

Original Research Paper

Effect of Complete Feed Silage Made from Agricultural Waste on Milk Yield and Quality of Dairy Cows

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Abstract: The problem facing dairy cow producers in tropical area is the low availability of proper nutrition, especially during the dry season. One solution to overcome this problem is to utilize technology of Complete Feed (CF) silage using ensiled several local abundant ingredients from agricultural wastes. This study aimed to find a formulation of CF silage from agricultural wastes as forage substitution for dairy cows to increase yield and quality of the milk. The study was conducted on dairy farms in Enrekang District, South Sulawesi of Indonesia. The formulations of CF silage used in the study were tested both in vitro and in vivo and compared with the farmer's practices that using elephant grass plus rice bran. A total of 20 Holstein Friesian dairy cows in 4-5 months lactation with a lactation period of 3rd-5th were used for in vivo study. The treatments were Elephant Grass + Rice Bran (EG-RB), Elephant Grass + Concentrate (EG-CON), Complete Feed Silage made from straws (CF-S) and complete feed silage made from straws and vegetable wastes (CF-VW). The results of this study showed that the dry matter intake and milk yield of dairy cow were higher in EG-CON, CF-S and CF-VW compared to EG-RB and were not different among EG-CON, CF-S and CF-VW. The crude protein, lactose, calcium and phosphorus of the milk were higher in the EG-CON, CF-S and CF-VW than EG-RB and were not different among EG-CON, CF-S and CF-VW. Fat content, density and pH of the milk were not different among treatments. In conclusion, in order to maintain and to improve the yield and quality of milk in dairy cows, the agriculture wastes, such as straws and vegetable wastes can be used as the basal feed of dairy cows for fodder substitution in the form of CF silage.

Keywords: Agricultural Waste, Dairy Cow, Complete Feed, Milk Yield and Quality

Introduction

The development of the dairy cow population in Indonesia tends to increase from year to year, but the problem is the availability of high feed quality and low production and quality of milk produced. In Enrekang District, South Sulawesi of Indonesia, dairy cows population increased from 500 heads in 2005 to 1,530 heads in 2010 (DPPE, 2011). The consequence of increased population is lack forage availability, especially during the dry season, so the milk production decreased significantly. During the dry season most farmers only use rice straw or corn straw as a source of forage without any processing for increasing its nutritional value (Baba *et al.*, 2011).

Furthermore Muktiani (2007) revealed that the main parts of dairy feeding are basically consist of roughage as the main feed and concentrates as a feed supplement. Source of roughage could be from grass, legume and agricultural waste, while the concentrates feed are generally consist of a mixture of feed materials as a source of energy and protein with a crude protein content >18% and crude fiber <18%.

Baba *et al.* (2011) reported that the availability of agricultural waste from food crops or from horticulture is quite plentiful in Enrekang. In the area of food crops, some agricultural wastes such as rice straw, corn straw and peanut straw, while in the horticulture area cabbage waste, carrots waste, coffee husk and corn straw are plentiful that can be used as a source of the roughage to

substitute of elephant grass. Generally, these agricultural wastes are low quality and the quality can be improved by mixing them with high quality but low prices of agro-industrial by product like rice bran, corn meal and coconut cake in the form Complete Feed (CF). This CF is expected can increase the milk production (Pangestu *et al.*, 2003; Ramli *et al.*, 2009). By proper formulation, it is expected that CF can meet the need for essential nutrients by animals. Moreover, the provision of CF to beef cattle is economically more favorable compared to conventional feeding (Mayulu *et al.*, 2009), because CF technology can reduce the use of labor and feeding time (Baba *et al.*, 2011). The ensiling of CF using local feed ingredients, the shortage of feed during the dry season may be can be alleviated.

In the tropical areas, increasing the availability of feed during the dry season can be conducted through hay and silage making. Because uncertainty of the weather during the growth season in the tropics, silage making may be more suitable to be used to conserve nutrients in the feed. By ensiling CF, more nutrients needed by animal like energy, protein and vitamin can be conserved.

One solution to overcome the low quality of agricultural wastes is to utilize CF technology by mixing the agricultural wastes with the high quality feed sources. The provision of complete feed to beef cattle is economically more favorable compared to conventional feed (Mayulu *et al.*, 2009), because CF technology can reduce the use of labor and feeding time (Baba *et al.*, 2011). By proper feed formulation, it is expected that the CF can meet the needs of essential nutrients by dairy cow. If the CF technology using local ingredients can be developed in Enrekang, the shortage of fodder can be alleviated. Wahjuni and Bijanti (2006) showed that the CF did not affect the performance of the liver and kidneys of dairy cows indicating that it was safe to be continuously used as feed. Similarly, the research of Mukodiningsih *et al.* (2008) showed that the use of CF to the calf starter caused rumen growth remains good in dairy calves.

This study was carried out to find a CF formulation with cheap local feed ingredients to substitute forage to increase the milk yield and quality of dairy cows.

Materials and Methods

The study was conducted on dairy farms in Enrekang District, South Sulawesi of Indonesia. The site was located at 3°33'57" S latitude and 119°47'31" E longitude at altitude about 1300 m above sea level with a daily average temperature of approximately 27.34°C. The climate of this area is tropical monsoon characterized by rainy season during November to June and dry season during July to November.

The feed ingredients that used in this study were agricultural wastes from food crops and horticulture

areas. In the food crops area, the sources of fibre for CF were rice straw and corn straw while the energy source obtained from rice bran and corn meal. Coconut cake was used as source of protein. In horticultural area, the sources of fibre for CF were corn straw, carrots waste, cabbage waste and coffee husk while the energy source using rice bran and corn meal. Coconut cake and tofu waste were used as source of protein.

Based on nutritional content of all feed materials, the CF formulations were prepared according to the feed requirements of dairy cows for milk production of at least 10 kg/head/day (NRC, 2001). Feed materials from the fibre sources were cut into small pieces and mixed with a source of energy, protein and mineral. The formulated of CF was put in plastic drums to be ensiled in an anaerobic condition during three weeks. After ensiling, the physical characteristic and chemical compositions of CF silage were analyzed.

Twenty Holstein Friesian dairy cows of 4-5 months in lactation with a lactation period of 3rd-5th were used for in vivo study. The study was arranged according to completely randomized design, consisted of 4 treatments and 5 replications. The treatments of the study are as follows:

- EG-RB = Elephant grass + rice bran (dairy cow farmer treatment)
- EG-CON = Elephant grass + concentrate
- CF-S = Complete feed silage made from straw
- CF-VW = Complete feed silage made from straw and vegetable waste

The composition and nutrient content of the feed for each treatment are shown in Table 1-4, respectively. The Total Digestible Nutrients (TDN) and Crude Protein (CP) content of feed ingredients in this research had met the requirement of dairy cows with body weight 350-400 kg for milk production of 10-15 kg/head/day (NRC, 2001).

The formulated feed and drinking water was given *ad libitum* to dairy cows in the morning and afternoon. The parameters measured were Dry Matter Intake (DMI), milk yield and quality. Feed intake obtained from the amount of one day consumption (24 h). Adaptation period lasted during 7 days and the milk yield was measured during 10 days. The CP, fat, lactose, calcium (Ca), phosphorus (P), pH and density of milk were analyzed. CP concentration was analyzed by Indirect Kjeldahl method (method 991.23; AOAC International, 2005) while fat by Babcock method (method 989.04; AOAC International, 2005), lactose by Nelson Somogy method (Sudarmadji *et al.*, 1997), Ca and P by Atomic Absorption Spectrophotometric and Colorimetric methods (method 991.25; AOAC International, 2005). pH was analyzed using a pH-meter and density by Lactodensimeter.

Table 1. Composition and nutrient content for EG-RB treatment

%									
Feed ingredients	Composition	TDN	Ash	CP	Fat	CF	NFE	Ca	P
Elephant grass	45	23.6	5.40	3.91	1.22	14.5	19.9	0.21	0.16
Rice bran	55	37.4	7.48	7.15	4.76	7.65	28.0	0.06	0.77
Total	100	61.0	12.9	11.1	5.98	22.2	47.9	0.27	0.93

Table 2. Composition and nutrient content for EG-CON treatment

%									
Feed ingredients	Composition	TDN	Ash	CP	Fat	CF	NFE	Ca	P
Elephant grass	45	23.6	5.40	3.91	1.22	14.5	19.9	0.21	0.16
Rice bran	20	13.6	2.72	2.60	1.73	2.78	10.2	0.02	0.28
Corn meal	5	4.04	0.11	0.54	0.21	0.13	4.01	0.01	0.02
Coconut cake	30	23.6	2.47	6.39	3.27	4.26	13.6	0.07	0.20
Total	100	64.8	10.7	13.4	6.43	21.7	47.7	0.31	0.66

Table 3. Composition and nutrient content for CF-S treatment

%									
Feed ingredients	Composition	TDN	Ash	CP	Fat	CF	NFE	Ca	P
Rice straw	10	4.32	1.69	0.42	0.15	3.25	4.50	0.04	0.03
Corn straw	35	21.0	3.57	3.47	0.62	9.59	17.8	0.43	0.04
Rice bran	20	13.6	2.72	2.60	1.73	2.78	10.2	0.02	0.28
Corn meal	5	4.04	0.11	0.54	0.21	0.13	4.01	0.01	0.02
Coconut cake	30	23.6	2.47	6.39	3.27	4.26	13.6	0.07	0.20
Total	100	66.6	10.6	13.4	5.98	20.0	50.1	0.57	0.57

Table 4. Composition and nutrient content for CF-VW treatment

%									
Feed ingredients	Composition	TDN	Ash	CP	Fat	CF	NFE	Ca	P
Cabbage waste	2	1.52	0.24	0.43	0.07	0.26	1.01	0.01	0.01
Carrots waste	2	1.83	0.29	0.29	0.29	0.12	1.01	0.01	0.02
Coffee husk	8	4.58	0.71	0.57	0.31	2.26	4.15	0.00	0.00
Corn straw	45	27.0	4.59	4.46	0.80	12.3	22.8	0.56	0.05
Coconut cake	16	12.6	1.32	3.41	1.74	2.27	7.26	0.04	0.11
Corn meal	2	1.62	0.04	0.22	0.09	0.05	1.60	0.00	0.01
Rice bran	20	13.6	2.72	2.60	1.73	2.78	10.2	0.02	0.28
Tofu waste	5	3.90	0.26	1.52	0.02	1.11	1.63	0.01	0.06
Total	100	66.7	10.2	13.5	5.05	21.2	49.7	0.65	0.54

The data collected were entered and organized in the excel spread sheet and then it were analyzed using descriptive statistics and GLM-Multivariate (SPSS, version 21) except for the data of physical characteristic and chemical composition of CF silage.

Results and Discussion

Physical Characteristics and Chemical Composition of Complete Feed Silage

Physical characteristics and chemical compositions of CF silage are presented in Table 5. Table 5 shows

that the CF silage made from agricultural waste had no any fungus, acid smell and the color was brownish green that similar with original ingredients of CF. The numbers of lactic acid bacteria in CF-S and CF-VW were 6.7×10^7 and 1.1×10^7 , respectively. Based on the physical characteristic and the number of bacteria CF silage had met the standards of good CF silage (Ramli *et al.*, 2009). As expected, the CP contents of CF-S of 13.9 and 13.6% in CF-VW had met standards for dairy cows feeding with body weight 350-400 kg for milk production of 10-15 kg/head/day (NRC, 2001).

Table 5. Physical characteristics and chemical compositions of each treatment

Physical and chemical characteristics	EG-RB	EG-CON	CF-S	CF-VW
pH	6.7	6.5	3.4	3.8
Smell	No	No	Acid smell	Acid smell
Color	Green	Green	Brownish green	Brownish green
Lactic acid bacteria	No	No	6.7×10^7	1.1×10^7
Fungus	No	No	No	No
Crude protein (%)	11.1	13.4	13.9	13.6
Crude fiber (%)	22.2	21.7	31.2	30.5
Nitrogen free extract (%)	47.9	47.7	39.7	36.6

Table 6. Feed intake and milk yield in each treatment

Parameters	Treatments				SEM	P
	EG-RB	EG-CON	CF-S	CF-VW		
Dry matter intake (kg/head/day)	8.01 ^a	9.53 ^b	9.62 ^b	9.94 ^b	0.236	0.007
Milk yield (kg/cow/day)	7.36 ^a	9.06 ^b	9.38 ^b	9.07 ^b	0.265	0.014

Different superscripts in the same row indicate significant difference ($p < 0.05$)

Table 7. The average of milk yield and quality of dairy cows in each treatment

Parameters	Treatments				SEM	P
	EG-RB	EG-CON	CF-S	CF-VW		
Crude protein (%)	1.45 ^a	2.97 ^b	3.20 ^c	2.86 ^b	0.159	0.000
Fat (%)	4.57 ^a	3.41 ^a	4.16 ^a	4.03 ^a	0.159	0.061
Lactose (%)	2.18 ^a	3.07 ^b	2.94 ^b	2.88 ^b	0.102	0.002
Calcium (%)	0.12 ^a	0.24 ^b	0.28 ^b	0.29 ^b	0.024	0.038
Phosphorus (%)	0.06 ^a	0.11 ^b	0.11 ^b	0.11 ^b	0.006	0.001
Density	1.03 ^a	1.03 ^a	1.03 ^a	1.03 ^a	0.000	0.762
pH	6.5 ^a	6.5 ^a	6.5 ^a	6.5 ^a		

Different superscripts in the same row indicate significant difference ($p < 0.05$)

Feed Intake and Milk Yield

Feed intake and milk yield of dairy cows in each treatment are shown in Table 6. The data in Table 6 shows that the Dry Matter Intake (DMI) was higher in EG-CON, CF-S and CF-VW treatments compared with EG-RB treatment, however there was no difference among EG-CON, CF-S and CF-VW treatments. This might be attributed to the low the dietary CP in EG-RB treatment compared with another treatment (Table 1-4). According to Aschemann *et al.* (2012) that the dietary CP as low as 12% depressed nutrient digestibility and microbial protein synthesis in the rumen. The DMI and milk production were decreased when feeding of metabolizable protein deficient diets (Lee *et al.*, 2011; 2012a). On the contrary, when DMI did not decrease, milk production was also not different from diets with adequate metabolizable protein (Lee *et al.*, 2012b; Giallongo *et al.*, 2015).

The milk yield of dairy cows (Table 6) was higher in EG-CON, CF-S and CF-VW treatments compared with EG-RB treatment and were not different among EG-CON, CF-S and CF-VW treatments. The result indicated that the agricultural wastes (straws and vegetable wastes)

can be used as the main feed for dairy cows to substitute elephant grass forage. The results of the present study are in agreement with Combellas and Martinez (1982) that dairy cows fed mixture of elephant grass and concentrate with crude protein content of 14.7% resulted in milk yield of 8.8 kg/cow/day. This milk yield is also in agree with Belhadia and Yakhlef (2013) who reported the milk yield of 9.78 kg/cow/day and Abdelaziz *et al.* (2013) with milk yield of 10.71 kg/cow/day.

In the present study, concentrate had positive effects on milk production and quality. The effectiveness of concentrate supplementation in the feeding system of dairy cows depends on forage crops, in which forage alone may not satisfy the nutritional requirements of high producing dairy cows because of its low quality (Intisar *et al.*, 2012). However, the amount of concentrate supplementation should consider the economics of feeding. Wanapat *et al.* (2011) revealed the importance of various protein sources for feed in lactating dairy cows.

For maintaining and increasing the productivity of dairy cows especially during the dry season when the forage availability was limited, applying CF method for feeding of dairy farm can reduce labor and feeding time

by 72% (Suharto, 2004). Feeding with CF silage from agricultural waste give another advantages, i.e., no competition between resource utilization for animal feed and for human food sources and reduce land use conflicts with other sectors mainly agric-food sector (Haryanto, 2009). Through CF silage technology formulated from agricultural waste such as corn straw, rice straw and wastes from the markets does not reduce the milk yield and quality. In fact, several studies have shown that the CF silage made from rice straws could increase milk production (Yusof *et al.*, 1998).

Milk Quality

The CP of milk was higher in CF-S treatment compared with EG-RB, EG-CON and CF-VW treatments (Table 7). CP content in EG-CON and CF-VW treatments were higher than EG-RB treatment, while CP content of EG-CON and CF-VW treatments was not different. The higher CP content in the milk of dairy cows in EG-CON, CF-S and CF-VW treatments compared to EG-RB treatment might be due to the higher CP contents in EG-CON, CF-S and CF-VW treatments compared to EG-RB. In the present study, feed formulation in the EG-CON, CF-S and CF-VW treatments have met the standard requirements for CP of dairy cows as recommended by the NRC (2001), especially on protein and carbohydrates. Dairy cows fed elephant grass plus rice bran only may be not met the needs of protein of dairy cows.

In the present study, the milk fat content, density and pH did not differ among treatments (Table 7). Broderick (2003) reported that the fat content of milk was not affected by the level of dietary protein. The results of current study are in agree with Combellas and Martinez (1982) that mixture of elephant grass and concentrate with CP of 14.7% fed to dairy cows resulted in milk CP and fat contents of 3.1 and 3.9%, respectively.

The lactose, Ca and P of milk were higher in EG-CON, CF-S and CF-VW treatments compared with EG-RB treatment and were not different among EG-CON, CF-S and CF-VW treatments (Table 7). Higher Ca and P content of the milk in the EG-CON, CF-S and CF-VW treatments may be due to the mineral needs of dairy cows are sufficient in this treatments, especially Ca and P. Dairy cows in EG-CON, CF-S and CF-VW treatments obtained the source of Ca and P from a wide variety of feedstuffs such as concentrate, compared with in EG-RB treatment in which the dairy cows were only obtained feed ingredients of elephant grass and rice bran which contain low levels of Ca and P.

Based on some parameters relating to the milk quality of dairy cows, it can be assumed that the milk quality of dairy cows is generally better in EG-CON, CF-S and CF-VW treatments in comparison to EG-RB treatment and generally there were no differences

among EG-CON, CF-S and CF-VW treatments. Thus the agricultural wastes such as straws and vegetable wastes can be used as a substitute for elephant grass in the form of CF silage, in an effort to improve the milk quality of dairy cows.

Conclusion

The physical characteristic and chemical compositions of CF silage formulated from agricultural wastes such as straws, vegetable wastes and mixed with agro-industrial by products can meet the standard for requirements of dairy cows. The CF silage was able to maintain and to improve the milk yield and quality of dairy cows. Thus, the agricultural wastes such as straws and vegetable wastes mixed with agro-industrial by products can be used as the basal feed of dairy cows for forage substitution in the form of CF silage.

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Author's Contributions

Ambo Ako: Designed, conducted the experiments, analyzed the data and wrote the manuscript.

Syahdar Baba: Performed the experiments and wrote the manuscript.

Fatma: Performed the experiments and analyzed the nutrient of feed ingredients.

Jamila: Performed the experiments and analyzed the milk quality.

Muhammad Rusdy: Aiding wrote the manuscript.

Ethics

This manuscript has not been published or presented elsewhere in part or in entirely and is not under the consideration by another journal. All the authors have approved the manuscript and agree with submission to the esteemed journal. There are no conflicts of interest to be declared.

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