Influences of Starch to Fiber Ratio in Total Mixed Rations on Rumen Fermentation and Ruminal Dry Matter and Organic Matter Degradability of Fiber Source in the Dairy Cows

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ABSTRACT

Manipulation of the proportion of feed ingredients in total mixed ration offered for the dairy cows may influence the utility and availability of consumed feed. The research was conducted in two consecutive experiments to elucidate the influences of starch to fiber ratios in total mixed rations on rumen fermentation, ruminal dry matter and organic matter degradability of fiber source in the dairy cows. The first experiment was carried out to determine the influences of the starch sources and the ratios of the starch to fiber in total mixed rations (TMR) on the pH and redoxpotential (Eh) of the rumen fluid of the dairy cows. Four feed formula containing with two different starch sources (cassava chip and ground corn) and two ratios of starch to fiber (60:40 and 40:60), respectively were formulated. Four Holstein x Thai-indigenous cross bred cows fitted with permanent ruminal fistula were allocated in a 2 x 2 factorial arrangement in a 4 x 4 Latin Square design to receive 4 different experimental feeds. The rumen fluid was taken every two hours from 0 to 8 hours post feeding for the pH and the Eh measurements. The second experiment was undertaken to evaluate the influences of starch sources and the ratios of the starch to fiber in total mixed rations on the ruminal dry matter and the organic matter degradability of ensiled Napier grass using as fiber source in the TMR. The animals from the previous experiment were further assigned in a 2 x 2 factorial experiment in a Randomized Complete Block design to evaluate the ruminal dry matter and organic matter degradability of fiber source of the TMR using the nylon bag technique. It was found that the ruminal pH and Eh of the cows fed with TMR containing different starch sources and starch to fiber ratios were not significantly different (P>0.05) across treatments. The TMR with a higher fiber content had a higher (P>0.05) ruminal pH at every hour post feeding. However, the ruminal degradability of the dry matter (P<0.05) and the organic matter (P<0.01) were significantly different among the treatments. The ratios of starch to fiber in TMR affect (P<0.05) the non water soluble but ruminally fermentable fraction (b), the potential degradability (PTDG) as well as the constant rate of degradability (c) of both of the dry matter and the organic matter. The results of these studies implied that TMR containing with different starch sources and ratios of the starch to fiber did not influence the rumen fermentation. However, feeding the cows with TMR containing with different starch sources and different ratios of starch to fiber influences the availability of both of the dry matter and the organic matter degradability of feed ingredient used as fiber source in the TMR.

KEY WORDS: Starch sources, Ratio of starch to fiber, Rumen fermentation, Dry matter degradability, Organic matter degradability, Total mixed ration

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INTRODUCTION

Starch is a source of carbohydrate obtained mostly from cereal grain and root crop as well as byproducts of these sources. On a chemical basis, starch is comprised of glucose molecules linked together by α -1,4 glygosidic linkage. Feeding the ruminant with high level of starch reduced the ruminal pH and may cause rumenitis and parakeratosis (Ørskov, 1986). Fiber is a main fraction of the plant cell wall contained mostly of carbohydrates. The most predominant component of fiber are cellulose hemicelluloses and lignin. To prevent the severe adverse effect of ruminal starch fermentation, providing the ruminant with optimum fiber content in the offered feed is must be taken into the considerations. The purpose of this experiment was to study the influence of ratio of starch to fiber in total mixed ration on ruminal pH redox potential(*Eh*) and on ruminal dry matter and organic matter degradation parameters of ensiled Napier grass used as fiber source of the TMR.

MATERIALS AND METHODS

Experiment1: Rumen fermentation study

Four Holstein x Thai-indigenous cross bred cows fitted with permanent ruminal fistula were allocated in a 2 x 2 factorial arrangement in a 4 x 4 Latin Square design to receive 4 different experimental feeds contained with 2 different starch source (cassava chip VS ground corn) and two different ratio of starch to fiber (high starch low fiber diets VS High fiber low starch diets)(Table 1). The rumen fluid was taken every two hours from 0 to 8 hours post feeding for the pH and the *Eh* measurements

Experiment2: Ruminal dry matter and organic matter degradation parameters study

Dry ensiled Napier grass was grind through a 1 mm screen for use as the sample for ruminal dry matter and organic matter degradation parameters study.

	Starch sources					
Ingredients	С	assava	Ground Corn			
	High starch	High fiber	High starch	High fiber		
Cassava ship	33.25	10.00	0	0		
Ground corn	0	0	38.25	11.45		
Soybean meal	17.00	15.00	13.00	15.50		
Molasses	3.50 3.00		3.50	3.50		
Vitamin-mineral premixed	0.50	0.50 0.50		0.50		
Dicalcium phosphate	1.00	1.00 1.00		1.00		
NaCl	1.00	1.00 1.00		1.00		
Ground sulfur	1.00	1.00	1.00	1.00		
Urea	1.00	1.50	1.00	1.25		
Palm oil	1.00	1.00	1.00	1.00		
Ensiled Napier grass	40.75	66.00	39.75	65.00		
Calculated Value (%DM basis)						
Crude Protein	12.00	12.08	12.21	12.12		
Metabolizable energy (kcal/kg)	2607	2408	2698	2424		
Ca	0.65	0.71	0.57	0.70		
Р	0.47	0.49	0.41	0.48		
Starch	48.64	28.86	43.77	28.06		
NDF	32.36	43.30	29.24	41.92		
% Starch in Total mixed ration	60	40	60	40		
% NDF in Total mixed ration	40	60	40	60		

 Table1: Feed ingredients and calculated values of four total mixed rations used for the experimentations (% DM basis)

RESULTS AND DISCUSSION

pH									
	Energy sources (A)			Ratio of starch to fiber (B)			_		
Hour after feeding (hr)	Cassava chip	Ground corn	P>F	60:40 (HSLF)	40:60 (LSHF)	P>F	SEM	A*B	
0	7.08	6.92	0.15	7.01	6.99	0.81	0.07	0.09	
2	6.93	6.90	0.61	6.87	6.96	0.22	0.04	0.04	
4	6.73	6.86	0.32	6.72	6.87	0.29	0.09	0.14	
6	6.82	6.95	0.20	6.79	6.97	0.10	0.06	0.18	
8	6.84	7.04	0.15	6.86	7.02	0.24	0.09	0.12	
<i>Eh</i> (mV)									
0	-30.56	-31.94	0.79	-34.69	-27.81	0.21	3.55	0.43	
2	-38.31	-40.25	0.64	-41.75	-36.81	0.25	2.75	0.05	
4	-49.44	-42.06	0.35	-50.25	-41.25	0.27	5.18	0.15	
6	-44.86	-37.03	0.18	-46.00	-35.94	0.10	3.66	0.16	
8	-39.94	-32.94	0.16	-38.94	-33.94	0.30	3.12	0.07	

Table 2: Influences of source of starch and ratio of starch to fiber in total mixed rations on change of pH and oxidation reduction potential (*E*h) of ruminal fluid of the dairy cattle

SEM = Stand error of the mean mV = Millivolt

The mean changes in rumen pH and *E*h over time are shown in Table 2. Both the effect of starch sources and starch to fiber ratios did not affect (P>0.05) to the rumen pH and the *E*h value in every collection periods. The pH value obtained from this work range from 6.72 to 7.08 which is classified as an optimum pH for rumen fermentation. The *E*h value range from -30.50 to -50.25 mV which is lower than the previous result reported by Marden, *et al.* (2005) with the value ranged from -73.5 to -266.8 mV. The lower reducing power of the *E*h value derived from this research work might ground on the fact that measuring of the *E*h value was done in the aerobic condition. The rumen fluid was allowed to contact with oxygen for short time, the reducing power was therefore lower than that of other reports (Table 2).

The degradation constants of both the dry matter and organic matter are shown in table3. It is clearly indicated that almost all of the ruminal dry matter and organic matter degradation parameters are not affected (P>0.05) by source of starch and ratios of starch to fiber in the TMR. There were, however, the higher level of starch in TMR affects the potential degradability of the dry matter (P<0.01), the not soluble but fermentable fraction (P<0.05) as well as the rate constant of degradation (P<0.05) of the dry matter of Napier grass which is used as fiber source in the TMR. Furthermore the use of ground corn as energy source also provide a higher (P<0.01) the water soluble fraction of the organic matter of Napier grass which is used as fiber source in the TMR, whereas the higher ratio of starch to fiber provide a higher rate constant of degradation (P<0.05) of the dry matter of Napier grass (Table 3).

Dry matter									
parameter Energy sources(A)			Ratio of Starch	SEM	A*B				
	Cassava chip	Ground corn	60:40	40:60					
а	20.21^b	22.72^{a}	22.29	20.65	0.69	0.84			
b	63.31	63.14	60.07 ^b	66.38 ^a	1.52	0.08			
c (fr/hr)	0.027	0.024	0.028^{a}	0.023 ^b	0.00	0.07			
ed1	56.59	56.24	56.84	55.99	0.45	0.53			
ed2	42.50	42.44	43.28	41.66	0.59	0.20			
ed3	36.36	36.64	37.28	35.73	0.64	0.23			
PTDG	83.90	85.87	82.26 ^b	87.5 1 ^a	0.08	0.03			
lag time(hr)	0.09	0.18	0.02	0.25	1.32	0.71			
	Organic matter								
а	15.04 ^B	18.96 ^A	16.31	17.70	0.735	0.46			
b	67.35	64.87	64.62	67.59	1.516	0.17			
c (fr/hr)	0.027	0.025	0.029 ^a	0.023 ^b	0.001	0.07			
ed1	54.21	54.10	54.43	53.89	0.505	0.88			
ed2	39.15	40.03	39.98	39.20	0.494	0.52			
ed3	32.44	34.06	33.50	33.00	0.514	0.67			
PTDG	82.39	83.83	80.93	85.29	1.434	0.08			
lag time(hr)	0.44	0.34	0.55	0.24	0.190	0.66			

Table 3: Influences of source of starch and ratio of starch to fiber in total mixed ration on the ruminal degradation parameters of dry matter and organic matter of ensiled Napier grass used as the principal fiber source in total mixed ration (%)

Degradation constants derived from the Ørskov and McDonald (1979) equation $P = a+b(1-e^{-ct})$ where P is degradability at time 't'; 'a', the rapidly soluble fraction; 'b', the potentially degradability of dry matter with in time 't', be degraded; 'c', the degradation rate of the 'b' fraction, PTDG = Potential degradability (a+b). Effective degradation in the rumen at 0.02, 0.05 and 0.08 fraction/hour passage rate is represented by ed1, ed2 and ed3 respectively and is calculated by using the Excel Application Programs for processing feed degradability data written by Chen (1995).

^{a, b}= Means in the same row of the same factor with different superscript differ significantly (P<0.05)

^{A, B,}= Means in the same row of the same factor with different superscript differ significantly (P<0.01)

SEM = Stand Error of Mean

CONCLUSIONS

The current studies results showed that the total mixed ration containing with different starch sources and ratios of the starch to fiber did not influence the rumen fermentation and the ruminal degradation parameters of both of the dry matter and the organic matter. Most of the ruminal degradation parameters measured throughout 4 days of the degradation study periods are not significantly different. This might mean that both of cassava chip and ground corn at the lower and higher ratio with fiber in the TMR could not alter the ruminal fermentation of the cattle used in this study.

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