ORIGINAL ARTICLE

Effect of synchronizing the rate of degradation of dietary energy and nitrogen release on growth performance in Brahman cattle

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Abstract

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The objective of this research was to determine the effect of synchronizing the rate of degradation of dietary energy and nitrogen release on growth performance in Brahman beef cattle. Fifteen Brahman cattle, 1.5 years old, with an average initial body weight of 184.8±11.1 kg were assigned to one of three treatments according to a randomized complete block design. Dietary treatments contained 3 levels of synchrony index (0.39, 0.56 and 0.74) that were derived from laboratory chemical composition analysis and degradation kinetics using nylon bag technique. Diets were fed at the rate of 2.5% BW by separate concentrate and roughage. Average daily gain increased linearly (P<0.05) with increase levels of synchrony index in the diets. The digestibility of dry matter, organic matter and neutral detergent fiber increased linearly (P<0.01). The digestibility of acid detergent fiber increased linearly (P<0.05). Ruminal total volatile fatty acids concentration increased linearly (P<0.05) at 6 h post feeding. Higher concentration and fluctuation of ruminal

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ammonia nitrogen and blood urea nitrogen were observed in animals that received lower synchrony index in their diets. Rumen microbial population tended to increase with diets having higher levels of synchrony index. The results indicated that synchronized rate of dietary energy and nitrogen degradation improved ruminal fermentation and digestibility, thus this increased the growth rate in Brahman cattle fed with rice-straw- based diets.

Key words : beef cattle, energy, nitrogen, growth performance, synchrony index, degradation

บทคัดย่อ

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ผลของการประสานเวลาอัตราการย่อยสลายอาหารพลังงานและการปลดปล่อยไนโตรเจนต่อสมรรถนะการเจริญเติบโตของโคเนื้อพันธุ์บราห์มัน

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การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อทดสอบผลของการประสานเวลาอัตราการย่อยสลายอาหารพลังงานและการปลดปล่อยไนโตรเจนต่อสมรรถนะการเจริญเติบโตของโคเนื้อพันธุ์บราห์มัน ในโคเพศเมียอายุหนึ่งปีครึ่ง จำนวน 15 ตัว มีน้ำหนักเริ่มต้นเฉลี่ย 184.8±11.1 กก. ตามแผนการทดลองแบบสุ่มสมบูรณ์ในบล็อค ทำการวิเคราะห์องค์ประกอบทางเคมี และประเมินคุณลักษณะการย่อยสลายของวัตถุดิบอาหารในกระเพาะหมักด้วยเทคนิคถุงไนล่อน เพื่อนำข้อมูลมาคำนวณสูตรอาหาร 3 สูตรให้มีระดับดัชนีการประสานเวลาเท่ากับ 0.39, 0.56 และ 0.74 โคได้รับอาหารในอัตรา 2.5 เปอร์เซ็นต์ของน้ำหนักตัว ให้อาหารโดยแยกอาหารข้นและอาหารหยาบ ผลการทดลองพบว่า อัตราการเจริญเติบโตเฉลี่ยต่อวัน การย่อยได้ของลิกโนเซลลูโลสเพิ่มขึ้นแบบเส้นตรง (P<0.05) เมื่อระดับดัชนีการประสานเวลาในสูตรอาหารเพิ่มสูงขึ้น การย่อยได้ของวัตถุแห้ง อินทรียวัตถุ และผนังเซลล์ เพิ่มขึ้นแบบเส้นตรง (P<0.01) ความเข้มข้นของกรดไขมันที่ระเหยได้ง่ายทั้งหมดในกระเพาะหมัก ณ ชั่วโมงที่ 6 หลังให้อาหารเพิ่มขึ้นแบบเส้นตรง (P<0.05) แอมโมเนียไนโตรเจนในของเหลวในกระเพาะหมักและยูเรียในเลือดมีความเข้มข้นและความผันแปรสูงในโคที่ได้รับสูตรอาหารที่มีดัชนีการประสานเวลาต่ำ ประชากรจุลินทรีย์ในกระเพาะหมักมีแนวโน้มเพิ่มสูงขึ้นเมื่อระดับดัชนีการประสานเวลาในสูตรอาหารเพิ่มสูงขึ้น ผลการทดลองนี้ชี้ให้เห็นว่า การประสานเวลาอัตราการย่อยสลายอาหารพลังงานและการปลดปล่อยไนโตรเจนในสูตรอาหาร สามารถปรับปรุงกระบวนการหมักในกระเพาะหมัก ค่าความสามารถในการย่อยได้และมีผลทำให้อัตราการเจริญเติบโตในโคเนื้อพันธุ์บราห์มันเพิ่มสูงขึ้น

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The current system of feed formulation for ruminants is mainly based upon the daily supply of nitrogen and energy to the rumen. Newbold and Rust (1992) suggested that even if the total amount of rumen degradable protein supplied each day meet the requirement, difference between feeds in rate of degradation of protein or energy substrate may cause short-term imbalances between nitrogen (N) and energy supply to rumen microorganisms. Synchronizing the rate of organic matter (OM) and N degradation can be optimal microbial protein synthesis in the rumen (Khorasani *et al*., 1994; Sinclair *et al*., 1993). Recently, the synchrony index was defined by Sinclair *et al*. (1993), who described the degree of synchrony between hourly supply of energy and N in the rumen calculated from the sum of *in situ* degradability data. Studies in sheep (Sinclair *et al*., 1995; Witt *et al*., 1999; Trevaskis *et al*., 2001; Richardson *et al*., 2003) and dairy cows (Kim *et al*., 1999) indicated, an improvement in microbial efficiency and yield when provided with synchronous diets. The

tropical forages and concentrate feedstuffs have a large proportion of lignified cell walls with low fermentation rates and digestibility, leading to low digestibility rates and limited intake (Ibrahim *et al*., 1995).

Limited information is available on the effect of synchronizing the rate of degradation of dietary energy and N release in tropical feedstuffs for growing beef cattle. The objective of this experiment was to examine the effect of synchronizing the rate of degradation of dietary energy and nitrogen release on rumen fermentation characteristics and growth performance in beef cattle fed rice- straw-based diet.

Materials and Methods

In situ degradability characteristics of feedstuffs

The feedstuffs were collected from various feed mills and organizations (Kantharavichai dairy cooperation, Khonkaen dairy cooperation, Mahasarakham University feed mill, Khon Kaen University feed mill, Numhenghoad feed suppliers, Chareon Esan commercial feed mill, Songserm Kankaset feed supplier) in the Northeast of Thailand. All feedstuffs samples (Table 1) were ground to pass through a 1 mm screen for *in situ* degradability study and chemical analysis. The feedstuffs sample were analyzed for dry matter (DM), crude protein (CP), ash (AOAC, 1990), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) (Van Soest *et al*., 1991).

Ruminal degradation measurement using the nylon bag technique was carried out after a two weeks adaptation period in two Brahman-Thai native crossbred beef steers (body weight of 250±15 kg, fitted with permanent rumen cannula). Steers were offered rice straw *ad libitum* and received concentrate at 0.5% BW. The concentrate consisted of 49.80% cassava chip, 17.5% rice bran, 14.60% palm meal, 7.0% soybean meal, 1.40% urea, 0.4% salt, 1.0% mineral mix and 8.30% sugarcane molasses.

Approximately 5.0 g (fresh matter) of each test feed was accurately weighed into the nylon bag with a mean pore size of 45 μm (Shabi *et al*., 1998). Bag plus sample were placed into the rumen 30 minutes after the morning meal and retrieved after period of 2, 4, 6, 12, 24 and 48 h. After removal from the rumen, bags were rinsed in pipe line fresh water and washed by hand under tap water until the water became clear. After washing, the bags were placed into a hot air dry force oven at 65ºC for 48 h and weighed. To determine the content of water soluble material, bags representing 0 h degradation also underwent the same washing procedure as the incubated bags. Dried residues of each incubation time from each steer were pooled, DM, organic matter (OM) and CP analyzed; then DM, OM and CP disappearance values were calculated as the difference between weight of nutrients before and after incubation of each sample. The degradability data obtained for

Table 1. Chemical composition of feed ingredients in the experiment.

	DM (%)	CP	Ash	NDF	ADF	ADL
		---------- %DM basis ----------				
Rice straw	91.50	3.0	13.64	72.13	53.28	4.89
Corn meal	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

Where DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL= acid detergent lignin.

Table 2. Degradability coefficient* of organic matter (OM) and nitrogen (N) of feed ingredients.

	OM degradability				N degradability			
	a	***b***	***c***	***a+b***	***a***	***b***	***c***	***a+b***
Rice straw	0.099	0.756	0.014	0.845	0.287	0.571	0.004	0.858
Corn meal	0.368	0.632	0.024	0.99	0.297	0.455	0.051	0.742
Cassava chip	0.777	0.222	0.033	0.999	0.600	0.198	0.065	0.798
Rice bran	0.404	0.365	0.176	0.769	0.367	0.428	0.156	0.785
Kapok seed meal	0.373	0.229	0.057	0.592	0.102	0.618	0.264	0.72
Soybean meal	0.343	0.656	0.045	0.999	0.122	0.877	0.038	0.999

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

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 and sugarcane molasses were also included in the database. It was assumed that 95% of urea N was degraded in the first hour after feeding, with remaining 5% of urea N degraded at a rate (*c*) = 0.5/h (Sinclair *et al*., 1995) and 100% of N and organic matter of molasses was degraded in the first hour post feeding.

Diet formulation and Synchrony index

The synchrony index of OM to N was calculated as follows:

Synchrony index =

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

Where; 25 = 25 g of N per kg OM truly digested in the rumen. A synchrony index of 1.0 represents perfect synchrony between N and energy supply throughout the day whilst values < 1.0 indicate the degree of asynchrony according to Sinclair *et al*. (1993).

The computer program described previously (Sinclair *et al*., 1993) was used. It was written to calculate dietary OM and N supply to the rumen and contains the database of raw material proximate analysis, fiber composition and degradation characteristics obtained from *in situ* degradability experiment (Tables 1 and 2). The program requires as input the proportion of each constituent in the diet, total dry matter intake per day (DMI), the time of feeding during the day and the outflow rate of solids (k) from the rumen. The formulation assumed that the animals were fed in two equal meals at 06.00 and 18.00 h, a DMI of 2.5% BW and had a ruminal outflow rate of 0.05/h.

Using the computer program, three diets were formulated to have a similar metabolizable energy (ME), crude protein (CP), rumen degradable protein (RDP) and rumen degradable organic matter (Table 3), but different synchrony index, at 0.39, 0.56 and 0.74, respectively.

Animals and experimental procedure

Fifteen female yearlings Brahman cattle with an initial live weight (means±SD) of 184.8±11.1 kg and 1.5 years old were used in feeding trials experiment. Clean water and mineral lick were offered and available at all times in the individual pens. Animals were fed at 2.5 % BW of dry matter weight per day in two equal portions at 06.00 and 18.00 h. The diets were offered by separate concentrate and roughage. The animals were randomly assigned to one of three treatments according to a randomized complete block design, from May 24, 2003 to July 23, 2003 at the Department of Animal

Table 3. Feed formulation and chemical composition of dietary treatment.

	Synchrony Index		
	0.39	**0.56**	**0.74**
Rice straw	54.80	54.80	54.80
Cassava chip	8.80	13.70	16.90
Rice bran	13.90	8.80	5.00
Corn meal	7.90	4.90	3.00
Soybean meal	-	5.00	13.50
Kapok seed meal	8.90	7.40	2.00
Salt (NaCl)	0.50	0.50	0.50
Urea	1.00	0.70	0.20
Mineral premix	0.50	0.50	0.50
Molasses	3.60	3.60	3.60
Total	100.00	100.00	100.00
Chemical composition (%)			
DM	92.53	92.21	93.74
OM	90.10	91.72	90.55
CP	10.66	10.79	10.83
NDF	54.37	50.78	50.96
ADF	34.45	30.65	30.95
ADL	4.29	4.52	3.01
Rumen degradable N	6.96	6.81	6.64
Calculated ME, Mcal/kg	2.19	2.22	2.26

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Rumen fluid samples were collected in the last day of the experiment at 0, 3, 6 and 9 h post morning feeding by vacuum pump and stomach tube technique. Ruminal pH was measured immediately after sampling using portable pH meter (handy Lab 1, CG 842 Schott). The rumen fluid was separated into two parts. In the first part, 5 mL of rumen fluid was separated from the mixed sample using four layers of cheesecloth and adding 45 mL of a fixing solution (10% of formalin in normal saline) for a total direct count of microorganisms in rumen fluid (Galyean, 1989). In the second part, 50 mL of rumen fluid was acidified with 5 mL of 6 N HCl and centrifuged at 2500 x g for 15 minutes and the clear supernatant was stored in plastic tubes at -20ºC until analyzed for rumen ammonia nitrogen (Bremner and Keeney, 1965) and total volatile fatty acid (TVFA) concentration (Briggs *et al.*, 1957).

Blood samples were collected from the jugular vein at the same time as rumen fluid sampling, using 10 mL heparinised vacutainers. The tube was gently inverted a couple of times, and then kept in an ice box and later centrifuged at 2500 x 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 -20ºC until analyzed for blood urea nitrogen (BUN) using BMG's urea reagent (Boehringer Mannheim, Indianapolis, IN).

Feeds were randomly collected and composited prior to analyses. Composited samples were ground to pass through a 1 mm screen and then analyzed for DM, CP and ash (AOAC, 1990), NDF, ADF, ADL (Van Soest *et al.*, 1991) and acid insoluble ash (AIA) (Van Keulen and Young, 1977).

Fecal grab samples were taken at 10.00 h for

three consecutive days and composited; the feces were placed into an oven at 65ºC for 72 h, weighed and ground to pass through a 1 mm screen and then analyzed for DM, ash, CP, NDF, ADF and AIA. The AIA content in feed and fecal were used to calculated digestibility (Schneider and Flatt, 1975).

Statistical analyses

The experimental data was subjected to the General Linear Models (GLM) Procedure for orthogonal polynomial contrast analysis of SAS (SAS, 1996) according to a randomized complete block design (RCBD) by using initial body weight as blocks. Significance was shown at $P<0.05$ unless otherwise noted.

Results and Discussion

Chemical composition and degradability characteristics of feedstuffs

Chemical composition and degradability characteristics of feedstuffs used in the experiment are shown in Table 1 and Table 2, respectively. The feedstuffs varied widely in terms of chemical composition and the rate (*c*) and extent (*a*+*b*) of degradability. The chemical composition of diets is presented in Table 3.

Ruminal fermentation characteristics, microbial population and BUN

Ruminal pH at 0, 3, 6 and 9 h post feeding and mean values are presented in Figure 1 and Table 4, respectively. Mean values of ruminal pH did not differ significantly ($P>0.05$) at any level of synchrony index. These findings were similar to those reported by other researchers (Witt *et al*., 1999; Sinclair *et al*., 1993; Sinclair *et al*., 1995; Trevaskis *et al*., 2001 and Chen and Hsu, 1998). Ruminal pH at 0, 3, 6, and 9 h post feeding was not affected by dietary treatments. Ruminal pH values were relatively with in the normal value range from 6.71 to 7.17. Ruminal pH values at 0, 3, 6 and 9 h post feeding was exhibited higher stability in animals offered high synchrony index diet (Figure 1).

Ruminal NH_3-N concentration at 0, 3, 6 and 9 h post feeding and mean values are presented in Figure 2 and Table 4, respectively. The NH_3-N

Table 4. Ruminal pH, ammonia nitrogen concentration (NH_3N), total volatile fatty acids concentration (TVFA), blood urea nitrogen (BUN) and rumen microbe population in Brahman cattle receiving diet containing three levels of synchrony index.

Parameters	Synchrony index			SEM	Polynomial contrast	
	0.39	0.56	0.74		Linear	Quadratic
Ruminal fermentation						
pH	6.98	6.89	6.99	0.06	NS	NS
NH_3N, mg%	6.65	6.70	6.03	0.26	NS	NS
TVFA, mM	73.74	88.23	85.16	3.31	NS	NS
BUN, mg%	12.77	11.04	11.13	0.63	NS	NS
Rumen microbe population						
Protozoa, $x10^5$ cell/mL	1.82	2.52	2.51	0.21	0.08	NS
Fungal Zoospore, $x10^4$ cell/mL	4.50	4.30	6.00	0.05	NS	NS
Total Bacteria, $x10^9$ cell/mL	5.48	6.38	6.40	0.84	NS	NS
Cocci, $x10^9$ cell/mL	5.06	5.91	5.88	0.82	NS	NS
Rod, $x10^8$ cell/mL	3.00	3.60	3.40	0.06	NS	NS
Spiral, $x10^8$ cell/mL	1.08	1.6	1.88	0.05	0.08	NS

Where SEM = standard error of the means, NS = not significantly different (P>0.05)

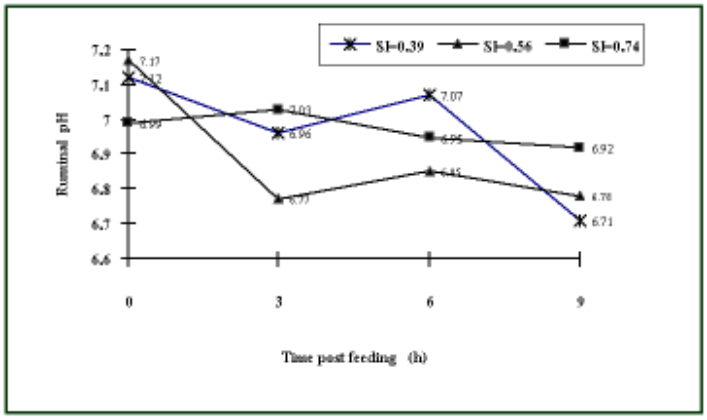

Figure 1. Ruminal pH in Brahman cattle receiving diet containing three levels of synchrony index (SI).

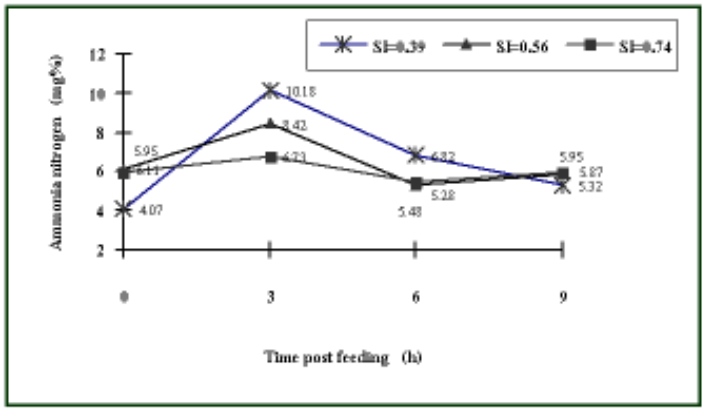

Figure 2. Ammonia nitrogen (mg%) in rumen fluid of Brahman cattle receiving diet containing three levels of synchrony index (SI).

concentration at 0, 6 and 9 h post feeding and mean values did not differ significantly, but NH_3-N concentration at 3 h post feeding tended to decrease linearly ($P<0.08$). The results were similar to the report of Kolver *et al*. (1998), Shabi *et al*. (1998) and Arieli *et al*. (1996). These researchers found that NH_3-N concentration was decreased in cows fed synchronous diet. Ruminal NH_3-N concentrations decreased when the synchrony index increased, indicating a more efficient capture of N for increased microbial protein synthesis. The result agrees with 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 animals receiving the highest synchrony index diet had the lowest fluctuation of NH_3-N concentration (Figure 2). Although animals received similar nitrogen and energy intake, the concentration of NH_3-N in animals fed high synchrony index diet was lower than that in animals fed low synchrony index diet. This result implies that the ruminal N supplied by the high synchrony index diet was utilized more rapidly than the ruminal N supplied by low synchrony index diet. The optimum NH_3-N concentration for microbial growth is suggested range from 5 to 8 mg%. Therefore, NH_3-N did not limited microbial growth during the period of measurements in this study.

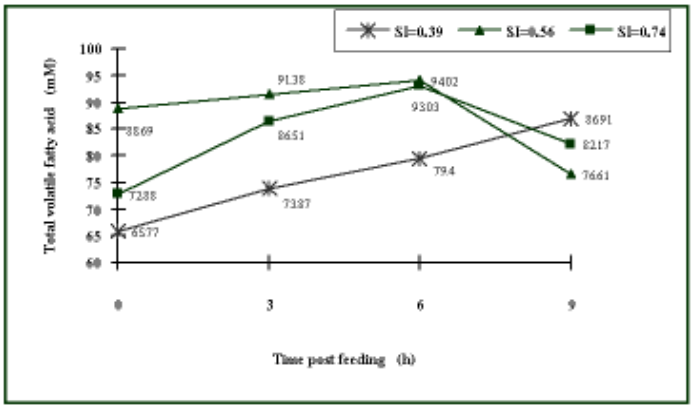

Figure 3. TVFA (mM) in rumen fluid of Brahman cattle receiving diet containing three levels of synchrony index (SI).

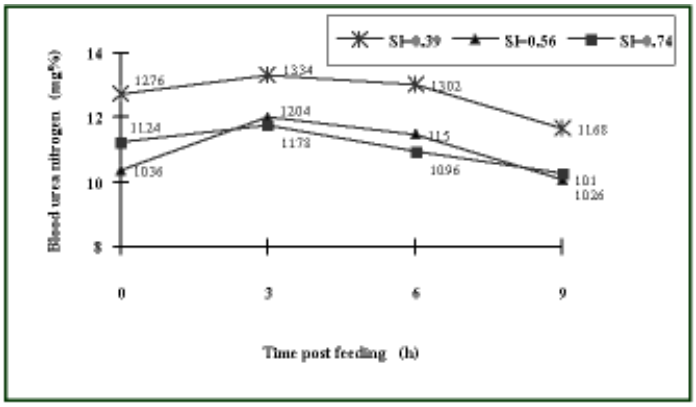

Figure 4. Blood urea nitrogen (mg%) of Brahman cattle receiving diet containing three levels of synchrony index (SI).

Total volatile fatty acids concentrations at 0, 3, 6, and 9 h post feeding and mean values are presented in Figure 3 and Table 4, respectively. Total volatile fatty acids concentrations at 6 h post feeding were significantly different ($P<0.05$) between treatments. The results indicated that maximum rumen fermentation rate was greatest at 6 h post feeding. Similar trends were also indicated for NH_3-N concentration (Figure 2).

Rumen microbe populations are presented in Table 4. Protozoa and spiral bacteria populations tended to increase linearly ($P<0.08$), but fungal zoospore were not significantly different ($P>0.05$). The total bacteria population in rumen fluid tended to increase linearly ($P<0.1$). Recently, it was reported that higher synchronizing rate of degradation of dietary energy and N release in the rumen beneficially increased microbial protein synthesis (Herrera-Saldana *et al*., 1990; Sinclair *et al*., 1993; Sinclair *et al*., 1995), thus supporting animal growth rate in sheep. Jouaney and Ushida (1999) reported that ruminal protozoa growth depends on high rate of soluble sugars and starches in the ration. It has been reported that inclusion of cassava replacing corn at a rate of up to 27% of total DMI fed with rice straw based diets had no effect on total feed intake and milk performance of dairy cows (Sommart *et al*., 2000a). The ration in this study was based on cassava chip which contains readily rumen fermentable starch (Sommart *et al*., 2000a),

particularly in the high synchrony index diet. Therefore, high soluble protein in diets and cassava starch possibly affected the rumen microbe population. Microbial biomass, net 15N incorporation into cells, volatile fatty acid production increased linearly with increasing levels of cassava inclusion in diets (Sommart *et al*., 2000b).

The use of soluble carbohydrates has been also criticized due to their effect on the ruminal population (Kim *et al*., 1999) and microbial protein synthesis (Sommart *et al*., 2000b), resulting in a lactic fermentation that leads to reduced ruminal pH (Strobel and Russell, 1986). The fungal zoospores were not significantly different (P<0.05). Total bacterial population in rumen fluid tended to increase linearly (P<0.1) when synchrony index increased. It is possible that the increased levels of synchrony index in the diets play an important role in increasing the bacterial population, thus increasing microbial protein synthesis. A similar finding was reported by Sinclair *et al*. (1993), Sinclair *et al*. (1995) and Chumpawadee *et al*. (2004).

Blood urea nitrogen concentration at 0, 3, 6 and 9 h post feeding and mean values are presented in Figure 4 and Table 4, respectively. The patterns of hourly BUN were similar between the treatments (Figure 4). Mean values of blood urea concentrations were not significantly different among animals fed all diets, although animals fed high synchrony index diet had lower concentrations of BUN. Cows fed the synchronous diet had significantly lower concentration of BUN at 2 h after ruminal ammonia peaked. Sinclair *et al*. (2000) also reported that animals offered energy and nitrogen asynchronous diet had high blood urea concentration. The synchronous diet could also avoid excessively high levels of plasma ammonia (Sinclair *et al*., 2000). High levels of BUN or plasma ammonia were possibly associated with alterated ovarian and uterine physiology, resulting in luteal insufficiency and embryonic loss (Butler, 1998 and Melendez *et al*., 2000).

Digestibility and average daily gain

Apparent digestibility of nutrients is presented in Table 5. Apparent digestibility of DM, OM, NDF and ADF were increased linearly (P< 0.05). Digestibility of CP also increased linearly (P<0.07) when animals recieved higher synchrony index diets. The results indicate that animals offered high synchrony index diet possibly also

Table 5. Feed intake, digestibility, body weight and average daily grain (ADG) of Brahman cattle receiving diet containing three levels of synchrony index.

	Synchrony index			SEM	Polynomial Contrast	
	0.39	0.56	0.74		Linear	Quadratic
Feed intake						
kg/d	4.6	4.6	4.6	0.08	-	-
%BW	2.5	2.5	2.5	0.0	-	-
Digestibility						
DM, %	59.33	64.65	68.09	1.25	0.004	NS
OM, %	60.32	66.18	69.30	1.27	0.003	NS
CP, %	66.84	69.97	71.24	0.93	0.07	NS
NDF, %	57.47	60.21	66.00	1.32	0.01	NS
ADF, %	55.02	53.11	62.85	1.50	0.02	NS
Initial weight, kg	184.5	183.6	186.2	3.44	NS	NS
Final weight, kg	210.2	214.4	219.9	7.39	0.03	NS
ADG, kg/d	0.42	0.52	0.56	0.02	0.03	NS

Where SEM = standard error of the means, NS = not significantly different (P>0.05)

had high nutrient uptake, thus increased average daily gain.

Average daily gain (ADG) increased linearly ($P<0.05$) with increasing synchrony index (Table 5). The result agrees with the report of Witt *et al*. (1999), who found that synchronous diet can improve the growth rate in lambs. The possible explanation for the increased ADG relies on high synchrony index that enhances the optimal ruminal fermentation, net microbial protein synthesis and nutrient uptake. Synchronizing the rate of carbohydrate and protein availability in the rumen has been reported to be beneficial in increasing microbial protein synthesis (Sinclair *et al*., 1993; Sinclair *et al*., 1995; Chumpawadee *et al*., 2004) and growth rate in lambs (Witt *et al*., 1997).

Conclusions

Synchronizing the rate of dietary energy and N supply in the rumen has the potential to improve beef cattle performance in the tropics. Apparent nutrient digestibility and average daily gain linearly increased with increasing levels of synchrony index. Ruminal pH, ammonia nitrogen and blood urea nitrogen pattern showed higher fluctuation when animals received lower synchrony index diets. Synchronizing the rate of dietary energy and N supply in the rumen resulted in an improvement of ruminal fermentation patterns, digestibility and average daily gain in beef cattle fed high fibrous tropical feedstuffs. Synchrony index should be considered for beef cattle feed formulation.

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