Introduction of 16% crude protein concentrate and Ca-FA feed to increase milk production for dairy cows on smallholder farms in Bogor Regency

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Abstract. This study aimed to improve the quality of feed to increase milk production of dairy cows at smallholder farms in Bogor Regency. Treatment for feed quality improvement consisted of G1: 16% crude protein (CP) concentrate + calcium fatty acid (Ca-FA); G2: 16% CP concentrate + without Ca-FA; G3: 12–14% CP concentrate + Ca-FA; G4: 12–14% CP concentrate + without Ca-FA (as a control), respectively. Experimental feeding was carried out for 3 months. The results showed that feeding of 16% protein concentrate and Ca-FA had a significant effect (P<0.05) on milk production vs control (G1 = 13.76 L, G2 = 10.16 L, G3 = 16.29 L vs G4 = 7.67 L), increased consumption of dry matter, protein, fat, and feed energy, respectively. Ca-FA supplementation had a significant effect (P<0.05) on Ca and P consumption only in cows received G3. Feeding of 16% CP concentrate increased protein intake so that the ration protein content increased to G1 = 14.25%; G2 = 13.98% vs G3 = 12.87%; G4 = 12.37%. In the current study can be concluded that diet improvement through the feeding of 16% CP concentrate and Ca-FA increased milk production by the increased consumption of feed nutrients.

1. Introduction
Friesian Holstein (FH) is a breed of dairy cows that have high milk production in their home countries and many other developed countries. The research stated that the production of FH from low to high milk production is between 25.9–37.8 kg/day [1]. Another report on milk production of two genetic of FH in 10–20 weeks of lactation under seasonal pasture-based management treatment averaged 21.92 kg/day [2]. Milk production of FH in Indonesia is an average of 13–20 liters/head/day. Meanwhile, milk production of FH in the smallholder farms in West Java was 15.4 L; Central Java 12.99 L; Yogyakarta 12.38 L; and East Java 13.78 L, respectively [3]. This production was still below the genetic potential of FH because of the difference in conditions.

The performance of milk production depends on genetic and environmental factors including aspects of reproduction, feed, lactation period, and good farming practices. The productivity of dairy cows in the smallholder farmer is still low. The feeding management was done by feeding concentrates and fresh grass and agricultural by-products whose availability depends on the season. Based on observations on the smallholder dairy farms in Tajurhalang village, Cijeruk district, Bogor regency, feeding management is concentrate at 12–14% of CP and feed forage by natural grasses and a small amount of elephant grass.
The recommendation of livestock nutritionist is 16% CP of concentrate for lactating dairy cows for optimal milk production [4]. Lactating dairy cows in Indonesia are recommended to feed at 14 or 18% of CP content.

Besides, for protein requirements, energy is one of the main nutrients that must be met in lactating dairy cows, especially in the first trimester because the cow has a negative energy balance as well as negative calcium (Ca) status [5,6]. During this period there was an increase in milk production until the peak production was reached which required a high energy consumption for milk production. The increase in energy intake can be done by increased the energy density of feedthrough fat utilization, including fatty acids (FA) as an energy source which is twice as high as carbohydrate [7]. FA feeding will be used mainly for milk fat synthesis when the cow is on the negative energy balance (lack of energy) during early lactation and it will be used for body fat deposition and milk fat synthesis when the cow is in the positive energy balance [8]. A special strategy needs to be applied in fat utilization in the ration of not more than 5% so that the rumen fermentation takes place properly. Furthermore, cows with high milk production need a high supply of minerals, especially Ca avoid hypocalcemia or milk fever, in clinical or subclinical forms. Milk fever is most commonly found in dairy cows that have recently given birth with high milk production [6,9]. This disease is characterized by a decrease in blood Ca levels to less than 5 mg/dl in normal conditions 9–12 mg/dL [6]. Hypocalcemia 90% is found within 48 hours after giving birth.

Supplementation of FA as an energy source in form of calcium-fatty acid (Ca-FA) was not degraded in the rumen and could directly be utilized by the cow as a form of energy. Supplementation of Ca-FA might provide additional energy for lactating cows so the milk production could be well maintained [10]. This research aimed to improve the quality of feed through the introduction of feed with a concentrate of 16% CP and Ca-FA to increase the milk production of the smallholder dairy cows in Bogor regency.

2. Materials and methods

2.1. Materials

Fourteen FH cows in the lactating period of 1–3 (from 6 breeders with 1–3 cows per farmer) were used in a randomized block design and placed in a cage bound and provided feeder and drinking water for each pen. The research was conducted in Tajurhalang village, Cijeruk district, Bogor regency in the year 2018.

2.2. Procedures

Feeding was consisted of forage and concentrate and drinking water was given ad-libitum for 3 months during the study. Natural grasses and elephant grass were fed freshly. Treatment feed concentrate was containing 16% CP while regular concentrate containing 12–14% CP was fed as a control. Both of the concentrates are produced by the Bogor Dairy Farmers Cooperative (KPS). Ca-FA supplements were fed for one month before and one month after delivery (early lactation) as much as 100 g/day. Ca-FA supplements were produced by the Indonesian Research Institute of Animal Production (IRIAP) Ciawi-Bogor [10]. The composition of Ca-FA contains 95% fat; 4.5% Ca; 0.54% NaCl; and GE 7021.5 kcal/kg or the equivalent of 17 MJ/Kg, respectively. The completed treatment groups were as followed: G1: 16% CP concentrate + Ca-FA; G2: 16% CP concentrate + without Ca-FA; G3: 12–14% CP concentrate + Ca-FA; and G4: 12–14% CP concentrate + without Ca-FA (as a control), respectively.

The feed concentrate and forage were fed two times per day every morning (at 05.00 am) and the afternoon (at 02.00 pm) before milking. The feed concentrate and forage were weighed each time and the remaining feed was measured once a week. Feed consumption was calculated from the average feed minus the average remaining feed. The metabolizable energy (ME) value of feed was calculated based on the formula CSIRO [11], i.e., ME (MJ) concentrate = (0.128 × organic matter digestibility (OMD)) + (0.248 × Fat) + 1.06 and ME grass = (0.169 × OMD)–0.199. The weight of the cow was determined
using the Rondo measuring instrument, which is a tool for measuring chest circumference equipped with a bodyweight scale (kg).

Assessment of body condition score (BCS) used a scale of 1–5. Milking was done two times per day every morning and evening. Then, the milk production data were calculated as a total daily milk production (morning + afternoon milking) and measured by using a glass scale. Recording Temperature Humidity Index (THI) was conducted by measuring temperature and humidity using the AccuWeather application. The formula for estimating THI is: \( \text{THI} = 0.8 \times T + RH \times (T-14.4) + 46.4 \); Where: \( T = \) temperature; \( RH = \) relative humidity and THI = Temperature Humidity Index. The time for weather measurements for temperature and humidity was done at 06.00 am and 02.00 pm. Parameter data were analyzed with a general linear model using SAS [12]. The model for the observed parameters \( Y = \mu + Ai + Bj + Eij \), where \( \mu \), mean; \( Ai \), the effect of i-treatment; \( Bj \), j-th block effect; \( Eij \), error i-th attempt on block j.

3. Results and discussions

3.1. Environmental conditions

Average data of measurements of temperature, humidity, and THI at 06.00 am and 02.00 pm in September–December 2018 in the barn environment were 22.13±1.64°C; 83.27±9.25%, and 69.72±2.21, respectively. Based on THI value, the Tajurhalang area is classified as a suitable zone for raising dairy cows produced milk normally and supported well for the dairy cow business. Moran (2005) states that the ideal THI value for dairy cows is less than 72 [13]. These results illustrated that low THI has a positive impact on milk production. THI level affected milk production consists of 5 levels: (1) no stress at THI level <72; (2) mid stress at THI level >72–78; (3) severe stress at THI level 79–88; (4) very severe stress at THI levels 89–98; and (5) resulting in livestock mortality at THI levels 99–111 [14], respectively.

In Indonesia, the ambient temperature ranges from 24–34°C with a humidity of 60–90%. This condition was by high solar radiation and housing condition resulted that dairy cow has difficulties produced the best products such as FH which is raised in subtropical areas [15]. High temperatures reduced feed intake so that dairy cows reduced the production of digestive heat, while sweat and water intake increased. Besides, neither feed intake and milk production reduced nor a negative energy balance occurred during heat stress [16].

3.2. Body score condition

BCS is a widely recommended method for evaluating the nutritional management of dairy cows. BCS assessment is easier and simpler to do because it does not require a weighing device, however, expertise and experience are needed. In the current study, the BCS of the dairy cows did not differ (P>0.05) in all the treatment groups, but the bodyweight was different in all the treatment groups (P<0.05) (see table 1). The BCS value of the cows ranged from 2.94 to 3.10 (on a scale of 1–5) indicated that the conditions of all cows are uniform and relatively ideal for lactating dairy cows. According to the results of previous research [17], the average BCS value of lactation in the grade A group of cows indicates the ideal BCS is 3.10 ± 0.22. While the BCS value measured on a scale of 1–9, the higher BCS 7–8 produced the lower milk production, while in an ideal BCS scale 5–6 produces the production of milk is optimize [18]. Lactating cows with an ideal BCS value can produce more milk than lactating cows with too high or low BCS. There is a positive correlation between BCS and milk production of a lactating dairy cow. Through BCS, it can be estimated that the achievement of body fat reserves will affect reproductive efficiency, while the reproductive efficiency of lactating dairy cows will be affected by milk production [18].

The breed and feeding system influenced both BCS and body weight (BW) [19,20]. The BW of dairy cows ranged from 417.38–574.94 kg (see table 1). The highest BW was shown in cows that consumed G3 treatment followed by G1, G2, and G4, respectively. The BW of G1 and G2 treatments did not show any difference because the feeding of 16% CP concentrate had met energy needs where the high CP
Table 1. Effect of 16% CP concentrate and Ca-FA on the BW and BCS of the cow

| Treatment group | G1 | G2 | G3 | G4 |
|-----------------|----|----|----|----|
| Concentrate CP 16% | Yes | Yes | No | No |
| Ca-FA | Yes | No | Yes | No |
| ∑ Data | 27 | 85 | 17 | 60 |
| Body weight (kg) | 465.74<sup>b</sup> | 464.01<sup>b</sup> | 574.94<sup>a</sup> | 417.38<sup>c</sup> |
| BCS | 3.10<sup>a</sup> | 3.03<sup>a</sup> | 2.96<sup>a</sup> | 2.94<sup>a</sup> |

G1: 16% CP concentrate + Ca-FA; G2: 16% CP concentrate + without Ca-FA; G3: 12–14% CP concentrate + Ca-FA; G4: 12–14% CP concentrate + without Ca-FA (control). abValues with a different superscript in the same row show significant differences (P<0.05).

The concentrate was composed of materials with high energy sources as well as 16% CP concentrate contained ME 11.5 MJ/kg. The added energy from Ca-FA to G1 treatment was not different from G2. However, when feeding with the regular concentrate CP 12–14% (G3 vs G4), feed additional energy sources from Ca-FA (in G3) showed an increase significantly in BW. The report stated that the energy value of FA was two times higher than carbohydrates [7]. The FA from Ca-FA was not degraded in the rumen and this would directly be utilized by the livestock as a form of energy [10].

3.3. Milk production

Milk production showed that feed treatment has a significant effect (P<0.05) on daily milk production (see figure 1). G3 treatment produced the highest milk production compared to G1, G2, and G4, respectively. Treatment of G1 vs G2 showed the effect of Ca-FA on the increase in milk production by 35.4% at giving 16% CP concentrate, while the G3 vs G4 treatment showed a very real role for Ca-FA in increasing milk production by 112.4% even though only with giving of 12–14% CP concentrate. The treatment of G2 vs G4 showed an increase in milk production by 24.5% by only giving concentrate 16% CP. Thus, feeding Ca-FA as an energy-dense supplement has a greater effect on milk production than the increase in concentrated content from CP 12–14% to CP 16%.

The results in this study are consistent with previous reports that feeding concentrate with CP 12, 13, and 15% resulted in milk production of 11.45, 12.42, and 12.65 L, respectively; compared to the control diet containing CP12% only resulted in milk production of 9.3 L. Thus the difference in protein concentrate content can increase milk production by 18% in Sleman Yogyakarta [22]. The average daily milk production for FH in West Java was 13.93±3.23 kg/head/day with a range between 8.17–25.25 kg [23] and 13.78±4.46 liters/head/day [3]. The differences in milk production resulted from differences in management and feeding system.

Additional energy sources are commonly provided to increase energy intake in high-production dairy cows, such as vegetable oils, fatty acids, and Ca-FA. In this study, feeding Ca-FA was able to increase energy intake, as the contribution of energy from fatty acids was twice that of the energy from cereals [21]. Ca-FA supplementation increased milk production by 7.41% and prevented a decrease in production during the lactation period compared to treatment without Ca-FA [10].
3.4. Nutrient consumption

Dairy cows get nutrient intake mainly from forage grass and concentrate feed. Substitution of concentrate feed with increased protein content from 12–14% to 16% and feeding of Ca-FA aims to meet the protein and energy needs of lactating cows and stimulate cows to consume more forage to increase production and higher nutritional value composition of milk. Feeding with adequate nutrients also prevents the occurrence of hypocalcemia in lactating cows post-partum. The concentrate and Ca-FA treatment had a significant effect (P<0.05) on the consumption of DM, CP, fat, energy, Ca, and P (see table 2).

Consumption of DM, CP, and fat in cows that receive G1 is not more than cows that receive G3. This increase in consumption showed that Ca-FA supplementation has no significant effect (P>0.05) on the fermentation process by microbes in the rumen as indicated by increased consumption of DM, CP, and fat. Meanwhile, cows that received G2 showed more consumption than G4 (P<0.05), indicating that feeding of 16% CP concentrate increased their consumption of DM, CP, and fat. Supplementation protected fat did not harm the rumen environment so that the process of fermentative digestion in the rumen could take place normally [21].

Cows that received Ca-FA supplements (G1 and G3) showed higher consumption of Ca and P than cows that did not receive Ca-FA supplements (G2 and G3). Feeding supplements of Ca-FA can increase energy intake and Ca mineral to support milk production and prevent hypocalcemia. Most of the cases of hypocalcemia are caused by a lack of feeding management [9].

![Figure 1](attachment:image.png)

**Figure 1.** Daily milk production of dairy cattle consumed four treatment groups. G1: 16% CP concentrate + Ca-FA; G2: 16% CP concentrate + without Ca-FA; G3: 12–14% CP concentrate + Ca-FA; G4: 12–14% CP concentrate + without Ca-FA (control). abc Values with different superscript showed significant differences (P<0.05).
Table 2. Effect of CP 16% concentrate and Ca-FA on nutrient consumption

| Treatment Group | G1  | G2  | G3  | G4  |
|-----------------|-----|-----|-----|-----|
| Ca-FA           | Yes | No  | Yes | No  |
| Concentrate CP 16% | Yes | Yes | No  | No  |
| ∑Data           | 42  | 153 | 31  | 89  |
| DM consumption (kg) | 18.15<sup>b</sup> | 17.48<sup>c</sup> | 21.13<sup>a</sup> | 15.74<sup>d</sup> |
| CP consumption (kg) | 2.58<sup>b</sup> | 2.44<sup>c</sup> | 2.71<sup>a</sup> | 1.95<sup>d</sup> |
| Fat consumption (kg) | 0.70<sup>b</sup> | 0.67<sup>c</sup> | 0.77<sup>a</sup> | 0.61<sup>d</sup> |
| ME consumption (MJ/day) | 154.91<sup>b</sup> | 154.60<sup>b</sup> | 172.87<sup>a</sup> | 136.94<sup>d</sup> |
| Ca consumption (g) | 174.07<sup>b</sup> | 170.75<sup>b</sup> | 218.61<sup>a</sup> | 166.13<sup>b</sup> |
| P consumption (g) | 30.26<sup>c</sup> | 28.94<sup>c</sup> | 41.22<sup>a</sup> | 37.86<sup>b</sup> |
| DM (%BW) | 4.16<sup>a</sup> | 3.78<sup>b</sup> | 3.69<sup>b</sup> | 3.58<sup>b</sup> |
| CP/DM (%) | 14.25<sup>a</sup> | 13.98<sup>b</sup> | 12.87<sup>c</sup> | 12.37<sup>d</sup> |

ME calculated based on CSIRO (2007)
Values with a different superscript in the same row showed significant differences (P<0.05).

DM consumption was positively related to BW of cows, where the highest DM consumption was showed by G3 with the highest BW (see table 1). However, in the percentage of the DM/BW value was smaller due to the large BW value (see table 2). Treatment G1 showed the most palatable ration as indicated by the highest amount of DM consumption to BW compared to others (G1 = 4.16% vs G2 = 3.78%; G3 = 3.69%; G4 = 3.58%). Feeding of 16% CP concentrate increased protein intake so that the ration protein content increased (G1 = 14.25%; G2 = 13.98% vs G3 = 12.87%; G4 = 12.37%).

4. Conclusions
Feeding 16% of CP concentrate can increase protein levels in DM intake by an average of 11.8%. Supplementation of Ca-FA for lactating dairy cows as energy-dense feed had a good effect on milk production. Feed quality improvement through feeding of 16% CP concentrate and Ca-FA increase milk production by increasing nutrient consumption.

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