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Parity-Associated Shifts in Viscosity and Physicochemical Profile of Friesian Holstein Colostrum

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Abstract**—** *Colostrum quality is a critical determinant of neonatal calf health and survival, as it provides essential nutrients and immunological protection during the early postnatal period. Among the biological factors influencing colostrum composition, parity has been recognized as an important determinant; however, integrated evaluations of multiple physicochemical properties across extended parity levels remain limited. This study aimed to evaluate the effect of parity (I–V) on viscosity and physicochemical composition of Friesian Holstein (FH) cow colostrum. Colostrum samples were collected and analyzed for viscosity, fat, protein, solids-not-fat (SNF), lactose, and total solids (TS). Descriptive statistics and analysis of variance were performed to evaluate parity-associated differences. The results showed that parity significantly affected fat, protein, SNF, and lactose ($p<0.01$), whereas viscosity and TS were not significantly influenced by parity ($p>0.01$). Fat concentration and viscosity tended to decrease with increasing parity, while protein, SNF, lactose, and TS generally increased. These findings indicate a compositional shift toward higher non-fat solid fractions in multiparous cows. The stability of TS across parities suggests compensatory changes among individual colostrum components. The results also highlight potential physiological adaptations in mammary gland function and in the transfer efficiency of immune components across successive lactations. These findings provide important information for improving colostrum management strategies and optimizing passive immunity transfer in dairy calves through parity-based colostrum quality evaluation.*

Keywords**—** *Colostrum quality; Friesian Holstein cows; Parity; Passive immunity transfer; Physicochemical composition*

I. INTRODUCTION

The dairy farming industry has a strategic role in providing nutritious food and supporting the economic sustainability of the livestock sector. The success of long-term milk production is greatly influenced by the management of the early phases of calf life. At birth, calves have an immune system that has not been optimally developed because there is no transplacental transfer of immunoglobulins. Therefore, calves rely heavily on the transfer of passive immunity through the consumption of colostrum immediately after birth. Colostrum is the first secretion of the postpartum udder gland that contains immunoglobulins, especially immunoglobulin G (IgG), as well as various nutrients and bioactive components that play an important role in protecting against disease, supporting early growth, and aiding the physiological adaptation of the neonatal [1].

Colostrum quality is a critical factor in calf health management because low-quality colostrum can increase the risk of failure in passive immunity transfer, which ultimately impacts long-term health, growth performance, and productivity. Calf mortality can be suppressed through the administration of sufficient quantities of high-quality colostrum as soon as possible after birth. However, the quality of colostrum is influenced by various factors, including breed, length of the dry period, maternal health status, and parity.

Identifying high-quality colostrum remains a major challenge in dairy farm management. Various factors are reported to affect colostrum composition, including the breeding season, parity, length of the dry period [2,3], colostrum volume [3,4], heat stress [5], and feed management during dry periods [6]. Several studies have shown that colostrum nutrient content tends to increase with increasing parity [7]. In addition, there are conflicting reports on the relationship between IgG concentration and colostrum volume: some studies show a significant association, while others do not [3,8].

Most research on colostrum quality in Friesian Holstein cattle has been conducted in subtropical regions, while information on colostrum quality in tropical conditions, especially in Indonesia, remains limited. Differences in environmental conditions, maintenance practices, and climate stress can affect colostrum composition. Therefore, this study aims to evaluate the effect of parity on the quality of colostrum of Friesian Holstein cattle reared in tropical environmental conditions in Indonesia.

II. MATERIALS AND METHODS

A. Ethical statement

The Ethics Commission of Muhammadiyah at Malang University approved this study, Number E.5.a/085/KEPK-UMM/III/2023.

B. Study location and research design

This research was carried out at PT. Greenfields Dairy Indonesia Farm 2, Blitar Regency, East Java Province, Indonesia. During the research period (October 2022 - February 2023), the total number of samples for Friesian Holstein cattle was 91, with parity I of 34 heads, parity II of 24 heads, parity III of 17 heads, parity IV of 11 heads, and parity V of 5 heads.

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C. Data collection

The secondary data collected include the quality of colostrum per parity for each FH dairy cow, determined through purposive sampling. Colostrum is collected within 30 minutes to 1.5 hours after birth by fully milking all four quarters of the mother's udder. A 10 mL sample was then collected using sterile milk tubes for evaluation. The parameters observed in this study were viscosity, fat content, solid non-fat (SNF), lactose, protein, and total solid colostrum. Viscosity was assessed by the refractometric method, using an optical Brix refractometer (Atago PAL-1 Refractometer Colustrum, Japan) with a scale of 0–53% Brix. The other parameters were tested using Lactoscan type MCC W V1.

D. Data analysis

All data were tabulated in the Excel program and analyzed descriptively. To test the effect of parity on colostrum quality, an analysis of variance (ANOVA) was performed using GenStat release 14.2. If the treatment effect was significant, the Duncan test was used.

III. Results and Discussion

Table 1 shows the nutritional quality and passive immunity transfer of colostrum across different parities. A total of 91 milk samples were analyzed across five lactation periods. Overall descriptive statistics showed that milk fat averaged 7.11±3.74% (range 3.72–9.71), protein 8.20±1.75% (7.10–9.36), total solids (TS) 29.14±4.80% (28.95–29.74), solids-not-fat (SNF) 22.00±4.86% (18.61–25.13), lactose 11.83±2.50% (10.22–13.50), and viscosity value 31.29±6.37% (7.48–13.75). When stratified by lactation period, clear numerical trends were observed. Viscosity and fat content show a declining trend. Meanwhile, the SNF, lactose, protein, and TS were uplining trends. One-way ANOVA indicated that the lactation period significantly affected milk fat, SNF, lactose, and protein contents ($P<0.01$). However, the lactation period did not significantly affect the viscosity or TS of colostrum ($P>0.01$).

TABLE I. Colostrum content of dairy cows' milk at different parities

Parameter	Parity				
	I	II	III	IV	V
Viscosity (%)	32.69±7.98	30.89±6.69	30.19±4.57	30.15±2.72	30.06±0.96
Fat (%)	9.71±3.78^{a}	6.66±3.00^{b}	5.10±2.96^{b}	4.76±1.16^{b}	3.72±0.92^{c}
Solid non-fat (SNF) (%)	18.61±4.51^{a}	22.77±4.04^{b}	24.90±3.69^{b}	24.93±3.87^{b}	25.13±2.14^{b}
Lactose (%)	10.22±2.50^{a}	12.25±2.22^{b}	13.10±1.49^{b}	13.21±2.14^{b}	13.50±1.17^{b}
Protein (%)	7.10±1.77^{a}	8.39±1.48^{b}	9.15±1.36^{b}	9.22±1.22^{b}	9.36±0.77^{b}
Total solid (%)	28.95±6.17	29.17±5.01	29.18±2.79	29.36±3.59	29.74±0.66

Note: Different notations on the same line show very noticeable differences ($P<0.01$)

The highest average viscosity of FH cow's milk in the study (Table 1) occurred at parity I in accordance with the opinion of [9] and [10], who stated that parity affects various aspects of colostrum production and quality, including viscosity, which is an important indicator of the concentration of bioactive components. Parity has a significant influence on colostrum characteristics, including viscosity [8]. [11] in their study on Jersey cattle showed that the viscosity of colostrum in primiparous (once-calving) cattle was higher than in multiparous (more than once-calving) cattle. Higher IgG concentrations in colostrum at parity I correlated with higher viscosity, as immunoglobulins are high-molecular-weight proteins that contribute to higher viscosity.

The average fat and solids-not-fat (SNF) content of FH dairy cows across parities showed that fat content decreased from the first to the fifth parity, while SNF content increased with parity. These results are in line with the research of [12], which explains that as the lactation period increases, colostrum tends to contain less fat but more lean solids. Primiparous cattle produce colostrum with a higher fat content (7.8%) than multiparous cattle, which is 5.9%. In contrast, SNF levels showed the opposite pattern, with lower levels in primiparas (20.9%) than in multiparas (22.9%) [12]. The mechanism of the effect of parity on colostrum fat levels is closely related to the development and maturation of the uterine glands. In cows with higher parity, the udder glands have undergone multiple cycles of development and involution, which affect the synthesis and secretion of milk components, including fat [13].

The colostrum protein fraction is essential because it includes not only immunoglobulins for passive immunity, but also other bioactive proteins that support calf development and health [7]. A number of studies have shown that parity significantly affects colostrum protein content in dairy cows. In general, multipara cattle tend to produce colostrum with higher concentrations of protein and immunoglobulins than primipara cattle [14], and these results are in accordance with the protein content of dairy cows' milk presented in Table 1. The distinction between primiparous and multiparous cattle is a key factor in understanding the impact of parity on colostrum proteins. The difference in colostrum protein between primiparous and multiparous cattle can be explained by several physiological mechanisms. Older cows are more likely to be exposed to environmental pathogens and antigens, so they have a more diverse and potent antibody repertoire to transfer to colostrum [3]. In addition, multiparous cow udders are thought to be more efficient at concentrating immunoglobulins from the blood into colostrum due to the maturation of the udder glands and the experience of repeated lactation cycles.

Lactose is of concern because it is the main carbohydrate source for calves and plays an important role in osmotic regulation [15]. The data in Table 1 showed a significant effect of parity ($P<0.05$) on colostrum lactose levels in dairy

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cows. The results of the study differ from those of [7] and [16], which reported that parity did not have a significant effect on colostrum lactose content in dairy cows. This finding is direct evidence that parity has a direct effect on lactose. Physiologically, this mechanism can be explained by the development and maturation of mammary glands, which differ between primipara and multipara cows, with multipara cows having more developed mammary tissue and a more mature synthesis capacity [17].

The total solids content is an important indicator of colostrum quality because it reflects the overall solutes and suspensions that include proteins, fats, lactose, minerals, and other dissolved compounds that together determine the nutritional value of colostrum for calves [18]. The results of the observations showed that parity did not affect the total solid colostrum content of dairy cows, but there was a tendency for it to increase with increasing parity. Parity is related to the concentration of IgG colostrum. Given that immunoglobulins are the main protein fraction in colostrum and contribute greatly to total solids, the effect of parity on IgG can also indirectly affect total solids [3]. The effect of parity on the total content of colostrum solids in dairy cows is an important area of research because total solids reflect nutrient density and overall colostrum quality.

Understanding the effect of parity can inform a colostrum application strategy. [19] evaluated the usefulness of digital Brix refractometers for assessing the risk of passive immunity transfer failure, focusing on heifer colostrum (heifer/primipara), underscoring the importance of considering parity in colostrum quality assessment. [20] emphasized that, in addition to antibodies, proteins, and immune cells in colostrum, other components can support the development of the calf's immune system, so colostrum management should not only be based on IgG but also consider other components. Primiparous cattle consistently produce colostrum with lower concentrations of protein and immunoglobulin than multiparous cattle [14]. Therefore, colostrum from primiparous cows should be assessed more strictly before giving it to calves. Although multiparous animals generally produce colostrum of higher quality than primiparous animals, increased parity is not always directly proportional to improved quality. At very high parity, quality may persist or decline, possibly due to age-related changes in udder function or decreased immune function [3]. This study shows that parity affects colostrum quality and has important implications for colostrum management practices on dairy farms in Indonesia, underscoring the need to identify factors related to colostrum quality to develop more appropriate management protocols. By understanding the role of parity, farmers can implement more targeted strategies for collecting and applying different colostrums to maintain adequate calf nutrition. Other studies confirm that parity should be considered alongside factors such as the length of the dry period, body condition, and health status when preparing colostrum management protocols.

IV. Conclusion

Parity significantly influences several key physicochemical characteristics of FH cow colostrum, particularly fat, protein, SNF, and lactose, while viscosity and TS remain relatively stable across lactations. The observed decrease in fat and viscosity indicates physiological and functional maturation of the mammary gland across successive lactations. Incorporating parity information into colostrum management programs can support more precise selection of high-quality colostrum and improve the efficiency of passive immunity transfer in newborn calves, ultimately contributing to improved calf health and dairy production sustainability.

V. Conclusion

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