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Effect of leucaena forage and silage substitution in concentrates on digestibility, nitrogen utilization and milk yield in dairy cows

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Abstract

This experiment was conducted to determine the effect of feeding leucaena forage and silage substitution in concentrate on the performances of dairy cows. Nine cross-bred Holstein Friesian cows (410±12kg) in the 12th week of lactation were randomly allocated to one of three treatment groups with three replicates/treatments in a completely randomized design. The three treatments were control diet without substitution of leucaena forage and silage (DLFS0), diet with substitution of leucaena forage 10% (DLF10) and diet with substitution of leucaena silage 10% (DLS10). Cows were fed treatments for 60 days. Although nutrient intakes were not significantly different ($p>0.05$) each other, digestibility of DLFS0 was significantly higher ($p<0.05$) than others. Conversely, nitrogen utilization and average milk yield of cows offered DLFS0 were significantly lower ($p<0.05$) than those of cows fed on DLF10 and DLS10. The highest feed cost ($p<0.05$) per kg of milk was found in DLFS0 and the lowest cost was observed in DLF10. Therefore, although the leucana forage and silage could be substitute up to 10% of concentrates without adverse effects on the performances of dairy cows, the substitution of leucaena forage gave the better performances than that of leucaena silage.

Key words: Leucaena, digestibility, milk yield, dairy cows

Introduction

The higher performances from the dairy cows could be achieved with the feeding of better nutritious complete feeds which is usually composite with the greater inclusion of concentrates in diets. However, the price of commercial concentrates is the major limiting factor for dairy production throughout the world because of their expensiveness. Thus, many researchers have been conducted researches such as increasing the efficiency of feed utilization with the supplementation of alternative cheap protein sources to overcome those problems. In this way, the nutritious tree forages have been used as the fodder supplements in diets to improve the performances of ruminant animals. Fodder trees and shrubs represent an enormous potential source of proteins for ruminants in the tropics (Devendar, 1992) and the mineral composition of those forages is also superior to that of tropical grasses (Norton, 1994).

Among the high nutritional potential tree forages, *Leucaena leucocephala* (leucaena) has become one of the legumes most commonly used in ruminant feeding practices because of its outstanding qualities such as excellent palatability, digestibility, intake, protein, energy, minerals and amino acids (Jones, 1979), low fibre content and moderate tannin content to promote by pass protein value (Wheeler, 1994) and its possible

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effect on the reduction of greenhouse gas. Shem *et al.,* (1998) stated that the net milk yield increased when cows were supplemented with leucaena in diets. The digestibilities of dry matter and protein of leucaena measured *in vivo* (Barros-Rodríguez *et al.,* 2012) are also notable. In addition, leucaena is a source of minerals such as sulfur which can enhance the population of cellulolytic fungi and bacteria in the rumen (Aregheore, 1999). Along these lines, leucaena (forage and silage) was interested to use as the supplementation or substitution of cheap protein source in the ruminant animals' feed. However, the comparison on the performances of dairy cows fed on different forms of leucaena (forage and silage) which are replaced in concentrates is still need to investigate for dairy farmers. Therefore, this experiment was intended to determine the effects of substitution of leucaena (forage and silage) in concentrate on the performances of dairy cows.

Materials and methods

Experimental animals and diets

Prior to the experiment, the animals were fed on the experimental diets for 2 weeks to become adaptation to these diets. Nine cross-bred Holstein Friesian cows (410±12kg) in the 12^{th} week of lactation were randomly allocated to one of three treatment groups with three replicates/treatments in a completely randomized design. The three treatments were DLFS0- control diet without substitution of leucaena in concentrate (58% urea-treated-rice-straw and 42% commercial concentrate), DLF10-diet with substitution of leucaena forage (LF) in 10% of concentrate and DLS10-diet with substitution of leucaena silage (LS) in 10% of concentrate. Cows were fed treatments twice a day (08:00 o'clock and 16:00 o'clock) for 60 days and water was freely accessible.

Measurements

During the feeding trial, all of the feedstuffs were weighed and sampled before feeding. Moreover, milk yield was also recorded three consecutive days in one week. Milk was analyzed once in every two weeks with Lactoscan. During collection period, milk samples, feedstuffs (offer and residues) samples were collected for chemical analysis. The feed residues were weighed and sampled before morning feeding and then removed. Faeces voided and urine outputs were recorded daily during the collection period.

Chemical analysis

Ground samples of feed (offer and residues) and faeces were analyzed for DM, organic matter (OM) and ether extract (EE) by the method described by AOAC (1990) and analyzed for neutral detergent fibre (NDF) and acid detergent fibre (ADF) by Goering and van Soest (1970). Faeces and urine were analyzed for nitrogen by using Kjeldahl method (Fross 2020 digester and Foss 2100 Kjeltec distillation unit) and CP was calculated as 6.25 x N (AOAC, 1990).

Statistical analysis

The data were subjected to the analysis of variance (ANOVA) and the significance of differences between treatments means were compared by Duncan's Multiple Range Test (DMRT) using SPSS (version 16.0) software.

Results

The chemical compositions of experimental feedstuffs and diets are presented in table 1. There was no widely variation in chemical compositions between LF and LS, and among experimental diets except ether extract (EE) content in which lower value was found in LS and DLS10, respectively. The contents of anti-nutritional factors such as tannin and mimosine were slightly higher in LF and LS feedstuffs, however low concentration of those factors was observed in both experimental diets, DLF10 and DLS10.

The nutrient intakes (metabolic size per body weight) of dairy cows offered the experimental diets were shown in table 2. All nutrient intakes were not significantly different ($p>0.05$) among the cows fed on experimental diets except ether extract intake (EEI), in which EEI of the cows fed on DLF10 was significantly higher ($p<0.05$) than those of the cows fed on other two diets.

The nutrient digestibilities of experimental diets were expressed in table 3. Generally the nutrient digestibilities of DLF10 tended to be

Table 1. Chemical compositions of experimental feedstuffs and diets

Description	DM	OM	CP	NDF	ADF	EE	Tannin	Mimosine
Experimental feedstuffs								
URS	43.72	79.64	7.96	65.22	47.40	1.61	0.00	0.00
CC	91.27	94.34	23.45	33.52	25.17	2.79	0.00	0.00
LF	28.56	91.70	30.01	26.43	16.42	3.25	6.86	4.82
LS	29.23	92.60	27.50	37.14	17.28	1.89	6.48	4.38
Experimental diets								
DLFS0	93.58	85.99	16.09	51.80	35.74	1.34	-	-
DLF10	92.58	86.08	16.31	49.36	34.38	1.87	0.48	0.34
DLS10	93.47	85.81	16.17	50.10	34.95	0.97	0.45	0.31

URS – urea treated rice straw; CC – commercial concentrate (contained 40% cottonseed cake, 35% broken chickpea and 25% chickpea husk on an as fed basis and provided 235g CP/kg DM); LF – leucaena forage; LS–leucaena silage.

Table 2. Nutrient intakes (g/kgBW$^{0.75}$) of cows fed on experimental diets

Description	Experimental diets			SEM	P value
	DLFS0	DLF10	DLS10		
DMI	128.25	130.18	128.50	0.66	0.497
OMI	110.82	112.45	111.00	0.57	0.501
CPI	20.79	21.32	20.86	0.13	0.211
NDFI	76.54	76.41	75.84	0.38	0.778
ADFI	59.79	59.24	58.52	0.33	0.322
EEI	2.61^{b}	2.70^{a}	2.59^{b}	0.02	0.040

DMI – dry matter intake; OMI – organic matter intake; CPI – crude protein intake; NDFI: – neutral detergent fibre intake; ADFI – acid detergent fibre intake; EEI – ether extract intake; $^{a, b}$ – Mean value with different superscripts with the same row are significantly different (P<0.05).

Table 3. Nutrient digestibility (%) of cows fed on experimental diets

Description	Experimental diets			SEM	P value
	DLFS0	DLF10	DLS10		
DMD	65.14^{a}	51.90^{b}	59.32^{a}	2.14	0.008
OMD	66.87^{a}	53.89^{b}	60.79^{ab}	2.16	0.015
CPD	61.86	56.27	55.20	1.49	0.139
NDFD	62.18^{a}	46.69^{b}	52.67^{ab}	2.73	0.032
ADFD	62.05^{a}	46.87^{b}	52.57^{b}	2.46	0.007
EED	87.42^{a}	70.80^{b}	81.40^{a}	2.62	0.003
TDN	59.98^{a}	48.37^{b}	54.55^{ab}	1.91	0.012
DCP	10.01	9.21	8.94	0.23	0.145

DMD – dry matter digestibility; OMD – organic matter digestibility; CPD – crude protein digestibility; NDFD – neutral detergent fibre digestibility; ADFD – acid detergent fibre digestibility; EED – ether extract digestibility; TDN – total digestible nitrogen; DCP – digestible crude protein; $^{a, b}$ – Mean value with different superscripts with the same row are significantly different (P<0.05).

Table 4. Nitrogen utilization (g/kgBW$^{0.75}$) of cows fed on experimental diets

Description	Experimental diets			SEM	P value
	DLFS0	DLF10	DLS10		
Nitrogen intake	3.28	3.41	3.37	0.03	0.188
Fecal nitrogen	1.61	1.65	1.68	0.07	0.939
Urine nitrogen	1.26	0.89	1.04	0.08	0.148
Nitrogen utilization	0.41^{b}	1.01^{a}	0.62^{b}	0.09	0.003

$^{a, b}$ – Mean value with different superscripts with the same row are significantly different (P<0.05)

lower comparison with other two diets, DLFS0 and DLS10. The dry matter digestibility (DMD) and ether extract digestibility (EED) of DLF10 were significantly lower (p<0.05) than those of DLFS0 and DLS10. Moreover, the values of organic matter digestibility (OMD), neutral detergent fibre digestibility (NDFD) and total digestible nitrogen (TDN) content of DLF10 were also significantly lower (p<0.05) than that of DLFS0, however it was not statistically different (p>0.05) with DLS10. For the acid detergent fibre digestibility (ADFD), the value of DLFS0 was

Table 5. Milk composition (%) of cows fed on experimental diets

Description	Experimental diets			SEM	P value
	DLFS0	DLF10	DLS10		
Fat	3.53^{b}	3.29^{b}	4.68^{a}	0.23	0.004
Protein	3.58	3.51	3.45	0.05	0.571
Conductivity	8.14	8.30	8.36	0.12	0.783
Density	32.96	32.55	32.28	0.34	0.763
Solid Not Fat	9.60	9.42	9.20	0.12	0.480
Lactose	5.03	4.99	4.90	0.05	0.638
Salt	0.91	0.90	0.87	0.01	0.511

^{a,b} – Mean value with different superscripts with the same row are significantly different

Table 6. Average milk yields of cows fed on experimental diets and feed cost per kg of milk

Description	Experimental diets			SEM	P value
	DLFS0	DLF10	DLS10		
Milk yield (kg/d)	7.21^{b}	11.73^{a}	10.06^{ab}	0.84	0.050
Feed cost (kyat)* Per kg of milk	233.33^{a}	164.33^{b}	215.00^{ab}	12.19	0.023

*1 US dollar is equivalent to 1250 kyat (Myanmar currency); ^{a,b} – Mean value with different superscripts with the same row are significantly different

significantly higher (p<0.05) than that of other two leucaena diets. However, no statistically difference (p>0.05) was observed in crude protein digestibility (CPD) and digestible crude protein (DCP) contents among the experimental diets.

The nitrogen utilizations of cows fed on the experimental diets were shown in table 4. Although the nitrogen intake, fecal nitrogen and urine nitrogen of cows fed on experimental diets were not significantly different (p<0.05) among them, the nitrogen utilization of cows offered the DLF10 was significantly higher (p<0.05) than that of other two diets which were not different as statistically (p>0.05).

The milk compositions of cows offered the experimental diets were presented in table 5. All of milk compositions were not significantly different (p>0.05) among the cows fed on experimental diets except milk fat content in which the cows fed on DLS10 was significantly higher (p<0.05) than that of cows offered other two diets, DLFS0 and DLF10, which were not significantly different (p>0.05) each other.

The average milk yields of cows offered the experimental diets and feed cost per kg of milk were described in table 6. The highest average milk yield (p<0.05) was found in cows fed on DLF10 and the lowest values (p<0.05) was observed in the cows fed on DLFS0. However, the average milk yield of cows fed on DLS10 was not significantly different (p>0.05) with other two diets, DLFS0 and DLF10. For the feed cost per kg of milk, the highest feed cost (p<0.05) per kg of milk was observed in DLFS0 and the lowest cost (p<0.05) was found in DLF10. The feed cost for DLS10 was not statistically different (p>0.05) with other diets.

Discussions

The nutrient intakes of cows fed on experimental diets were not significantly different among them except EEI which was highest in cows offered DLF10 (table 2). This finding is not consistent with the reports of Wahynni *et al.,* (1972); Jones (1979) and Giang *et al.,* (2016) who stated that supplementation of leucaena forage and silage in the diets can improve the intake of cattle. Leucaena supplemented diets can give higher palatability which lead to increase feed intake. However, in this experiment, the inclusion level of leucaena is 10% of concentrate in diets. It means that a lower inclusion level of leucaena can't give the higher palatability and stimulate to increase feed intake in ruminants.

Generally the lowest nutrient digestibility was found in DLF10 compare with other two diets, DLFS0 and DLS10 which were not significantly different each other (table 3). This result also argues to the findings of Hongo *et al.,* (1986) and Giang *et al.,* (2016) who presented that nutrient digestibility could be increased with the supplementation of leucaena forage and silage in the diets of ruminants. Moreover, leucaena is also a rich source of minerals such as sulfur, which is can act as enhancer of rumen microbial populations (mainly cellulolytic fungi and bacteria) (Aregheore, 1999). On the other hands, although the secondary compound (such as tannin) has the adverse effects on the feed intake and nutrient digestibility, feeding small amount of this compound to animals has positive effect without reducing dry matter intake and nutrient degradation (Barry and Duncan 1984). In this study, the content of secondary compound (tannin) is low level which has no adverse effect on the intake and degradation of nutrients.

Although the nitrogen intakes of cows were not statistically different among them, the highest nitrogen utilization ($p<0.05$) was observed in cows fed on DLF10 (table 4). It might be due to the variation of urine nitrogen contents of cows offered the experimental diets. It is because excessive accumulation of ammonia in the rumen leads to increase urine nitrogen and thereby lowering nitrogen utilization. The phenolic hydroxyl groups of tannins bind to dietary protein to form tannin-protein complex which can avoid excessive protein degradation in rumen (Barry and Duncan, 1984; Waghorn *et al.,* 1987). Therefore, the nitrogen utilizations of cows fed on DLF10 and DLS10 were higher than those of cows offered without leucaena diet (DLFS0).

The milk fat content of cows fed on DLS10 was higher than cows offered other two diets, while the rest milk compositions were not different each other (table 5). Although the contents of dietary fibre and fat contained in diets can alter the milk fat content, those values of experimental diets in this study were not significantly different each other (table 1). However, the ruminal microflora could be changed with the supplementation of leucaena in the diets because it is a rich source of sulfur which can enhance the ruminal microbial populations mainly the cellulolytic microbes (Aregheore, 1999). Improved cellulolytic activity in the rumen leads to increased production of acetate from the fermentation process, thereby increasing the milk fat content because acetate is the precursor of milk fatty acid synthesis in mammary gland (Sutton, 1980). However, the cows offered DLF10 were not consistent with those reports.

The average milk yield of cows offered the diets containing leucaena (DLF10 and DLS10) was significantly higher than those of cows fed on diets containing no leucaena (DLFS0) (table 6). It might be due to increase amount of bypass protein to the lower parts of gastrointestinal tract. Consuming the moderate level of secondary compound (tannin) contained in leucaena has the positive effects on the performances of ruminant animals. The tannin binds with protein to form tannin-protein complex which prevent the excessive protein degradation in the rumen and increased the bypass protein to the lower parts of gastrointestinal tract and amount of essential amino acids supply, resulting in higher animal production (Barry and Duncan 1984; Waghorn *et al.,* 1987; Wanapat *et al.,* 2015).

The lowest feed cost per kg of milk was found in cows fed on DLF10 and a highest value was observed in cows offered DLFS0. It could be due to substitution of the cheap leucaena forage into the expensive concentrate. Moreover, the higher performance (average milk yield) was also achieved with the substitution of that cheap leucaena forage. Aung *et al.,* (2016) also reported that substitution of alternative cheap protein sources (*Albizia saman* pods) in expensive concentrate could reduce the feed cost per kg of milks and enhance the performances of dairy cows.

Conclusions

When leucaena forage and silage were substituted in the concentrates, although nutrient intakes were not significantly different each other, digestibility of diet, DLFS0 was generally higher than other two diets, DLF10 and DLS10. Conversely, nitrogen utilization and average milk yield of cows offered DLFS0 were lower than those of cows fed on other diets, DLF10 and DLS10. Therefore, the feed cost per kg of milk was also different among the experimental diets. Between the leucaena substituted diets, DLF10 and DLS10, the higher performances were observed the cows fed on the DLF10. Therefore, the leucana forage and silage could be substitute up to 10% of concentrates without adverse effects on the performances of dairy cows. Moreover, the substitution of leucaena forage to concentrate gave the better performances than that of leucaena silage. For the further researches, it would be suggested that the higher inclusion level of leucaena forage and silage in commercial concentrate on the performances of dairy cows should be evaluated.

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