Analysis of the relationship between udder characteristics and milk production in dairy cows

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Abstract. This research aims to investigate the relationship between udder characteristics such as udder width, udder height, udder depth, and milk production in dairy cows. The research was conducted on 100 heads of Crossbreed Friesian Holstein (CFH) lactation period owned by various small-scale farmers in KAN Jabung, Malang Regency. Data analysis was calculated using regression analysis and correlation. The research showed that the average udder width of dairy cows was ±12 cm, udder height was ±19 cm, udder depth was ±21 cm, and milk production was ±15 litres/day. linear regression analysis the relationship between udder width and milk production, the equation obtained was $Y_a = 1.50 + 1.11X_a$ with a correlation of 0.50. The relationship between udder height and milk production showed $Y_b = 14.59 + 0.01X_b$ with a correlation of 0.0063. The relationship between udder depth and milk production resulted in the equation $Y_c = 20.66 - 0.27X_c$ with a correlation of 0.16. The research demonstrates a moderate positive relationship between udder width and milk production. Conversely, the relationships between udder height, udder depth, and milk production are very weakly positive. It is crucial to also consider other influencing factors, such as genetics, feed management, health conditions, and production phases, which can significantly impact milk production.

1 Introduction

Milk secretion is a complex biological process in which the mammary glands of mammals, including cows, produce and secrete milk. This process begins with hormonal stimulation that triggers the activity of the mammary glands to produce and secrete milk [1]. In dairy cows, milk secretion occurs throughout the lactation cycle. This cycle is divided into several phases, including the peak and declining milk production phases.

A deep understanding of the factors affecting milk production becomes crucial in achieving this goal. One factor that has attracted the attention of researchers and livestock practitioners is the characteristics of the udder in dairy cows, including the width, height, and depth. The width, height, and depth of the udder affect the capacity and efficiency of the lactation process in dairy cows [2]. The udder's width, height, and depth affect the lactation process's capacity and efficiency in dairy cows [3].

It is important to conduct specific and relevant analyses to understand the relationship between udder characteristics and milk production in dairy cows So the aim of this research is to determine the relationship between udder characteristics such as udder width, udder height, udder depth, and milk production in dairy cows. Through a deeper understanding of this relationship, it is hoped that useful guidance can be provided in efforts to improve the productivity and welfare of dairy cows as well as the overall success of the dairy cattle industry in Indonesia.

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2 Materials and methods

2.1 Research materials

The subjects used in this research were 100 heads of Crossbreed Friesian Holstein (CFH) during lactation period located in the working area of KAN Jabung, Malang Regency, East Java.

2.2 Research methods

The research method used was a survey by directly observing the udder width, udder height, and udder depth about milk production in dairy cows.

2.3 Research procedures

2.3.1 Research preparation

- Obtain permission from KAN Jabung to conduct the research.
- Survey the research locations in Hamlet Dempok, Gading Kembar, and Gunung Kunci, Jabung Sub-District, Malang Regency.
- Select 100 heads of Crossbreed Friesian Holstein (CFH) during lactation period to be used in the research.

2.3.2 Data collection

- Measure udder characteristics and daily milk production.
- Measure udder characteristics according to [4] as follows:

a. Udder width

Measure udder width horizontally from the rear of the udder in centimeters (Figure 1).

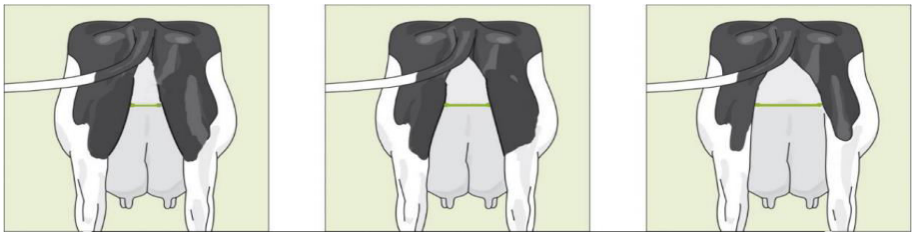

Fig. 1. Udder width measurement.

b. Udder height

Measure udder height from the base of the vulva to the top of the udder in centimeters (Figure 2).

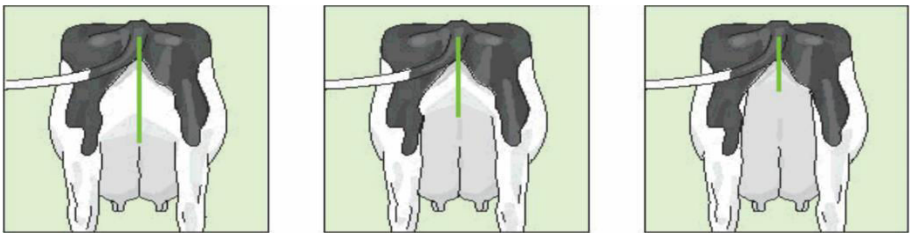

Fig.2. Udder height measurement.

c. Udder depth
Measure udder depth from the bottom of the udder to the hock point in centimeters (Figure 3).

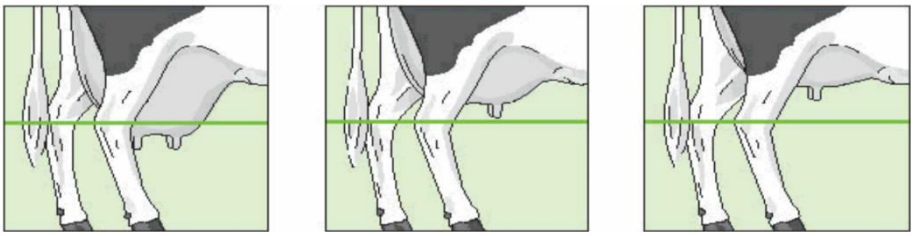

Fig.3. Udder depth measurement.

2.4 Research variables

The research variables are udder width, udder height, depth, milk production.

2.5 Data analysis

To determine the relationship between udder characteristics and milk production, simple linear regression was used [5]. Specifically, the analysis focused on testing the relationship between udder width and milk production using the following formula:

$$Y = \alpha + \beta X \quad (1)$$

Information :
Y = Udder width/udder height/udder depth
α = Constant
β = Intercept
X = milk production

- To determine the relationship between variables X and Y including the strength, significance, and direction of the relationship, you can use the correlation coefficient test:

$$r = \frac{n(\sum xy - (\sum x)(\sum y)}{\sqrt{\{n\sum x^2 - (\sum x)^2\}\{n\sum y^2 - (\sum y)^2\}}} \quad (2)$$

- To assess the extent to which the variability of the dependent variable (Y) can be explained by the independent variable (X), you can test the coefficient of determination. The formula for calculating the coefficient of determination, often denoted as R^2, is:

$$KP = r2 \times 100\% \quad (3)$$

Information :
KP = Coefficient of determination value
R = Correlation coefficient

3 Results

3.1 Location Conditions Results

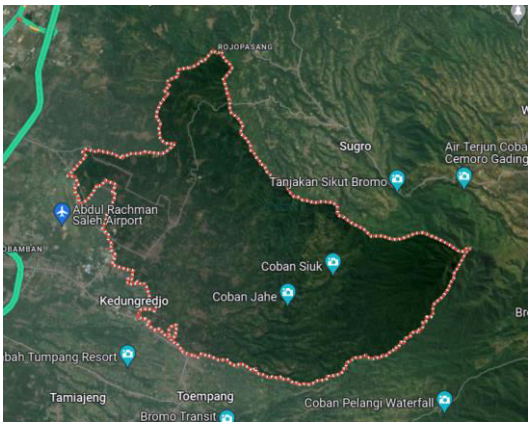

Fig. 4. Map of Jabung District, Malang Regency.

The research was conducted in the working area of KAN Jabung, Located in Jabung District, Malang Regency (Figure 4), from September to October 2023. Jabung Sub-District is located approximately 17 km from Malang City at an altitude of around 600 meters above sea level. This area experiences an annual rainfall of about 550 mm and a maximum temperature of approximately 32°C, creating a suitable environment for livestock activities. KAN Jabung currently has around 2,423 active members, predominantly engaged in dairy farming. The farmers in this region have chosen CFH cows due to their remarkable adaptability to Indonesia's climate.

The dairy barns of local farmers are strategically located next to or behind their houses, allowing for more efficient management of their livestock. This proximity facilitates quicker response times and better monitoring of the cows. The feeding regimen for these cows is quite structured, occurring 2-3 times daily. The diet mainly consists of 60% green fodder and 40% concentrate. Green fodder includes sugarcane tops, elephant grass, odot grass, and corn, with daily intake ranging from 30-45 kg. The concentrate portion of the feed is a mixture designed to complement the green fodder, ensuring the cows receive a balanced diet. This mixture includes JAB Feed, tofu waste, brewery waste, and leftover bread, amounting to about 5-20 kg per day. Such a diet not only meets the nutritional needs of the cows but also makes use of locally available resources, thereby reducing feed costs and supporting sustainable farming practices.

KAN Jabung plays a crucial role in facilitating milk collection from its member farmers. It has established multiple milk collection points, or PPS, in various villages. These points are equipped with essential facilities such as coolers, generators, and milk quality testing tools. This infrastructure ensures that the milk collected from the farmers is kept fresh and meets quality standards before it reaches the market. The PPS centers operate during specific hours, opening in the morning from 05:00-06:00 and in the afternoon from 14:30-16:00. This schedule accommodates the farmers' routines, allowing them to deliver milk at convenient times. By providing these facilities and supporting efficient milk collection, KAN Jabung significantly enhances the productivity and profitability of dairy farming in the Jabung area, benefiting both the farmers and the local community.

3.2 Relationship between Udder Width and Milk Production in Dairy Cows

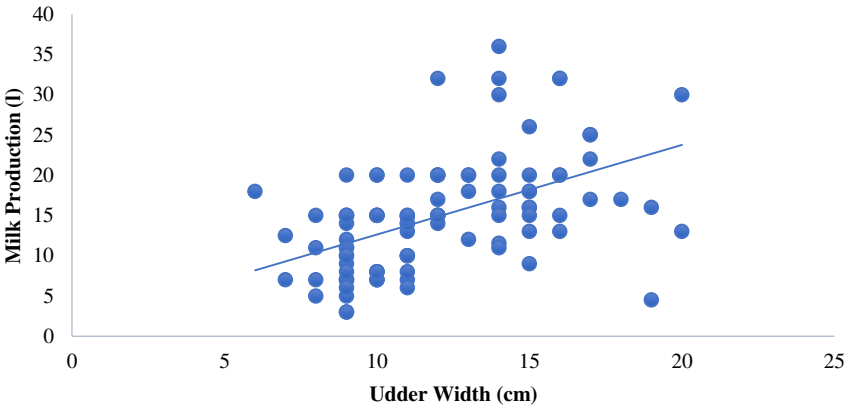

Fig. 5. Relationship between udder width and milk production in dairy cows.

The linear regression analysis of the relationship between udder width and milk production yielded the equation Ya = 1.50 + 1.11Xa, with a correlation coefficient of 0.50, indicating a moderate positive correlation. This suggests that an increase in udder width is associated with an increase in milk production, although the strength of this relationship is not particularly strong. Figure 5 illustrates that cows with larger udder widths generally produce more milk.

3.3 Relationship between Udder Height and Milk Production in Dairy Cows

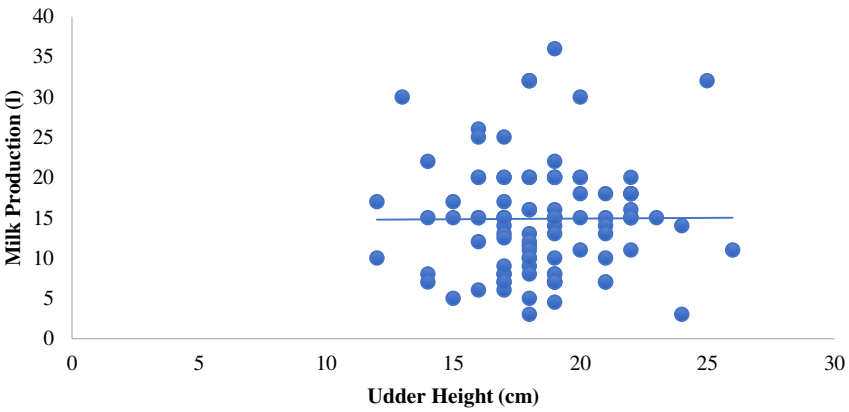

Fig.6. Relationship between udder height and milk production in dairy cows.

The relationship between udder height and milk production is represented by the equation $Y_b = 14.59 + 0.01X_b$ (Figure 6). This implies that each unit increase in udder height is associated with an increase in milk production by 0.0168 liters. The correlation coefficient for this relationship is 0.0063, reflecting a very weak positive correlation. Figure

6 illustrates that while the regression analysis suggests a positive relationship between udder height and milk production, the strength of this relationship is quite minimal and varies significantly.

3.4 Relationship between Udder Depth and Milk Production in Dairy Cows

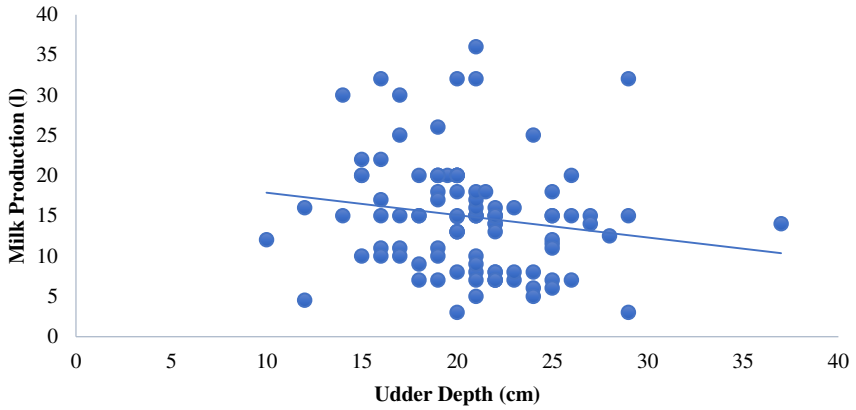

Fig. 7. Relationship between udder depth and milk production in dairy cows.

The linear regression analysis between udder depth and milk production results in the equation $Y_c = 20.66 - 0.27X_c$, with a correlation coefficient of 0.16, suggesting a very weak positive correlation. This indicates that udder depth has a minimal impact on milk production. According to the research findings shown in Figure 7, an increase in udder depth is associated with a decrease in milk production by approximately 0.27 liters.

4 DISCUSSION

The study aimed to explore the relationships between various udder dimensions width, height, and depth and milk production in dairy cows. Understanding these relationships is crucial for dairy farmers and breeders who aim to enhance milk yield through selective breeding and optimized management practices. The findings provide valuable insights into which udder dimensions are more influential on milk production and can help guide future breeding strategies.

The width of the udder and milk production in dairy cows are crucial elements in dairy farming, influencing breeding and management strategies. The research identified a moderate positive relationship between the width of the udder and the amount of milk produced, indicating that cows with wider udders tend to produce more milk. This relationship is attributed to the larger milk storage capacity in wider udders, which can accommodate more alveoli and larger cisterns, thus allowing for greater milk accumulation between milkings. The high milk production associated with wider udders can be clearly seen in figure 5. This finding aligns with the general understanding that anatomical and physiological traits of the udder significantly influence milk yield. This relationship is due to the greater milk storage capacity of wider udders, which can accommodate more alveoli and larger cisterns, thus allowing greater milk accumulation between milkings, this statement is also supported by [6] states that udder width is positively related to milk yield, reinforcing the idea that wider udders increase milk storage capacity and overall production potential. This statement is also reinforced by the statement that wider udders have more

secretory cells that can be used to secrete milk. This is in line with the basic concept that udder width is directly related to the milk storage capacity and the number of secretory cells contained therein [4].

The study observed a weak but positive correlation between udder height and milk production in dairy cows, highlighting an intriguing yet modest relationship. The regression analysis yielded a minimal impact of udder height on milk production, indicating that each incremental increase in udder height contributed very little to the overall milk yield. This suggests that udder height is not a critical determinant of milk production. The slight positive correlation implies that while taller udders may have a marginally higher capacity for milk storage, this dimension alone does not significantly influence the total milk yield. Figure 6 in the current study depicts the relationship between udder height and milk production, revealing a slight positive trend but an overall weak correlation. This visual representation confirms that while a relationship exists, it is not strong enough to justify significant adjustments in breeding programs aimed at increasing udder height. The scatter plot likely illustrates a broad range of data points, suggesting considerable variability and the impact of additional factors beyond udder height. This observation aligns with [4], which also indicates a low correlation between udder height and milk production. Contributing factors to milk production include nutrition, health, genetics, and management [7].

Udder depth and milk production in dairy cows presents an intriguing dynamic, where deeper udders seem to be linked to a reduction in milk production. The study's findings indicate a very low positive correlation, with deeper udders leading to a decrease in milk production by approximately 0.27 liters. This suggests that while there may be more storage capacity in deeper udders, it does not translate into higher milk yield and may, in fact, hinder optimal milk production. Figure 7 visually supports the study's findings, showing that deeper udders are associated with decreased milk production. The scatter plot likely illustrates a downward trend, emphasizing the negative impact of increased udder depth on milk yield. This visual representation reinforces the idea that excessively deep udders are not advantageous for milk production and may even present additional challenges for dairy farmers. Furthermore, research by [8] indicates that deeper udders can prolong the milking process. During milking, ensuring that all milk is properly extracted from deeper udders requires more effort and time. This not only slows down the milking process but also increases the risk of incomplete milking, which can lead to udder health issues and further decrease milk production. the additional challenges posed by deeper udders in maintaining cleanliness and managing infections can further impair milk yield, in maintaining hygiene and managing infections can adversely affect milk yield [9]. Udder infections such as mastitis, which are more prevalent in deeper udders, can significantly reduce milk production. Mastitis can decrease milk production by 15-20% of the total milk yield [10]

In terms of dairy management, selecting cows with wider udders might improve milk production. However, it's crucial to adopt a comprehensive approach that considers multiple traits. Maintaining udder health, preventing mastitis, and ensuring overall cow well-being are essential for maximizing productivity. Additionally, genetic selection programs should evaluate a range of traits to achieve balanced improvements in milk production. Providing nutritionally rich feed and proper care can help ensure optimal growth and development of the udder [11].

5 CONCLUSIONS

The research demonstrates a moderate positive relationship between udder width and milk production. Conversely, the relationships between udder height, udder depth, and milk production are very weakly positive. It is crucial to also consider other influencing factors,

such as genetics, feed management, health conditions, and production phases, which can significantly impact milk production.

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