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Milk Quality, Curd, and Whey Percentages of Holstein Friesian Cows at Different Lactation Phases

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ABSTRACT

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The lactation phase of dairy cows is very important in determining the quality of milk produced. The lactation phase is divided into three phases: early, mid, and late lactation. The objective of this study was to determine the milk quality and percentage of curd and whey of Holstein Friesian dairy cows at different lactation phases. This study was conducted using a completely randomized design (CRD) with 3 treatments and 5 replicates of each treatment. The treatments in this study were P1 = early lactation, P2 = middle lactation, and P3 = late lactation. The research data were processed through the SPSS application using the ANOVA test and if there was a difference between treatments, it would be further tested using the Duncan test. The lactation phase significantly ($P < 0.05$) affected the fat content and curd production of *Holstein Friesian* cow milk, but did not significantly affect the protein content, pH, specific gravity (BJ), and viscosity of *Holstein Friesian* cow milk. The lactation phase has a significant impact on the milk quality and percentage of curd and whey in *Holstein Friesian* dairy cows. It has been observed that during the late lactation phase, the milk quality tends to be higher, which is a noteworthy finding for dairy farmers.

Keywords: Phase of lactation, physical quality, chemical quality, curd, and whey

INTRODUCTION

Demand for milk has been increasing yearly due to the growing population and awareness of the importance of consuming protein from dairy cows. However, domestic milk production seems unable to meet the required quantity and quality, as stated by [1]. It's important to note that quality milk is not only determined by its taste but also by its nutritional content. Milk comprises protein, fat, carbohydrates, minerals, and vitamins. However, various factors can influence the quality of milk produced by smallholder farms in Indonesia, including external factors such as feed and environment, as well as internal factors like genetics and lactation phases [2].

The lactation phase of dairy cows is essential in determining the quality of milk produced. It's divided into three phases: early, mid, and late lactation. Dairy cows in early lactation increased milk yield and reached peak milk yield on days 90–140. After that, milk yield decreases until the final lactation phase, where the cow enters a dry period before parturition [3]. In early lactation, dairy cows often experience a negative energy balance due to their high energy requirements, which exceed the energy needed to produce milk. This causes dairy cows to use fat reserves in body tissues to meet their energy requirements. However, as the lactation phase progresses, dairy cows undergo a period of positive energy balance, which causes milk yield to continue to increase [4]. The lactation phase, including early, middle, and late lactation, can impact the quality of milk produced. In particular, milk fat and protein content tend to increase during the late lactation. Dairy farmers must know these changes and adjust their management practices accordingly to ensure the best possible milk quality [5].

It's essential to note that the nutritional adequacy of dairy cows in each lactation phase is different, which can affect their metabolism and ultimately impact the production and quality of milk yield. Providing feed with higher levels of crude protein during the middle lactation phase could lead to an increase in milk yield. This could be useful information for those involved in dairy farming or animal nutrition. Therefore, it's important to ensure dairy cows have adequate energy to maintain their productivity and produce high-quality milk. This study aims to determine Holstein Friesian dairy cows' milk quality and percentage of curd and whey at different lactation phases.

MATERIALS AND METHODS

Research Design

During the dry season, this research was conducted in Baba Hamlet, Cendana Village, Enrekang Regency, South Sulawesi. The temperature during the research varied from 24°C to 31°C, with humidity ranging from 57–87%. The research location was 3°29'12.12" South Latitude and 119°51'40.319" East Longitude, at an altitude of 47 meters above sea level (map coordinates). There are 15 lactating Holstein Friesian dairy cows with an average body weight of \pm 500 kg. This study used 15 Holstein Friesian dairy cows consisting of 3 treatments at different lactation phases, with cows 4–5 years old and giving birth 1–2 times. In the morning and evening, feeding was carried out in the elephant grass (*Pennisetum purpureum*) and concentrates. The feed for the animal consists of a ratio of 75% forage and 25% concentrate, with the feed amount

not exceeding 3% of the animal's body weight. The concentrate is made from a mixture of bran and tofu pulp, with a ratio of 75% bran and 25% tofu pulp. Additionally, the concentrate has a standard crude protein (CP) of 14.5% and a total digestible nutrient (TDN) of 72%.

This study used a Complete Randomized Design (CRD), with 3 treatments and 5 replications for each treatment. The treatments in this study are as follows:

- P1= Early Lactation (1–3 months),
- P2= Mid Lactation (4–7 months),
- P3= Late Lactation (8–10 months).

Measurements and Parameters

Milk Specific Gravity (SG), pH, Protein, and Milk Content

Milk protein and fat content measurements and the test were conducted at the Feed Chemistry Laboratory in the Faculty of Animal Husbandry at Hasanuddin University. To measure the milk pH, a pH meter was used immediately after milking, and the pH meter's value indicated the milk's pH. For measuring the milk-specific gravity (SG) by David's method [6]. It allowed the milk samples to stand at 50–70°F, homogenized them, and poured them into a measuring cup. Then, it inserted a lactodensimeter into the measuring cup, allowed it to settle, and observed the scale that appeared on the lactodensimeter (LR). Finally, measured the milk temperature using a thermometer, and if the milk temperature was above 60°F, then the authors corrected the milk temperature (CLR) based on the measurement. The lactodensimeter scale is increased by 0.1 for every 1-degree increase in temperature above 60°F at LR. The lactodensimeter scale is reduced by 0.1 for every 1-degree drop in temperature below 60°F at LR

Then, to get the SG value, use the following formula:

$$\text{Specific Gravity} = 1 + \frac{\text{CLR}}{1000}$$

Viscosity

Viscosity is measured using an Ostwald viscometer, for which the formula used to measure milk viscosity is referred to by Rizqiyati et al. [7] as follows:

$$\text{Viscosity} = \frac{\rho_{\text{sample}} \times t_{\text{sample}} \times \eta_{\text{water}}}{\rho_{\text{water}} \times t_{\text{water}}}$$

$$\rho_{\text{sample}} = \frac{m_1 - m_2}{v}$$

Descriptions:

m1: empty pycnometer weight (g)

m2 : empty pycnometer weight + samples weight (g)

v : pycnometer volume (ml)

ρ : sample density (g/ml) (air = 1 g/ml)

η : water viscosity

t : time (s)

Curd and Whey percentage

Milk curd and whey percentages were measured by heating 1 kg of fresh milk using the low-temperature, long-time (LTLT) method, as described in [8]. Then, 4 cc of papain enzyme solution was added, and after the curd and whey were separated, the curd and whey were weighed to calculate the curd and whey production using the formula according to Estikomah [9] as follows:

$$\text{Curd Percentage} = \frac{\text{Curd weight}}{\text{Milk initial weight}} \times 100\%$$

$$\text{Whey Percentage} = \frac{\text{Whey weight}}{\text{Milk initial weight}} \times 100\%$$

Statistical Analysis

The research data will be processed statistically using the SPSS application. Statistical analysis using the ANOVA test. If there is an effect between the treatments, it will be further tested using the Duncan test.

RESULTS AND DISCUSSIONS

Chemical Quality of Holstein Friesian Dairy Cows' Milk in Different Lactation Phases

The results of research on Holstein Friesian dairy cows' protein and fat content in different lactation phases are presented in Table 1. The lactation phases had a significant effect ($P < 0.05$) on milk fat content but did not have a significant effect ($P > 0.05$) on milk protein content. The milk protein and fat levels decrease in the middle lactation phase and then increase again in the late lactation phase. Meanwhile, the peak protein and fat content of milk reached P3.

Table 1. Protein and fat content of Holstein Friesian dairy milk

Parameters	Treatments			P
	P1	P2	P3	
Protein (%)	2.36±0.20	2.24±0.17	2.46±0.30	0.358
Fat (%)	1.84±0.56 ^{ab}	1.57±0.86 ^a	3.55±0.78 ^b	0.002

Note: Different superscripts in the same row indicate significant differences ($P < 0.05$); P1 Early Lactation, P2 Mid Lactation, P3 Late Lactation.

The decrease in protein content in the middle lactation phase can occur due to the influence of high milk yield in the early lactation phase [10]. Milk yield is increased, which can result in a decrease in milk protein levels. This is because the volume of milk secreted is increased without a proportional increase in milk protein synthesis, which can reduce milk protein concentration [11]. However, milk fat levels in the early and middle lactation phases still do not meet the quality requirements of fresh milk due to low milk fat content [12]. The difference in milk fat content in each lactation phase can occur because of the negative energy balance of dairy cows in the early lactation phase. During early lactation, postpartum dairy cows may experience a negative energy balance (NEB), resulting in decreased performance and low-quality milk [13].

This occurs when the energy required to produce milk and recover from giving birth exceeds the energy obtained from feed intake. NEB is caused by a nutritional imbalance, which leads to the mobilization of lipid, glycogen, and protein reserves in the body. This can also impact the protein and fat content in the milk [14].

Milk protein and fat content can also be influenced by the ratio of forage feed and concentrate feed intake [15, 16]. The ratio between grass and concentrate plays a crucial role in determining the protein consumption of livestock. Additionally, the quality of milk is also determined by the adequacy of CP. Increasing CP levels from 11% to 16% can increase milk protein and fat [17].

Physical Quality of Holstein Friesian Dairy Cows' Milk in Different Lactation Phases

Research data on the physical quality of Holstein Friesian cows' milk at different lactation phases are presented in Table 2. The lactation phases did not significantly affect Holstein Friesian milk's pH, SG, and viscosity, according to the data presented in Table 2.

Table 2. pH, SG, and viscosity of Holstein Friesian dairy cows' milk

Parameters	Treatments			p
	P1	P2	P3	
pH	6.75±0.08	6.85±0.02	6.83±0.10	0.133
SG (g/ml)	1.030±0.003	1.029±0.002	1.031±0.002	0.388
Viscosity (cP)	1.0±0.1	1.0±0.1	1.1±0.1	0.452

Note: P1= Early Lactation, P2= Mid Lactation, P3= Late Lactation, SG=Specific Gravity

The pH of milk remained within the standard range of cow's milk pH, according to the SNI [18] guidelines. The SG and viscosity of milk were not significantly different across all treatments, as they are influenced by the number of solids, including protein, fat, minerals, and vitamins, in the milk [19, 20]. Additionally, the temperature of the milk at the time of measurement can also affect the SG and viscosity value of milk, as a decrease in temperature can cause fat clumping. Thus, an increase in fat content and sample temperature can impact the results of measuring milk's specific gravity and viscosity [21].

Although the fat content in milk during different lactation phases varies significantly, it does not seem to impact viscosity values. However, the viscosity tends to be highest towards the end of lactation when the fat content is also high. It's worth noting that the higher the solids content in the milk, the higher its viscosity. The higher protein and fat content allows more particles to bind water molecules, resulting in a higher water-binding capacity and increased viscosity. These findings have been supported by previous research [22, 23].

This study found that milk protein levels were similar across the lactation phases but tended to be higher at the end of lactation. It's also notable that all parameters tended to follow a similar pattern, with milk quality starting at a moderate level at the beginning of lactation, decreasing in mid-lactation, and then increasing again towards the end. At the end of the lactation period, dairy cows demonstrate their peak performance, outperforming all other stages of lactation. This phase is characterized by their remarkable ability to convert nutritional components into milk, leading to a rich, high-protein yield that underscores their efficiency and

productivity [24, 25]. These findings could be useful for dairy farmers in adjusting their management practices to optimize milk quality throughout the lactation cycle. Understanding the lactation cycle is essential for farmers seeking to optimize milk quality through effective feed management. The provision of high-quality feed is directly associated with improved milk composition in dairy cows [26]. Research indicates that cows receiving rations containing 18% CP produce significantly higher protein content in their milk compared to those on a 16% CP diet [25]. This compelling evidence underscores the importance of nutritional strategies tailored specifically to each phase of lactation. By ensuring that cows receive the appropriate nutrients, farmers can maximize both the quality and yield of milk, ultimately enhancing productivity and profitability in their dairy operations. Embracing these targeted feeding practices is not merely advantageous; it is vital for success in today's competitive dairy industry.

Milk Curd and Whey Production of Holstein Friesian Cows at Different Lactation Phases

Milk curd and whey production data for Holstein Friesian cows in various lactation phases are presented in Table 3. Lactation significantly affects curd production from the milk of Holstein Friesian cows ($P < 0.05$). However, it did not significantly affect whey production ($P > 0.05$). The production of curd in P3 was discovered to be significantly different from that of P2, but not significantly different from P1. It was observed that the lactation phase had a significant impact ($P < 0.05$) on curd production derived from milk of Holstein Friesian cows. However, it did not significantly impact whey production ($P > 0.05$).

Table 3. Friesian Holstein cow milk curd and whey production

Parameters	Treatments			P
	P1	P2	P3	
Curd (%)	19.4±1.8 ^{ab}	18.8±1.6 ^a	22.1±2.9 ^b	0.028
Whey (%)	68.2±3.4	72.4±2.5	68.6±2.8	0.089

Note: ^{a,b}Different superscripts in the same row indicate significant differences ($P < 0.05$); P1 Early Lactation, P2 Mid Lactation, P3 Late Lactation.

The curd production in P3 was attributed to the high protein and fat content in P3 compared to P1 and P2 (as shown in Table 1). The protein and fat content of milk affect the quantity of curd produced [27]. More fat and protein in milk result in more curd production. A higher amount of curd implies a higher yield value. When milk is coagulated, the primary product is curd, and the by-product is whey in liquid form [28].

Coagulants help milk proteins bind together, forming a solid or curd, as the fat in the milk coagulates [29]. Milk's protein and fat content can be used to estimate the curd produced. This is because certain levels of protein and fat are needed to achieve the desired texture and consistency in the curd-making process. The highest whey production was found in P2, and the whey produced indicates a lower curd formation [30]. High whey production is indicative of low milk solids [31]. Several factors influence the yield and whey production during the production of curd. These factors include the heating method, which involves various temperatures ranging from 80-100°C, and the concentration of coagulant used, which ranges from 0.3–1.5%, resulting in different yields and whey production.

CONCLUSIONS

The physical quality of milk obtained from Holstein Friesian dairy cows can be markedly influenced by the specific lactation phase during which it is produced. It has been observed that the late lactation phase tends to exhibit higher milk quality values compared to other phases. The lactation phase in dairy cows significantly influences milk quality. This study investigates the quality of milk produced at different stages of lactation, serving as an indicator of the cow's nutritional adequacy during each phase. Notably, the late lactation stage exhibits higher levels of milk components, including protein, fat, and curd, compared to earlier stages of lactation.

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AUTHORS' CONTRIBUTIONS

Conceptualized the study and drafted and revised the manuscript. All Author: Conducted experiments and analyzed data. All authors have read and approved the final manuscript.

COMPETING INTERESTS

The authors have to declare that they have no competing interests.

ETHICAL CLEARANCE

No ethical clearance to use animals as research objects was declared

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