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Research Article

Introduction of Complete Ration Silage to Substitute the Conventional Ration at Traditional Dairy Farms in Lembang

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Abstract

Background and Objective: Unsustainable forage supply is one of the limiting factors when providing sufficient nutrients for dairy cattle. Although silage technology has been available for years, their utilization in the traditional dairy farming community of Koperasi Peternak Susu Bandung Utara (KPSBU) Lembang has not been popular. An experiment was conducted to evaluate the impact of collectively made Complete Ration Silage (CRS) to substitute the current ration used by the farmers. **Materials and Methods:** Three types of rations (R0, R1 and R2) were tested to substitute 0, 20 and 40% of the conventional ration. This experiment used 12 Friesian Holstein cows with initial conditions of 463.28±42.18 kg b.wt., 20±3.27 L daily milk and 1-3 lactation cycle(s) and 3.5±1.6 months in milk. The cows were grouped according to their initial body weight before being assigned to the treatments. The parameters observed in this experiment included the physical and fermentative characteristics of the CRS, nutrient contents, fermentability, digestibility and the intake of the rations. The impact that the rations had on the performances of the cows were observed in terms of manure score, milk production and quality, body weight gain, body condition score and technical and economical feed efficiencies. **Results:** The results showed that R2 produced significantly higher values ($p<0.05$) in fermentability, manure score and milk production compared to those produced by R0 and R1. There were no significant differences in feed intake, digestibility, milk production, BCS and feed efficiencies. **Conclusion:** It can be concluded that the substitution up to 40% of the conventional ration with CRS can be done to sustain a supply of high-quality nutrients for dairy cows kept by traditional farmer and will improve the competitive technical and economical efficiencies and have a positive impact on the dairy cows' performance.

Key words: Completed ration silage, conventional ration, digestibility, feed efficiency, milk production

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Over the last decade, the Indonesian national milk demand has increased in line with the increasing population and awareness of food quality intake, focusing especially on the sufficiency of protein. The dairy cattle population, which produces milk, has an important role in national food security. The DGLS[1] reported an increased demand in milk from 0.88 million tons in 2001 to 2.4 million tons in 2009. However, the increase was not supported by the ability of local production to supply the milk. Furthermore, DGLS[1] reported that the contribution of the domestic supply was 25-30%. One of the reasons for the low domestic milk contribution was that the low milk production was due to a lack of quality, quantity and continuity of high quality fresh forage during the drought season. This condition led to an insufficiency of nutrients in dairy cattle[2].

The silage technique has been known for its capability to conserve forage and prevent the loss of nutrient. This technique conserved forage at certain concentrations of moisture due to the fermentative activity of lactic acid bacteria, which could produce lactic acid and conserve the forage anaerobically in a silo[3]. This technique can be used by traditional dairy farmers to overcome the shortage of forage and provide sustainable, high-quality forages.

Despal *et al.*[2] reported that tropical forages contained high moisture and low Water Soluble Carbohydrate (WSC) content, which made the forage less suitable for ensiling. The addition of an absorbent agent and WSC source such as concentrate prior to ensiling will improve the fermentation characteristics of the silage produced. Many efforts have been attempted to improve tropical forage silage quality such as those of Despal *et al.*[4], Ramli *et al.*[5] and Zahera *et al.*[6] These studies produced relatively higher quality ramie leaves by adding several types of concentrates, produced silage based on vegetable waste by adding formulated concentrate and produced corn silage by adding a limited amount of concentrate. If the concentrate used in ensiling were formulated to match the dairy cattle requirement, then complete feed silage can be produced.

The application of the silage technique among traditional dairy farmers in Indonesia is still limited due to the lack of equipment, space for the production and storage of silage, time, workers and knowledge of formulating feed as to match the requirements[2]. An effort to overcome these problems has been initiated by the KPSBU cooperative by making silage collectively. This effort used equipment and a large trench silo that was owned by the cooperative and distributed the silage to the farmers when needed. Large-scale silage production increased production efficiency[7]. Moreover, the cooperative can help farmers to formulate the rations needed by the farmer.

Although many studies have shown that complete feed silage can be used as the only daily feed for dairy cattle, it is not typically used in traditional dairy farming. Moreover, the collection of natural grass and the harvesting of cultivated forage are still considered the competitive advantages of traditional dairy farming over commercial farming, when aiming to reduce the feed cost. Therefore, the application of complete feed silage in traditional dairy farming is suggested only until the level at which it can provide advantages and overcome the lack of nutrients, especially during the shortage periods. Lestari *et al.*[8], Zahera *et al.*[6] and Nugroho *et al.*[9] tested the utilization of complete feed silage to substitute conventional rations that are used by traditional farmers in the KPSBU demo farm. The results will be introduced to the members adjacent to the farm through active research.

The objectives of this research were to introduce complete feed silage to KPSBU members, to compare the impact of complete feed silage utilization and to find the best level of its utilization to achieve the best dairy cattle performance and farming income.

MATERIALS AND METHODS

Experimental site: The experiment was conducted at the KPSBU member farms located in Cisaroni Village-Lembang, West Bandung Regency, West Java Province of Indonesia. It is located at 6°80'48.67'' S latitude, 107°61'23.74'' E longitude and 1285 m altitude. The site is characterized by a warm-humid tropical climate with an average 20°C annual air temperature (max 26.5°C and min 14.2°C), relative humidity (77%) and annual rainfall (3047 mm). Laboratory work was conducted at Bogor Agricultural University Campus, Bogor.

Experimental animals: Twelve Friesian Holstein (FH) lactating cows with the initial conditions of 463.28±42.18 kg b.wt., 20±3.27 L daily milk and 1-3 lactation cycles, 3.5±1.6 months in milk were divided into 4 groups based on their initial body weight. Within each group, the treatments were assigned randomly (randomized block design). The cows were kept in individual stalls equipped with a feed bank and drinking bowl to facilitate individual feeding. Before the experiment, the stalls were cleaned with water and disinfected. The cows were treated for any internal parasites with the application of anti-parasite albendazole (from PT Tekad

Mandiri Citra, Indonesia) dosed at 25 g/400 kg b.wt., orally. The cows were washed with water and the teat was dipped with povidone iodine (Intercide from PT Tekad Mandiri Citra, Indonesia).

Silage production: The silage was made with 4 main ingredients: maize, concentrate, molasses and starter. The maize was purchased from the Saguling maize plantation. The concentrate was produced by the cooperative (mako) and molasses were purchased from the cooperative feed mill. Lactobacillus-mix starter (SBP) was purchased from CV. Agro Indo Utama, Yogyakarta. Silage ingredient compositions were calculated based on the average requirement of the cows that were used in this experiment. Maize plants were harvested at 90 days. The leaves, stems and cobs were chopped into 2 cm pieces using a locally made chopper machine (CV Pusaka Jaya Putera, Pangalengan, West-Java, Indonesia) that was equipped with a 24 HP Honda motor. The amount of 7431.01 kg chopped maize, 494.16 kg concentrate, 74.31 kg molasses and 0.52 kg starter were weighed and prepared to make 8 tons of complete feed silage. The silage was made in a 9 t capacity $2\times2\times2$ m^3 concrete silo. Compacting was done manually. The silo was covered with blue polyethylene (0.4 mm thick, 3 m wide and 5 m length) and held down by reused tyres. The silo was opened for sampling and feedout with a daily rate of 40-50 cm.

Silage quality evaluation: Silage qualities were measured according to the physical, chemical and fermentative characteristics of the silage. Physical characteristics were evaluated by 3 trained panelists who observed the color, odor, texture, moisture and spoilage of the silage. Chemical characteristics were evaluated by sending a silage sample to the laboratory for proximate analysis to measure Dry Matter (DM), ash, fat, Crude Protein (CP), Crude Fiber (CF) and Nitrogen Free Extract (NFE) was calculated by difference, while TDN was calculated with the Sutardi[10] formula; TDN (%) = 25.6+0.53CP+1.70 fat-0.474CF+0.732 NFE for CF<18% and CP>20%, TDN (%) = 70.6+0.259 CP+1.01 fat-0.76 CF+0.0991 NFE for CF>18% and CP<20%.

Fermentative characteristics were examined with the pH value, ammonia (NH_3) and Volatile Fatty Acids (VFA) concentrations in the supernatant generated from 10 g silage dissolved in 100 mL of distilled water. The pH values were determined using a pH meter (The Hanna Instruments HI98107 pHep® pH tester, Hanna Instrument, Rhode Island, USA) and according to the Naumann and Bassler[11] procedure. The NH_3 concentration was analyzed with Conway methods and VFA was analyzed using steam distillation methods[12]. The Water Soluble Carbohydrate (WSC) content was analyzed using the phenol method as described by Singleton and Rossi[13]. The Fleigh Number (FN) of the silage was calculated according to Idikut *et al.*[14] following the formula; FN = 220+(2×% DM-15)-(40×pH). The silage was determined to be excellent (NF>85), very good (60-80), good (40-60), fair (20-40) or poor (<20).

Experimental diets: Diets were formulated to fulfill requirements of the dairy cows (463.28±42.18 kg b.wt., 20±3.27 L daily milk and 1-3 lactation cycles) that were used in this experiment according to NRC[15]. Ingredients used in the experimental diets consisted of complete feed maize-based silage, napier grass, natural grass, concentrate and cassava waste. Three types of rations were formulated as treatments to fulfill the requirements of the cows that were used. The rations were R0 (control ration that was currently used by the farmers), R1 (ration that contained 20% complete feed silage) and R2 (ration that contained 40% complete feed silage). The composition of each ration and its nutrient contents are shown in Table 1.

Table 1: Ration composition and nutrient contents

Ingredients	R0	R1	R2
	(%)		
Concentrate	58.00	50.00	43.00
Elephant grass	13.00	19.00	11.50
Cassava waste	22.00	5.00	2.50
Corn silage	0.00	20.00	40.00
Natural grass	7.00	6.00	3.00
Total	100.00	100.00	100.00
Nutrient composition			
Dry matter (%)	56.73	52.78	50.91
Crude protein (% DM)	11.70	12.70	12.78
Crude fat (% DM)	2.46	2.65	2.83
Crude fiber (% DM)	15.13	17.38	18.06
NFE (% DM)	56.39	53.78	56.33
TDN (%)	65.82	64.95	66.45

R0: Current ration, R1, R2: Rations contained 20 and 40% complete feed silage

Feeding trials: The initial body weight of each cow was measured to estimate the amount of feed offered. The amount of DM feeds offered was 3.5% of body weight and was distributed into three feeding times. Water was provided *ad libitum*. The cows were fed at 7 AM, 12 PM and 5 PM for 35 days during the preliminary phase and 7 days during the collecting period. Complete feed silage was given after concentrate feeding but before fresh forage. Data were collected during the collecting period. During the collecting period, the amount of feed offered and the residue were recorded and sampled to calculate feed and nutrient intake. Measurements were conducted using balances (Satler Brecknell 235-6S mechanical suspended weigher with 50 kg capacity, 200 g readability, Germany) and PA2201 analytical balances (2200 g capacity, 100 mg readability, China). Two kilogram of each napier and natural grass samples were collected, dried in an oven at 60 °C (Swallow Lte. Scientific Ltf Serial No. K11755, England) for 48 h and then ground for filtering through a 1 mm screen. Samples were then stored before being sent to the laboratory for proximate composition analysis.

Ration fermentability and digestibility: The fermentability and digestibility of the rations were assessed using one and two stage in vitro methods[16]. The fermentability of organic matter to form VFA and of protein to form NH_3 were measured in the supernatant after 4 h of *anaerobic* incubation: 0.5 g grounded sample was mixed with 10 mL of rumen liquor and 40 mL of buffer[17] in a 100 mL glass tube and placed in a 39°C water-filled shaker bath. The VFA concentration in the supernatant was quantified using the steam distillation method and NH_3 was quantified using the Conway method[12]. The digestibility of DM and Organic Matter (OM) were assessed with the same procedure as with fermentability. However, the *anaerobic* incubation was extended to 48 h before it was stopped by the addition of 2 drops of saturated $HgCl_2$ and the solution was transferred into a 50 mL centrifuge tube. The incubated sample was centrifuged at 4000 rpm for 14 min to separate feed residue from supernatant. The residue was then returned to a 100 mL glass tube. Fifty milliliters of 15% HCl-pepsin solution was added and incubated in a water-filled shaker bath aerobically for 48 h. The feed residues, after the fermentative and enzymatic digestion, were separated from the supernatant by the filtration method, which used Whatman filter paper No. 41 with the help of a vacuum pump. The filter and residue were dried in an oven at 105°C for 24 h for DM determination and in a furnace at 600°C for 6 h for ash determination. The digestibility of DM and OM were calculated by subtracting the amount of DM and OM in the residue from the sample.

Performance measurements: The performance of dairy cows fed with Complete Ration Silage (CRS) was observed as the short, medium and long-term impacts. The short-term impact was observed from manure evaluation. The medium-term impact was observed from milk production and components. The long-term impact was observed from body weight changes and body condition scores. Manure was evaluated by washing manure, scoring manure and observing manure color[18]. Washing manure was done by washing a cup of fresh manure through a 6-8 square inch screen with a stream of cold water for 30 min. The remaining feces were observed in order to assess whether the feed digestion was optimal. Scoring manure was done using the Michigan Scoring System (MSS), which scored manure according to its consistency. The system produced a 1-5 score: 1 was given to samples with a very liquid consistency, 2 for runny, 3 for optimal, 4 for thicker and 5 for firm fecal balls. Manure color indicated the correct proportion of forage to concentrate used and the rate of bile and passage. Manure color could also detect hemorrhage problems that might have occurred in the small intestine or rectum.

Milk production was measured twice a day for 7 days at 4 AM and 3 PM after the 35 day preliminary phase using a volumetric measuring jug capacity 2 L, readability 100 mL from PT Gesunde Medicalindo Persada (GM-SL013-2L). A 50 mL sample of each measurement was taken for milk component analysis. Analysis was conducted using the lactoscan milk analyzer type SL from Milkotronic Ltd, Bulgaria to analyze the fat (FAT), non-fat solids (SNF), proteins, lactose and water content percentages, temperature (°C), freezing point, salts and density of milk.

Body Weight (BW) at the beginning and at the end of the experiment was estimated from Heart Girth (HG) by using the formula; BW (kg) = 4.277 HG-393.13 described by Lukuyu *et al.*[19]. The cow body was scored by examining and palpating the fat storage at the backbone, loin and rump areas using a scale of 1-5 with increments of 0.25; a score of 1 was for a cow that was too slim and 5 for an overweight cow[20].

Technical and economic efficiency: Technical Efficiency (TE) of feeds used in dairy cows was calculated according to the Linn[21] formula; TE = Milk production (kg)/DM feed intake (kg). Economic Efficiency (EE) was calculated according to the Casper and Mertens[22] formula; EE = Feed cost (Rp)/revenue from milk (Rp).

Experimental design and data analysis: Randomized block design was used in this experiment. The feeding trial used the initial body weight as the block, whereas the fermentability and digestibility trial used the rumen liquor source as the block. The experiment tested the 3 levels of complete feed silage that was used to substitute the conventional ration of dairy farming, namely, R0, R1 and R2 for 0, 20 and 40% rate of substitutions, respectively. Each treatment was repeated four times. The mathematical model of the design was $Y_{ij} = m+a_i+b_j+e_{ij}$, where Y_{ij} is the observation value at treatment-i and block-j, m is the overall mean, a_i is the effect of ration-i, b_j is the effect of block-j and e_{ij} is the error of treatment-i and block-j. The different responses of the treatments with the probability ($p<0.05$) were tested using one way analysis of variance except for milk production, which used analysis of covariance. Significant differences between treatments were further tested for orthogonal contrast using the statistical package software SPSS version 20 from the IBM corporation[23].

Table 2: Quality of corn silage

Parameters	Values
Physical	
Color	+++++
Odor	Slightly sour
Texture	+++++
Moisture	+++++
Mold (%)	1.65
Chemical	
Dry matter (%)	28.231
Ash (%)	7.16
Crude fat (%)	2.84
Crude protein (%)	8.29
Crude fiber (%)	24.01
Beta-N (%)	57.69
TDN (%)	63.09
Fermentative	
PH	3.8
WSC (%)	4
Value of fleigh (FN)	109.46

+: Poor, ++: Fair, +++: Good, ++++ : Very good, +++++: Excellent

RESULTS AND DISCUSSION

Complete feed silage quality: The quality of silage produced in this experiment is shown in Table 2. The silage has good physical characteristics as shown by its color, odor, texture, moisture and spoilage. The color of the silage is very similar to the mixture of its ingredients prior to ensiling. Despal *et al.*[7] explained that a good silage quality is colored similarly to the pre-ensiling condition. The dark color produced after ensiling inferred low silage quality. The odor produced by the silage was like fresh lactic acid. Lactic acid was produced by the work of lactic acid bacteria (LAB) during ensiling. Bad odor silage smelled like butyric acid or ammonia. The ammonia odor was produced from the degradation of proteins, whereas butyric acid was produced from the activity of *Clostridium tyrobutyricum* (butyric acid bacteria), which was usually associated with anaerobically unstable silages. The bacteria were capable of converting lactic acid into butyric acid[24]. As the butyric acid concentration in silage increases, the quality of the silage decreases[25]. The silage texture was good and had no difference from its ingredients. Bacterial spores were not found in the silage. The amount of mold found in the silage was insignificant (1.65%). Despal *et al.*[7] explained that mold found at the top of silage during feedout could reach up to 10%. Mahlkow and Thaysen[26] found 11.8% stability losses of maize silage. The mold found in this experiment was mostly located at the top of the trench during the aerobic feed-out phase. Mold is usually found in silage due to failure in maintaining anaerobic conditions. Forristal and O'Kiely[27] reported that the major molds found in silage were *Penicillium*, *Aspergillus*, *Mucor*, *Rhizopus*, *Geotrichum* and *Byssochlamys*. The mold growth caused not only the deterioration of the nutritive value of the silage but also produced direct spores and mycotoxins sources that might cause health concerns to animals.

The chemical compositions of the silage are shown in Table 2. The chemical composition of the produced silage depended on the material or ingredients used to make the silage. The DM produced by silage was 28.231% which indicated a medium quality of silage. The DM in silage produced in this experiment was lower compared to the 33.8% found by Moorby *et al.*[28]. Compared to the initial DM content of the material used (32.5%), it showed that 13.07% of the DM material was degraded during the ensiling process. The DM degradation rate found in this experiment was higher than the 6.11% rate found by Despal *et al.*[4] on ramie silage supplemented with cassava waste on the laboratory scale and the 7.5% rate found by Mahlkow and Thaysen[26] on large-scale maize silage with tractor compaction. The high DM degradation rate found in this experiment was due to large scale silage production with manual compaction. Manual compaction left more air in the silo in comparison to tractor compaction, which led to extensive microbial activity that degraded the organic material in the silo. Using the milk yield equation based on the maize silage dry matter (MDM) from Keady[29]: $MY (kg) = 21.86+0.0408\ MDM-0.0000615\ MDM^2$, the best maize silage DM was 33.17%. The 28.231% DM silage produced in this experiment is estimated to have produced 23.06 kg daily milk.

The CP content of the silage produced was 8.29%, lower compared to the 10.7% reported by Moorby *et al.*[28]. Compared to the initial 8.99% CP content of the material used, it was found that the degradation of CP during the ensiling process was 7.83%. The degradation rate found in this experiment was lower than the 16.96% rate reported by Despal *et al*.[4]. The relatively lower CP degradation rate in this experiment was caused by the low CP content of the material used, the addition of concentrate and the inoculant, which increased the rate of lactic acid formation in the silo and limited the growth of yeast[30].

The CF content of the silage produced in this experiment was 24.01%. This value was higher than the 21% found by Umiyasih and Wina[31] due to the stages of the maize used (dough-dents stages). According to Tarigan *et al*.[32], the protein and carbohydrate contents of the plants at this stage are low and the fiber content is high.

According to Despal *et al*.[7], the cows used in this experiment, with initial conditions of 463.28±42.18 kg b.wt., 20±3.27 L daily milk and 1-3 lactation cycle, 3.5±1.6 months in milk, required 15.52 kg DM daily with 66.5 and 14.1% of TDN and CP contents, respectively. The TDN and CP content of the silage produced showed that the silage cannot be used to satisfy the cows' nutritional requirement and should thus be combined with other ingredients because the target in this experiment only introduced up to 40%.

According to Idikut *et al*.[14], the silage produced in this experiment was categorized as excellent with the NF 109. The high NF was supported by the low pH value of the silage (3.8), similar to what was reported by Kondo *et al*.[33] on maize silage. Low WSC (4%) residue in the silage showed that the WSC content was converted by lactic acid bacteria to produce acid and to lower the silage pH value.

Inclusion of the silage in dairy cow ration

Ration intake: The intake of rations in this experiment is shown in Table 3. There were no significant differences in total Dry Matter Intake (DMI) between the rations. However, the inclusion of silage in the rations improved the ratio of forage to concentrate DMI from 20:80-25:75. The ratio of forage:concentrate found in this research was lower than normal. According to Musnandar[34], the ideal forage to concentrate ratio was 50:50. However, in small breeds of cows (460 kg BW) and to obtain high milk production (20 L), the ideal ratio was difficult to achieve if the farmer used only low-quality forage such as tropical grass. A daily milk production of up to 17 L could be maintained with a 50:50 forage:concentrate ratio[8]. Greater milk production required a relatively higher density of nutrients in the ration. Therefore, increasing the concentrate used in a ration is one strategy to achieve this goal. The shift from a high forage to a high concentrate diet linearly increased the DMI, NE_L intake, C18:2n-6 intake and milk yield and decreased milk fat content, as reported by Sterk *et al*.[35]. However, an 80% intake of concentrate in R0 is unacceptable because it will increase the risk of metabolic disorder[34]. The low forage:concentrate intake ratio in this experiment was due to the quality and quantity of forage. Providing small amounts of late mature napier grass dominated by stems led to the low intake of forage.

Total DM intake was related to the cows' nutritional requirements, which was related to BW, milk production, age and physiological statues[2]. As mentioned above, the cows used in this experiment, with initial conditions of 463.28±42.18 kg b.wt., 20±3.27 L daily milk and 1-3 lactation cycle(s) and 3.5±1.6 milk months, required 15.52 kg DMI or 3.35% BW[14]. The total of DMI intake (% BW) measured in this experiment (3.47% for R0, 3.11% for R1 and 3.3% for R2) were sufficient to fulfill the nutrient requirements, except for R1. In R1, the ration intake was sufficient to support only for maintenance and production but was not sufficient to support cattle growth (Table 3, 4).

Ration fermentability and digestibility: The fermentability and digestibility of the ration are shown in Table 3. Volatile Fatty Acid (VFA), as the product of organic matter degradation and ammonia (NH_3), as the product of protein degradation in rumen, demonstrated that all of the rations used in this experiment could be categorized as fermentable rations that could produce the VFA and NH_3 needed for optimal microbial growth[36]. The R1 and R2 were significantly more fermentable compared to R0 due to the inclusion of silage in the ration[2]. The inclusion of corn silage in the ration increased the

Table 3: Feed intake, fermentability and digestibility

Parameters	R0	R1	R2
DMI of forages (kg head^{-1} day^{-1})	3.13±0.47	3.68±0.65	3.84±0.83
DMI of concentrate (kg head^{-1} day^{-1})	12.38±0.22	11.00±2.51	11.31±0.87
DMI of forage:concentrate ratio	20:80	25:75	25:75
DMI of ration (kg head^{-1} day^{-1})	15.51±0.54	14.68±2.74	15.15±0.88
DMI (% BW)	3.53±0.10	3.17±0.92	3.3±0.51
VFA (mM)	115.71±19.04^c	127.31±25.79^b	143.13±22.60^a
NH_3 (mM)	8.99±1.12^b	10.47±1.36^a	11.06±1.74^a
DMD (%)	71.40±2.56	71.78±2.42	72.13±3.80
OMD (%)	71.56±3.05	71.85±3.70	72.93±5.48

R0: Current ration, R1, R2: Rations contained 20 and 40% complete feed silage, means in the same line with different superscript differ significantly ($p<0.05$)

fermentability of the ration in the rumen by providing more soluble carbohydrate and providing more energy sources, such as VFA, for growth of microorganism[37].

Additionally, McDonald *et al.*[36] explained that type of feed used by animals could influence VFA production in the rumen. The values of VFA found in this experiment were higher than those found by Lestari *et al.*[8], with VFA values ranging from 91.64-118.69 mM. However, the VFA values in this experiment were lower than those found by Despal *et al.*[4] on ramie leaves silage (127-164 mM).

The concentration of NH_3 in the rumen depended on the amount of protein degraded, the rumen pH value and the length of the fermentation process[38]. The concentration of rumen NH_3 found in this experiment was significantly influenced by the type of rations. Similar to VFA production, the NH_3 concentration also increased in the silage which contained rations. The relatively lower NH_3 concentration in R0 was due to the difficulties of the rumen's microbial community with degrading protein in the ration. Other factors, such as protein content and type of feeds, also influenced NH_3 production in the rumen[4,39]. According to McDonald *et al.*[36], all rations used in this experiment produced NH_3 in the optimal range (6-21 mM) for microbial protein synthesis and the NH_3 values were not lower than 4.86 mM[40].

The statistical analysis of digestibility data showed that there were no significant differences among the treatments. The digestibility values found in this experiment were higher than those found by Despal *et al.*[41] but lower than those found by Zahera *et al.*[6]. According to Jayanegara *et al.*[42], the digestibility of organic matter was influenced by the crude protein content in the ration. The crude protein content in the ration influenced both the rumen microbial growth and their ability to digest organic material in the ration. A relatively higher amount of CP in rations (R1 and R2) tended to produce a relatively higher, although statistically insignificant, organic matter digestibility.

Manure score: The scores of cattle manure after feeding different levels of silage are shown in Table 4. Increasing levels of silage in the ration improve manure score from 2.63-2.88, which is closer to the ideal score (3) of manure. An improved manure score was due to the increasing proportion of forage, which led to the increase in CF content in the ration. In contrast, the manure score in R0 declined from 2.63-2.42 (point scale 1-5 basis). The relatively low feces score in R0 resulted from the high proportion of concentrate used in the ration to fulfill the high nutrient requirement of a lactating cow. The high-producing cows used in this experiment required a high nutrient intake[15]. The utilization of low-density nutrient forage, such as napier grass, as a basal diet implied the common use of highly dense feed sources such as concentrate, which contained low fiber contents. According to Wells[18], the utilization of high-density nutrient in ration produced low manure scores.

Milk production and quality: Milk production was influenced by the dry matter and nutrient intake. Milk production and component from cows fed with different rations are shown in Table 4. There are no significant differences in milk production and components between the rations used

Table 4: Dairy cow performances fed with different level of corn silage ration

Parameters	R0	R1	R2
Manure score			
Before	2.63±0.24	2.44±0.43	2.63±0.32
After	2.42 ± 0.25^{b}	2.60 ± 0.36^{ab}	2.88 ± 0.14^{a}
Milk production (L day^{-1})			
Before	21.87±0.63	20.64±0.34	17.48±0.51
After	22.04±0.64	20.94±0.80	19.34±0.49
Δ of milk production	0.18 ± 1.29^{b}	0.37 ± 0.56^{b}	1.91 ± 1.73^{a}
Milk components			
Fat	3.40±1.20	3.65±1.07	4.00±0.84
SNF	7.55±0.26	7.97±0.09	8.13±0.31
Lactose	4.17±0.16	4.40±0.06	4.48±0.17
Protein	2.79±0.11	2.95±0.05	3.00±0.11
Salt	0.62±0.03	0.65±0.01	0.67±0.02
Body weight (kg)			
Before	447.35±7.33	475.46±55.71	467.04±62.29
After	464.99±10.80	478.50±52.62	495.73±57.14
Daily gain	0.50 ± 0.16^{ab}	0.09 ± 0.20^{b}	0.82 ± 0.34^{a}
Body condition score			
Before	2.69±0.24	2.44±0.43	2.63±0.32
After	2.81±0.13	2.56±0.38	2.88±0.25

R0: Current ration, R1, R2: Rations contained 20 and 40% complete feed silage; means in the same line with different superscript differ significantly ($p<0.05$)

in this experiment. Covariate analysis, which considered the initial milk production, showed that milk production in R2 increased at a better rate than in R1 and R0. The high milk production in R2 might have been caused by the relatively higher proportions of forage intake, fermentability and digestibility of the ration. Higher forage intake in R2 led to higher amounts of milk fat[2] and other components (SNF). The amounts of milk production that was measured in this experiment ranged from 19.34-22.04 L head^{-1} day^{-1} and were higher than those found by Lestari *et al.*[8], which ranged from only 16.99-18.01 L head^{-1} d^{-1}. High DM intake with a high concentrate proportion in the R0 supported the high nutrient requirement of the cow. However, a high proportion of concentrate produced a low CF content in the ration and increased the risk of metabolic disorders, such as acidosis[43], due to the decrease in chewing time[44]. However, Nasrollahi *et al.*[45] found that some cows might be more tolerant of a high concentrate diet.

Body weight and score: The body weights and scores of the cattle measured in this experiment are shown in Table 4. The average daily gain of cattle that consumed R2 ration was higher than those of R0 and R1. Improvement of body weight of cattle that consumed R2 ration showed that the ration satisfied not only the cattle's requirement for maintenance and milk production but also their body storage. Body storage was the last priority of nutrient distribution after all other requirements of nutrients had been fulfilled[2]. The results showed that the R2 ration was a balanced ration that could fulfill the nutrient requirement for maintaining high milk production while maintaining the cows' body conditions[15]. The improvements in the Body Condition Scores (BCS) support this argument (Table 4). The cows used in this experiment were in positive energy balance, as demonstrated by the increases in body weight and score.

The Average Daily Gain (ADG) of a R2 cow was 0.82 kg. It was higher than that found by Lestari *et al.*[8], which reported average daily gains only up to 0.72 kg. The higher ADG of cows fed with R2 was caused by the high intake and digestibility of the R2 ration[46] compared to the ADG in R0 and R1.

According to Roche *et al.*[47], the ideal BCS needed during drying to support a consecutive milk production period was 3.5 (scale 1-5). The score was continuously reduced until 3 months in milk and then slightly rebounded until the drying period. The cows used in this experiment were at peak to mid lactation (3.5±1.6 months in milk), as shown by the increasing BCS during the experiment. At the end of the experiment, the R0, R1 and R2 cows' body scores were 2.81, 2.56 and 2.88, respectively. The score was projected to further increase over the next 2-3 months and to reach 3.5 BCS by the end of the milking period (before drying).

Technical and economical efficiencies: The average technical and economical efficiencies of the rations are shown in Table 5. There were no significant differences in the efficiencies of the rations. The average technical efficiency found in this experiment was higher than that of Lestari *et al.*[8] but economically lower. The higher technical efficiency of the ration found in this experiment was due to high digestibility and milk synthesis efficiency[21]. Furthermore, Casper[48] explained that a low feed conversion efficiency could be influenced by digestive problems in animal's body, which could lead to a decrease in precursor availability for milk synthesis.

The average economic efficiency found in this experiment was not influenced by the type of ration used. The economical efficiencies of feed used in this experiment were 1.53, 1.72 and 1.61 for R0, R1 and R2, respectively. According to Linn[21], a normal economical feed efficiency should not be less than 1.4. The economic efficiency was influenced by milk production and price as well as the feed cost. A relatively high milk production and price, in combination with the relatively low feed cost, produced higher economical efficiencies.

The ration price to produce a liter of milk was similar between R0 and R2 and relatively cheaper for R1. This result demonstrated that the inclusion of complete feed silage based on maize was economically competitive to the current ration used by traditional farmers. By using a conserved formulated ration, a sustainable supply of balanced and high-quality nutrients for dairy cows could be achieved.

Table 5: Technical and economical efficiencies

	Efficiency		
Treatments	Technical	Economical	Price of rations (IDR L^{-1})
R0	1.35±0.12	1.53±0.11	2740.79±329.93
R1	1.42±0.19	1.72±0.21	2554.33±353.13
R2	1.31±0.04	1.61±0.09	2736.90±100.01

R0: Current ration, R1, R2: Rations contained 20 and 40% complete feed silage

CONCLUSION

It was concluded that the inclusion of up to 40% complete feed silage based on maize could serve as a sustained and balanced high-quality supply of nutrients for dairy cows that are kept under the traditional dairy farming system by KPSBU cooperative members. The ration was technically and economically competitive to the current ration used by farmers and improved milk production and quality as well as the body condition scores of the cows.

SIGNIFICANCE STATEMENT

This study discovers an alternative collective technique in making complete ration silage based on maize. This technique can supply of balanced and high quality nutrients for dairy cows kept under a traditional farming system. The introduction of 40% complete ration silage in lieu of the traditional ration improved dairy cows' performances at competitive technical and economic efficiencies. This study will help researchers investigate the critical areas of complete feed silage production in the traditional dairy farming system which have been challenging. A new focus on optimizing the logistic aspect of silage may therefore be explored in the future.

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