ค่าความสมดุลของพลังงานและไนโตรเจนในขบวนการเมตาโบลิซึมของโคพื้นเมืองไทยที่เลี้ยงด้วยหญ้ารูซี่แห้งและเสริมกากถั่วเหลืองระดับต่าง ๆ

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บทคัดย่อ

การทดลองครั้งนี้เป็นการศึกษาถึงผลของระดับโปรตีนในอาหารของโคพื้นเมืองที่กินหญ้ารูซี่แห้งเสริมด้วยกากถั่วเหลืองระดับต่างๆ ที่มีต่อความสมดุลของพลังงานและไนโตรเจนในขบวนการเมตาโบลิซึมรวมถึงการย่อยได้ของเยื่อใยในโคพื้นเมือง โดยใช้โคพื้นเมืองไทยจำนวน 4 ตัว เลี้ยงด้วยหญ้ารูซี่แห้งที่มีโปรตีนหยาบ 2.2% เป็นอาหารหยาบหลัก เสริมด้วยกากถั่วเหลืองเพื่อให้อาหารมีโปรตีนหยาบรวมแตกต่างกัน 4 ระดับ คือ 2.1%, 6.1%, 10.1% และ 14.1% จากการทดลองพบว่า ค่าการย่อยได้ของเยื่อใยหยาบ (CF) เยื่อใย NDF และเยื่อใย ADF ของหญ้ารูซี่แห้งในโคพื้นเมืองที่ได้รับหญ้ารูซี่แห้งเป็นอาหารอย่างเดียวไม่แตกต่างกันทางสถิติกับโคพื้นเมืองที่มีการเสริมกากถั่วเหลืองทุกระดับ จากรายงานก่อนหน้านี้พบว่า คุณค่าทางโภชนะและโภชนะที่ย่อยได้เกือบทุกชนิดในโคพื้นเมืองมีค่าค่อนข้างสูงกว่าสัตว์อื่นๆ แม้ว่าจะต้องมีการศึกษาต่อไปเพื่อหาข้อสรุปถึงความสามารถในการใช้ประโยชน์จากอาหารของโคพื้นเมืองก็ตาม แต่ก็พบว่ามีแนวโน้มที่โคพื้นเมืองมีความสามาถในการย่อยเยื่อใยและการใช้ประโยชน์จากพลังงานในอาหารได้ดีกว่า

(**คำสำคัญ**: โคพื้นเมืองไทย, การย่อยได้ของเยื่อใย, การเสริมโปรตีน, ขบวนการเมตาโบลิซึมของพลังงาน, ขบวนการเมตาโบลิซึมของไนโตรเจน)

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โดยค่าความสมดุลพลังงานของโคพื้นเมืองมีค่าเพิ่มขึ้นตามปริมาณกากถั่วเหลืองที่เสริมมากขึ้น และจากรายงานก่อนหน้านี้พบว่า ค่าความร้อนที่ร่างกายผลิตขึ้น (HP) จะเพิ่มขึ้นตามระดับกากถั่วเหลืองที่เพิ่มมากขึ้น และค่าสมดุลพลังงานเพิ่มขึ้นไม่แตกต่างกันทางสถิติกับการเสริมกากถั่วเหลืองในระดับต่ำ โคพื้นเมืองของไทยมีความสามารถในการใช้พลังงานในอาหารได้สูงและมีความต้องการพลังงานเพื่อการดำรงชีพในระดับต่ำ เพราะฉะนั้นจึงทำให้ค่าความสมดุลพลังงานและไนโตรเจนอยู่ในระดับที่ยังชีพได้ถึงแม้ว่าสัตว์จะไม่ได้รับอาหารที่มีพลังงานสูงก็ตาม ดังนั้นระบบการเลี้ยงโคพื้นเมืองด้วยอาหารคุณภาพต่ำจึงน่าจะเป็นการพัฒนาการผลิตสัตว์แบบยั่งยืนของไทยต่อไป

Energy and nitrogen metabolism of Thai native cattle given Ruzi grass hay with different levels of soybean meal

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Abstract

A metabolism trial was conducted with four Thai native cattle given Ruzi grass hay with different levels of soybean meal in order to examine the effect of protein level on fiber digestion, and the balances of energy and nitrogen. The Ruzi hay contained only 2.2% of CP. CP contents in four dietary treatments ranged from 2.1 %, 6.1 %, 10.1%, and 14.1% by supplement of soybean meal. The CF, NDF and ADF digestibilities of Ruzi grass hay in the animals given only Ruzi grass hay were not different from those given the supplement of soybean meal. Nutritive values and most of the nutrient digestibilities were higher in native cattle than in the other animals observed in the previous reports. Although further studies are required to conclude the comparison in the ability to utilize nutrients, Thai native cattle seemed to have a higher ability to digest fiber and to utilize energy in feed. The energy retention progressively increased according to the soybean meal supplement. In the previous studies, heat production increased according to the soybean meal supplement and the energy retention did not significantly increase from that in the lower supplement.

(**Key words**: Thai native cattle, Fiber digestion, Protein supplement, Energy metabolism, Nitrogen metabolism)
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The native cattle seemed to have a higher ability to utilize energy in feed and have a lower energy requirement for maintenance. Consequently, more energy became available and the balance of protein and energy was sustained even though the animals did not receive energy-rich feed. A system utilizing Thai native cattle with low quality feed will contribute to the sustainable development of animal production in Thailand.

Introduction

Animals have been selected by farmers for their particular characteristics or cultural value whilst they were also adapting genetically to local conditions, diseases, available feed, climate, predators and many other persistent variables imposed by the local environment. The result has been the development of breeds that contribute to local, national and, eventually, global needs and demands (FAO, 1999). There are 3 groups of native cattle recognized in Thailand according to their native region: 1) Northeastern group, red brown color; 2) Southern group, dark brown color; 3) Northern group, white color. The Thai Government Department of Livestock Development has started a project entitled "Genetic Improvement on Characteristic of Thai native Cattle" in order to preserve groups of native cattle as genetic resources and to improve their performance. The Northeastern group has been kept at Ubonratchathani Livestock Breeding Station and has been examined. The recorded birth weight, yearling weight, weight at first estrus and calving interval examined were: 15.4±2.5 kg, 140.2 ± 21.5 kg, 166.7 ± 17.5 kg, 366 days, respectively (Ubonratchatani Livestock Breeding Station, 1999).

The Northeastern group of Thai native cattle is considered to be well adapted to extensive grazing and to have an ability to utilize low quality feed. However, scientific elucidation has not yet been completed to clarify their digestion physiology and nutrient requirements. This study is aimed at examining the effect of protein levels on energy and nitrogen balances, and fiber digestion in the Thai native cattle.

Materials and method

The animals used in the present study were from the Northeastern group of Thai native cattle kept at Ubonratchatani Livestock Breeding Station, Department of Livestock Development. Four castrated male cattle (average body weight at the beginning of the trial: 168 kg) were housed individually in metabolic crates with free access to water. The animals were subjected to the following four dietary treatments:

1) 100% of Ruzi grass hay (*Brachiaria ruziziensis*).
2) 91.5% of Ruzi grass hay and 8.5% of soybean meal.

3) 82.9% of Ruzi grass hay and 17.1% of soybean meal.

4) 74.3% of Ruzi grass hay and 25.7% of soybean meal.

The treatments were conducted in this order. All animals were treated in order to remove endo- and ecto-parasites prior to the start of the experiment. Feeds were offered in two equal meals at 0800 and 1700h, and the daily amount given was 1.7% of the animal's body weight. Each treatment consisted of a 9-day preliminary period and a 5-day collection period. Before starting the first treatment, a one-week additional preliminary period was assigned to every animal for the purpose of adaptation to the new roughage and the metabolic crate. When the hay was refused during the collection period in the first treatment, the refusal was collected and subjected to chemical analysis.

The amount of feces was measured over the five-day collection period. An aliquot of feces sample was dried at 60^{o}C, left in a room, and measured as air dry matter. Five feces samples collected from each animal during the collection period were ground, mixed and subjected to chemical analysis. An aliquot of ground feces was dried at 120^{o}C and measured as dry matter (DM). The total amount of urine was collected into acid and measured every day over the five-day collection period. After the last dietary treatment, the animals were fasted for 4 days. Furthermore the total amount of urine was collected over the last two days of the fasting period. Blood was collected from the jugular vein into a heparinized tube at 0730h before the feeding at the end of feeding trial and fasting period. The plasma was separated by centrifugation and kept in a freezer until analysis was performed.

Oxygen consumption and the productions of carbon dioxide and methane were measured with a ventilated flow-through method using a facemask during the last 4 days of the feeding period and the last 2 days of the fasting period. The system consisted of a face mask (Sanshin Kogyo Ltd., Japan), flow cell (Thermal flow cell FHW-N-S, Japan Flow Cell Ltd., Japan), oxygen analyzer (Xentra 4100, Servomex Ltd., UK), carbon dioxide analyzer (Infra-red gas analyzer, VIA510, Horiba, Japan) and methane analyzers (Infra-red gas analyzer, VIA300, Horiba,

Japan).Gas analyzers were calibrated against certified gases (Saisan Ltd., Japan), with known gas concentrations at least two times a day. These measurements were conducted 6 times per days, each 6-10 minutes in duration, with the following schedule: 0700, 1000, 1300, 1600, 1900, 2200 and 0100h.

The DM, crude protein (CP), ether extract (EE), crude fiber (CF), and ash in oven dried (60°C) feed and feces samples were determined by the method of AOAC (1975). Acid detergent fiber (ADF) was determined by the method of Goering and Van Soest (1970), and neutral detergent fiber (NDF) by the method of Van Soest *et al*. (1991). The nitrogen content in urine was determined by the method of AOAC (1975). The allantoin content in urine was determined by the method of Young and Conway (1942). Glucose and urea nitrogen (PUN) in blood plasma were measured using diagnostic kits (Biotech Reagent, Thailand) based on the enzyme-calorimetric method. The total protein content in the blood plasma was measured using diagnostic kits (Biotech Reagent, Thailand) based on the Biuret method. Non esterified fatty acid (NEFA) in the blood plasma was measured using diagnostic kits (NEFA C-Test Wako, Wako Pure Chemical Industries, Ltd.). Albumin in the blood plasma was measured using diagnostic kits (Biotech Reagent, Thailand) based on the bromocresol green method. Heat combustion of oven-dried feed and feces samples and oven-dried (60°C, 48 hours) urine were also determined using an adiabatic calorimeter (Shimadzu CA-4PJ, Japan). Heat production (HP, kJ) was calculated by the equation, $HP = 16.18*O_2 + 5.02*CO_2 - 2.17*CH_4 - 5.99*N$, where O_2, CO_2 and CH_4 represent volumes of oxygen consumed, carbon dioxide and methane produced (1) and N is the quantity of urinary nitrogen excreted (g) (Brouwer, 1965).

A general linear model (SAS, 1989) was used to analyze the effects of dietary treatments with a model including treatments and individual animals. Duncan’s new multiple range test was applied to analyze the differences among the treatments.

Results

The chemical composition of feed and the ratio of the ingredients are shown in Tables 1 and 2, respectively. The CP contents of Ruzi grass hay and soybean meal were 2.2% and 48.3%, respectively. The CP contents of the feed ranged from 2.1% to 14.1% depending on the levels of soybean meal supplemented.

As the animals refused a part of the feed in treatment 1, the DM intake was lower in treatment 1 than in the others.

The digestibilities of nutrients are shown in Table 3. DM and OM digestibilities were the lowest in treatment 1, followed by treatments 2 and 3. They were highest in treatment 4. The CP digestibility differed according to the levels of soybean meal supplemented. The digestibility of NFE showed a similar trend as that of CP although the values in treatments 2 and 3 were not significantly different from those in treatment 1 and 4. There was no difference in EE, CF, NDF and ADF among the treatments.

The energy and nitrogen balances were compared among the treatments on the basis of metabolic body size (Table 4). The gross energy (GE), digestible energy (DE) and metabolizable energy (ME) intakes increased according to the levels of soybean meal although there was no significant difference in GE among treatments 2, 3 and 4 and in ME and DE between treatments 2 and 3. Energy loss into feces was the lowest in treatment 4, and there was no difference among treatments 1, 2 and 3. Energy loss into urine was higher in treatments 2 and 3 than in treatments 1 and 4. The energy loss during fasting was not different from those in treatments 1 and 4. Energy loss into methane was the lowest in treatment 4, and was not different among treatments 1, 2 and 3. Heat production was significantly higher in treatments 2 and 3 than in treatment 1, and the value in treatment 4 was between those. The fasting heat production was significantly lower than any of the feeding treatments. Energy retention increased according to the levels of soybean meal supplement.

The ratios of DE to GE, and ME to GE, *i.e*. metabolizability, increased according to the levels of soybean meal supplement, although there was no significant difference between treatments 2 and 3. The ratio of urine to GE was significantly higher in treatment 3 than in treatments 1 and 4. The ratio of methane to GE was lower in treatment 4 than in the other treatments. The ratio of ME to DE was higher in treatment 4 than the other treatments. The ratio of HP to GE was not different among the treatments.

ME requirements for maintenance were calculated (245 KJ/BWkg$^{0.75}$) by the regression analysis of energy retention against ME intake on the basis of metabolic body size with the data of treatments 1-5.

Nitrogen intake, excretion into urine and retention significantly increased according to the levels of soybean meal supplement. Although nitrogen excretion into feces also showed a similar trend, there was no difference between treatments 3 and 4. Nitrogen excretion into urine during fasting was between the values of treatments 1 and 2.

Methane production per OM intake was significantly lower in treatment 4 than in the other treatments.

Table 5 shows the comparison of nutrient digestibilities and nutritive values of Ruzi grass hay among the treatments. The values of soybean meal were estimated by an extrapolation of data in treatments 1-4. The values of Ruzi grass hay in each treatment were then estimated by using the values of soybean meal. There was no difference in the nutrient digestibilities and nutritive values of Ruzi grass hay among the treatments.

The NEFA, glucose, total protein, PUN and albumin concentrations in blood plasma are shown in Table 6. NEFA was not different among the feeding treatments and the value during fasting period was much higher than the values of the feeding treatments. Glucose and total protein were not different among all the treatments. PUN increased according to the levels of soybean meal. The value during fasting was not different from the values of treatment 3. Albumin was not different among the feeding treatments but was higher during the fasting period than during the feeding period.

Discussion

In developing countries (tropical), the animal must depend on locally available byproducts of agriculture and industry, which are often deficient in certain nutrients. In these countries there is a need to optimize production from the available resources by providing minimum amounts of the deficient nutrients (Leng, 1995). Thai native cattle used to be a popular livestock in Thailand, and are considered to adapt well in a harsh environment. The Ruzi hay used in this trial contained only 2.2% of CP, which was much lower than the value of rice straw according to Standard Tables of Feed Composition in Japan (Agriculture, Forestry and Fisheries Research Council Secretariat, 1995). However, any of the fiber fraction digestibilities of Ruzi grass hay were not improved by the supplement of soybean meal. This was similar to the finding in swamp buffalo in the previous report (Kawashima *et al.*, 2000c). It showed the animal has an ability to digest fiber well even without protein supplement. Homma (1994) reported that ammonia nitrogen in rumen fluid was higher in swamp buffalo than in Holstein cattle when both animals were given Thimothy hay *ad libitum*. He suggested that this be related to higher nitrogen content in saliva in swamp buffalo and to their ability to concentrate rumen fluid due to a higher ability to absorb water from rumen. The ability for rumen microbes to digest fiber fraction in rumen even if the feed does not contain enough amounts of protein would be favored. This might be a common characteristic of the native ruminants, which have been selected for their harsh feeding environment.

Similar trials were carried out with sheep, Brahman cattle (Kawashima *et al.*, 2000b), and swamp buffalo (Kawashima *et al.*, 2000c). As the feed utilized in each trial was not the same, the data among the trails cannot be simply compared. Considering from the CP content of Ruzi grass hay in each trail, the quality of Ruzi grass hay in the present study would be the lowest quality. However, nutritive value and most of the nutrient digestibilities were higher in native cattle than in the other animals documented in the previous reports. Although further studies are required to conclude the comparison in the ability to utilize nutrients, Thai native cattle seemed to have a higher ability to digest fiber and to utilize energy in feed.

Although the comparison in ME requirements for maintenance among Brahman cattle, swamp buffalo and Thai native cattle will be discussed in depth in the following report. It was noted that ME requirements for maintenance obtained from the present study (245 KJ/BWkg$^{0.75}$) were clearly lower than that in the other animals. More data should be accumulated in order to conclude the value. However, Thai native cattle would have a lower basal metabolism.

In the previous trial with Brahman cattle (Kawashima *et al.*, 2000b), although a minimum amount of soybean meal supplement (8% soybean meal of the whole ration) improved energy retention, further supplement did not significantly improved it. However, the energy retention in Thai native cattle progressively increased according to the amount of soybean meal supplement. In the previous trial with Brahman cattle, heat production increased according to the soybean meal supplement. But in Thai native cattle, the increase in heat production by the supplement was relatively small, which would be the major reason for the improvement of energy retention by the supplement. Thai native cattle seemed to have a higher ability to utilize energy in feed.

Methane is considered a ‘greenhouse gas’. Methane production by cattle typically accounts for 5.5% to 6.5% of GE intake (Johnson and Ward, 1996). The value in the present study was equivalent to their value except for the treatment when the animals were given the highest amount of soybean meal. Krishna *et al*. (1978) estimated higher CH_4 yields of 9% in Indian cattle fed on a slightly higher maintenance diet and low quality feed. On the other hand, Kurihara *et al*. (1997) reported that methane production per unit DM intake increased with the rise in CP content of diets from 4% to 9% in the cattle. In the present study, there was no significant difference in methane production per OM intake among the feed, of which CP contents ranged 2% to 10%. The value was lower in the feed, which contained CP 14%. The assumptions that the animals fed on low quality feed produce more methane, which was applied by Crutzen *et al*. (1986) for the estimation of methane production by ruminants cannot be simply applied for every kind of ruminants. As the data on methane production by the native ruminants is still limited, further studies are clearly required.

In the previous study (Kawashima *et al*., 2000a), NEFA content in blood during fasting became significantly higher in cattle than in buffalo. On the other hand, PUN was significantly higher in buffalo than in cattle during the fasting period. It was considered, therefore, that swamp buffalo had an ability to maintain a higher level of urea recycled than cattle, which might be related to a higher ability to mobilized energy from body tissue protein during fasting and consequently a higher PUN content in water buffalo. On the other hand, cattle mobilized more energy from fat and consequently showed higher NEFA content during fasting. In the present study, NEFA content dramatically increased during fasting period. The manner of energy mobilization during fasting in the native cattle was considered to be similar to that in Brahman cattle. Nitrogen excretion during fasting was in between treatments

1 and 2 in native cattle, and was lower than the values in Brahman cattle and swamp buffalo in the previous studies. Native cattle have a higher ability of nitrogen resorption in the kidneys. The PUN levels in native cattle were similar or higher than that of Brahman cattle and swamp buffalo.

The number of native cattle has been decreasing in Thailand. Agricultural byproducts, such as rice straw and sugarcane top, are not well utilized and some are burnt in the fields. The present study showed advantages of the native cattle in utilizing low quality feed. Therefore, a system utilizing native cattle with low quality feed could be rebuilt up for the sustainable development of animal production in Thailand.

Conclusion

From a metabolism trial of four Thai native cattle, given Ruzi grass hay with different levels of soybean meal in order to examine the effect of protein level on fiber digestion, and the balances of energy and nitrogen. It can conclude that the CF, NDF and ADF digestibilities of Ruzi grass hay in the animals given only Ruzi grass hay were not different from those given the supplement of soybean meal. Nutritive values and most of the nutrient digestibilities were higher in native cattle than in the other animals observed in the previous reports. Although further studies are required to conclude the comparison in the ability to utilize nutrients, Thai native cattle seemed to have a higher ability to digest fiber and to utilize energy in feed. The energy retention progressively increased according to the soybean meal supplement. In the previous studies, heat production increased according to the soybean meal supplement and the energy retention did not significantly increase from that in the lower supplement. The native cattle seemed to have a higher ability to utilize energy in feed and have a lower energy requirement for maintenance. Consequently, more energy became available and the balance of protein and energy was sustained even though the animals did not receive energy-rich feed. A system utilizing Thai native cattle with low quality feed will contribute to the sustainable development of animal production in Thailand.

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Table 1. Chemical composition of feed

	OM[1]	CP	EE	NFE	CF	NDF	ADF	Ash	GE
	------	------	------	------ %DM	------	------	------		MJ/DMkg
Ruzi grass hay	95.3	2.2	1.2	51.6	40.3	78.9	52.6	4.7	17.7
Soybean meal	92.8	48.3	2.0	36.9	5.6	12.4	8.6	7.3	19.4

[1]: OM, organic matter; CP, crude protein; EE, ether extracts; NFE, nitrogen free extracts; CF, crude fiber; NDF, neutral detergent fiber; ADF acid detergent fiber and GE, gross energy.

Table 2. Feed composition and DM intake

Treatment		1	2	3	4	SE[1]
Ingredients						
Ruzi grass hay	% of DM	100.0	91.5	82.9	74.3	0.0
Soybean meal	% of DM	0.0	8.5	17.1	25.7	0.0
CP content	%	2.1	6.1	10.1	14.1	0.0
DM intake	$G/BWkg^{0.75}$	53.9	57.0	57.6	58.1	0.7

[1] : SE, standard error; DM. Dry matter; CP, crude protein.

Table 3. Digestibility of nutrients of native cattle given Ruzi grass hay with different levels of soybean meal (%)

Treatment	1	2	3	4	SE[1]
DM	52.6^{c}	57.3^{b}	57.1^{b}	61.4^{a}	1.1
OM	54.7^{c}	59.3^{b}	59.1^{b}	63.2^{a}	1.1
CP	0^{d}	54.6^{c}	67.6^{b}	78.2^{a}	2.8
EE	3.3	26.9	17.4	36.7	8.7
NFE	52.5^{b}	55.6^{ab}	56.3^{ab}	60.3^{a}	1.5
CF	63.4	66.2	62.3	62.1	1.0
NDF	58.4	60.0	57.3	58.7	1.6
ADF	61.7	63.7	61.4	62.0	1.2

[1] : SE, standard error; DM. Dry matter; OM, organic matter; CP, crude protein; EE, ether extracts; NFE, nitrogen free extracts; CF, crude fiber; NDF, neutral detergent fiber and ADF acid detergent fiber.

[a, b, c, and d] : Means with different superscripts among treatments that significantly differ ($P<0.05$)

Table 4. Energy and nitrogen metabolisms, and urinary allantoin excretion in Thai native cattle given Ruzi grass hay with different levels of soybean meal

Treatment		1	2	3	4	5[2]	SE[1]
Body weight	kg	168 [a]	167 [a]	165 [b]	162 [c]	153 [d]	1
GE intake	$KJ/BWkg^{0.75}$	958 [b]	1019 [a]	1038 [a]	1055 [a]		13
DE intake	$KJ/BWkg^{0.75}$	480 [c]	564 [b]	590 [b]	650 [a]		17
ME intake	$KJ/BWkg^{0.75}$	416 [c]	489 [b]	509 [b]	596 [a]		18
Energy loss into							
Feces	$KJ/BWkg^{0.75}$	478 [a]	456 [a]	448 [a]	406 [b]		12
Urine	$KJ/BWkg^{0.75}$	13 [b]	24 [a]	26 [a]	15 [b]	7 [b]	3
Methane	$KJ/BWkg^{0.75}$	50 [a]	51 [a]	55 [a]	38 [b]		2
Heat production	$KJ/BWkg^{0.75}$	311 [b]	339 [a]	337 [a]	321 [a b]	157 [c]	7
Energy retention	$KJ/BWkg^{0.75}$	105 [c]	149 [b c]	172 [b]	275 [a]	-157 [d]	19
DE/GE		0.500 [c]	0.553 [b]	0.570 [b]	0.615 [a]		0.012
ME/GE		0.434 [c]	0.480 [b]	0.491 [b]	0.564 [a]		0.014
Methane/GE		0.052 [a]	0.050 [a]	0.053 [a]	0.036 [b]		0.002
Urine/GE		0.014 [b]	0.023 [a b]	0.025 [a]	0.015 [b]		0.003
Heat production/GE		0.326	0.334	0.326	0.305		0.009
ME/DE		0.868 [b]	0.867 [b]	0.863 [b]	0.916 [a]		0.008
Nitrogen intake	$g/BWkg^{0.75}$	0.184 [d]	0.560 [c]	0.928 [b]	1.306 [a]		0.011
Nitrogen loss into	$g/BWkg^{0.75}$						
Feces	$g/BWkg^{0.75}$	0.225 [c]	0.254 [b]	0.301 [a]	0.285 [a]		0.007
Urine	$g/BWkg^{0.75}$	0.074 [c]	0.206 [b]	0.286 [a b]	0.333 [a]	0.178 [b c]	0.034
Nitrogen retention	$g/BWkg^{0.75}$	-0.114 [d]	0.100 [c]	0.341 [b]	0.688 [a]	-0.178 [d]	0.032
Methane/OM	L/OMkg	24.7 [a]	24.0 [a]	25.5 [a]	17.7 [b]		0.9
Allantoin	Mmol/day	36.0 [a]	48.6 [a]	37.2 [a b]	31.0 [a b]	11.7 [b]	8.1

[1] : SE, standard error; GE, gross energy; DE, digestible energy; ME, metabolizable energy; OM, organic matter.

[2] : Treatment 5 means the levels during fasting period. Data is the least square means for four animals.

[a, b, c, and d] : Means with different superscripts among treatments that significantly differ ($P<0.05$)

Table 5. Digestibility and nutritive value of Ruzi grass hay

Treatment		1	2	3	4	SE[1]
DM	%	52.6	54.8	51.6	53.7	1.4
OM	%	54.7	56.9	53.9	55.7	1.4
CP	%	-22.6	-18.1	-34.6	-14.1	5.6
EE	%	3.3	18.4	-4.5	10.6	10.3
NFE	%	52.5	53.4	51.5	53.2	1.8
CF	%	63.4	66.9	63.8	64.6	1.0
NDF	%	58.4	60.2	57.6	59.3	1.7
ADF	%	61.7	63.8	61.6	62.5	1.2
DE	MJ/kg	8.89	9.18	8.78	9.02	0.28
ME	MJ/kg	7.71	7.79	7.19	7.97	0.31
TDN	%	52.2	54.6	51.3	53.3	1.4

[1] : SE, standard error; DM. Dry matter; OM, organic matter; CP, crude protein; EE, ether extracts; NFE, nitrogen free extracts; CF, crude fiber; NDF, neutral detergent fiber and ADF acid detergent fiber; DE, digestible energy; ME, metabolizable energy; TDN, total digestible nutrients.

Table 6. NEFA, glucose, total protein, urea nitrogen and albumin concentration in blood plasma of Thai native cattle given Ruzi grass hay with different levels of soybean meal

Treatment		1	2	3	4	5[2]	SE[1]
NEFA	mEq/l	0.342 [b]	0.248 [b]	0.170 [b]	0.290 [b]	1.497 [a]	0.081
Glucose	mg/dl	81.0	74.7	83.1	87.5	80.7	2.9
Total protein	g/dl	8.18	8.55	8.26	8.17	8.06	0.28
PUN	mg/dl	5.61[d]	13.71[c]	19.85 [b]	24.83 [a]	17.55 [b]	0.92
Albumin	g/dl	4.17 [b]	4.07 [b]	4.14 [b]	4.22 [b]	4.65 [a]	0.10

[1] : SE, standard error; NEFA, non-esterified fatty acid; and PUN, plasma urea nitrogen.

[2] : Treatment 5 means the levels during fasting period.

[a, b, c, and d] : Means with different superscripts among treatments that significantly differ (P<0.05)