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Rumen Fermentation and Milk Quality of Dairy Cows Fed Complete Feed Silages

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ABSTRACT

This study was conducted to evaluate the rumen fermentation and milk quality of Friesian Holstein (FH) cows given complete feed silages during lactation. Twelve FH cows in 5th mo lactation were offered four dietary treatments in a completely randomized design with three replications. The treatments were, control diet (NS) containing 50% concentrate, 45% elephant grass and 5% sun flower meal; grass complete feed silage (GS) containing 50% concentrate, 45% elephant grass and 5% sunflower meal; rice straw complete feed silage (RSS) containing 50% concentrate, 30% elephant grass, 15% rice straw and 5% sunflower and palm oil frond complete feed silage (PKS) containing 50% concentrate, 30% elephant grass, 15% palm oil frond, and 5% sunflower meal. Ensilage was done with addition of *Lactobacillus plantarum* 1A-2 and cellulase enzyme. Analysis of variance and Duncan test were applied to compare the different among the means of treatments. Complete feed silages had range of pH between 3.89-4.44, temperature of 28.0-29.67 °C and lactic acid bacteria of 0.54-1.50 x 10^8 cfu/g. Crude protein intake of RSS was the highest among treatments. Acetate concentration in rumen liquor was more than 70%. Milk yield and protein were not different among treatments. GS gave the highest milk fat (5.66%). The conclusion was that both complete feed silages, using rice straw or palm oil frond can be used as alternative rations for lactating dairy cows.

Key words: complete feed, silage, Friesian Holstein, palm oil frond, rice straw

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi fermentasi rumen dan kualitas susu sapi Friesian Holstein. Dua belas ekor sapi dibagi menjadi empat perlakuan dalam rancangan acak lengkap dengan tiga ulangan. Perlakuan terdiri atas kontrol (NS), yaitu ransum bukan silase yang terdiri atas 50% konsentrat, 45% rumput gajah, 5% bungkil biji matahari; silase komplit rumput (GS) terdiri atas 50% konsentrat, 45% rumput gajah, 5% bungkil biji matahari; silase komplit jerami padi (RSS) terdiri atas 50% konsentrat, 30% rumput gajah, 15% jerami padi, 5% bungkil biji matahari; dan silase pelepah sawit (PKS) terdiri atas 50% konsentrat, 30% rumput gajah, 15% pelepah sawit, 5% bungkil biji matahari. Silase komplit dibuat dengan penambahan bakteri *Lactobacillus plantarum* 1A-2 0,5 ml/kg dan enzim selulase 1 ml/kg. Data dianalisis menggunakan analisis ragam dan rataan perlakuan yang menunjukkan perbedaan diuji menggunakan uji Duncan. Silase komplit yang dihasilkan berkualitas baik dengan pH 3,89-4,26, suhu 28-29,67 °C, dan total bakteri asam laktat (BAL) 0,54x10^8-1,50x10^8 cfu/g. Sapi yang diberikan RSS memiliki konsumsi protein kasar paling tinggi, konsentrasi asetat cairan rumen lebih dari 70%, dan nyata meningkatkan kadar lemak (5,66%). Kesimpulan kajian ini adalah bahwa silase komplit jerami padi maupun pelepah sawit dapat digunakan sebagai ransum alternatif untuk sapi perah.

Kata kunci: Friesian Holstein, jerami padi, silase komplit, pelepah sawit

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INTRODUCTION

In Indonesia the dairy industry development is still widely open along with the increasing of the population and the demand of milk-origin protein. Milk consumption increases from 6.91 kg/capita/year (2008) to 8.90 kg/capita/year (2009) (Direktorat Jenderal Peternakan, 2010). It is a challenge for farmers to increase the production and quality of milk by using proper feed management. Feed is absolutely required and should be available both quantitatively and qualitatively in the whole year.

Indonesian farming is performed traditionally which depend upon the availability of local feed ingredients, such as grass, agricultural by products, and legume. The availability of feed is influenced by the season. Feed for dairy cattle are abundant in the rainy season. Conversely, feed is difficult to obtain in dry season. So it needs feed conservation in order to fill up the requirement. The utilization of agricultural by products as dairy cattle feed is an alternative way to fill up the nutritional requirements, especially when the forage as a fiber source is difficult to obtain. One of the feed conservation is by making the complete feed silage.

Complete feed silage is made from a mixture of some feed ingredients including forage, concentrate, and additives. The advantage of complete feed silage is that it can be made any time and has long shelflife to solve the problem of feed shortage during dry season. Complete feed silage is expected to be used for maintaining the productivity of dairy cows. The use of rice straw and palm oil frond in the completed feed silage as grass substitution was evaluated in this study. This study was conducted to evaluate the rumen fermentation and milk quality of Friesian Holstein (FH) cows given complete feed silage during lactation.

MATERIALS AND METHODS

Animals and Diets

Twelve FH grade cows in 5th mo lactation with an initial milk yield of 4 L with body weight of 300 kg were allocated into 4 dietary treatments in a completely randomized design. The dietary treatments were as follows: control diet (NS) contained 50% concentrate, 45% elephant grass and 5% sun flower meal; grass complete feed silage (GS) contained 50% concentrate, 45% elephant grass and 5% sun flower meal; rice straw complete feed silage (RSS) contained 50% concentrate, 30% elephant grass, 15% rice straw and 5% sun flower and palm oil frond complete feed silage (PKS) contained 50% concentrate, 30% elephant grass, 15% palm oil frond and 5% sun flower meal. Ensilage was done with addition of *Lactobacillus plantarum* 1A-2 and crude cellulase.

The experimental concentrate contained crude protein 16%-17%, crude fat 6%-7%, crude fiber 15%-16%, and TDN 70%-72%. Elephant grass of 50 days old was harvested. The grasses were withered for 2 h to reduce the water content, and then chopped into 3 cm length. Rice straw and palm frond were also chopped. Concentrate and grass, rice straw or palm frond were mixed. The homogeneous materials were then inserted into the silos. Ensilage was done by fermenting complete diets with addition of *L. plantarum* 1A-2 and crude cellulase obtained from the Microbiology Laboratory of Indonesian Institute of Sciences (LIPI). Fermentation was carried out for about 30 d. The ration and chemical composition are shown in Tables 1 and 2.

Feeding trial was done for 2 mo, with a week adaptation period. The ration was given at 07:00 am and 15.30 pm. During the first one week, experimental diets were offered *ad libitum* to determine the amount of offered diets during the experimental period. Drinking water was given *ad libitum*. The cows were milked at 5:00 am and 14:00 pm. Rumen fluid was taken before morning feeding for one animal in each treatment. The pH and temperature of complete feed silage, nutrient intake, rumen fluid characteristics, milk yield and composition were determined.

Proximate analysis was applied to analyze the nutrient content of feed and rations. Concentration of NH_3 (mM) in rumen fluid was determined using Conway method (1962), pH was measured using a pH meter. Partial VFA concentration (%) was analyzed using a Gas Chromatography CHROMPACK CP 9002. Conditions of injector and detector temperatures were of 250 and 270 °C, the column temperature was 115 °C. Carrier gas N_2 was 25 mL/min, H_2 was 40 mL/min and air pressure

Table 1. Composition of the experimental diets

Feed ingredients	Treatments			
	NS	GS	RSS	PKS
Elephant grass (%)	45	45	30	30
Concentrate (%)	50	50	50	50
Sun flower meal (%)	5	5	5	5
Rice straw (%)	-	-	15	-
Palm oil frond (%)	-	-	-	15
L. plantarum 1A-2 (mL/kg)	-	0.5	0.5	0.5
Crude cellulase (mL/kg)	-	1	1	1

Note: NS= non silage, GS= grass silage, RSS= rice straw silage, PKS= palm oil frond silage.

Tabel 2. Chemical composition of the experimental diets

Parameters	Treatments			
	NS	GS	RSS	PKS
Dry matter (%)	85.23	88.32	88.87	87.87
Crude protein (%)	13.87	13.89	14.42	13.68
Crude fat (%)	4.16	2.57	2.52	2.75
Crude fiber (%)	19.62	20.39	17.86	23.16
NFE (%)	46.62	42.31	44.55	39.39
TDN (%)	69.08	62.38	59.77	58.99
ADF (%)	46.23	48.72	38.93	37.66
NDF (%)	67.70	60.06	58.58	61.72

Note: NS= non silage, GS= grass silage, RSS= rice straw silage, PKS= palm oil frond silage, NFE= N-free exact, TDN= total digestible nutrient, ADF= acid detergent fiber, NDF= neutral detergent fiber.

was 300 mL/min. The milk quality parameters include milk lactose (%) was analyzed by Teles method, milk fat (%) was analyzed by Gerber method and milk protein (%) was analyzed by using Formol titration method. Lactic acid bacteria (LAB) population in complete feed silages was analyzed by total plate count (TPC) using MRS medium.

Statistical Analysis

Data of nutrient consumption, milk quality and quantity were subjected to analysis of variance for completely randomized design using GLM procedure. Duncan's multiple range test was used to identify significant differences between means.

RESULTS AND DISCUSSION

Complete Feed Silage Quality

The pH, temperature and total lactic acid bacteria of complete feed silages are shown in Table 3. The pH of complete feed silages was in the range of 3.89-4.44, GS (3.93), RSS (4.44), and PKS (3.89). Levitel *et al.* (2009) reported that pH value is one of the factors determining the level of success a product of fermentation. Ratnakomala *et al.* (2006) reported that the addition of LAB (*L. plantarum* 1A-2) for elephant grass silage resulted in lower pH and higher lactic acid. Similar findings have also been reported by Li *et al.* (2010) using *L. plantarum* for rice straw silage, Filya *et al.* (2007) for alfalfa silage, and Kung *et al.* (2003) using LAB (*Lactobacillus buchneri* 40788) for alfalfa silage can reduce the pH and proteolysis. The low acidity created by lactic acid bacteria inhibits the growth of unwanted bacteria.

The temperature of complete feed silage was in the range of 28-29.67 ^{o}C. Temperature changes during the fermentation process were a normal state. Decreasing in temperature was accompanied by the decreasing in pH. Production of lactic acid by lactic acid bacteria utilizing water soluble carbohydrates (WSC) of the feed components is a part of fermentation process, that contributes to the reduction of silage pH (Ennahar *et al*., 2003). The normal temperatures during ensilage process is 25-37 ^{o}C (Okine *et al*. 2005) and 30 ^{o}C (Levitel *et al*. 2003) that will produce good quality silage. The number of LAB colonies developed in complete feed silages was between 0.54-1.5 x10^8 cfu/g. The minimum population of LAB as epiphyte microorganisms in the raw materials should be at least 10^6 cfu/g (Bolsen *et al.* 2000; Widyastuti 2008). The result indicated that fermentation of complete feed during ensilage contributed to the good quality of the ration.

Table 3. Mean of pH, temperature, and total lactic acid bacteria of complete feed silage

Parameters	Treatments		
	GS	RSS	PKS
pH	3.93	4.44	3.89
Temperature (^{o}C)	29.00	29.67	28.00
Lactic acid bacteria (cfu/g)	1.5 x10^8	0.64x10^8	0.54x10^8

Note: NS= non silage, GS= grass silage, RSS= rice straw silage, PKS= palm oil frond silage. Results of analysis of Applied Microbiology Laboratory Sciences, Center for Biotechnology-LIPI, 2012.

Nutrients Intake

Feed intake depends upon several factors, including the type of diet, nutrient concentration, and palatability. Means of nutrients intake are shown in Table 4. Treatments of GS and RSS increased (P<0.05) dry matter and crude protein intake. Dry matter (DM) consumption of dairy cows in this study was around 4% of body weight (BW). According to NRC (2001), DM consumption in dairy cows ranged from 2% to 4% of BW. The average crude protein intake was significantly higher in cows fed ration RSS, and GS than NS and PKS. The average crude protein intake in dairy cows was ranged from 1.77-1.92 kg/head/d. Adequacy of protein will affect the production and quality of milk.

The highest crude fiber (CF) consumption was occurred in the treatment of PKS group, this is in line with the higher silage quality. CF consumption in dairy cows affected the levels of acetic acid in the rumen which further affected to the fat content of milk. Minimum requirement of crude fiber in the ration of lactating dairy cows is 17% of DM. Crude fiber is associated with milk fat content, if CF consumption is less than 17%, it will result in lower milk fat content. The crude fat consumption was different in all treatments. The use of NS crude fat consumption was higher than complete feed silage. The crude fat content in the diet should not exceed than 6%-7% of DM (NRC 2001). Rations that have high fat will reduce dry matter intake. Crude fat consumption in this study was approximately 3%-4% of DM. It was in accordance with the NRC (2001). The highest fat content in control ration was around 0.53 kg (4% of DM).

Rumen Fermentation

Ammonia levels, pH, acetate, propionate, and butyrate are shown in Table 5. Ammonia levels are the main product of the amino acid deamination and can be used as a source of N for microbial growth. The average of rumen fluid ammonia levels were in the range of

Table 4. Nutrients intake of dairy cows fed experimental rations (kg)

Daily nutrient intake	Treatments			
	NS	GS	RSS	PKS
Dry matter	12.78±0.01^b	13.20±0.09^a	13.31±0.12^a	12.77±0.11^b
Crude protein	1.77±0.00^c	1.83±0.01^b	1.92±0.00^a	1.75±0.01^d
Crude fiber	2.51±0.00^c	2.69±0.02^b	2.38±0.00^d	2.96±0.02^a
Crude fat	0.53±0.00^a	0.34±0.00^c	0.33±0.00^d	0.35±0.00^b

Note: NS= non silage, GS= grass silage, RSS= rice straw silage, PKS= palm oil frond silage. Means in the same row with different superscript differ significantly (P<0.05).

Table 5. Ammonia, pH, acetate, propionate and butyrate rumen fluid of dairy cows fed treatment rations

Rumen fluid characteristics	Treatments			
	NS	GS	RSS	PKS
NH_3 (mM)	3.76±0.01	2.82±0.01	2.82±0.01	2.35±0.01
Rumen pH	6.52±0.11	7.3±0.14	6.65±0.14	6.21±0.14
Acetate (%)	74.08±0.66	79.14±0.37	76.32±0.65	78.45±0.52
Propionate (%)	17.58±0.06	15.45±0.03	17.46±0.14	16.87±0.01
Butyrate (%)	8.34±0.04	5.41±0.01	6.22±0.04	4.69±0.07

Note: NS= non silage, GS= grass silage, RSS= rice straw silage, PKS= palm oil frond silage.

Table 6. Mean of milk yield, fat, protein and lactose of dairy cows fed experimental rations

Milk yield and content	Treatments			
	NS	GS	RSS	PKS
Milk production (L)	3.98±0.47	2.40±1.26	3.24±0.79	2.36±0.91
Protein (%)	3.40±0.37	3.85±0.88	3.42±0.71	3.57±0.34
Fat (%)	3.40±0.52^{b}	5.66±0.92^{a}	4.33±0.98^{ab}	4.36±0.38^{ab}
Lactose (%)	3.89±0.35^{a}	2.78±0.22^{b}	3.31±0.12^{b}	2.94±0.34^{b}

Note: NS= non silage, GS= grass silage, RSS= rice straw silage, PKS= palm oil frond silage. Means in the same row with different superscript differ significantly (P<0.05).

2.35-3.76 mM. The average ammonia levels resulted in this study were lower than that reported by Jatkauskas & Vilma (2006) that the cattle given grass silage mixed legume was about 8.03-9.11 mM.

The fermentation produces energy, gas (methane and carbon dioxide), and VFA (volatile fatty acids). The average of acetic acid in the rumen fluid showed more than 70% in all treatments. Cows given grass silage had acetate concentration up to 79.14%. This strongly supports the formation of milk fat concentration, while propionate will support the formation of milk lactose. The average propionate was in the range of 16.87%-17.58%, while butyrate was 5.41%-8.34%. This acetate concentration was higher than the result reported by Prayitno *et al*. (2009) who stated that the acetic acid concentration of dairy cows supplemented with *Sapindus rarak* and garlic extract ranged between 63.67%-75.21%.

The average of cow rumen fluid pH in all treatments was around 6.2-7.3. These values are in the normal range for the fermentation process. Sung *et al*. (2007) stated that the rumen fluid pH should be maintained more than 6 during fermentation because it is very efficient for microbial growth and fiber digestion in the rumen.

Milk Quality

Milk yield, protein, fat, and lactose milk concentration are shown in Table 6. The milk yield and milk protein content were not different in all treatments. Milk production ranged from 2.36-3.98 L/d, with protein concentration ranged from 3.40% to 3.85%. The milk protein quality resulted from this study was higher than SNI standard (BPS, 1998) with minimum 2.8%. This situation can be explained that the dairy cows were in late lactation condition (5th mo of lactation). The highest milk fat content was obtained in cows given GS. This is most likely affected by the acetate content of the rations (Table 5). This suggested that the provision of complete feed silage produced milk fat content better than NS. The milk fat content will affect the milk price. The milk fat content is also influenced by the acetate concentration which is one of milk fat precursor. The increasing of milk fat usually followed by a reduction in milk production up to 10% per month for the restoration of body tissue lost during the early period of lactation (Tyler & Ensminger, 2006). The energy from the ration was used mainly for body maintanence then the rest of energy was for milk production.

The fat and protein milk content of complete feed silage rations in this study were higher than those reported by Dewhurst *et al*. (2003), where cows were fed ration containing grass silage, alfalfa, and clover leaf and Moorby *et al* (2009), where cows were fed 100% grass silage**.** The value of milk lactose was significantly higher in cows fed NS. The value of milk lactose has strong relation to propionate. The low concentration of milk lactose is in consequence of low propionate in the rumen fluid (Table 5). Propionate will be converted to glucose, and then used for milk lactose synthesis. The lactose value in this study was lower than the result reported by Ramli *et al*. (2009) who stated that the concentration of lactose of dairy cows given silage complete ration of vegetable waste was 7.69%.

CONCLUSION

Complete feed silages based on rice straw or palm oil frond can be used as an alternative ration for lactating cows during dry season. The use of rice straw or palm oil frond depends on the availability of the materials in the location.

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