Effect of Different Tropical Feed Resources on Rumen Ecology and Feed Intake of Beef Cattle

ผลของแหล่งอาหารหยาบในเขตร้อนที่แตกต่างกัน ต่อนิเวศวิทยารูเมน และปริมาณการกินได้ในโคเนื้อ

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ABSTRACT

This experiment was to study on effect of different tropical feed sources on rumen ecology and feed intake. Four, fistulated castrated male crossbred cattle were randomly in a 4 x 4 Latin square design. The treatments were: T1) urea-treated (5%) rice straw (UTS); T2) cassava hay (CH); T3) fresh cassava foliage (FCF); T4) UTS : FCF (1:1 dry matter basis). During the first 14 days, all animals were fed on concentrate 0.3% of body weight and were fed on respective diets on ad libitum basis. Rumen fluid and blood samples were collected on the last day of each period and then analyzed for microorganisms (total viable and cellulolytic bacteria), NH_3-N, VFA and blood urea-nitrogen. Ruminal pH and rumen temperature was measured immediately after the fluid was sampled. The results revealed that the use of UTS as a roughage source could maintain optimal levels of rumen pH, temperature, NH_3-N, total and VFAs concentration. Moreover, total viable and cellulolytic bacteria population were enhanced ($P < 0.05$). In addition, roughage intake and total DM intake were highest in UTS as a roughage source. Animals fed with FCF had a higher tendency in C3 production ($P < 0.05$) while a lower cellulolytic bacteria was found. It was also observed that feeding FCF as a full-feed resulted in anorexia and ataxia as well as frequent urination, therefore FCF could only be partially fed and/or wilting, moreover, combinational use of FCF and UTS could also be possible.

Key Words : cassava hay, cassava foliage, urea-treated rice straw, rumen ecology
คำสำคัญ : มันเฮย์ มันสำปะหลังสด ฟางหมักยูเรีย นิเวศวิทยารูเมน

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บทคัดย่อ

การศึกษาในครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของการใช้แหล่งอาหารหยาบที่แตกต่างกันต่อนิเวศวิทยาและปริมาณการกินได้ของโคเนื้อ โดยใช้โคเนื้อจำนวน 4 ตัวที่ทำการเจาะกระเพาะแบบถาวร ตามแผนการทดลองแบบ 4 x 4 ลาตินส์สแควร์ มีกลุ่มทดลองดังนี้ กลุ่มทดลองที่ 1 โคเนื้อได้รับฟางหมักยูเรีย 5 เปอร์เซ็นต์ กลุ่มทดลองที่ 2 โคเนื้อได้รับมันเฮย์ กลุ่มทดลองที่ 3 โคเนื้อได้รับมันสำปะหลังสด กลุ่มที่ 4 โคเนื้อได้รับฟางหมักยูเรียร่วมกับมันสำปะหลังสด ในอัตราส่วน 1:1 (น้ำหนักแห้ง) ในช่วง 14 วันแรกสัตว์ทดลองทุกตัวได้รับอาหารข้นเสริมในอัตรา 0.3 เปอร์เซ็นต์น้ำหนักตัว และได้รับอาหารตามกลุ่มทดลองแบบเต็มที่ ทำการสุ่มเก็บตัวอย่างของเหลวรูเมน และเลือดในวันสุดท้ายของแต่ละระยะทดลอง ทำการวิเคราะห์จุลนทรีย์ในรูเมนได้แก่ กลุ่มแบคทีเรียทั้งหมด และแบคทีเรียที่ย่อยสลายเยื่อใย แอมโมเนีย-ไนโตรเจน กรดไขมันที่ระเหยได้ และยูเรีย-ไนโตรเจนในกระแสเลือด ทำการสุ่มวัดค่าความเป็นกรด-ด่าง และอุณหภูมิภายรูเมนทันทีหลังจากสุ่มเก็บตัวอย่าง จากการทดลองพบว่า การใช้ฟางหมักยูเรียเป็นแหล่งอาหารหยาบหลักทำให้ค่าความเป็นกรด-ด่าง อุณหภูมิ แอมโมเนีย-ไนโตรเจน และกรดไขมนระเหยได้ในรูเมนอยู่ในระดับที่เหมาะสม นอกจากนี้ยังพบว่า ประชากรแบคทีเรียทั้งหมด และแบคทีเรียที่ย่อยสลายเยื่อใยมากกว่ากลุ่มทดลองอื่น ๆ อย่างมีนัยสำคัญ ($P < 0.05$) และส่งผลต่อปริมาณการกินได้ของอาหารหยาบ และปริมาณการกินได้ทั้งหมดเพิ่มขึ้นอย่างมีนัยสำคัญด้วย ($P < 0.05$) ส่วนโคเนื้อที่ได้รับมันสำปะหลังสดเป็นแหล่งอาหารหยาบนั้นพบว่า ความเข้มข้นของกรดโพรพิออนิคเพิ่มขึ้น ในขณะที่ประชากรแบคทีเรียที่ย่อยสลายเยื่อใยลดลง และจากการสังเกต พบว่าโคเนื้อที่ได้รับมันสำปะหลังสดแบบเต็มที่นั้นจะอาการทางระบบประสาทผิดปกติ เช่น ปัสสาวะตลอดเวลา ดังนั้นการให้มันสำปะหลังสดเป็นอาหารสัตว์ควรจะมีการตากแดดก่อน และการใช้ร่วมกับฟางหมักยูเรียจึงน่าจะเป็นอีกหนึ่งแนวทางที่เป็นไปได้

INTRODUCTION

Feeding the bugs, feeding the cows has been commonly referred to in ruminant production. As rumen is an essential fermentation vat to initiate anaerobic fermentation by prevailing microorganisms (bacteria, protozoa and fungi) for subsequent fermentation end-products for animal uses. Bacteria are the most numerous of these microorganisms and play a major role in the biological degradation of dietary fiber. *Fibrobacter succinogenes*, *Ruminococcus albus* and *R. flavefaciens* are presently recognized as the major cellulolytic bacterial species found in the rumen (Koike and Kobayashi, 2001). Currently, many researchers have been interested in studying rumen ecology and finding possible approaches in enhancing rumen functions. Local feed resources, particularly low-quality roughages and agricultural crop-residues, are of prime importance for ruminants raised in the tropics. These feeds exhibit close relationships with rumen ecology, microbes and rumen fermentation patterns. A number of dietary factors could influence rumen fermentation especially the basal roughage sources, their physical form and fermentation end-products (Wanapat, 2004).

During a long dry season, ruminants in the tropics are normally fed on low-quality roughages and agricultural crop-residues and by-products such as rice straw (Wanapat, 1999).

Cassava (*Manihot esculenta*, Crantz) is an important cash crop widely grown in sandy loam soil, low fertilizer and under hot long dry season. Whole cassava (cassava hay, CH) was introduced by Wanapat et al. (1997) into a dry season feeding system for ruminants by managing cassava crop growth in order to obtain optimal yield and good quality. However, the use of CH and fresh cassava foliage (FCF) in ruminant feeds have not yet been substantiated. It was therefore the objective of this experiment to investigate the use of different tropical feeds as a roughage source on rumen ecology and voluntary feed intake of beef cattle.

MATERIALS AND METHODS

Four, fistulated castrated male crossbred cattle were randomly in assigned a 4 x 4 Latin square design to investigate the effect of different tropical feed sources on rumen ecology, voluntary feed intake. There were four dietary treatments; T1) urea-treated (5%) rice straw (UTS); T2) cassava hay; T3) fresh cassava foliage (FCF) and T4) UTS : FCF (1:1 dry matter basis). Concentrate was offered at 0.3% of body weight/hd/d. All animals were kept in individual pens and received free choice of water. The experiment was conducted for four periods, each period lasted to 21 days. During the first 14 days, all animals were fed on respective diets on ad libitum basis.

UTS, CH, FCF and concentrate were sampled to be analyzed for chemical composition. CH was prepared according to Wanapat et al. (1997) using whole cassava crop grown after 3 months and its regrowth every two months, chopped and sun-dried about 2 days until the remaining dry matter was to least 85%. FCF were harvested every morning and afternoon, chopped by hands and fed animal immediately.

Rumen fluid and blood samples were collected at 0, 2, 4 h-post feeding on the last day of each period. Rumen fluid was measured for pH immediately, NH_3-N concentration (Bromner and Keeney, 1965), VFA by using HPLC and analyzed for microorganisms by role tube technique (total viable and cellulolytic bacteria) (Hungate, 1969). Blood samples were analyzed for blood urea nitrogen (BUN) (Crocker, 1967) .

All data were subjected to analysis of variance using Proc. GLM (SAS, 1985) and treatment means were statistically compared by Duncan's New Multiple Range Test (Steel and Torrie, 1980)

RESULTS AND DISCUSSIONS

Feed ingredients and chemical composition are presented in table 1. Formulations of concentrate using simple and locally available feed ingredients, is contained 12.8%CP. Urea-treated rice straw contained 7.2 %CP, while cassava hay (CH) and cassava foliage (FCF) consisted of 24.7 and 25.3%CP, respectively.

Rumen ecology parameters were measured for temperature, pH, temperature, NH_3-N volatile fatty acids (VFA) and microorganism population. In addition, BUN was determined to see its relationship with rumen NH_3-N and protein utilization. As shown in table 2, rumen pH and temperature were similar among treatments and the values were quite stable at 6.6-6.9 and 39.3-39.6 °C, respectively. Ruminal NH_3-N concentration were higher in FCF, CH and UTS:FCF (1:1 DM basis) treatments ($P < 0.05$) (14.9, 14.7 and

14.0 mg%, respectively) than in UTS treatment (12.1 mg%). However, higher NH_3-N levels in FCF, CH and UTS:FCF (1:1 DM basis) treatments were in range of optimal level of ruminal NH_3-N (15-30 mg %) (Perdok and Leng, 1990). It should be noted that these rumen NH_3-N levels were in good range and suitable for rumen ecology particularly for further microbial protein synthesis (Kanjanapruthipong and Leng, 1998; Wanapat and Pimpa, 1999). Blood-urea nitrogen (BUN) concentration has been reported to be closely related with rumen NH_3-N, however at this stage, these values were not yet available. As for total volatile fatty acid were higher in UTS treatment than UTS:FCF treatments ($P < 0.05$) and were similar range with CH and FCF treatments, C_2 were highest in CH and UTS:FCF treatment ($P < 0.05$) than those in UTS and FCF treatments. However, C_3 concentration was highest, while cellulolytic bacterial population was lowest in FCF treatment, while C_4 concentration were similar among treatments.

Table 1 Chemical composition of urea-treated (5%) rice straw (UTS), cassava hay (CH), fresh cassava foliage (FCF).

Feedstuffs	**Levels of cassava hay in concentrate mixture ,%**			
	Concentrate	**UTS**	**CH**	**FCF**
Cassava chip	58.0	-	-	-
Rice bran	37.0	-	-	-
Urea	3.0	-	-	-
Mineral mix	1.0	-	-	-
Sulphur	1.0	-	-	-
Total	**100**	-	-	-
Chemical compositions				
DM, %	95.2	55.0	87.0	30.6
		% of DM		
OM	92.2	84.5	85.9	87.2
Ash	5.8	15.5	14.1	12.8
CP	12.8	7.2	24.7	25.3
NDF	17.7	78.6	58.4	57.5
ADF	8.4	51.3	44.5	43.9

UTS = urea-treated rice straw, CH = cassava hay, FCF = fresh cassava foliage,
DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral-detergent fiber,
ADF = acid detergent fiber.

With regards to rumen microorganisms, total viable bacteria and cellulolytic bacteria population were highest in UTS treatment at 5.7 x 10^{10}CFU/ml and 6.5 x 109 CFU/ml, respectively ($P < 0.05$). Ruminal bacteria play a particularly important role in the biological degradation of dietary fiber because of their much larger biomass and biological activities (Koike et al., 2003).

Table 3 shows data on roughage DM intake and total DM intake the value were highest in UTS treatment ($P<0.05$) in term of %BW and g/kgW0.75 (2.5 and 109.3, respectively). It was also observed that feeding FCF as a full-feed resulted in anorexia and ataxia as well as frequent urination, therefore FCF could only be partially fed and/or wilting. In addition combinational use of FCF and UTS could also be possible.

Table 2 Effect of various sources of tropical roughages on rumen ecology and blood - urea nitrogen (BUN) in beef cattle.

Items	Treatments				SEM
	UTS	CH	FCF	UTS:FCF	
Ruminal pH	6.6[a]	6.9[b]	6.9[b]	6.6[a]	0.09
Ruminal temperature,°C	39.3[a]	39.3[a]	39.3[a]	39.6[b]	0.07
NH_3-N concentration, mg%	12.1[a]	14.7[b]	14.9[b]	14.0[b]	0.39
Total volatile fatty acid, mM	108.3[a]	103.1[ab]	103.5[ab]	101.9[b]	2.52
Acetic acid, mol/100 mol	69.8[ab]	72.4[a]	63.6[b]	71.5[a]	1.23
Propionic acid, mol/100mol	20.6[a]	17.5[a]	26.2[b]	18.0[a]	1.28
Butyric acid, mol/100mol	9.6	10.2	10.3	10.5	0.25
Total viable bacteria, x 10^{10} CFU/ml	5.7[a]	4.2[b]	3.8[b]	5.2[a]	0.44
Cellulolytic bacteria, x 10^{9} CFU/ml	6.5[a]	4.3[ab]	2.5[b]	5.8[a]	0.89
Blood urea nitrogen, mg%	6.9[a]	8.8[ab]	10.3[b]	7.5[a]	0.88

[a,b] values on the same row with different superscripts differ ($P < 0.05$)

SEM = standard error of the mean, UTS = urea-treated rice straw, CH = cassava hay, FCF = fresh cassava foliage, UTS : FCF at (1:1 DM basis)

Table 3 Effect of various source of tropical roughages on feed intake in beef cattle.

Items	Treatments				SEM
	UTS	CH	FCF	UTS:FCF	
Roughage DM intake/day					
kg	8.3[a]	6.7[ab]	5.4[b]	8.7[a]	0.76
%BW	2.2[a]	1.8[b]	1.8[b]	1.9[b]	0.09
g/kgW0.75	96.0[a]	80.3[b]	75.1[c]	89.2[ab]	4.64
Total DM intake/day					
kg	9.4[ab]	7.8[bc]	6.3[c]	10.0[a]	0.83
%BW	2.5[a]	2.1[b]	2.1[b]	2.2[b]	0.09
g/kgW0.75	109.3[a]	93.4[b]	87.5[bc]	103.0[ab]	4.86

[a,b,c] values on the same row with different superscripts differ ($P < 0.05$)

SEM = standard error of the mean, UTS = urea-treated rice straw, CH = cassava hay, FCF = fresh cassava foliage, UTS : FCF at (1:1 DM basis)

Concentrate was offered at 0.3% of body weight/hd/d.

CONCLUSIONS AND RECOMMENDATIONS

Based on this experiment, the results demonstrate that the use of urea-treated rice straw as a roughage source could provide effective fiber, maintain higher pH, improving rumen NH_3-N, VFA and increased total viable and cellulolytic bacteria and may play an important role in changing predominant rumen cellulolytic bacteria species, hence further research warrants undertakings. It was interesting to obtain that in CH as compared with FCF resulted in higher C_2 and cellulolytic bacteria while in FCF C_3 was higher but with lower cellulolytic bacteria also. In addition, it was also observed that feeding FCF as a full-feed resulted in anorexia and ataxia as well as frequent urination, therefore FCF could only be partially fed and/or wilting, however, combinational use of FCF and UTS could also be possible, while use of CH can be fully practiced.

For further study there is a need for the investigation on the use of specific primers to identifying predominant of cellulolytic bacteria by using PCR technique.

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