduce or prevent the entry of microbes into milk. This treatment can reduce about 70% of bacteria in fresh milk.

3.1.9. *Staphylococcus aureus*

Staphylococcus aureus is a pathogenic bacterium that is often found in contaminated milk and often causes subclinical or chronic mastitis (Hayati *et al*. 2019). Subclinical contamination of *S. aureus* in milk does not cause physical changes in milk, therefore consumers are often unaware of its presence. The maximum limit of *S. aureus* set based on SNI 3141.1:2011 is 1×10^2 CFU/ml (BSN, 2011). The results (Table 9) showed that post-harvest treatment had a significant effect ($p = 0.000$) on *S. aureus*. The milking time is also significant ($p = 0.006$), while milking time and interaction between treatments had no significant effect ($p = 0.673$) on *S. aureus*. V2 has a much better amount of *S. aureus* than V1. Modern post-harvest handling methods can reduce the amount of *S. aureus* by 43.33%. In general, the weaning time data showed that P1 had a lower amount of *S. aureus* than P2 weaning although the difference was not significant, as well as the P1V2 interaction had a higher amount of *S. aureus* than other treatments.

Table 9. Effect of treatments on the average of *S. aureus* (log CFU/ml) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)	Average
V1 (Conventional)	2.02±0.07	2.11±0.07	2.07±0.08^A
V2 (Modern)	1.68±0.14	1.82±0.08	1.75±0.13^B
Average	1.85±0.21^b	1.97±0.16^a	

Note: Superscript with different letters on the same row or column shows a significant difference ($p < 0.05$). Lowercases for milking time (P), UPERCASES for handling methods (P).

Bacterial contamination in milk begins during milking. Hijriah *et al*. (2016) stated that milk contamination by microorganisms can occur during milking, handling, storage, and pre-processing. The application of technology in the milking process, such as the use of milking machines, can reduce contamination. This is because milking machines help maintain the health of the cow's udder and nipple, as well as improve milk production and overall health of cows. This statement is in line with the results of studies that show that the number of bacteria in modern post-harvest treatment is less than in conventional post-harvest treatment. Referring to the parameters of milking time, the results of this study are also in accordance with the research conducted by Reguillo *et al*. (2018) which stated that morning milking produces a lower number of milk microbes compared to afternoon milking. This is because milk is not immediately cooled after milking. High temperatures and humidity can cause bacteria to multiply faster in the milk.

Table 10. Effect of treatments on the average of coliform (log CFU/ml) of fresh milk

Treatment	P1 (Morning)	P2 (Afternoon)
V1 (Conventional)	3.56±0.02^a	3.54±0.02^a
V2 (Modern)	3.30± 0.03^c	3.33±0.03^b

Note: Superscript with different letters shows a significant difference ($p < 0.05$).

3.1.10. Coliform

The statistical test in Table 10 showed that the handling and interaction between treatments had a significant effect on coliform, with $p = 0.000$ for handling methods and $p = 0.019$ for interaction. The milking time had no significant effect ($p = 0.511$) on coliform. The highest coliform count in V1P2 interactions, which is 2.11 log CFU/ml and lowest in V2P1, which is 3.30 log CFU/ml. From the results of the study, it is known that modern treatment can reduce the number of coliforms by 40.97% compared to conventional treatment. Coliform can be used as an indicator of contamination because it is directly proportional to the level of water pollution. High coliform levels indicate low levels of hygiene and sanitation, as well as the possibility of fecal contamination (Wijayanti *et al*., 2017). Coliform V1 3.55 log CFU/ml higher than V2 3.31 log CFU/ml. This relatively high amount of coliform is caused by several factors, namely lack of hand hygiene for milking, lack of cleanliness of the cage, contaminated groundwater used to clean the cage and equipment, the location of the disposal of livestock manure which is not far from the milking site, the non-use of disinfectants, equipment that is not properly dried, and concentrate sacks placed on the floor of the cage so that they can be contaminated with cow dung.

3.2. Biplot Analysis

Biplot analysis can provide a good idea of the relationship between observation variables. The results of the biplot analysis are presented in Figure 2. Based on the biplot display presented visually and simultaneously in a graph, there are four important things that can be observed, namely the proximity between variables, correlations between variables, diversity of variables, and interpretation of variable values in an object.

3.2.1. Proximity and Correlation between Variables

The quadrants in Figure 2 show the proximity or similarity of the characteristics of the variables studied. Variables that are in the same quadrant are said to have similar quality characteristics that are quite close when compared to variables that are in different quadrants. A variable that has a positive correlation is depicted with two lines that have the same direction or form a narrow angle <90^o, whereas a variable that has a negative correlation is depicted as two lines in opposite directions or form a blunt angle >90^o. Two lines with angles close to 90^o (right angles) show no correlation.

Quadrant I variables (BJ, lactose, protein, BK, and BKTL) have a positive relationship, meaning that if BJ is high, lactose, protein, BK and BKTL are also high. When viewed in terms of the method and handling of milking time, in general, the five variables are not influenced by the handling method but are influenced by the milking time. Quadrant II variables (TPC, *S. aureus*, and coliform) are aspects of biological quality whose value is highly dependent on the treatment method applied. Quadrant III variables (fat content) have a negative correlation with quadrant I variables such as BJ, meaning that the higher the fat content, the lower the BJ, and vice versa. The quadrant IV (pH) variable is related to the presence of microorganisms in milk. High pH values (alkaline) have poor quality and indicate abnormalities in dairy cows such as mastitis, on the other hand, low pH values (acid) also have poor quality because they indicate microbial contamination.

3.2.2. Diversity of Variable

Variables that have a small diversity value are described as short vectors, whereas variables that have large diversity values are described as long vectors. Figure 2 shows that BK and protein have a small diversity value because the vector length is shorter, while the fat, lactose, BJ and BKTL levels tend to have similar diversity because the vector length is almost the same. TPC, *S. aureus*, coliform and pH have great diversity values because the vectors are longer.

3.2.3. Interpretation of Variable Values on an Object

An object located in the direction of the variable vector is said to have a value above average, on the other hand if the object is located opposite the direction of the variable vector, then it has a value below the mean. An object that is almost in the middle means that it has a value close to the average. The results of the Score Plot analysis are presented in Figure 2. The results of the Score Plot analysis showed that V1P2 TPC, *S. aureus*, and coliform had the highest values (above average), whereas V2P1 and V2P2 that had opposite directions had lower values (below average). V2P1 has higher lactose, BK, protein, BKTL, and BJ values (above-average values).

3.3. Analytic Hierarchy Process (AHP) Optimization

Analytic Hierarchy Process (AHP) is a theory of measurement through paired comparisons and relies on expert considerations to obtain a priority scale (Destari, 2015). Data from interviews with officers and tests were used as the basis for modeling. The hierarchical arrangement of the AHP model consists of 4 (four) levels and is presented in Figure 3(a). The model in Figure 3(a) will be the basis of the hierarchy of the Expert Choice 11 model presented in

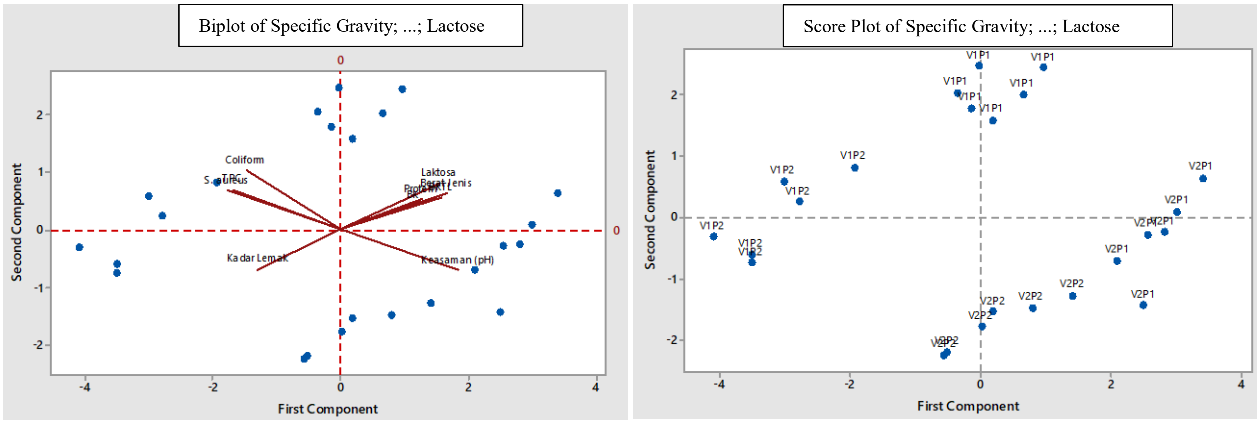
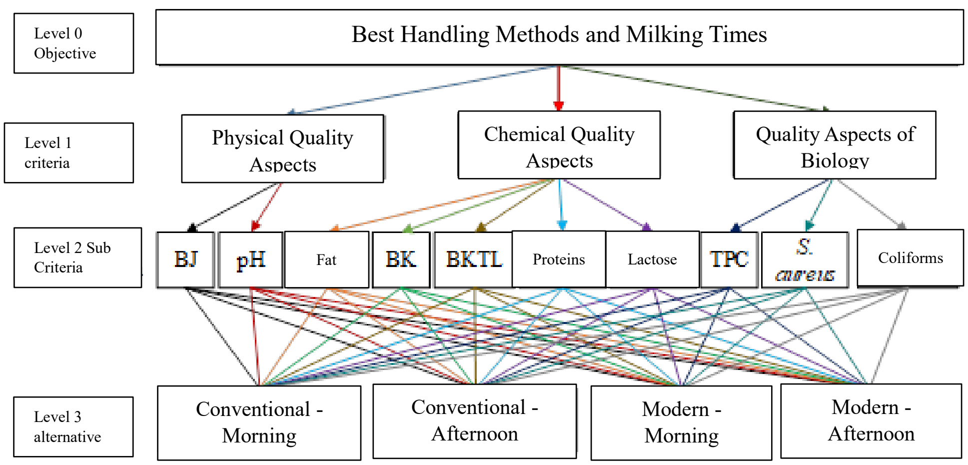
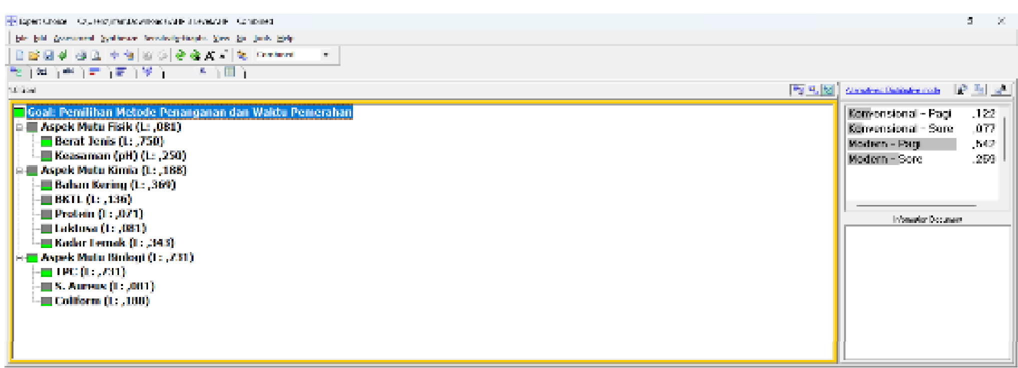


Figure 2. Biplot analysis results



(a)



(b)

Figure 3 Hierarchical structure of the AHP Model (a) Modeling; (b) Expert choice

Figure 3(b). The left part of Figure 3(b) shows the criteria and sub-criteria, while the right side shows the alternatives. The alternative is ranked according to the weighting given so that an alternative ranking is obtained globally. Weight shows the magnitude of the influence of criteria in determining the quality of fresh milk. The results of the processing of Expert Choice 11 data obtained that modern handling and morning milking time are the best methods in producing the most optimal milk quality.

The results of the weight distribution graph are presented in Figure 4. This graph provides a visual representation of the relative priorities set for various criteria or alternatives in the decision-making framework so that users can quickly identify more important criteria or alternatives. The graph shows that modern treatment and morning milking time generally yield better scores than other treatments. Conventional handling and morning milking time produced the second best score in physical and chemical quality aspects, but produced poor scores in biological quality aspects.

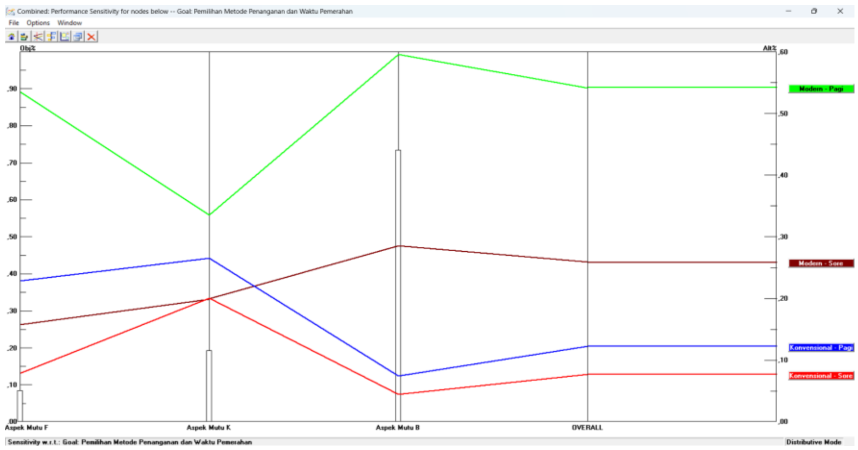


Figure 4. Weight distribution chart

4. CONCLUSION

Post-harvest management had a significant effect ($p < 0.05$) on pH, TPC, *S. aureus*, and coliform. Milking time had a real effect ($p < 0.05$) on BJ, pH, BK, fat content, BKTL, protein, lactose, TPC, and *S. aureus* which produced the best values at the time of milking in the morning compared to the afternoon, except for fat content. Modern post-harvest handling yields the best value compared to conventional ones. The interaction of milking time and harvest-post-harvest handling had a significant effect ($p < 0.05$) on pH, TPC, and *S. aureus* where the interaction of morning milking time and modern handling methods yielded the best value. Modern post-harvest handling can reduce the amount of fresh milk TPC by 32.73%, *S. aureus* by 43.33%, and coliform by 40.97% compared to conventional post-harvest handling methods.

Biplot analysis showed that V1P2 TPC, *S. aureus*, and coliform had the highest values (above average), whereas V2P1 and V2P2 that had opposite directions had lower values (below average). V2P1 has higher values of lactose, BK, protein, BKTL, and BJ (above-average values). AHP's optimization shows that morning milking time and modern handling methods are the most optimal combination to produce fresh milk that has the best quality. The second best combination is afternoon milking time and modern handling methods.

Suggestions that can be given based on the results of the study are: The milking interval in this study is 10:14 producing milk that is less than optimal for afternoon milking. It is recommended to use an interval of 12:12 with afternoon milking starting around 17:00. Milking at 17.00 is also quite appropriate if you consider the air temperature that has begun to decrease compared to 15.00 so that the quality of the milk produced can be better.

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