Effects of Synchronizing the Rate of Dietary Energy and Nitrogen Release on Ruminal Fermentation, Microbial Protein Synthesis, Blood Urea Nitrogen and Nutrient Digestibility in Beef Cattle

S. Chumpawadee*, K. Sommart[1], T. Vongpralub[1] and V. Pattarajinda[1]
Department of Agricultural Technology, Faculty of Technology, Mahasara Kham University
Mahasara Kham 44000, Thailand

ABSTRACT : The objective of this research was to determine the effects of synchronizing the rate of dietary energy and nitrogen release on: ruminal fermentation, microbial protein synthesis, blood urea nitrogen, and nutrient digestibility in beef cattle. Four, two-and-a-half year old Brahman-Thai native crossbred steers were selected for the project. Each steer was fitted with a rumen cannula and proximal duodenal cannula. The steers were then randomly assigned in a 4×4 Latin square design to receive four dietary treatments. Prior to formulation of the dietary treatments, feed ingredients were analyzed for chemical composition and a nylon bag technique was used to analyze the treatments various ingredients for degradability. The treatments were organized in four levels of a synchrony index (0.39, 0.50, 0.62 and 0.74). The results showed that dry matter digestibility trend to be increased ($p<0.06$), organic matter and acid detergent fiber digestibility increased linearly ($p<0.05$), while crude protein and neutral detergent fiber digestibility were not significantly different ($p>0.05$). Higher concentration and fluctuation of ruminal ammonia and blood urea were observed in the animal that received the lower synchrony index diets. As the levels of the synchrony index increased, the concentrations of ruminal ammonia nitrogen and blood urea nitrogen, at the 4 h post feeding, decreased linearly ($p<0.05$). Total volatile fatty acid and bacteria populations at the 4 h post feeding increased linearly ($p<0.05$). Microbial protein synthesis trend to be increase ($p<0.08$). The results of this research indicate that synchronizing the rate of degradation of dietary energy and nitrogen release improves ruminal fermentation, microbial protein synthesis and feed utilization. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 2 : 181-188)***

Key Words : Beef Cattle, Dietary Energy, Microbial Protein, Synchrony Index, Nutrient Digestibility

INTRODUCTION

Microbial protein synthesis is important for ruminant. Current concepts of ruminant nutrition focus on maximizing ruminal microbial protein production. Microbial protein can supply from 70% to 100% of amino acids to ruminant (AFRC, 1992). High microbial protein production can decrease the need for supplementing rumen undegradable protein (Blummel et al., 1999). Microbial yield in rumen depends largely on the availability of carbohydrate and nitrogen (N) in the rumen. Nocek and Russell (1988) suggested that the efficiency of microbial growth and microbial protein production may be improved by balancing the overall daily ratio of ruminally available energy and N in the diet. Shabi et al. (1998) found that the available energy in the rumen (Ruminal degradable organic matter) is the most limiting factor of ruminal N utilization. In some *in vitro* studies, bacteria yield was increased by a synchronous supply of N and carbohydrates (Henning et al., 1991). Synchronization of the rate of dietary energy and nitrogen release has been suggested as a means of improving both microbial protein flow at the duodenum, and the efficiency of microbial protein synthesis (Sinclair et al., 1993; Kim, 2001; Trevakis et al., 2001) a more efficient capture of rumen degraded nitrogen would reduce the excretion of urinary nitrogen (Sinclair et al., 1993), and fermentative carbon losses in CO_2 and CH_4 (Blummel et al., 1999).

With respect to tropical feedstuffs, limited information is available on synchronizing the rate of degradation of dietary energy and nitrogen release in beef cattle diet. The aim of this study was to investigate the synchrony index on ruminal fermentation, microbial protein synthesis, blood urea nitrogen and nutrient digestibility in beef cattle fed high fibrous tropical feedstuffs.

MATERIALS AND METHODS

In situ degradation characteristics of feedstuffs

Feedstuffs were collected from various feed mills and organizations (Kantharavichai dairy cooperation, Khonkaen dairy cooperation, Mahasara Kham University feed mill, Khon Kaen University feed mill, Numhenghoad feed suppliers, Chareon Esan commercial feed mill, Songserm Kankaset feed supplier) in the North East of Thailand. All test feed samples (Table 1) were ground to pass through a 1 mm screen for nylon bag incubation and chemical analysis.

* Corresponding Author: Songsak Chumpawadee. Tel: +66-043-743135, Fax: +66-043-743135, E-mail: songsakchum@yahoo.com
[1] Department of Animal Science, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand.
Received December 28, 2004; Accepted June 25, 2005

Table 1. Chemical analysis of feedstuffs used for feed formulation in the experiment

Feedstuffs	DM (%)	CP	Ash	NDF	ADF	ADL
		---------- % DM basis ----------				
Rice straw	91.50	3.0	13.64	72.13	53.28	4.89
Corn ground	92.20	8.53	1.69	13.25	3.63	0.41
Cassava chip	93.40	1.89	2.01	6.93	6.35	1.87
Rice bran	91.70	14.26	6.31	20.29	8.12	2.61
Kapok seed meal	91.01	28.09	8.91	42.50	29.49	16.34
Soybean meal	91.31	47.24	7.12	12.84	8.26	0.10

DM = Dry matter, CP = Crude protein, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ADL = Acid detergent lignin.

Table 2. Degradability characteristic of organic matter and nitrogen of feedstuffs using nylon bag technique

	a	b	c	a+b
Organic matter degradability				
Rice straw	0.09	0.75	0.014	0.84
Corn ground	0.36	0.63	0.024	0.99
Cassava chip	0.77	0.22	0.033	0.99
Rice bran	0.40	0.36	0.176	0.76
Kapok seed meal	0.37	0.22	0.057	0.59
Soybean meal	0.34	0.65	0.045	0.99
Nitrogen degradability				
Rice straw	0.28	0.57	0.004	0.85
Corn ground	0.29	0.45	0.051	0.74
Cassava chip	0.60	0.19	0.065	0.79
Rice bran	0.36	0.42	0.156	0.78
Kapok seed meal	0.10	0.61	0.264	0.71
Soybean meal	0.10	0.89	0.038	0.99

$P = a+b(1-e^{-ct})$, a = the rapidly soluble fraction. b = the potentially degradable fraction c = the rate of degradation of fraction b.

The feedstuff samples were analyzed for dry matter (DM), crude protein (CP) and Ash (AOAC, 1990), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) (Van Soest et al., 1991).

Two Brahman-Thai native crossbred beef cattle steers with an average body weight of 250±15 kg were fitted with permanent rumen cannula and offered rice straw *ad libitum*. They were fed concentrate (49.80% cassava chips, 17.5% rice bran, 14.60% palm meal, 7.0% soybean meal, 1.40% urea, 0.4% salt, a 1.0% mineral mix and 8.30% sugarcane molasses) at 0.5% BW. A ruminal degradation measurement using the nylon bag technique was carried out after a two week adaptation period.

Approximately 5.0 g (as fed basis) of each test feed was accurately weighed into a nylon bag with a mean pore size of 45 μm (Shabi et al., 1998). The bag was placed into the rumen of the beef steers, 30 min after the morning meal and retrieved after periods of 2, 4, 6, 12, 24 and 48 h. After removal from the rumen, the bags were washed by hand under tap water until the rinse water became clear. After washing, the bags were placed into a hot, dry, forced air oven at 65°C for 48 h and weighed. To determine the content of water soluble material, bags representing 0 h degradation were washed using the same washing procedure as the incubated bags. The dried residue from the incubation period of each steer was pooled and analyzed for DM, organic matter (OM) and CP. Organic matter and CP disappearance values were calculated as the difference between the weight of the nutrient before and after incubation of each sample. The degradability data obtained for OM and N for each feed were fitted to the equation $P = a+b(1-e^{-ct})$ (Ørskov and McDonald, 1979), where P is the amount degraded at time *t*, *a* is the rapidly soluble fraction, *b* is the potentially degradable fraction, *c* is the rate of degradation of fraction *b*. The results are presented in Table 2.

Urea was also included in the data-base and it was assumed that 95% of urea N was degraded in the first hour after feeding, with the remaining 5% of urea N degraded at a rate (c) = 0.5/h (Sinclair et al., 1995). Sugarcane molasses was assumed at 100% of N and OM degraded in the first hour post feeding.

Diet formulation

The synchrony index of N to OM was calculated according to Sinclair et al. (1993) as follows:

$$\text{Synchrony index} = \frac{25 - \sum_{1-24} \frac{\sqrt{\left[(25 - hourlyN/OM)^2\right]}}{24}}{25}$$

Where 25 = 25 grams of N per kilogram of OM truly digested in the rumen (Czerkawski, 1986), an asynchrony index of 1.0 represents perfect synchrony between nitrogen and energy supply throughout the day whilst values<1.0 indicate the degree of asynchrony.

Using the computer program described previously (Sinclair et al., 1993), which contains the database of raw material proximate analysis, fiber composition and degradation characteristics obtained from the experiment are presented in Table 1 and 2. The program requires as input: a proportion of each constituent in the diet, dry matter intake per day (2.0% BW), the time of feeding (fed in equal amounts at 12 h interval) and the outflow rate of solids (k = 0.05).

Using the program, four diets were formulated to have a

Table 3. Feed formulation and chemical composition of dietary treatment

Ingredient	Synchrony index			
	0.39	0.50	0.62	0.74
Rice straw	54.8	54.8	54.8	54.8
Cassava ship	8.8	11.9	14.7	16.9
Rice bran	13.9	11.9	7.0	5.0
Corn ground	7.9	4.9	4.9	3.0
Soybean meal	-	3.0	7.5	13.5
Kapok seed meal	8.9	7.9	5.9	2.0
Salt (NaCl)	0.5	0.5	0.5	0.5
Urea	1.0	0.8	0.5	0.2
Mineral mix	0.5	0.5	0.5	0.5
Molasses	3.6	3.6	3.6	3.6
Total	100.0	100.0	100.0	100.0
Predicted chemical composition				
Total digestible nutrient (%)	58.06	58.33	59.17	59.62
Metabolizable energy (MJ/kg)	9.16	9.20	9.37	9.45
Crude protein (%)	10.01	10.10	10.16	10.62
Rumen degradable OM (%)	44.06	45.16	46.14	47.51
Rumen degradable N (%)	6.96	6.85	6.59	6.64
Neutral detergent fiber (%)	49.05	48.43	47.34	45.89
Acid detergent fiber (%)	34.02	33.91	33.46	32.69
Analyzed chemical composition				
Dry matter (%)	92.53	93.02	93.51	93.74
Ash (%)	9.01	9.46	9.33	9.45
Crude protein (%)	10.66	10.19	10.35	10.83
Neutral detergent fiber (%)	54.37	50.60	50.61	50.96
Acid detergent fiber (%)	34.15	32.80	33.69	30.95
Acid detergent lignin (%)	4.29	3.88	3.87	3.01

similar total digestible nutrient (TDN), metabolizable energy (ME), crude protein (CP), rumen degradable protein (RDP) and rumen degradable organic matter (Table 3), but differed in synchrony index 0.39, 0.50, 0.62 and 0.74 respectively.

Animal and feeding

Four Brahman-Thai native crossbred steers weigh 276.5±10.5 kg, fitted with permanent cannula in the rumen and a T piece cannula in the proximal duodenum, were used for experiment. The animals were fed at the rate of 2.0% BW in two equal meals at 7.00 h and 19.00 h. Clean water and mineral lick were offered and available at all time in the individual pens. A metabolism trial was carried out at the Department of Agricultural Technology, Mahasara Kham University, Thailand, from May 25, 2003 to August 16, 2003. The animals were weighed at the beginning and end of each period.

Sample collection and preparation

The roughage and concentrate were sampled every three weeks, and the composites prior to chemical composition analysis. The daily feces in their entirety were collected for five days during a collection period. It was weighed and mixed well and a 10% sub sample was taken and stored at -20°C. At the end of each collection period the daily fecal samples were bulked for each animal. Ten percent of each mixed well-bulked sample was taken for estimation of digestibility of DM, OM, CP, NDF and ADF.

One hundred ml of ruminal fluid was collected at the end of each sampling period at 0, 2, 4, 6, 8 and 10 h post feeding via rumen cannula. Ruminal pH was measured immediately after sampling using a potable pH meter. Rumen fluid samples were then filtered through four layers of cheesecloth. Samples were divided into two portions. One portion was used for ammonia nitrogen and total volatile fatty acid analyses where 5 ml of 6 N HCl was added to 50 ml of rumen fluid. The mixture was centrifuged at 2,500×g for 15 minutes and the clear supernatant was stored in plastic tubes at -20°C until analyzed for rumen ammonia nitrogen (Bremner and Keeney, 1965) and total volatile fatty acid concentration (Briggs et al., 1957). Another portion was fixed with 10% formalin solution in normal saline (0.9% NaCl) for direct total count of microorganism in rumen fluid (Galyean, 1989).

Samples of jugular blood were drawn into heparinised vacutainers (10 ml for sample) at the same time rumen fluid sampling and centrifuged at 2,500×g for 15 minutes. The plasma was then transferred into storage tube and labeled with date and animal identification. The plasma samples were kept at -20°C until analyzed for BUN (BMG's urea reagent, Boehringer Mannheim, Indianapolis, IN).

Table 4. Digestibility of nutrient (%), ruminal pH, ammonia nitrogen (mg %), total volatile fatty acid (mM) and blood urea nitrogen (mg %) of Brahman-Thai native beef cattle receive diet containing four levels of synchrony index

	Synchrony index				SEM	Polynomial contrast		
	0.39	0.50	0.62	0.74		L	Q	C
Nutrient digestibility								
DM (%)	65.60	65.98	67.22	68.34	0.53	0.06	NS	NS
OM (%)	69.46	69.84	70.90	72.21	0.46	0.03	NS	NS
CP (%)	69.88	69.78	70.41	72.04	0.60	NS	NS	NS
NDF (%)	66.19	62.14	64.56	65.53	0.83	NS	NS	NS
ADF (%)	57.06	54.81	59.07	58.31	1.22	0.03	NS	NS
Ruminal								
pH	6.60	6.69	6.70	6.66	0.07	NS	NS	NS
NH_3N (mg %)	9.86	8.67	8.70	7.58	0.45	NS	NS	NS
TVFA (mM)	72.79	83.25	86.00	83.25	3.72	NS	NS	NS
Blood								
BUN (mg %)	10.53	9.91	9.18	9.53	0.34	NS	NS	NS

DM = Dry matter, OM = Organic matter, CP = Crude protein, NDF= Neutral detergent fiber, ADF = Acid detergent fiber.
NH_3N = Ammonia nitrogen, TVFA = Total volatile fatty acid, BUN = Blood urea nitrogen, SEM = Standard error of the means.
NS = Not significantly different (p>0.05), L = Linear, Q = Quadratic and C = Cubic.

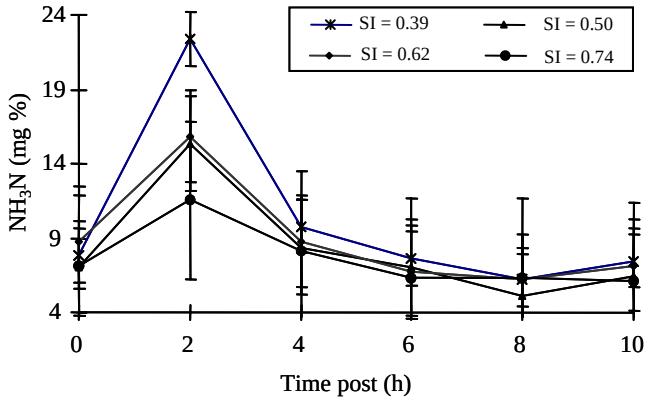

Figure 1. Hourly NH_3-N (mg %) in cattle receiving a diet containing four levels of synchrony index (SI).

Dry matter digesta flow to the duodenum was estimated using the chromic oxide marker technique according to Zinn et al. (1981). Animals were fed diets contained 0.4% of chromic oxide for three days prior to duodenum fluid collection. A 100 ml of duodenum digesta was sampled at duodenum twice daily for three consecutive days (04.00 h, 12.00 h on day 1: 08.00 h, 20.00 h on day 2: 16.00 h, 24.00 h on day 3). Duodenal digesta samples were separated into two parts, 1) 50 ml of digesta were oven dried at 65°C for 72 h, ground and analyzed for chromic oxide following the procedure of Siddons et al. (1985), 2) 50 ml of digesta samples were lyophilized and subsequently analyzed for total N by the micro-Kjeldahl method (AOAC, 1990) and for purine content (Zinn and Owens, 1986). To analyze ruminal bacteria isolation, rumen fluid was collected via cannula at the end of each collection period. The ruminal bacteria cells were promptly isolated following the procedure of Cecava et al. (1990). Isolated bacteria cells were lyophilized and analyzed following the same procedures as with the duodenal digesta.

Statistical analysis

A 4×4 Latin square design (four animals; four periods) was carried out in this experiment. Each period consisted of 21 days (14 days for adaptation and 7 days for sample collection). All data obtained from the experiment were subjected to the General linear Models (GLM) procedure for orthogonal polynomial analysis of SAS (SAS, 1996)

RESULTS AND DISCUSSION

Chemical composition and degradability characteristic of feed ingredients and chemical composition of diets

Chemical composition and degradability characteristics for the OM and N of feed ingredients used in the experiment are shown in Table 1 and 2 respectively. The feed ingredients varied widely in terms of composition and degradability characteristic. The crude protein content ranged from 1.89% for cassava chips to 47.24% for soybean meal. Ash content ranged from 1.69% for corn grounds to 13.64% for rice straw. Cell wall content ranged from 6.93% for cassava chips to 72.13% for rice straw. The rapidly soluble fraction (a) of OM and N were highest in the cassava chips. Sommart (1998) suggested that cassava and urea are known to be readily degraded in the rumen and thus may provide rumen synchrony when fed to animals. The potentially degradable fraction (b) of OM was highest in rice straw and soybean meal. The rate of degradation of fraction b (c) of OM was highest in rice bran.

A chemical analysis of the four diets is presented in Table 3. All four diets had a similar chemical composition. The crude protein, ash, and NDF content were approximately 10.50%, 9.30% and 51.63% respectively.

Effect of synchronizing the rate of dietary energy and nitrogen release on nutrient digestibility

Apparent DM, OM, CP, NDF and ADF digestibility are

Table 5. Direct total count microorganism population in ruminal fluid of Brahman-Thai native beef cattle receive diet containing four levels of synchrony index

Parameter	Synchrony index				SEM	Polynomial contrast		
	0.39	0.50	0.62	0.74		L	Q	C
Protozoa ($\times10^5$ cell/ml)	11.1	11.6	14.1	12.9	1.10	NS	NS	NS
Fungal zoospore ($\times10^4$cell/ml)	4.1	3.6	3.1	2.8	0.82	0.05	NS	NS
Total bacteria ($\times10^9$ cell/ml)	9.9	11.8	11.9	13.4	1.26	NS	NS	NS
Cocci ($\times10^9$ cell/ml)	7.4	7.4	8.1	8.0	1.59	NS	NS	NS
Rod ($\times10^8$ cell/ml)	4.7	5.3	4.1	4.1	0.08	NS	NS	NS
Spiral ($\times10^8$ cell/Ml)	1.6	2.2	2.2	2.1	0.02	0.05	NS	NS

Means (0-10 h), SEM = Standard error of the means, NS = Not significantly different (p>0.05), L = Linear, Q = Quadratic, C = Cubic.

shown in Table 4. The levels of the synchrony index in the rations had an affect on DM OM and ADF digestibility. Dry matter digestibility trended to increase linearly (p<0.06), OM and ADF digestibility increased linearly (p<0.05) with an increasing synchrony index. Synchrony index levels did not affect the digestibility of CP and NDF (p>0.05). In addition, results in this experiment found that a higher synchrony index increased both the microbial population (Table 6) and microbial fermentation, which would improve digestion of DM, OM and ADF.

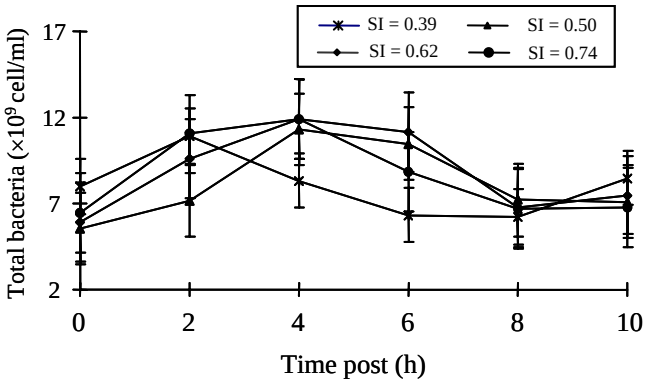

Figure 2. Hourly total bacteria population in cattle receiving diet containing four levels of synchrony index (SI).

Effect of synchronizing the rate of dietary energy and nitrogen release on rumen fermentation

Ruminal pH are presented in Table 4. Ruminal pH did not differ significantly at any level of the synchrony index (p>0.05). This finding was similar to those reported by other researchers (Sinclair et al., 1993; Witt et al., 1999; Thevaskis et al., 2001). Ruminal pH at 0, 2, 4, 6, 8 and 10 h post feeding were not affected by dietary treatments. Values were relatively stable at 6.0-6.7, and all treatment means were within the normal range which has been reported as optimal pH (6.0-7.0) for microbial digestion (Hoover, 1986).

Ruminal NH_3-N concentrations at 0, 2, 4, 6, 8 and 10 hours post feedings are presented in Table 4 and Figure 1. Ruminal NH_3-N concentrations at 0, 6, 8, 10 h post feedings and the means were not significantly different (p>0.05) at any level of the synchrony index; however, at the 2 and 4 h post feedings they decreased linearly (p<0.01 and p<0.05 respectively). The results were similar to Arieli et al. (1996), Kolver et al. (1998) and Shabi et al. (1998). Joo et al. (2005) suggested that rumen ammonia releasing rate influenced on microbial protein synthesis in the rumen. Ruminal NH_3-N concentration decreased, when the synchrony index increased indicating a more efficient capture of N for increased microbial protein synthesis. The result agrees with the statement of Sinclair et al. (1993); Sinclair et al. (1995) and Trevaskis et al. (2001), who found that a synchronous diet improved microbial protein flow at the duodenum and increased the efficiency of microbial protein synthesis. The patterns of NH_3-N concentration post feeding (see also Figure 1) fluctuated the least in animals receiving the highest synchrony index diet.

Total volatile fatty acid (TVFA) concentrations are presented in Table 4. Total volatile fatty acid concentrations were not significantly different among treatments (p>0.05); however, TVFA concentrations at the 4 h post feeding increased linearly (p<0.05) as levels of the synchrony index increased in the diets. The data in this experiment indicated that ruminal fermentation was greatest at the 4 h post feeding. This result disagrees with Sinclair et al. (1993), Sinclair et al. (1995), Chen and Hsu, 1998 and Witt et al. (1999), who reported that synchronous diets had no effect on VFA concentration. Higher TVFA concentration at the 4 h post feeding might have been related to the microbial population in the rumen that increased at the same time as optimum pH.

Effect of synchronizing the rate of dietary energy and nitrogen release on blood urea nitrogen

Blood urea nitrogen (BUN) concentrations are presented in Table 4. Blood urea nitrogen concentrations at the 4 and 8 h post feeding decreased linearly (p<0.05) as the levels of the synchrony index increased. The results disagree with Sinclair et al. (2000), who found that plasma urea levels were not affected by synchronous and asynchronous diets. Nevertheless, in this experiment BUN concentration showed a similar trend as the NH_3-N concentration in rumen (see also 1). This result agrees with Vongsumphan and Wanapat (2004), who found that an increase in rumen

Table 6. Flow of nitrogenous components at the duodenum and efficiencies of microbial protein synthesis and Average daily gain (kg/d), of Brahman-Thai native beef cattle receive diet containing four levels of synchrony index

Parameter	Synchrony index				SEM	Polynomial contrast		
	0.39	0.50	0.62	0.74		L	Q	C
Duodenal flow								
Total N, g/d	110.0	117.1	127.9	114.1	5.01	NS	NS	NS
Microbial N, g/d	37.1	44.6	46.0	51.6	2.39	0.08	NS	NS
Non microbial N (g/d)	72.9	72.5	81.9	62.4	3.17	NS	NS	NS
Microbial efficiency								
Microbial- N (g/kg OMADR)	25.0	26.9	28.6	26.3	1.41	NS	NS	NS
Microbial- N (g/kg OMTDR)	15.4	18.5	18.9	20.4	0.97	NS	NS	NS
Microbial- N (g/kg DMI)	6.1	7.6	7.9	8.8	0.43	0.06	NS	NS

OMADR = Organic matter apparent degraded in rumen, OMTDR = Organic matter truly degraded in rumen, DMI = Dry matter intake.
SEM = Standard error of the means, NS = Not significantly different ($p>0.05$), L = Linear, Q = Quadratic, C = Cubic.

NH_3-N levels results in increased levels of BUN. Present experiments found that beef cattle fed a diet containing a higher synchrony index had a lower BUN, indicating that a synchronous diet increased N utilization in rumen. Similarly, Sinclair et al. (1993) found that a synchronous diet improved efficiency capture of N in sheep.

Effect of synchronizing the rate of dietary energy and nitrogen release on rumen microorganism population

Table 5 and Figure 2 show mean of the total bacteria, fungal zoospore and protozoa population. The mean of the total bacteria and protozoa population were not significantly different ($p>0.05$), but the mean of fungal zoospore decreased linearly ($p<0.05$) with an increased level of the synchrony index. The protozoa and fungal zoospore populations at 0, 2, 4, 6, 8 and 10 h post feeding were not significantly different ($p>0.05$). The total bacteria population at the 4 h post feeding increased linearly ($p<0.05$). The total bacteria population at the 6 h post feeding trend to be increased ($p<0.06$). It is possible that the increased levels of synchrony index in the diets may play an important role in increasing bacterial population, thus increasing microbial protein synthesis (see also Table 6). A similar finding was reported by Sinclair et al. (1993), Sinclair et al. (1995) and Kim (2001).

Flow of the nitrogenous component at the duodenum and microbial protein synthesis

Duodenal flow of some nitrogenous constituents and microbial protein synthesis are presented in Table 6. Total N and non microbial N flow at the duodenum were not significantly different ($p>0.05$). The microbial N flow at the duodenum trended to increase linearly ($p<0.08$) with the level of the synchrony index. The result agrees with the works of Sinclair et al. (1993), Sinclair et al. (1995), Kim (2001) and Trevakis et al. (2001). The efficiency of microbial protein synthesis in terms of microbial N g/kg OMADR and microbial N g/kg OMTDR was not significantly different ($p>0.05$), but in terms of microbial N g/kg DMI trended to increase linearly ($p<0.06$). High levels of readily fermentation carbohydrate in aration reduced the efficiency of microbial protein synthesis in the rumen (Kim et al., 2005). However, synchronizing readily fermentation carbohydrate with non protein nitrogen (NPN) for improve efficiency of microbial protein synthesis should be considered (Chanjula et al., 2004). Nocek and Russell (1988) suggested that the efficiency of microbial growth and microbial protein production may be improved by balancing the overall daily ratio of ruminally available energy and N intake in the diet. Microbial yield in the rumen depends on many factors such as the availability of carbohydrates and N in the rumen (Shabi et al., 1998), ruminal pH (Finlayson, 1986), physiological effects (Hoover and Stokes, 1991), sources and levels of N components (Stern and Hoover, 1979) and stabilizing ruminal fermentation (Khorasani et al., 1994). It has been suggested that matching or synchronizing the supply of energy and N supply in the rumen may improve microbial growth (Sinclair et al., 1993). Chamberlain and Choung (1995) concluded that there was little benefit in maintaining a synchronized supply of NH_3-N and energy release in the rumen, although they did suggest that more results were required on the synchronization of energy with other nitrogenous substrates, including peptides and amino acids.

CONCLUSION

Synchronizing the rate of degradation of dietary energy and nitrogen release using tropical feedstuffs improved ruminal fermentation, nutrient digestibility and microorganism population. Additionally, a higher synchrony index can enhance microbial protein synthesis. Therefore, a synchrony index should be considered for beef cattle's feed formulation.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to

Assistant Professor Dr. Opart Pimpa for his excellent animal surgery. We are grateful to the Department of Agricultural Technology, Faculty of Technology, Mahasarakham University and Department of Animal Science, Faculty of Agriculture, Khon Kaen University for supporting experiment facilities. Financial support was provided by 'The Khon Kaen University's Graduate Research Fund, Academic Year 2003.

REFERENCES

AFRC. 1992. Technical Committee on Response to Nutrients No.9. Nutritive Requirements of Ruminant Animal: Protein Nutrition Abstracts and Reviews (Series B). 62:787-818.

AOAC. 1990. Official Methods of Analysis Association. 15th edn. Association of Official Analytical Chemist. Arlington, Virginia.

Arieli, A., Z. Shabi, I. Bruckental, H. Tagari, Y. Aharoni, S. Zamwell and H. Voet. 1996. Effect of the degradation of organic matter and crude protein on ruminal fermentation in dairy cows. J. Dairy Sci. 79:1774-1780.

Blummel, M., A., I. Givens, H. P. S. Makkar and K. Becker. 1999. Preliminary studies on the relationship of microbial efficiencies of roughage *in vitro* and methane production *in vivo*. Proc. SOC. Nutr. Physiol. 8:76-85.

Bremner, J. M. and D. R. Keeney. 1965. Steam distillation methods of determination of ammonia, nitrate and nitril. Anal. Chem. Acta. 32:485-495.

Briggs, P. K., J. F. Hogan and R. L. Reid. 1957. The effect of volatile fatty acid, lactic acid, and ammonia on rumen pH in sheep. Aust. J. Agric. Res. 8:674-710.

Cecava, M. J., N. R. Merchen, L. C. Gay and L. L. Berger. 1990. Composition of ruminal bacterial harvested from steers as influenced by dietary energy-level, feeding frequency, and isolation techniques. J. Dairy Sci. 73:2480-2488.

Chamberlain, D. G. and J. J. Choung. 1995. The importance of rate of ruminal fermentation of energy sources in diets for dairy cows. In Recent Advances in Animal Nutrition. (Ed. P. C. Garnsworthy and D. J. A. Cole). Nothingham: Nothingham University Press. pp. 3-27.

Chanjula, P., M. Wanapat, C. Wachirapakorn and P. Rowlinson. 2004. Effect of synchronizing starch sources and protein (NPN) in the rumen on feed intake, rumen microbial fermentation, nutrient utilization and performance of lactating dairy cows. Asian-Aust. J. Anim Sci. 17(10):1400-1410.

Chen, C. and J. Hsu. 1998. The effect of starch and protein degradation rates, hay sources and feeding frequency on rumen microbial fermentation in continuous culture system. In: Proceedings of National Science Council, Republic of China, Part B Life Science, 22:159-165.

Czerkawski, J. W. 1986. An Introduction to Ruminal Studies. Oxford: Pergamon Press (Ed. H. J. Finlayson) 1986. The effect of pH on the growth and metabolism of *Streptococcus bovis* in continuous culture. J. Appl. Bacteriol. 61:201-208.

Galyean, M. 1989. Laboratory Procedure in Animal Nutrition Research. Department of animal and rang sciences. New Mexico State University, USA.

Henning, P. H., D. G. Steyn and H. H. Meissner. 1991. The effect of energy and nitrogen supply pattern on rumen bacterial growth *in vitro*. Anim. Prod. 53:165-175.

Hoover, W. H. 1986. Chemical factors involved in ruminal fiber digestion. J. Dairy Sci. 69:2755-2766.

Hoover, W. H. and S. R. Stokes. 1991. Balancing carbohydrates and proteins for optimum rumen microbial yield. J. Dairy Sci. 74:3630-3644.

Joo, J. W., G. S. Bae, W. K. Min, H. S. Chai, W. J. Maeng, Y. H. Chung and M. B. Chang. 2005. Effect of protein sources on rumen microbial protein synthesis using rumen simulated continuous culture system. Asian-Aust. J. Anim. Sci. 18(3):326-331.

Khorasani, G. R., G. Deboer, B. Robinson and J. J. Kennelly. 1994. Influence of dietary protein and starch on production and metabolic responses of dairy cows. J. Dairy Sci. 77:813-284.

Kim, C. H. 2001. Effect of different protein sources given synchronously or asynchronously in to the rumen of consuming a beef cattle diet high in concentrate on the synthesis of microbial protein. J. Anim Sci. Technol. 43:831-840.

Kim, K. H., S. S. Lee and K. J. Kim. 2005. Effect of in traruminal sucrose infusion on volatile fatty acid production and microbial protein synthesis in sheep. Asian-Aust. J. Anim. Sci. 18(3):350-353.

Kolver, E., L. D. Muller, G. A. Varga and T. J. Cassidy. 1998. Synchronization of ruminal degradation of supplemental carbohydrate with pasture nitrogen in lactation dairy cows. J. Dairy Sci. 81:2017-2028.

Nocek, J. E. and J. B. Russell. 1988. Protein and energy as on integrated system. Relationship of ruminal protein and carbohydrate availability to microbial synthesis and milk production. J. Dairy Sci. 71:2070-2083.

Ørskov, E. R. and I. McDonald. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. Agric. Sci. 92:499-504.

SAS. 1996. SAS User's Guide: Statistics, Version 6.12th Edition. SAS Institute Inc. Cary, NC.

Siddons, R. C., J. Paradine, D. E. Beever and P. R. Cornell. 1985. Ytterbium acetate as a particulate-phase digesta-flow marker. Br. J. Nutr. 54:509-519.

Shabi, Z., A. Arieli, L. Bruckental, Y. Aharoni, S. Zamwel, A. Bor and H. Tagari. 1998. Effect of the synchronization of the degradation of dietary crude protein and organic matter and feeding frequency on ruminal fermentation and flow of digesta in the abomasum of dietary cows. J. Dairy Sci. 81:1991-2000.

Sinclair, L. A., P. C. Garnsworthy, J. R. Newbold and P. J. Buttery. 1993. Effect of synchronizing the rate of dietary energy and nitrogen release on rumen fermentation and microbial protein synthesis in sheep. J. Agric. Sci. 120:251-263.

Sinclair, L. A., P. C. Garnsworthy, J. R. Newbold and P. J. Buttery. 1995. Effects of synchronizing the rate of dietary energy and nitrogen release in diets with a similar carbohydrate composition on rumen fermentation and microbial protein synthesis in sheep. J. Agric. Sci. 124:463-472.

Sinclair, K. D., L. A. Sinclair and J. J. Robinson. 2000. Nitrogen metabolism and fertility in cattle: In adaptive changes in intake and metabolism to diet differing in their rate of energy release

in the rumen. J. Anim. Sci. 78:2659-2669.

Sommart, K. 1998. The use of cassava in ruminant diets based on low quality roughages. Ph.D. Thesis, University of Newcastle upon Tyne.

Stern, M. D. and W. H. Hoover. 1979. Methods for determining and factors affecting rumen microbial protein synthesis: a review. J. Anim. Sci. 49:1590-1603.

Trevaskis, L. M., W. J. Fukerson and J. M. Gooden. 2001. Provision of certain carbohydrate based supplements to pasture fed sheep as well as time of harvesting of the pasture influences pH, ammonia concentration and microbial protein synthesis in the rumen. Aust. J. Exp. Agric. 41:21-27.

Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber, and Non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583-3597.

Vongsamphan, P. and M. Wanapat. 2004. Effect of levels of cassava hay (CH) supplementation in native beef cattle feed on rice straw. In: Proceeding of the Agricultural Seminar, Animal Science/Animal husbandry. Held at Sofitel Rajaorcid hotel 27-28 January 2004, 255-270.

Witt, M. W., L. A. Sinclair, R. G. Wikinson and P. J. Buttery. 1999. The effects of synchronizing the rate of dietary energy and nitrogen supply to the rumen on the production and metabolism of sheep food characterization and growth and metabolism of ewe lams given food *ad libitum*. Anim. Sci. 69:223-235.

Zinn, R. A., L. S. Bull and R. W. Hemken. 1981. Degradation of supplemental proteins in the rumen. J. Anim. Sci. 52:857-865.

Zinn, R. A. and F. N. Owens. 1986. A rapid procedure for purine measurement and its use for estimating net ruminal protein synthesis. Can. J. Anim. Sci. 66:157-166.