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Correlation of Udder Morphometry and Daily Milk Production with Milk Quality in Friesian Holstein Crossbred (FHC) Cows

Ahmad Dzikrullah[1], Dan Sucik Maylinda[2]

[1]Postgraduate Program Student, Faculty of Animal Husbandry, Universitas Brawijaya

[2]Lecturer of Faculty of Animal Husbandry, Universitas Brawijaya
Corresponding author: *sucik[at]ub.ac.id*

Abstract: ***Research was focused on local dairy cows in East Java, that isFriesian Holstein Crossbred (FHC). The location of the research was in the traditional dairy cattle rearing in East Java, Indonesia. Udder morphometry is one of the indicators in determining daily milk production of dairy cows. The aim of this research was to obtain information related to the relationship between udder morphometry with daily milk production and milk quality, and to discribe the milk production and its relationship with milk quality, so that it can be used to develop appropriate selection program in dairy cattle breeding programs. The samples used were 122 FHC cows that were measured for daily milk production and udder morphometry using a tape measure (animeter). The results showed there was an non significant relationship (P > 0.05) between udder morphometry and milk production, while the relationship between milk production and milk quality (lactose, fat and protein) produced of this FHC cows was found to be significant (P < 0.05). The correlation between udder morphometry and milk production was varied from (r = 0.03) to (r = 0.11). Relationship also showed a moderate relationship (r = 0.301) and (r = 0.303) between milk production and milk quality. The conclusion of this research is that udder morphometry cannot be used as s predictor on milk production. High milk production will increase fat and protein production.***

Keywords: Friesian Holstein Crossbred (FHC), udder morphometry, milk production, fat production, protein production

1. Introduction

Breeding programs are generally divided into two important aspects, namely selection and mating programs. Selection can be defined as the selection of livestock for breeding in the next generation through phenotypic values displayed by the parent. Identification of phenotypic and genetic characteristics of livestock is important to obtain data or information used in breeding programs or improvement of genetic quality in individual livestock (Ciptadi, Aulannia'm, Budiarto, dan Oktanella., 2019). In dairy livestock selection programs, several important traits for selection can directly and indirectly affect milk production. Morphologically and physiologically the udder plays an important role in milk production of dairy cows. Udder shape or udder morphometry size is a criterion for selection programs because it is thought to have a relationship with milk production traits. In the study of Mingoas, Ndukum, Dakyang, and Zoli (2017) showed that there was a positive correlation between the shape and size of the udder and milk production of zebu cows (r = 0.60) between the diameter (240.21 ± 28.58 mm) and height (131.12 ± 23.64 mm) of the udder (p < 0.001) and between the length (39.51 ± 6.44 mm) and diameter (19.85 ± 3.08 mm) of the teat (r = 0.78). Large udder morphometry (width, length and depth) is thought to be associated with milk production because it has the potential to produce more milk. This study was conducted with the aim of obtaining useful information regarding the relationship between udder morphometry with daily milk production and milk quality to develop appropriate selection criteria in dairy cattle breeding programs.

2. Materials and Methods

This research was conducted in Pandesari village, Pujon, Malang Regency, East Java 65391 coordinates 7°51'41.7 "S 112°28'36.6 "E with an altitude of 1200 meters above sea level with temperatures ranging from 18oC to 25oC and an average humidity of 74%. Measurement of udder morphometry and milk production was conducted from August 18 to September 20, 2022. The research material used 122 FHCcows in lactation period II - IV with milking frequency twice per day, average body weight reached 425 ± 59.3 kg and milk production 11.13 ± 4.43 l/day. The livestock samples used belonged to traditionally reared farmers located in adjacent pens. Measuring instruments such as measuring tape (animeter) to measure the udder, measuring container used to measure milk production, lactoscan used to determine the content of milk components (fat, protein and lactose).

Measurement of udder morphometry using animeter (cm) which includes: 1.) Udder length, measured from the longest circular front udder to meet the front back.2.) Front udder width, measured from the upper front udder of the right side to the top of the left side.3.) Rear udder width, measured from the upper rear udder of the right side to the top of the left side.4.) Front udder depth, measured from the depth of the upper abdomen to the bottom of the front udder.5.) Back udder depth, measured from the upper back udder attachment to the longest back udder.6.) Distance between teats, measured from each end of the front, back, right side and left side teats. Udder volume (cm3) was calculated from measurements of udder length, width and depth. (Kuczaj., 2003; Solechah, et al, 2019; Gavan and Mihaela, 2021). All udder mormometry data were analyzed for normality of

Kolmogrov - Smirnov distribution to determine the normality of distribution, followed by linear regression test between one variable and another. Linear regression has the equation Y = a + bX, where X is the independent variable and Y is the dependent variable, statistical analysis was carried out with a 95% significance level.

3. Results and Discussion

Measurement Results of Udder Morphometry, Daily Milk Production, and Milk Quality

Based on udder morphometry and milk production measurements, the averages are presented in Table 1 and Table 2. The average milk production of FHC cows during the study reached 11.13 liters/day. Several factors can affect milk production including lactation period, lactation period, milking management, feeding, hormonal factors and environment. Milk production of FHC cows kept in tropical environment tends to be lower than FHC cows kept in temperate climate. Based on the research of Usman, Qureshi and Wang (2013) showed that the production performance of FHC cows in the tropical environment is lower by 40% to 60% compared to the maintenance in the sub - tropical environment. In a moderate environment milk production can produce 9 - 12 liters/day. In addition to the environment that can affect milk production of dairy cattle, milk production can be affected by the shape and capacity of the udder. Udder morphometry is important to note because it can affect the production and quality of milk produced. Ishag, Abdella and Ahmed (2012) reported that the development of udder shape causes an increase in milk production trends, because udders with good size development have a level of readiness of secretory cells and hormonal systems that are positively related to physiological status and reproductive status. In this study, FHC cows that are in the lactation period aged 3 - 7 years were used so that udder morphometric growth is relatively more stable and linear with good hormonal conditions. Estrogen in this phase has an impact on the udder morphomentry network to stimulate the release of prolactin (PRL), anatomically large udder will increase the number of prolactin receptors (PRL) so it is possible that milk production will increase (Soeharsono., et al, 2020). Kuczaj (2003) states that morphometry or ideal udder shape has an udder depth of 26.92 cm, with an udder length of 43.92 cm and an udder width of 36.65 cm. The distance between the front, back and distance between the sides of the teat is 18.95 cm, 10.22 and 13.17 cm respectively.

Table 1: Mean udder morphometry measurements

Udder Morphometry	Average
Front udder depth (cm)	22, 64 ± 2, 82
Back udder depth (cm)	28, 30 ± 3, 74
Udder length (cm)	42, 22 ± 4, 19
Front udder width (cm)	34, 95 ± 7, 02
Rear udder width (cm)	35, 95 ± 7, 00
Distance between front teat (cm)	7, 44 ± 2, 23
Distance between rear teat (cm)	2, 89 ± 1, 23
Rear front teat distance (left) (cm)	6, 18 ± 2, 02
Rear front teat distance (right) (cm)	6, 43 ± 1, 90

Milk quality (protein, fat, and lactose) is presented in Table 2 analyzed using lactoscan. The value of milk quality in this study is quite high, obtained the average quality of milk with protein 3.38 ± 0.30%, fat 4.42 ± 1.46%, lactose 5.03 ± 0.59%. Based on the milk quality data, it is known that it meets the SNI 8984: 2021 standard which explains that good milk quality has a minimum of 2.8% protein, a minimum of 3% fat and a minimum of 4.10% lactose. The highest milk quality value is shown by lactose with 5.03 ± 0.59%. Lactose is a combination of glucose and galactose that plays a role in giving sweetness to milk caused by ruminal fermentation of crude fiber in feed that produces propionic acid (Suhendra, Anggiati, Sarah, Nasrullah, Thimoty, and Utama, 2015). The increase or decrease in milk quality can be caused by feed, management, and rearing environment. Feed has a significant influence on milk quality, Acharya, et al. (2015) mentioned that milk fat content will tend to increase when cows are given high - protein feed. In the research of Huda, Ndaru, Ridhowi and Andri (2019) reported that feeding with crude protein of 19.84% showed that the quality of fat produced was 3.87 ± 0.27%.

Table 2: Average Daily Production and Milk Quality

Variables	Mean ± SD
Milk production (l)	11, 13 ± 4, 43
Protein (%)	3, 38 ± 0, 30
Fat (%)	4, 42 ± 1, 46
Lactose (%)	5, 03 ± 0, 59

SD = Standard of deviation

Correlation of Udder Morphometry with Daily Milk Production of FHC Cows

Table 2 presents the correlation coefficients for udder morphometric traits with daily milk production of FH cows which varied from 0.03 to 0.11. The results of simple linear regression analysis showed an insignificant relationship (P > 0.05) between udder morphometry and milk production. Front and rear udder depth showed a low relationship (r = 0.11 and r = 0.08) with regression equations Y = 7.36 + 0.17X and Y = 13.64 - 0.09X (R2 = 0.120 and R = 0.006) which means 12% and 0.6% of milk production was influenced by front and rear udder depth, while 88% was influenced by other factors. Udder length, udder width and distance between nipples all three had a similarly low relationship with milk production (r = 0.06 - 0.11), with regression equations Y = 10.97 + 0.04X, Y = 12.49 - 0.04X and Y = 12.70 - 0.25 X, respectively. The highest correlation value was shown by the correlation of front udder depth with milk production and the distance between the front right rear nipple with milk production each reached (r = 0.11). The lowest correlation value was shown by the correlation of left front rear udder distance with milk production with a correlation value of (r = 0.01) and the coefficient of determination (R^2 = 0.001). Negative regression coefficient values shown by rear udder depth, front udder width, and distance between rear udders can be caused by various factors including lactation period with different ages, environment, and maintenance management (maintenance procedures, feed, and animal health).

Udder morphometry is one of the important traits that can be considered for widespread use in livestock breeding selection programs. Morphometry which includes the length, width, and depth of the udder is one of the factors that affect milk production. The size of udder morphometry is strongly

influenced by the age of the livestock so that different milk production results are possible in each individual livestock even during the same lactation period. Age can be an indication of the readiness of organs (alveoli cells) and tissues in the udder to produce milk. Young livestock have smaller udder volume dimensions compared to older livestock, this can be interpreted that the ideal age of livestock with the readiness of organs and tissues in the lumen of the alveoli or udder can provide a positive relationship to udder volume in livestock which will affect the size of milk production produced. Habib, Suprayogiand Sambodho (2014) added that the amount of milk produced by a dairy animal is influenced by the volume of the udder in which there are many secretory cells. In an udder has a morphology in the form of a set of alveolus that form a lobule wrapped by connective tissue or lobes that play a role in milk production which will be channeled through the ductus system to the sinus lacriferus and gland system. The larger the size of the udder, the greater the milk production is possible (Eliyani, dan Ratnani., 2019).

Table 3: Regression equation, correlation coefficient (r), coefficient of determination (R2) and P value between udder morphometry and milk production.

Udder Morphometry	Regression Equation	r	R^2	P Value
Front udder depth (cm)	Y = 7, 36 + 0, 17X	0, 11	0, 120	0, 24
Back udder depth (cm)	Y = 13, 64 - 0, 09X	0, 08	0, 006	0, 40
Udder length (cm)	Y = 10, 97 + 0, 04X	0, 04	0, 008	0, 97
Front udder width (cm)	Y = 12, 49 - 0, 04X	0, 06	0, 004	0, 49
Rear udder width (cm)	Y = 10, 45 + 0, 02	0, 03	0, 001	0, 74
Distance between front teat (cm)	Y = 9, 63 + 0, 20 X	0, 10	0, 011	0, 26
Distance between rear teat (cm)	Y = 11, 49 - 0, 13 X	0, 04	0, 010	0, 69
Rear front teat distance (left) (cm)	Y = 11, 28 - 0, 02 X	0, 01	0, 001	0, 90
Rear front teat distance (right) (cm)	Y = 12, 70 - 0, 25 X	0, 11	0, 012	0, 24

Correlation of milk production with milk quality of FHC

Daily milk production has a close relevance to the quality of milk produced. The relationship between milk production with lactose, fat and milk protein produced by FHC dairy cows obtained a real relationship ($P < 0.05$) with correlation coefficient values for lactose and protein respectively ($r = 0.301$) and ($r = 0.303$) so that it can be interpreted that the relationship between milk production with lactose has a moderate positive relationship, while for fat obtained ($r = 0.158$) a low positive relationship is not meaningful. Sugiyono et al (2014) stated that the value of r = +0.10 to +0.29 is interpreted as having a low positive relationship that is not meaningful, while r = +0.30 to + 0.49 is interpreted as having a moderate positive relationship.

Table 4: Regression equation, correlation coefficient (r) and coefficient of determination (R2) between milk production and milk quality

Milk components	Regression Equation	r	R^2	P Value
Lactose	Y = 5, 48 - 0, 04X	0, 301	0, 091	0.000
Fat	Y = 5, 02 - 0, 05X	0, 158	0, 025	0, 082
Protein	Y = 3, 61 - 0, 02X	0, 303	0, 092	0, 000

The results of simple regression testing between milk production and milk quality are presented in Table 4 with regression equation results for lactose (Y = 5.48 - 0.04X), fat (Y = 5.02 - 0.05X), and protein (Y = 3.61 - 0.02X). Based on the resulting equation, it shows that there is a negative influence between milk production and the quality produced with (X) worth - 0.04, - 0.05, and - 0.02 respectively. This means that the value describes that every 1 scale increase in milk production will reduce milk quality (lactose, fat, and protein) by - 0.04 liters, - 0.05 liters, and - 0.02 liters, respectively, or it can be concluded that the greater the milk production produced by individual livestock can affect the level of milk quality, especially in fat and protein. Milk production in general can affect the percentage of milk components. Milk production will cause an increase in the percentage of lactose because lactose is a limiting factor that controls the size of the blood osmosis pressure in the lumen which is regulated by Cl - , K+, and Na+ ions, the more of these components will increase osmosis pressure so that the secreted water will increase and cause the specific gravity of milk to decrease and can reduce milk protein and fat levels (Solechah, et al., 2019).

4. Conclusions

It is concluded that there is a low relationship between udder morphometry and milk production of FHC cows, where udder depth and distance between nipples have significance to milk production, with a correlation coefficient (r) of 0.11 and a coefficient of determination R^2 of 12%. The milk production of FHC cows in Pujon district meets the Indonesian National Standard (SNI) for milk production and milk quality.

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