Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan
ISSN 2303-2227 eISSN 2615-594X
Accredited by National Journal Accreditation No. 105/E/KPT/2022

Vol. 12 No. 2 Juni 2024, Hlm: 50-59
DOI: https://doi.org/10.29244/jipthp.12.2.50-59
Available online at https://journal.ipb.ac.id/index.php/ipthp/index

Milk Production and Morphometrics Derived from Digital Images of Friesian and Holstein Cows in Different Lactation Periods

M. A. F. Nasution[1*], A. Atabany[2], B. P. Purwanto[3], & W. A. Zahra[2]
[1]Graduate School of Animal Production and Technology, Faculty of Animal Science, IPB University, IPB Dramaga Campus, Bogor 16680
[2]Department of Animal Production and Technology, Faculty of Animal Science, IPB University, IPB Dramaga Campus, Bogor 16680
[3]Vocataional College, IPB University, Gunung Gede Campus, Bogor 16151
*Corresponding author: nasutionfarhan29@yahoo.co.id
(Received 07-02-2024; Revised 04-05-2024; Accepted 10-06-2024)

ABSTRACT

This study was conducted to analyze milk production and morphometrics derived from digital images of Friesian and Holstein cows in smallholder farms located in Pondok Rangon, Lembang, and Cibungbulang Bogor in different lactation periods. The morphometric parameters measured in this study included body length, height, chest girth, and body weight. The findings indicated that Holstein cows exhibited greater body length, height, chest girth, and body weight compared to Friesian cows across all farms. Milk production in Friesian cows remained relatively stable from lactation periods one to three. Additionally, body length, height, chest girth, and body weight were found to influence the milk production of both Friesian and Holstein cows. Cows with longer body lengths, greater heights, higher body weights, and wider chest girths tended to produce more milk. Chest girth and weight emerged as the primary factors influencing milk production in Friesian and Holstein cows, while height, body length, and lactation period also played significant roles.

Keywords: friesian and holstein cattle, milk production, morphometrics

ABSTRAK

Penelitian ini dilakukan untuk menganalisis produksi susu dan morfometrik sapi Friesian dan Holstein di peternakan rakyat yang berlokasi di Pondok Rangon, Lembang dan Cibungbulang Bogor yang berbeda masa laktasinya dengan menggunakan citra digital. Parameter morfometrik yang diukur pada penelitian ini adalah panjang badan, tinggi badan, lingkar dada, dan berat badan. Hasil penelitian menunjukkan bahwa panjang badan, tinggi badan, lingkar dada dan bobot badan sapi Holstein lebih tinggi dibandingkan sapi Friesian di semua lokasi. Produksi susu pada sapi Friesian cenderung stabil pada periode laktasi I hingga III. Panjang badan, tinggi badan, lingkar dada dan berat badan mempengaruhi produksi susu sapi Friesian dan Holstein. Sapi dengan panjang badan lebih panjang, tinggi badan lebih tinggi, bobot badan lebih berat, dan lingkar dada lebih lebar cenderung menghasilkan susu yang optimal. Lingkar dada dan bobot merupakan faktor utama yang mempengaruhi produksi susu sapi Friesian dan Holstein. Faktor kedua lainnya adalah tinggi badan, panjang badan dan masa menyusui.

Kata kunci: sapi friesian dan holstein, produksi susu, morfometrik

INTRODUCTION

The dairy cattle in Indonesia reached 592.000 in 2022, with the national milk production recorded at 968.98 thousand tonnes, This number increased by 0.23% compared to 2021 (BPS 2022). The dairy cow population in Indonesia is predominantly comprised of Friesian Holstein (FH) cows, which are genetically derived from a cross between Friesian and Holstein breeds. The Friesian breed originated from England, New Zealand, and the Netherlands and typically exhibits smaller stature compared to Holstein cows (Elischer 2014).

The lactation period refers to the duration during which cows produce milk following calving, and the length of this period, spanning from the birth of the calf until the dry period, significantly influences milk production. The peak of milk production and the duration of the lactation period greatly impact the total volume of milk produced, particularly during 1st, 2nd, and 3rd periods. Cows with longer lactation periods typically exhibited higher milk production. Research indicated that milk production tended to peak in the early months of lactation before gradually decreasing over time (Astuti 2022). Furthermore, according to (Astuti 2022); Holdorf *et al.* (2023), dairy cow milk production are influenced by a number of factors, including the amount of feed given, month of lactation, lactation period, and milking management.

Morphometrics is a quantitative method used to identify the body characteristics of cows by encompassing both their shape and size. According to (Grzesiak *et al*. 2023) Increasing body measurements such as weight, height, and body length of cows from birth to weaning could increase milk production in the first lactation. Cows that received high-quality nutrients in their early lives tended to experience optimal growth and consequently produced higher milk yields (Mihaela *et al.* 2023). The Body Score Condition (BSC) could serve as an indicator for such growing period (Piazza *et al.* 2022). The length (Soeharsono *et al.* 2009), height (Petrovska and Jonkus 2014), and chest girth (Maherlan *et al.* 2021) are used as the parameters for morphometric information. Furthermore, the body body weight had an influence of 23.8% on increasing milk production (Sya'adah and Surjowardojo 2022).

However, manual measurement of body weight had several problems, including inducing stress in animals, which led to less accurate results. Hence, it is important to develop morphometric measurements, especially based on the chest girth and body length of dairy cows, to aid in calculating and improving the prediction of body weight. By conducting digital image processing from photos of dairy cows, the accuracy of measurements is expected to improve. Furthermore, the results could provide input for breeders and livestock center managers to gain insight and in-depth knowledge about factors affecting milk production in Friesian and Holstein cows.

MATERIAL AND METHODS

Data Collection

The research was conducted from March to October 2023 in Farm 1, Farm 2, and Farm 3. Farm 1 was located in Pondok Ranggon Village, Cipayung District, East Jakarta. Dairy cows were the dominant livestock kept, with a population of 1100 heads or the equivalent. Farm 2 was situated in the Lembang Dairy Cooperative (KPSBU), West Bandung Regency, West Java. The area had the highest population and milk production in West Java Province, Indonesia, with the population reaching 24,913 cows (BPS 2022). Farm 3 was located in Cibungbulang, Bogor city, where data were collected from the dairy cooperative of KPS. The total population in Farm 3 reached 1370 cows (BPS 2022).

The main data, including body length, height, and chest circumference of the cows, were collected through digital images and analyzed using ImageJ. The Body Condition Score (BCS) information was gathered by observing the fat deposits on the animals bodies. The BCS score for dairy cows ranged between 1 and 9 points (ICAR 2018). The score of 1-2 indicated thinness, 3-4 borderline condition, 5 borderline condition, 6 average, 7-8 over-conditioned, and a score of 9 indicated being too fat (Lan and Kenas 2022).

Materials

The Image-J software was used to collect and process the data. In Farm 1, data from 23 Friesian cows (45.10%) and 28 Holstein cows (54.90%) were collected. In Farm 2, data from 42 Friesian cows (56.0%) and 33 Holstein cows (44.0%) were collected. In Farm 3, data from 22 Friesian cows (39.29%) and 34 Holstein cows (60.71%) were collected. The total number of samples in this study was 182 cows, consisting of 87 or 47.8% Friesians and 95 or 52.2% Holsteins.

Data Analysis

Indicators measured in morphometric identification included chest girth, height, and body length, based on measurements from the literature (Table 1). Morphometric measurements utilize an equation formula involving two indicators, chest girth and weight measurements. The chest girth based on the diameter of *a* to *b* = thighs width*; c* to *d* = thighs length (Figure 1). According to Hidayat (2016) the chest girth formula used is as follows (Equation 1) :

$$CG = \frac{1}{2}\pi(D1 + D2) \text{ ..... (Equation 1)}$$

where:

CG	: chest girth;
D1	: diameter a to b; and
D2	: diameter c to d (Fig1)

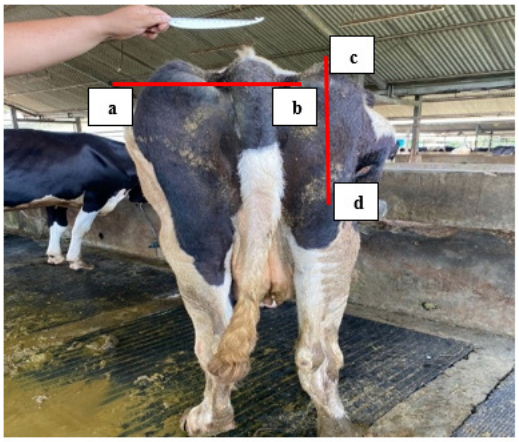
To determine the weight of cows, this research used the Schrool Formula (Equation 2):

$$Weight = \frac{(CG+22)^2}{100} \text{ ..... (Equation 2)}$$

Table 1. The identification of Frisien cows and Holstein

Cows breed	Morphometrics			Phenotype		Physiology	
	BL (cm)	H (cm)	CG (cm)	Color	Size Body	Fat (%)	Protein (%)
Holsteins	166.68	142.00	188.79	DominantWhite	Higher, shape smaller head	4.72	3.5
Friesians	162.76	138.60	183.42	DominantBlack	Shorter, head shape larger and has a head crest	3.66	2.78

Note: BL= Body Length; H= Height; CG= Chest girth; Source: Sieber *et al.* (1988); Roseler *et al.* (1997); Aucgist *et al.* (2004); Domecq *et al.* (1997); Albarrán-Portillo *et al.* (2013)



a to b = thighs width; c to d = thighs length

Figure 1. Illustration of a Cows Body Measurements

The body measurements of Friesian and Holstein cows were descriptively analyzed by describing the mean (x), standard deviation (SD) and coefficient of variation. Morphometric data were analyzed using the t-test to compare morphometrics between Friesian and Holstein cows (Sugiyono 2019).

The prediction of milk production data was obtained based on the average milk production per cow in Farm 1. The predicted milk production in Farm 1 was used as a reference for predictions for Farm 2 and Farm 3 because individual milk production data for the animals in these farms were not available. For milk production predictions, researchers utilized the Ali-Schaeffer equation, with independent predictors including body length, height, chest girth, and body weight (Steel and Torrie 1991). The regression model equation for estimating milk production (Equation 3):

$$Y = \alpha + \beta_1 . X_1 + \beta_n . X_n \text{ ..... (Equation 3)}$$

Where:
Y : milk production (milk yield)
X1 : body length
X2 : height
X3 : chest girth
X4 : weight
β : Regression coefficient; and
α : Constant

Furthermore, to analyze the influence of morphometric and lactation level on milk production in Friesian and Holstein cows, estimates were conducted using multiple linear regression analysis (Ghozali 2018) in (Equation 4; Equation 5). Multiple linear regression was conducted to analyze the factors that could influence the milk production of Friesian and Holstein cows.

Friesian Cows:

$$mp = \beta_0 + \beta_1 bl_i + \beta_2 h_i + \beta_3 cg_i + \beta_4 w_i + \beta 5\ lct_i + \varepsilon 1 \text{..... (Equation 4)}$$

Holstein Cows:

$$mp = \beta_0 + \beta_1 pb_i + \beta_2 h_i + \beta_3 cg_i + \beta_4 w_i + \beta 5\ lct_i + \varepsilon 2 \text{..... (Equation 5)}$$

Where:
mp = Milk production
bl_i = body length
h_i = height
cg_i = chest girth
w_i = weight
lct_i = lactation
β_0 = intercept or constant
β1- β5 = independent variable coefficient
ε =*error*

Finally, Principal Component Analysis (PCA) aimed to describe complex data in a lower dimensional space by projecting data into principal components, which were linear combinations of the original variables used. PCA was used to obtain size and shape equations derived from the correlation matrix (Ghozali 2018) (Equation 6).

$$Yj = a_1 jX_1 + a_2 jX_2 + a_3 jX_3 + \cdots + ajX_9 \text{..... (Equation 6)}$$

Information:
Yj : jth principal component (j=1,2)
X-X9 : Variables 1,2,3,…9
a1j-a3j : Eigenvectors to 1,2,3.

Comp1 was determined based on the morphometrics used to analyze milk production influence and had a higher number, while Comp2 was determined based on the morphometrics that also influenced milk production but had a lower number than Comp1.

RESULTS AND DISCUSSION

Weight and Morphometric Characteristics

Cows' morphometric data provide insights into morphological variations among cow breeds, differences

between individuals, and the implications for productivity, health, and adaptability of cows to their environment (Albarrán-Portillo and Pollott 2013). The weight and morphometric characteristics of Friesian and Holstein cows using digital images shown in Table 2.

Based on Table 2, it is evident that the body length, height, chest girth, and weight of Holstein cows were higher than those of Friesian cows in the second and third lactation. These findings are consistent with the results of another study conducted by (Piazza *et al*. 2022); Filian

Table 2. Weights and morphometrics of Friesian and Holstein cows using digital images

Location/ Period	Cows									
	Friesians					Holsteins				
	Obs	Mean	SD	Min	Max	Obs	Mean	SD	Min	Max
Farm 1										
Lactation I										
BL (cm)	9	163.89	1.45	162	166	5	173.80	1.64	172	176
H (cm)	9	132.22	1.48	130	134	5	135.00	1.58	133	137
CG (cm)	9	180.11	1.74	168	199	5	192.60	3.78	189	198
W (kg)	9	409.93	5.50	361	488.41	5	460.65	16.30	445.21	484
Lactation II										
BL (cm)	10	164.10	2.08	160	167	7	174.14	2.85	168	177
H (cm)	10	137.10	1.85	135	140	7	137.29	1.11	136	139
CG (cm)	10	176.90	8.12	159	186	7	195.29	4.27	189	201
W (kg)	10	396.21	31.67	327.61	432.64	7	472.29	18.57	445.21	497.29
Lactation III										
BL (cm)	4	167.00	1.41	166	169	16	175.00	6.32	163	182
H (cm)	4	140.00	1.41	138	141	16	144.00	3.72	139	152
CG (cm)	4	172.25	9.67	162	181	16	196.31	7.66	173	207
W (kg)	4	378.03	37.52	338.56	412.09	16	477.15	32.54	380.25	524.41
Lactation I - III										
BL (cm)	23	164.52	2.04	160	169	28	174.57	4.97	163	182
H (cm)	23	135.70	3.42	130	141	28	140.71	4.88	133	152
CG (cm)	23	177.35	10.33	159	199	28	195.39	6.38	173	207
W (kg)	23	398.42	41.67	327.61	488.41	28	472.99	27.25	380.25	524.41
Farm 2										
Lactation I										
BL (cm)	16	154.81	7.30	141	169	8	157.25	6.63	151	169
H (cm)	16	138.25	2.41	131	141	8	148.25	9.19	130	156
CG (cm)	16	195.44	7.11	179	212	8	200.25	5.20	191	209
W (kg)	16	473.26	30.82	404.01	547.56	8	494.19	23.09	453.69	533.61
BL (cm)	22	149.41	8.74	140	169	17	155.65	7.82	146	171
H (cm)	22	138.77	1.48	136	141	17	146.12	4.47	142	153
CG (cm)	22	193.41	7.56	169	204	17	200.24	4.02	192	206
W (kg)	22	464.56	31.76	364.81	510.76	17	494.04	17.78	457.96	519.84
Lactation III										
BL (cm)	4	155.00	8.04	147	166	8	161.63	15.17	139	181
H (cm)	4	139.25	1.26	138	141	8	145.25	2.82	140	149
CG (cm)	4	197.75	6.75	189	204	8	195.13	9.60	178	204
W (kg)	4	483.24	29.50	445.21	510.76	8	472.24	40.99	400	510.76
Lactation I - III										
BL (cm)	42	152.00	8.42	140	169	33	157.48	9.83	139	181
H (cm)	42	138.62	1.86	131	141	33	146.42	5.61	130	156
CG (cm)	42	194.60	7.29	169	212	33	199.00	6.25	178	209
W (kg)	42	469.65	31.06	364.81	547.56	33	488.79	27.07	400	533.61

Table 2. Weights and morphometrics of Friesian and Holstein cows using digital images (continue)

Location/ Period	Cows									
	Friesians					Holsteins				
	Obs	Mean	SD	Min	Max	Obs	Mean	SD	Min	Max
Farm 3										
Lactation I										
BL (cm)	8	161.00	2.98	157	165	15	167.87	3.56	156	172
H (cm)	8	137.75	1.49	136	141	15	141.33	2.29	139	148
CG (cm)	8	195.75	3.45	192	201	15	199.33	3.20	195	206
W (kg)	8	474.26	15.13	457.96	497.29	15	489.98	14.22	470.89	519.84
Lactation II										
BL (cm)	8	162.50	2.45	159	166	8	169.25	2.96	165	173
H (cm)	8	138.75	1.67	136	141	8	142.50	3.51	138	149
CG (cm)	8	197.00	4.44	190	204	8	199.88	3.18	196	204
W (kg)	8	479.78	19.48	449.44	510.76	8	492.37	14.11	475.24	510.76
Lactation III										
BL (cm)	6	161.33	2.58	158	165	11	166.09	3.59	162	171
H (cm)	6	139.00	1.41	137	141	11	142.45	2.02	138	145
CG (cm)	6	196.67	1.75	194	199	11	198.64	3.29	192	202
W (kg)	6	478.18	7.65	466.56	488.41	11	486.90	14.46	457.96	50.76
Lactation I - III										
BL (cm)	22	161.64	2.65	157	166	34	167.62	3.55	156	173
H (cm)	22	138.45	1.57	136	141	34	141.97	2.53	138	149
CG (cm)	22	196.45	3.40	190	204	34	199.24	3.16	192	206
W (kg)	22	477.33	14.93	449.44	510.76	34	489.55	13.99	457.96	519.84

Note: BL= Body Length; H= Height; CG= Chest girth; W= Weight; Min= Minimum; Max= Maximum; Mean ± SD=Mean ± Standard Deviation

Table 3. Differences in Weight and Morphometric Characteristics of Friesian and Holstein Cows in Pondok Rangon, Lembang, and Cibungbulang dairy Cows Area Using Digital Images

Size	Cows	(Mean±SD)					
		Lactation I	p-value	Lactation II	p-value	Lactation III	p-value
BL (cm)	Friesians	158.8±6.6	0.0001a**	155.7±9.6	0.0013a**	161.1±6.3	0.0018a**
	Holsteins	165.9±7.4		163.1±10.4		169.1±10.1	
H (cm)	Friesians	136.5±3.2	0.0000b**	138.3±1.7	0.0000b**	139.3±1.3	0.0000b**
	Holsteins	142.2±6.8		143.3±5.1		143.8±3.2	
CG (cm)	Friesians	191.3±10.7	0.0010b**	190.0±10.4	0.0000a**	190.0±13.0	0.1102a
	Holsteins	198.4±4.7		199.1±4.3		196.8±7.1	
W (kg)	Friesians	456.2±44.9	0.0010b**	450.5±43.4	0.0000b**	451.0±53.3	0.1102a
	Holsteins	485.9±20.7		488.9±18.8		479.1±30.1	

Note: BL= Body Length; H= Height; CG= Chest girth; W= Weight. The p value is calculated based on statistical tests (a: two-sample Wilcoxon rank-sum (mann-Whitney) test and b: t test); **p value < 0.05

et al. (2016); GBD (2022) The body length and height of Holstein cows were observed to be higher than those of Friesian cows, while the chest girth of Holstein cows was wider compared to Friesian cows. In the study of (Hakim *et al.* 2019), showed the average of body weight for Friesian cows was 507.09.

Table 3 showed the comparison of the body weight and morphometric characteristics of Friesian and Holstein cows. The results indicated a significant difference in body length, height, chest girth, and weight between Friesian cows and Holstein cows in the first and second lactation periods ($p<0.05$). In the third lactation period, body length and height differed significantly, but the chest girth and weight were similar. Our study aligns with the study conducted by (Syukriani *et al.* 2022), indicated that Friesian breed cows had relatively lower production and smaller bodies compared to Holstein breeds. Additionally, body weight and body length were greatly influenced by genetic factors, diet, and

Table 4. Estimator of milk production in Friesian and Holstein Cows in Different Lactation Periods

Lactation Period	Cows nation			
	Friesian (Liter/lactation)		Holstein (Litres/lactation)	
	Min-Max	Mean±SD	Min-Max	Mean±SD
Lactation I	656.9-3641.1	2298.8 ± 765.5	2013.4-3826.2	2994.8±438.4
Lactation II	300.7-3293.4	2292.2 ± 679.8	2190.6-3879.4	3081.1±447.3
Lactation III	733.4-3169.9	2347.8 ± 768.1	1516.9-3586.4	2969.4 ±423.3

management. Friesian cows tended to have smaller bodies and compact body proportions with a distinctive black and white color pattern. On the other hand, Holstein was one of the largest cow breeds, with a long and tall body. Holstein cows tended to have larger morphometric measurements compared to Friesians (Breukelen *et al.* 2019).

Milk Production

The lactation period in cows typically lasted around 305 to 365 days (Elischer 2014). In our study, it was observed that milk production in Friesian cows remained stable in the first lactation at 2298.8 liters, in the second lactation at 2292.2 liters, and in the third lactation at 2347.8 liters. Conversely, milk production in Holstein cows tended to stabilize in the first lactation at 2994,8 liters, increased in the second lactation to 3081.1 liters, and decreased in the third lactation to 2969,4 liters. Additionally, a dairy cow which calved for the first time at the age of 24 months (2 years) will produce around 80% of its peak production in the second lactation and around 90% in the third lactation (Astuti 2022). This shown that milk production increased after the first lactation and peaked during the second lactation. While milk production in the third lactation remained high, it might experience a slight decrease compared to the second lactation. Milk production continued to increase from 3 years of age to 7 or 8 years of age, followed by periodic decreases. Friesian Holstein (FH) cows require an ideal body weight to achieve optimum milk production. Our study indicated that milk production increased after the first lactation and reached its peak in the second lactation, although it did not reach 100% of peak production (Table 4). These findings are consistent with FH cows in Indonesia being capable of producing less than 16 kg of milk per cow per day (Toharmat *et al.* 2007).

Body Condition Score (BCS)

Table 5 showed the body condition scores (BCS) of the cows in three different locations. BCS was a crucial factor that significantly influenced the level of milk production in dairy cows. The accurate estimation of BCS values impacted the milk production of dairy cows (Yusuf and Surjowardojo 2021). The average Friesian and Holstein cows in Pondok Rangon, Lembang, and Cibungbulang dairy cow farms fell within the category of BCS 4, indicating that the breeds of cows had the ideal body condition (Table 5). The ideal BCS score for dairy cows falls within the range of 1-9 points (ICAR 2018). This research was consistent with previous findings, in terms of the population, the highest BCS score was 4.8, and the lowest was 4.5, indicating the ideal BCS score. The average BCS of Holstein cows in this study was similar to the BCS measurements reported by (Piazza *et al.* 2022) with the average BCS score close to 5. Cows with an ideal body condition score are in a healthy condition, having sufficient body fat to support good reproduction and milk production.

Table 5. Body Condition Score (BCS) in Friesian and Holstein Cows

Lactation	BCS (Mean±SD)	BCS Category	Information
Friesians			Ideal
			· The ribs are covered by a layer of meat or muscle.The ribs are covered by a layer of meat or muscle.
I	4.848 ± 0.667	BCS 4	· The spine and pelvis are covered by fat, but can still be used.
II	4.625 ± 0.806	BCS 4	· Fat The spine and pelvis are covered by fat, but can still be developed. The spine and pelvis are covered by fat, but can still be developed.
III	4.642 ± 0.928	BCS 4	· Brow fat can be seen quite clearly
I-III	4.712 ± 0.776	BCS 4	The cows's brow fat is quite clearly visible. The cows's brow fat is quite clearly visible.
Holsteins			Ideal
I	4.500 ± 0.745	BCS 4	· The ribs are covered by a layer of meat or muscle.
II	4.750 ± 0.762	BCS 4	· The spine and pelvis are covered by fat, but the ribs can still be covered by a layer of flesh or muscle.
III	4.685 ± 0.676	BCS 4	· Fat The spine and pelvis are covered by fat, but the brow fat can still be seen quite clearly.
I-III	4.652 ± 0.725	BCS 4	· Brow fat can be seen quite clearly

Relationship of Morphometric and Lactation Level with Milk Production

Milk production in Holstein and Friesian cows was influenced by various factors, including morphometric characteristics, cows age, feed management, climate, and environmental factors (Syukriani *et al*. 2022). Table 6 showed a significant relationship between height and milk production, with a correlation coefficient value of 0.627 ($p<0.05$). Furthermore, there was a very strong relationship between chest girth and cow weight with milk production, with values of 0.957 and 0.958 respectively. A correlation coefficient of >0.8 is considered high (Sugiyono 2019). Our study revealed that cows exhibiting greater body height, weight, and chest girth tended to produce optimal milk yields. According to (Buckley *et al.* 2000); (Solechah *et al.* 2019), the linear body measurements of chest girth, udder dimensions, body length, body height, and body weight were found to positively correlate with milk production.

Moreover, the correlation coefficient between the lactation period and milk production was 0.095, indicating a very low relationship. It was different from the research findings that, the correlation values between body length and height on milk production were 0.722 and 0.654, respectively, categorizing them as strong (Zein *et al.* 2018). This result is supported by (Siska and Anggrayni 2020), the correlation value of 0.28 indicates a weak relationship between lactation level and milk production.

Based on the correlation analysis, a multiple linear regression analysis was subsequently conducted. Table 6 presents the estimation results of the multiple linear regression analysis. Based on these findings, the overall model equations are as follows (Equation 7 and Equation 8):

Friesian Cows Model:

$$mp = -42.520 + 0{,}004\ bl_i + 0{,}142\ h_i + 0{,}093\ cg_i + 0{,}025\ w_i - 0{,}002\ lct_i \quad \text{(Equation 7)}$$

Holstein Cows Model:

$$mp = -42.585 + 0{,}004\ bl_i + 0{,}142\ h_i + 0{,}094\ cg_i + 0{,}024\ w_i - 0{,}002\ lct_i \quad \text{(Equation 8)}$$

Based on Table 6, the results of the multiple linear regression analysis are provided for two model equations, the value Prob > F or p is obtained value< *a* (0.05). Therefore, body length, height, chest girth, weight, and lactation level were found to have a significant effect on milk production in both Friesian and Holstein cows. Our study indicates that morphometric factors, including body length, height, chest girth, and weight, can serve as references for estimating milk production. Cows with proportional body lengths have sufficient body capacity to produce and support greater milk yields. According to (Putra *et al.* 2019); Zein *et al*. (2018), the study showed that the body length, body height, and chest depth were morphometric parameters that affected milk production. Friesian cows with higher heights usually reached reproductive maturity faster. Cows that had reached reproductive maturity could start lactation earlier, subsequently increasing their overall productivity period.

The taller Friesian and Holstein cows were, the more milk they produced. Milk production increased or decreased linearly based on body length (Soeharsono *et al*. 2009). The body length of the cows, including the length of the small intestine, affected the cows ability to absorb nutrients from the feed consumed. The longer the small intestine was the more area for nutrient absorption was available, potentially leading to obtaining more nutrients from the feed. Additionally, cows with optimal chest girth tended to have stable milk production (Soeharsono *et al.* 2009). According to (Maherlan *et al.* 2021) the body length and chest girth played a significant role in influencing milk production. A larger chest girth indicated that the cows had a greater lung capacity to ensure adequate oxygen supply to the body, including the mammary glands. Sufficient oxygen was an important factor in the metabolic processes required for optimal milk production (Maherlan *et al*. 2021).

The weightier body cows have a larger digestive capacity. Our study indicates the body weight of the cows align with milk production 23.8%. Body weight which

Table 6. Results of multiple linear regression for body length, height, chest girth, weight, and lactation period on milk production

MP	Friesian Cows			Holstein Cows		
	Coef.	t	P>ItI	Coef.	T	P>ItI
BL	0.00470	104.73	0.000***	0.00476	129.74	0.000***
H	0.14283	890.97	0.000***	0.14283	2.055.37	0.000***
CG	0.09384	87.61	0.000***	0.09449	42.47	0.000***
W	0.02599	100.84	0.000***	0.02584	50.18	0.000***
LCT	0.00025	0.47	0.641	-0.00024	-0.61	0.545
_cons	-425.206	-460.65	0.000	-425.852	-218.54	0.000
Number of obs			87			95
F(5,81)			99.999.00			99.999.00
Prob > F			0.000***			0.000***
R-squared			1.000			1.000
Adj R-squared			1.000			1.000
MSE Root			0.00307			0.00305

MP= Milk Production; BL= Body Length; H= Height; CG= Chest girth; W= Weight; LCT= lactation. The p value is calculated based on the multiple linear regression statistical test. **significant at 5% or $p < 0.05$.

of dairy cows can optimize milk production (Yusuf and Surjowardojo 2021). Dairy cows with an ideal weight tended to have minimal body fat. Excessive body fat in cows could lead to dense fat deposits in the body, posing risks of health problems such as ketosis and inhibiting milk production (Siska and Anggrayni 2020). The ideal body weight of the cows tended to result in healthier cows, which in turn had a positive effect on optimal milk production. In line that the increased in body weight of cows from birth to weaning was observed to correlate with increased milk production in animals reared during their first lactation (Grzesiak *et al*. 2023). There was a positive relationship between livestock body weight and milk production. Livestock that had optimal body weight tended to have higher milk production potential (Mihaela *et al.* 2023). Otherwise, thin cows might have experienced an energy deficiency, which could have reduced milk production. Meanwhile, lactation level could not be used as a reference for increasing milk production (Grzesiak *et al.* 2023).

Principal Component Analysis (PCA)

Based on the results of Figure 2, it was shown that the line decreased quite sharply from factor one to factor two. These results indicated that there were 2 major components which were the main factors in supporting milk production in Friesian and Holstein cows (Table 7). Based on Table 7, it could be concluded that there were 2 components, which included:

1. Comp1: Chest girth and weight.
2. Comp2: Body length, height and lactation period

Table 7. Principal component analysis results

Variable	Comp1	Comp2
Body Length	-0.101	0.527
Height	0.350	0.384
Chest Girth	0.658	-0.045
Weight	0.657	-0.041
Lactation Period	-0.031	0.755

Comp1= 1st component; Comp2= 2nd component

The main factors that influenced milk production in Friesian and Holstein cows were chest girth and cow weight. Chest girth in cows was related to lung capacity and stomach capacity, which could also affect the cow's ability to consume feed and produce milk. Cows with heavier body weight had more energy reserves in the form of body fat, which could be used to support milk production when feeding conditions were not optimal. A long lactation period could influence milk production, with longer lactation periods tending to produce more milk if supported by good rearing management. Additionally, the breed of cows also influenced production. Our study showed similar findings with the study of (Prabowo *et al.* 2023), indicating that shoulder width, chest girth, waist width, rump width, distance between the spine and pelvic bones (thurl), width of the two hip bones at the back (pin), and rear udder width were identified as significant components of body width.

CONCLUSION

The milk production of Holstein cows was higher than Friesian cows based on the total number per lactation period and the total lactations observed. Holstein cows had a larger body size compared to Friesian cows. Body height, chest girth, and body weight influenced milk production in Friesian and Holstein cows, indicating that the taller or larger the body size of Friesian and Holstein cows influenced higher milk production. Both Friesian and Holstein cows with a larger body size produced more milk.

ACKNOWLEDGEMENT

The researcher would like to thank the Pondok Rangon Dairy Farm, DKI Jakarta, the Lembang Dairy Farming Cooperative, West Bandung Regency, West Java, and the Cibungbulang Milk Production and Livestock Business Cooperative, Bogor West Java, for providing a place for this research so that the research ran smoothly.

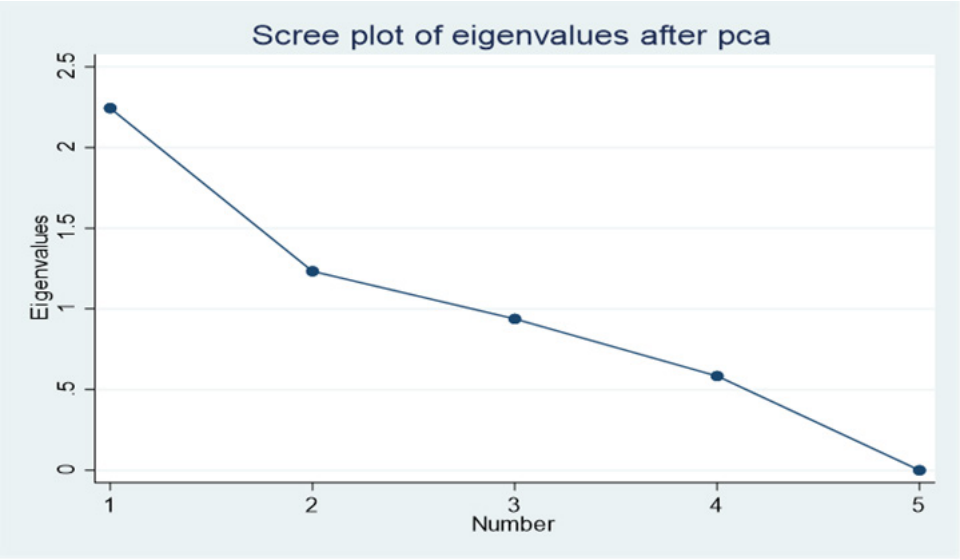


Figure 2. Scree plot

REFERENCES

Albarrán, P. B., & G. E. Pollott. 2013. The relationship between fertility and lactation characteristics in Holstein cows on United Kingdom commercial dairy farms. J. Dairy Sci. 96:635–646.

Astuti. 2022. Effect of different lactation periods on production and physical quality of fries holstein dairy cow milk. Thesis, Universitas Hasanuddin. Makassar.

Auldist, M. J., K. J. Johnston., N. J. White., W. P. Fitzsimons., & M. J. Boland. 2004. Characterization of Holstein and normande whole milk mirnomes highlights breed specifcities a comparison of the composition, coagulation characteristics and cheesemaking capacity of milk from Friesian and jersey dairy cows. Journal of Dairy Research. 7(1):51-57.

BPS. 2022. Populasi Sapi Perah menurut Provinsi (Ekor) 2012-2022. https://www.bps.go.id/indicator/24/470/1/populasi-sapi-perah-menurut-provinsi.html. [6 September 2022].

Breukelen, V. A. E., H. P. Doekes., J. J. Windig., & K. Oldenbroek. 2019. Characterization of genetic diversity conserved in the gene bank for dutch cattle breeds. Diversity. 11(229):2-13.

Buckley, F., Dillion., J. Mee., R. Evans., & R. Veerkamp. 2000. Trends in genetic merit for milk production and reproductive performance. Teagasc-National Dairy Conference 2000. Paper 3.

Domecq, J., A. L. Skidmore., J. W. Lloyd., & J. B. Keneene. 1997. Relationship Between Body Condition Scores and Milk Yield in a Large Dairy Herd of High Yielding Holstein Cows. J Dairy Sci 80:101–112.

Elischer, M. 2014. Histori of Dairy Breeds: Holstein. Michigan (USA): Michigan State University.

Filian, B. V., S. B. Santoso., D. W. Harjanti., & W. D. Prastiwi. 2016. Hubungan paritas, lingkar dada dan umur kebuntingan dengan produksi susu sapi friesian holstein di BBPTU-HPT Baturraden. Agripet. 16(2):83-89.

Ghozali, I. 2018. Aplikasi Analisis Multivariate dengan Program IBM SPSS 25. Badan Penerbit Universitas Diponegoro: Semarang.

Grzesiak, W., D. Zaborski., R. Pilarczyk., J. Wójcik., & K. Adamczyk. 2023. Classification of daily body weight gains in beef calves using decision trees, artificial neural networks, and logistic regression. Animals. 13(1956):1-16.

Hakim, A., H. Nuraini., R. Priyanto., & T. Harsi. 2019. Dimensi Tubuh Sapi Friesian Holstein dan Limousin Betina Berdasarkan Morfometrik dengan Citra Digital. Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan. 7(2):47-56.

Holdorf, S. J., K. E. Kendall., M. J. Ruh., G. J. Caputo., S. J. Combs., W. E. Henisz., T. Brown., R. E. P. Bresolin., J. R. R. Ferreira., & H. M. Dorea. 2023. White, Increasing the prepartum dose of rumen-protected choline: Effects on milk production and metabolism in high-producing Holstein dairy cows, Journal of Dairy Science. 106(9):5988-6004.

ICAR. 2018. Section 5-ICAR guidelines for conformation recording of dairy cattle, beef cattle, dual purpose cattle and dairy goats. https://www.icar.org/Guidelines/05-Conformation-Recording.pdf. [9 September 2022].

Lan, L. S., & Kenas. 2022. Effects of low pasture quality on body condition score and reproductive performance of beef cattle. Int. J. Dairy Sci. 17:13-23.

Maherlan, D., A. Atabany., & B. P. Purwanto. 2021. Penerapan citra digital sebagai metode analisis hubungan morfometrik tubuh sapi perah FH dengan produksi susu di Cibungbulang Bogor. Animal Production Technology. 1-14.

Mahmudi, M., R. Priyanto., & J. Jakaria. 2019. Karakteristik morfometrik sapi aceh, sapi PO dan sapi Bali berdasarkan analisis komponen utama (AKU). Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan. 7(1):35-40.

Mihaela, I., C, Andrei., D. D. Dronca., N, Ghebangsaim., & R. A. Popa. 2023. Estimation of correlation coefficients between milk yield and morphological traits in a population of lacaune sheep. Scientific Papers. Series D. Animal Science. 66(1).

Petrovska, S., D. & Jonkus. 2014. Milking technology influence on dairy cow milk productivity and quality. Engineering for Rural Development. 13:89–93.

Piazza, M., D. Giannuzz., R. Tessari., E. Fiore., M. Gianesella., S. S. Pegolo., E. Schiavon., F. Trevisi., C. A. Piccioli., L. Cecchinato, & Gallo. 2022. Associations between ultbangsaound hepatic measurements, body measures, and milk production traits in Holstein cows. Journal of Dairy Science. 105(8):7111-7124.

Prabowo, S., Ş. İnal., & M. Garip. 2023. Dairy cattle body width principal component and the correlation level to milk yields as an option for selection approach. Tropical Animal Science Journal. 46(3):269-279

Putra, Y. E., S. Mulyani, & S. Mumpuni. 2019. Hubungan morfometri dengan produksi susu sapi perah peranakan Friesian Holstein (PFH). Ovozoa. 8(1):49-53.

Roseler, D. K., D. G. Fox, A. N. Pell, & L. E. Chase. 1997. Evaluation of Alternative Equations for Prediction of Intake for Holstein Dairy Cows. Nutrition, Feeding, and Calves. 80(1):864-877.

Sieber, M., A. E. Freeman, & D. H. Kelley. 1998. Relationships Between Body Measurements, Body Weight, and Productivity in Holstein Dairy Cows. J Dairy Sci. 71:3437-3445.

Siska, I., Anggrayni, & L. Yoshi. 2020. Body condition score (BCS), tingkat laktasi dan hubungannya dengan produksi susu sapi perah peranakan Friesian Holstein (PFH). Jurnal Ilmu Ternak. 20(2):115-125.

Soeharsono, S. Mulyati, S. Utama, Wurlina, P. Srianto, T. I. Restiadi, & I. Mustofa. 2020. Prediction of daily milk production from the linear body and udder morphometry in Holstein Friesian dairy cows. Veterinary World. 13(3):471-477.

Solechah, A. W., D. W. Harjanti, & R. Hartanto. 2019. Hubungan antara Morfologi Ambing, Produksi Susu

dan Komponen Susu pada Sapi Friesian Holstein. Jurnal Agripet: 19(2):91-98.

Sugiyono. 2019. Statistika untuk penelitian. Bandung: Alfabeta.

Sya'adah, N., & P. Surjowardojo. 2022. Hubungan body condition score (BCS) dan bobot badan dengan produksi susu sapi perah PFH di unit KPSP setia kawan nongkojajar pasuruan. Jurnal Sains Peternakan. 10(1):5-12.

Syukriani, D., I. Irda, & D. Kurnia. 2022. Ilmu ternak perah. Sumatra Barat: Politeknik Pertanian Negeri Payakumbuh: Payakumbuh.

Toharmat, T. R. R., N. Nahrowi, R. R. A. Maheswari, L. Abdullah, D. Evvyernie, C. Sumantri, A. D. Lubis, I. G. Permana, S. Burhanudin, A. Atabany, K. Hamzah, F. Luthan, T. Setiawati, D. Yulizar, G. Wahyuni, N. L. Santoso, & R. D. Tobing. 2007. Review Agribisnis Persusuan Di Indonesia. Jakarta (ID). Kerjasama Tim Fakultas Peternakan IPB dan Deptan: Jakarta.

Yusuf, V. M., & P. Surjowardojo. 2021. Hubungan antara body condition score (BCS), periode laktasi dan produksi susu pada sapi perah peranakan Friesian Holstein (PFH). Universitas Brawijaya. Malang.

Zein, D. S., A. Atabany, & I. Komala. 2018. Hubungan ukuran tubuh sapi FH menggunakan metode citra digital terhadap produksi di WWF Bogor. Nutrition and Feed Technology. 2019. Hubungan morfometri dengan produksi susu sapi perah peranakan Friesian Holstein (PFH). Ovozoa. 8(1):49-53.