Production and Fatty Acid Content of Friesian Holstein Crossbred's Milk Fed Fermented Completed Feed or Silage as Forage Replacement

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ABSTRACT
This research was intended to determine the effect of replacing forage with fermented completed feed or silage on milk production and fatty acids of Friesian Holstein Crossbred. This research used 6 of 3rd – 6th month lactating cows in average weight of 386.2±30.3 kg. The study consisted of 3 dietary treatments: concentrates + forages as usual (R1; control), concentrate + silage (R2), and fermented complete feed (R3). All dietary treatments were fed to the cows by following a switchback design that divided into three periods (P1, P2, and P3) that lasted for five weeks each, including a week of feed adaptation. The parameters observed were feed consumption, milk production, and milk quality, such as density, total solid non-fat, fat, and fatty acids. Results showed that replacing forages with fermented complete feed or silage did not affect milk production (12.2, 12.5, and 12.0 L/day)), density (1.023, 1.024, and 1.024), total solid non-fat (8.03, 8,50, and 7.37), fat (3.35, 3.37, and 4,92%), monounsaturated fatty acids (26.8, 29.7%, and 29.0%), and polyunsaturated fatty acids at (2.98, 3.60, and 2.82%, respectively). It can be concluded that silage and fermented completed feed can be used to substitute forage for Friesian Holstein Crossbred without negatively affect milk production and quality.

Keywords: *Milk production, Milk fatty acids, Fermented complete feed, Silage, Forage replacement, Friesian Holstein crossbred.*

1. INTRODUCTION

Production and quality of milk are influenced by feed, genetic, and environment [1]. Physical and chemical quality of fresh cow's milk changes in season and lactation period, in respect of cow's breed, feed, feeding system, frequency of milking, and milking methods [2]. However, feed is the biggest factor that most influences the quantity and quality of milk. Feed limitations, especially forage for dairy cows, are often experienced by farmers during the dry season. One of the applicable strategies for providing basal feed during this season is conservation or preservation of forage. Silage is one of the most popular feed technologies applied by farmers to solve forage scarce during dry season. Since silage has a low pH (<4.2) due to its controlled fermentation under anaerobic conditions [3], it can be stored for months under this controlled condition.

On the other hand, feed processing technology has been developed in a more practice and ready-to-use kind of feed; this is when the complete feed or total mixed ration (TMR) that consist of forage and concentrate mix was introduced. Furthermore, to preserve this mixture, this complete feed went into fermentation process. A fermented complete feed is a mixture of feed ingredients that have been formulated according to the animal's requirement and fermented under anaerobic conditions [4]. During fermentation, structure carbohydrates were hydrolyzed into non-structural carbohydrates. This increase feed quality, especially its digestibility. The provision of fermented complete feed can certainly increase the effectiveness of feeding as well as feed and time efficiency. The fermented complete feed has been formulated according to the nutrient requirement of the animal so that farmers no longer need to add other feed ingredients except water. Providing complete feed to livestock also ensures even distribution of the daily nutrient intake of the ration, so that fluctuations in ecosystem conditions in the rumen are reduced or maintain rumen conditions to remain stable [5].

The provision of fermented feed such as silage that can maintain the quality of forage nutrients and fermented complete feed which can improve the quality of dairy feed and will increase milk production. Maintained the feed quality can affect milk production and quality to remain consistent. Improved feed quality can also affect the quality improvement of milk produced. This study aims to determine the effect of fermented complete feed or silage as a substitute for forage for milk production and milk quality of Friesian Holstein Crossbred (FHC) dairy cows. Milk quality is meant in addition to density and fat content, as well as it's fatty acid content both monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA).

2. MATERIALS AND METHODS

The experiment was conducted at Andini Gotro Dairy Farmer Group, Batang, Tambakrejo, Tempel, Sleman Yogyakarta (latitude 7°55′06″S, longitude112°34′35″E, elevation 704 m) from August 2018 to January 2019. The climate is tropical with a wet season from November to April and a dry season from May to October. The average rainfall during 2018 was around 3 230 mm. The mean minimum and maximum temperature and humidity during the experiment (April to August 2018) were 17.8 to 31.5°C and 69.2 to 87.0%, respectively.

Feed sample analysis was conducted at the Laboratory of Feed Technology, Department of Feed and Animal Nutrition, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta. Determination of density and fat content was conducted at Laboratory Milk and Egg Technology, Department of Animal Product Technology, Faculty of Animal Science, Universitas Gadjah Mada, while determination of milk fatty acids was conducted at Integrated Research and Testing Laboratory (LPPT) of Universitas Gadjah Mada.

Thirty crossbred Friesian Holstein × local bulls were used (3.0 – 6.5 years of age lactating) with mean live weight (LW) of 386.2±30.3 kg and milk production 9 to 18 L/day. The animals were purchased from the local cattle market. The animals were weighed every week in the morning before feeding, and feed offered was adjusted accordingly. Animals were held in individual stalls with individual feed troughs in an animal house with roofing and a concrete floor.

Thirty animals were randomly allocated to the treatments, and they were arranged in a randomized block design using initial LW as a block. Five treatment diets were applied, and six animal replications were used for each treatment. The three diets had different levels of corn stover: R1 consisted of basal feed (15 kg fresh corn stover) plus 11 kg concentrate (feed as commonly used by farmers), R2 consisted of 12 kg of corn stover silage and 11 kg concentrate, and R3 consisted of 22 kg of fermented complete feed (11 kg of corn stover + 11 kg concentrate). The concentrate used is adjusted by administering a mixture of concentrates to R1 and R2. The composition of the concentrate feed was listed in Table 1. Due to the commercial concentrates used in this experiment was not produced by the factory (Warga Mulya® Cooperative), concentrates used in periods 2 and 3 were slightly different to those in period 1.

The feed was given twice a day, in the morning at 07.00 WIB and in the afternoon at 16.00 WIB. Each treatment added 3 kg of tofu waste.

Table 1. Concentrate feed composition during research

No.	Feed ingredients	Feeding percentage (%)	
		Period 1	Period 2 and 3
1	Warga Mulya concentrate	45.4	-
2	Primavit® concentrate	-	49.3
3	Bran pollard	18.2	28.2
4	Copra meal	9.10	8.40
5	Rice bran	27.3	-
6	Soybean peel	-	14.1
Total		100	100

The study was divided into three periods: P1, P2, and P3, each period lasted for five weeks, including one week for feed adaptation. Adaptation is done in the first week, during the period of feed replacement according to treatment. The study was conducted using a switchback design [6]. Feeding arrangements according to the design are listed in Table 2.

Table 2. Switchback design of the research

Period	Group		
	Group I (Cattle 1 and 2)	Group II (Cattle 3 and 4)	Group III (Cattle 5 and 6)
Period 1	R2	R3	R1
Period 2	R3	R1	R2
Period 3	R1	R2	R3

Table 3. Chemical composition and total digestible nutrient of feed with different treatment

Diet	Period	DM (%)	Feed composition (% DM)					
			OM	CP	EE	CF	NFE	TDN[1)]
R1	1	56.7	87.0	11.8	3.40	23.2	48.6	60.7
	2	58.9	83.2	9.8	2.12	21.0	50.4	60.8
	3	58.9	83.2	9.7	2.12	21.0	50.3	60. 8
	Average	58.2	84.5	10.4	2.55	21.8	49.8	60.7
R2	1	47.0	87.9	10.9	3.20	21.4	52.5	62.3
	2	51.6	85.1	10.4	2.32	22.8	49.6	62.8
	3	51.6	85.3	10.4	2.32	22.7	49.6	62.8
	Average	50.1	86.0	10.6	2.61	22.3	50.6	62.6
R3	1	43.1	88.6	10.4	5.24	21.6	51.5	61.2
	2	54.3	87.6	12.1	4.48	19.2	49.9	61.4
	3	54.3	87.7	12.1	4.48	19.3	49.9	61.4
	Average	50.6	88.0	11.5	4.73	20.0	50.5	61.3

DM: dry matter, OM: organic matter, CP: crude protein, EE: extract ether, CF: crude fiber, NFE: nitrogen-free extract, [1)]TDN: total digestible nutrients (According to regression Harris, 1972, *cited* [12])

Variables observed in the study included dry matter, crude protein, and total digestible nutrients (TDN) consumption, milk production, and milk quality (dry matter, fat, and milk fatty acids). Milk production (L/head/period) was converted to a full lactation period (10 months), based on the amount of production and percentage per month of lactation: first, second, third, fourth, fifth, fifth, sixth, seventh, eighth, ninth and tenth in a row: 13, 13, 12, 12, 10,10, 9, 8, 7, and 6% respectively [7].

Chemical analysis for determining the chemical composition of feed was carried out using the Wendee method [8]. Measurement of milk density was carried out using a lactodensimeter [9]. Determination of milk protein content was carried out using the Kjeldahl method [8]. Determination of milk fat was carried out using the Babcock method [10], while milk fatty acids are carried out using gas chromatography [11].

2.1. Silage making

Cornstalk is chopped using a chopper into 3 to 5 cm length. Chopped cornstalk then withered to around 35% dry matter and mixed with 5% (W/W) molasses. The molasses used are dissolved in water with ratio 2:1 [3]. Cornstalk and molasses mixture was put into a 80 kg capacity plastic drum, compacted, tightly closed, then stored in room temperature for 21 days.

2.2. Fermented completed feed making

Fermented complete feed (FCF) was made using cornstalks and a concentrated mixture. Cornstalks were chopped using a chopper into 3 to 5 cm and withered. A 1-ton withered cornstalks and concentrate mix was added 20 mL of Saus Burger Pakan® (SBP) (CV Agro Lestari, Yogyakarta) and 500 mL of molasses that were dissolved in 3 liters of water. The mixture then was put into an 80 kg plastic drum, compacted, tightly closed, and stored for 7 days.

3. RESULTS AND DISCUSSION

3.1. Feed composition

Chemical composition and TDN of feed with different treatment R1, R2, and R2 were presented in Table 3.

3.1.1. Dry matter intake

Table 4 showed that dry matter intake (DMI) of the R1 was the highest ($P<0.05$) compared to the R2 and R3 (16.9 vs. 13.0 and 11.7 kg, respectively). This result is related to the highest DM content of R1 compared to the others. The average intake in this study was 13.9 kg/head per day or about 3.59% of bodyweight.

3.1.2. Crude protein intake

Statistical analysis of crude protein intake did not show any significant effects between R1, R2, and R3 (Table 4). This due to the R1 contain the highest DMI but lower protein content compared to the R2 and R3. Cattle with a bodyweight of about 450 kg and 13.6 L milk production per day, requires 1.52 kg crude protein [13]. These imply that required crude protein for the R1 has been fulfilled, while for the R2 and R3 was still not enough.

Table 4. Dry matter and nutrient intake of dairy cow feed with different diet

Variable	Period	Diet (kg/day)			Average
		R1	R2	R3	
Dry matter	1	16.5±0.00	12.21±0.00	10.8±0.00	13.1±2.95
	2	17.1±0.00	13.43±0.00	10.9±0.00	13.8±3.12
	3	17.1±0.00	13.43±0.00	13.6±0.00	14.7±2.07
	Average	16.9[a]±0.37	13.02[b]±0.70	11.7[c]±1.59	13.9±2.48
Crude protein	1	1.94±0.00	1.33±0.00	1.12±0.00	1.46±0.43
	2	1.67±0.00	1.40±0.00	1.32±0.00	1.53±0.14
	3	1.69±0.00	1.40±0.00	1.64±0.00	1.66±0.26
	Average	1.76±1.56	1.38±0.04	1.36±0.14	1.55±0.27
Ether extract	1	0.56±0.00	0.39±0.00	0.56±0.00	0.50±0.10
	2	0.34±0.00	0.31±0.00	0.49±0.00	0.39±0.09
	3	0.36±0.00	0.31±0.00	0.61±0.00	0.43±0.16
	Average	0.43[b]±0.12	0.34[c]±0.00	0.55[a]±0.06	0.44±0.12
Crude fiber	1	3.82±0.00	2.62±0.00	2.33±0.00	2.92±0.79
	2	3.59±0.00	3.06±0.00	2.08±0.00	2.91±0.77
	3	3.59±0.00	3.06±0.00	2.61±0.00	3.09±0.49
	Average	3.67[a]±0.13	2.91[b]±0.25	2.34[c]±0.27	2.97±0.61
Nitrogen-free extract	1	8.00±0.00	6.41±0.00	5.54±0.00	6.65±1.25
	2	8.61±0.00	6.66±0.00	5.42±0.00	6.90±1.61
	3	8.61±0.00	6.66±0.00	6.78±0.00	7.35±1.09
	Average	8.41[a]±0.35	6.58[b]±0.14	5.92[c]±0.75	6.97±1.20
Total digestible nutrients	1	9.98±0.00	7.60±0.00	6.60±0.00	8.06±1.74
	2	10.4±0.00	8.44±0.00	6.68±0.00	8.50±1.86
	3	10.3±0.00	8.44±0.00	8.33±0.00	9.05±1.16
	Average	10.3[a]±0.24	8.16[b]±0.48	7.20[c]±0.98	8.54±1.46

[a,b,c] : Different superscript in same row show significant different (P<0,05).

Table 5. Milk production of a dairy cow with different diet

Period	Milk production during one lactation period (liter)			Average
	R1	R2	R3	
1	3,262±1,526.2	3,140±281.7	3,970±135.5	3,458±448.2
2	4,770±226.3	3,438±1,171.4	3,755±879.9	3,987±695.6
3	4,077±774.3	4,365±275.7	3,700±1,315.2	4,047±333.5
Average	4,036±754.6	3,648±638.47	3,808±143.0	3,831±527.2

3.2. Total digestible nutrients intake

The TDN intake of the R1 was the highest, then followed by the R2 and R3 (10.3, 8.16, and 7.20%; respectively; P<0.05; Table 4). This difference related to the DMI of R1 that was higher than R2 and R3. Cattle with a bodyweight of about 450 kg and 13.6 L milk production per day requires 7.61 kg of TDN [13]. This means that the TDN requirement for the R1 and R2 has been fulfilled, while for the R3 did not.

3.3. Milk production

Milk production from this research was converted into one lactation period production using Yaap formula (1955). Data on milk production presented in Table 5.

Although the R1 numerically showed a higher milk production (4,036 L or 13.2 L/day) than the R2 and R3 (3,648 L or 12.0 L/day and 3,808 L or 12.5 L/day, respectively), these results did not statistically different. This shows that the provision of silage and fermented complete feed did not affect the production of the cows. However, since the R1 had higher DM, CP, and TDN intakes than the R2 and R3, this imply that the R2 and R3 were more efficient in nutrient utilization. Milk production in this research is in line with the production of FHC milk of [14] experiment that produced 3,847 L of milk in one lactation period.

3.4. Milk quality

Milk quality including density, fat, and solid non-fat (SNF) are listed in Table 6, levels of unsaturated fatty acids are listed in Table 7, monounsaturated fatty acids (MUFA) are listed in Table 8, while polyunsaturated fatty acids (PUFA) are listed in Table 9.

3.4.1. Milk density

The milk density among treatments was not significantly different (Table 6). The National Standards Agency (2011) stated that good quality milk has a minimum density value of 1.0270 [15]. The low milk density in this research indicated that milk produced by farmer's cows has a poor quality, which may be resulted from the low mineral content in feed.

3.4.2. Milk fat

Statistical analysis did not show any differences among treatments on the milk fat (Table 6). The National Standards Agency (2011) stated that the standard value of minimum milk fat content is 3.0% [15]. Milk fat content in this research was above the national standard value. This showed that all dietary treatments contained adequate crude fiber as substrate source of acetic acids, which is precursor of milk fat.

3.4.3. Milk solid non-fat

The solid non-fat (SNF) among dietary treatments was not significantly different (Table 6). One of the factors that may affects the SNF value of milk was the milk fat. Since the milk fat content among treatments was not different, thus the SNF also related. The greater milk fat content, the less SNF content in milk [16].

Table 7 showed that dietary treatments did not affect unsaturated fatty acids contents. Monounsaturated fatty acid (MUFA) ranged from 26.7 to 29.6%, while polyunsaturated fatty acid (PUFA) ranged from 2.83 to 3.60%. This data were is similar to previous study [17] that reported that MUFA in milk fatty acids ranged from 25 to 30% and PUFA was below 4%.

MUFA that consisted of palmitoleate, oleate, and eicosenoat in this research were lower (Table 8) than previously stated in [18] and there were no significant effects showed among treatments. In his report, [18] stated that the quality of MUFA is described by the oleic acids content which should be around 29.6% and palmitoleic acids at 1.80%, while [19] stated that oleic acid ranged 29.1 to 30.6%, and palmitoleic acid ranged 1.49 to 1.51%.

The PUFA content that consisted of linoleic, linolenic, eicosadienoate, eicosapentanoat, docosahexanoat, also was not affected by dietary treatments (Table 9). The linoleic acids ranged from 1.89 to 2.26% while linolenic acids ranged from 0.58 to 1.02%. The quality of PUFA was described by the linoleic acid content (2.10%) and linolenic acid (0.50%) [18]. In another study, [19] reported that linoleic and linolenic acids contents were at around 0.77 and 0.14%, respectively.

Table 6. Nutrient composition of milk from PFH dairy cow with different diet

Variable	Period	Diet (%)			Average
		R1	R2	R3	
Milk density	1	1.0220 ±0.003	1.0240±0.001	1.0250±0.003	1.0237±0.002
	2	1.0245±0.001	1.0230±0.000	1.0255±0.001	1.0243±0.001
	3	1.0245±0.002	1.0250±0.000	1.0220±0.004	1.0238±0.002
	Average	1.0237±0.001	1.0240±0.001	1.0242±0.002	1.0239±0.001
Milk fat	1	3.25±0.35	3.35±0.21	3.00±0.00	3.20±0.18
	2	3.85±0.07	3.65±0.07	3.50±0.14	3.67±0.18
	3	2.95±0.07	3.10±0.84	8.25±0.35	4.77±3.02
	Average	3.35±0.46	3.37±0.28	4.92±2.90	3.88±1.66
Milk SNF	1	7.70±0.33	7.80±0.01	7.86±0.64	7.79±0.82
	2	8.11±0.20	7.94±0.27	8.09±0.19	8.05±0.93
	3	8.27±0.17	9.70±6.70	6.16±1.44	8.05±1.78
	Average	8.03±0.30	8.50±1.06	7.37±1.06	7.96±0.90

4. CONCLUSION

Based on the stability of milk production and quality, the main purpose of preserving forage into silage was a success. The main purpose of fermented complete feed to conserve the feed was also achieved, although it did not improve feed quality. Thus, it can be concluded that conserving forage as silage, as well as conserving feed as fermented completed feed, can substitute some parts of fresh forage for Friesian Holstein Crossbred.

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Table 7. Unsaturated fatty acid (% fat) of milk from a dairy cow with different diet

Variable	Period	Diet			Average
		R1	R2	R3	
Monounsaturated fatty acid	1	31.0±1.00	32.3±0.38	31.2±1.20	31.5±0.69
	2	18.8±0.67	28.0±1.27	27.0±0.29	25.0±4.48
	3	29.2±0.41	29.1±0.43	28.6±0.44	29.0±0.29
	Average	26.7±6,00	29.8±2.22	29.0±2.19	28.5±3.65
Polyunsaturated fatty acid	1	2.23±0.01	3.55±0.03	3.20±0.23	3.01±0.69
	2	3.64±0.03	3.43±0.11	2.34±0.03	3.14±0.70
	3	2.99±0.03	3.81±0.09	2.88±0.03	3.23±0.51
	Average	2.95±0.71	3.60±0.19	2.83±0.46	3.13±0.56

Table 8. Monounsaturated fatty acid (% fat) of milk from a dairy cow with different diet

Variable	Period	Diet (%)			Average
		R1	R2	R3	
Palmitoleat	1	1.88±0.61	2.14±0.23	1.70±0.01	1.90±0.22
	2	1.71±0.20	2.07±0.28	1.98±0.21	1.92±0.18
	3	2.23±0.76	2.11±0.11	2.55±0.66	2.30±0.23
	Average	1.94±0.27	2.10±0.04	2.07±0.44	2.04±0.27
Oleat	1	28.3±2.09	29.9±0.88	28.9±2.99	29.0±0.82
	2	17.8±1.73	25.7±3.49	24.9±0.62	22.8±4.35
	3	26.7±0.39	26.7±1.16	25.9±0.58	26.5±0.46
	Average	24.4±5.60	27.4±2.20	26.6±2.10	26.1±3.50
Eicosenoat	1	0.79±0.31	0.23±0.02	0.62±0.61	0.55±0.29
	2	0.30±0.08	0.24±0.05	0.14±0.03	0.22±0.78
	3	0.28±0.07	0.24±0.01	0.19±008	0.24±0.05
	Average	0.46±0.29	0.23±0.10	0.32±0.26	0.33±0.22

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Table 9. Polyunsaturated fatty acid (% fat) of milk from dairy cow with different diet

Variable	Period	Diet (%)			Average
		R1	R2	R3	
Linoleat	1	1.91±0.04	2.04±0.01	2.26±0.39	2.07±0.17
	2	2.45±0.06	2.35±0.32	1.67±0.04	2.16±0.43
	3	1.94±0.08	2.38±0.26	1.76±0.79	2.02±0.32
	Average	2.09±0.30	2.26±0.20	1.89±0.32	2.08±0.29
Linolenat	1	0.10±0.00	1.19±0.12	0.62±0.73	0.64±0.55
	2	0.89±0.03	0.76±0.23	0.37±0.12	0.67±0.27
	3	0.68±0.02	1.10±0.00	0.79±0.08	0.85±0.22
	Average	0.58±0.41	1.02±0.23	0.59±0.21	0.72±0.34
Eicosadienoat	1	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
	2	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
	3	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
	Average	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
Eicosapentanoat	1	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
	2	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
	3	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
	Average	0.10±0.00	0.10±0.00	0.10±0.00	0.10±0.00
Docosahexanoat	1	0.11±0.00	0.12±0.01	0.18±0.01	0.14±0.04
	2	0.10±0.00	0.12±0.01	0.10±0.00	0.11±0.01
	3	0.17±0.07	0.13±00	0.13±0.04	0.14±0.02
	Average	0.13±0.04	0.12±0.01	0.14±0.00	0.13±0.03

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