ORIGINAL ARTICLE

Effect of levels of urea and cassava chip on feed intake, rumen fermentation, blood metabolites and microbial populations in growing goats

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Abstract

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The study was conducted to assess effect of levels of urea and cassava chip (CC) on feed intake, rumen ecology, blood metabolites and microbial populations. Four, Thai Native X Anglo Nubian crossbred growing male goats with an average liveweight 19.0±1 kg were randomly assigned according to a 4x4 Latin square design to receive one of four diets: T_1=urea at 0 % (CC=30%), T_2=urea at 1% (CC=40%), T_3=urea at 2% (CC = 50%) and T_4=urea at 3%(CC=60%), of DM basis, respectively. Elephant grass (*Pennisetum purpureum*) was offered on an ad lib basis. The results revealed that total DM intake (%BW and g/kg $W^{0.75}$) and BW

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change were similar among treatments (p>0.05). Likewise, rumen pH, BUN, blood glucose, PCV and microbial populations were similar among treatments (p>0.05), while NH_3-N increased as the urea level increased and were found highest (p<0.05) in T_4 at 12.8 mg/dL. Based on this experiment, it can be concluded that a higher level of urea (3%) could be used with a high level of CC in concentrate and it was good approach in exploiting the use of local feed resources for goat production.

Key words: urea; cassava chip; growing goat; rumen fermentation; microbial populations

บทคัดย่อ

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ผลของระดับยูเรียและมันเส้นในสูตรอาหารข้นต่อปริมาณการกินได้ กระบวนการหมักในกระเพาะหมัก เมแทบอไลซ์ในกระแสเลือด และประชากรจุลินทรีย์ในแพะรุ่น

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การศึกษาผลของระดับยูเรียและมันเส้นในสูตรอาหารข้นต่อปริมาณการกินได้ กระบวนการหมักในกระเพาะหมัก เมแทบอไลซ์ในกระแสเลือด และประชากรจุลินทรีย์ในแพะรุ่น โดยใช้แพะรุ่นลูกผสมพื้นเมือง-แองโกลนูเบียน 50% เพศผู้ มีน้ำหนักตัวเฉลี่ย 19 $\pm$1 กก. สุ่มแพะให้ได้รับอาหารตามแผนการทดลองแบบ 4x4 ลาตินสแควร์ (Latin square design)โดยทำการศึกษาผลของระดับการเสริมยูเรียและมันเส้น 4 ระดับ ได้แก่ เสริมยูเรียที่ระดับ 0 (CC=30%), 1(CC=40%), 2 (CC=50%) และ 3 (CC=60%)% ตามลำดับ และได้รับหญ้าเนเปียร์สดเป็นอาหารหยาบอย่างเต็มที่ จากการทดลองพบว่า ปริมาณการกินได้ทั้งหมดของวัตถุแห้ง (%BW and g/kg $W^{0.75}$) และน้ำหนักตัวไม่แตกต่างกันทางสถิติ (P>0.05) ค่าความเป็น กรด-ด่าง (pH) ภายในกระเพาะรูเมน ยูเรีย-ไนโตรเจนในกระแสเลือด กลูโคสในกระแสเลือด ค่าปริมาตรเม็ดเลือดแดงที่อัดแน่นและประชากรจุลินทรีย์มีค่าไม่แตกต่างกัน ขณะที่ค่าความเข้มข้นของแอมโมเนีย-ไนโตรเจน (ammonia-nitrogen, NH_3-N) เพิ่มขึ้นตามระดับของยูเรียที่เพิ่มขึ้นและสูงสุดในกลุ่มที่ได้รับยูเรียในอาหารข้นที่ 3% (12.8 mg/dL) จากผลการทดลองนี้สามารถสรุปได้ว่า ยูเรียสามารถใช้ได้ในระดับสูง (3%) ร่วมกับมันเส้นในสูตรอาหารข้นและเป็นลู่ทางในการใช้วัตถุดิบในท้องถิ่น

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Rumen microbial growth is dependent on the availability of N in the form of peptides, AA, and NH_3 (Russell *et al*., 1992). Fibrolytic bacteria use ammonia as a chief N source (Russell *et al*., 1992) to meet the N demands of rumen microbes. NPN should be able to substitute for at least a portion of the ruminally degradable protein (RDP) as recommended 60 to 65% of CP as RDP, and roughly 50% of the RDP as soluble protein (NRC, 1989).

Urea is a source of ruminally degradable N that is used extensively in ruminant diets. Because of its low cost and ease of incorporation,urea is often the sole source of supplemental N in finishing diets. Therefore, information was sought regarding the usefulness of urea in stimulating microbial growth and, subsequently, metabolizable protein. One of the major factors influencing the utilization of ruminal ammonia for microbial growth is the availability of carbohydrates to the rumen organisms. While it is known that non-structural carbohydrates (NSC) such as starch promote utilization of NH_3-N in the rumen,maximizing rumen microbial protein synthesis requires the timely availability of nitrogen and carbohydrate sources suitable for rapid microbial growth (Sniffen and Robison, 1987). Cassava chip (CC) is an excellent source of NSC and is the major starch source fed to ruminants in Thailand and many tropical countries. In an earlier *in situ*

experiment, Chanjula *et al*. (2003) reported that the rate and extent of ruminal degradability of CC is higher than sweet potato, corn meal and rice bran. Currently, CC was reported to be the most digestible (>98%) in terms of total tract digestibility (Huntington, 1997). It is an important source of energy for microorganisms. However, the optimum level of NPN to NSC is likely to vary with the degree of substitution and data to validate this apporoach in typical goat diets are limited. Our objective was to determine the effect of levels of urea in concentrate on feed intake, ruminal fermentation, blood metabolites and microbial populations of growing goats.

Materials and and Methods

Animals and experimental diets

Four Thai Native X Anglo Nubian crossbred growing male goats (approximately 8 months old) averaging 19 ± 1 kg (mean ± SD) (initial BW) were randomly assigned to dietary treatments according to a 4 x 4 Latin square design experiment to study the effect of levels of urea and cassava chip on feed intake, ruminal fermentation, blood metabolites and microbial populations. Four isonitrogenous-isocaloric experimental diets were given as shown in Table 1. The dietary treatments were; Control T_1= urea at 0 % (CC = 30%); T_2= urea at 1% (CC = 40%); T_3= urea at 2% (CC = 50%) and T_4 = urea at 3% (CC = 60%), of dietary dry matter (DM), respectively

All goats were drenched for internal worms (Ivermectin, IDECTIN®, The British Dispensary, Co., Ltd.) and injected with vitamins A, D_3 and E prior to commencing the experiment. Each goat was kept individually in ventilated metabolism crates in well-ventilated sheds where water and mineral salt were available at all times. During each period, all animals received a concentrate diet at 2% BW (DM basis) and were allowed to consume with chopped (3-5cm) fresh elephant grass (FEG, *Pennisetum purpureum*) on an *ad libitum*, allowing for 10% refusals. Feeds were provided twice daily in two equal portions at 0800 and 1600 daily. Feed refusals were weighed and recorded daily at 0700.

Table 1. Ingredient and chemical composition of goat rations (% DM basis).

Composition	Dietary treatment (% urea)[1]			
	T1(0)	T2(1)	T3(2)	T4(3)
Ingredients, %				
Cassava chip, CC	30.00	40.00	50.00	60.00
Palm cake kernel, PCK	10.00	10.00	10.00	10.00
Soybean meal, SM	21.35	14.00	6.65	0.00
Broken rice, BR	14.65	11.00	7.35	3.00
Rice bran, RB	20.00	20.00	20.00	20.00
Urea	0.00	1.00	2.00	3.00
Molasses	1.00	1.00	1.00	1.00
Salt	1.00	1.00	1.00	1.00
Dicalcium	1.00	1.00	1.00	1.00
Sulfur	0.50	0.50	0.50	0.50
Mineral mix[a]	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Estimated nutrients (%)				
TDN, %	77.89	76.81	75.74	74.65
CP	14.00	14.00	14.00	14.00
ME, Mcal/kg DM[2]	2.81	2.77	2.73	2.70
Concentrate cost, US $ /kg[3]	0.15	0.13	0.12	0.10
Concentrate cost, %	0.00	10.71	21.43	31.17

[1] T1 = Level of urea 0%, T2 = Level of urea 1%, T3 = Level of urea 2%, T4 = Level of urea 3%,
[a] Minerals and vitamins (each kg contains): Vitamin A: 10,000,000 IU; Vitamin E: 70,000 IU; Vitamin D: 1,600,000 IU; Fe: 50 g; Zn: 40 g; Mn: 40 g; Co: 0.1 g; Cu: 10 g; Se: 0.1 g; I: 0.5 g.
[2] Metabolizable energy (ME) = TDN*0.04409*0.82, [3] Official rate of exchange: 41 Baht=US $ 1

Fresh orts samples were bulked by pen and subsamples, dried at 60°C, were used for dry matter determinations. This information was used to calculate fresh elephant grass (FEG) intake. Feed samples were obtained each time experimental diets were oven dried at 60°C for 72 h and ground to pass through a 1-mm sieve, and composited by period on equal weight basis for further analysis. Goats were weighed at the beginning of each experimental period before the 0800 feeding.

Sampling processing

Each experimental period lasted for 21 days; 15 days were used to measure feed intake and the last 6 days were used to measure digestibility using total collection method. This comprised of 5 days of total collection of feces and urine, followed by 1 day of rumen fluid and blood collection. At the end of each period, rumen fluid samples were collected by a stomach tube at 0 and 4 h-post feeding. Then, the pH of the rumen samples was measured immediately by pH meter (Orion Research portable meter 200 series, USA). Rumen fluid samples were then strained through two layers of cheesecloth. Samples were divided into two portions. One portion was used for NH_3-N and VFA analyses where 3 mL of H_2SO_4 solution (1M) were added to 30 mL of rumen fluid. The mixture was centrifuged at 16000 x *g* for 15 min and supernatant stored at -20°C prior to NH_3-N and VFA analyses. Another portion was fixed with 10% formalin solution in normal saline (0.9% NaCl) (Galyean, 1989). The total direct count of bacteria, protozoa and fungal zoospores was made using the methods of Galyean (1989) based on the use of a haemacytometer (Boeco) under a light microscope (Olympus BX51TRF, No. 2B04492, Olympus optical Co. Ltd., Japan). Blood samples (about 10 mL) were collected via jugular vein into heparinized tubes at the same time as rumen fluid sampling (0 and 4 h-post feeding). Then blood samlpes were centrifuged at 4°C at 3300 x *g* for 15 min and supernatants were separated and frozen at -20°C until analysis.

Laboratory analyses

Feed, refusal and feces were analyzed in duplicate for DM, ash, CF, ether extract and Kjeldahl N using AOAC (1995) procedures. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) fractions were determined with the procedure of Goering and Van Soest (1970). Hemicellulose is the difference between NDF and ADF, and cellulose is the difference between ADF and ADL, respectively. Digestion coefficients were calculated by using the formula given by Schneider and Flatt (1975). Blood urea nitrogen (BUN) was determined according to the method of Crocker (1967) and for ruminal NH_3-N using the micro kjeldahl method (AOAC, 1990). Plasma glucose and packed cell volumn (PCV) were measured by commercial kits (No. 640, Sigma Chemical Co., St. Louis, USA).

Statistical analyses:

All data obtained from the experiment were subjected to ANOVA for a 4x4 Latin square design using the General Linear Models (GLM) procedure of the Statistical Analysis System Institute (SAS, 1990). Data were analyzed using the model

$$Y_{ijk} = \mu + M_i + A_j + P_k + \varepsilon_{ijk}.$$

Where Y_{ijk} observation from animal j, receiving diet i, in period k; μ, the overall of mean, M_i, the mean effect of level urea (i = 1, 2, 3, 4), A_j, the effect of animal (j = 1, 2, 3, 4), P_k, the effect of period (k = 1, 2, 3, 4), ε_{ijk}, the residual effect. Treatment means were statistically compared using Duncan's multiple range test (DMRT) (Steel and Torrie, 1980). Relationships describing the effect of levels of urea and cassava chip on feed intake, ruminal fermentation, blood metabolites and microbial populations were studied by orthogonal contrasts.

Results and Discussion

Chemical composition of feeds

Average chemical composition of roughage and experimental diets are presented in Table 2. Experimental diets contained similar concentrations of DM, ash, OM, CP, EE, CF, ADF and ADL. Diets containing high levels of urea and cassava-based diets had a slightly higher NFE and nonstructural

Table 2. Chemical composition of the experimental diets and elephant grass.

Chemical composition on	Dietary treatment (% urea)[1/]				
Dry matter basis, %	T1(0)	T2(1)	T3(2)	T4(3)	Elephant grass
DM [2/]	90.01	89.90	89.38	89.76	91.61
Ash	8.72	8.79	8.66	8.58	10.62
OM	91.28	91.21	91.34	91.42	89.38
CP	14.10	14.04	14.07	14.01	10.64
EE	5.83	5.32	5.23	5.31	3.89
NFE [3/]	62.58	63.89	63.47	64.59	43.16
NSC [4/]	48.98	45.65	46.24	49.82	9.87
CF	7.92	7.96	7.94	7.51	31.69
NDF	21.52	26.20	25.17	22.28	64.98
ADF	11.49	11.58	11.76	11.56	37.75
ADL	2.15	2.25	2.38	2.63	3.43
Hemicellulose [5/]	10.03	14.62	13.41	10.72	27.23
Cellulose [6/]	9.34	9.33	9.38	8.93	34.32

[1/] **T1 = Level of urea 0%, T2 = Level of urea 1%, T3 = Level of urea 2%, T4 = Level of urea 3%,**
[2/] **DM: dry matter; OM: organic matter; CP: crude protein; EE: ether extract; NFE: nitrogen free extract; NSC: nonstructural carbohydrate; CF: crude fiber; NDF: neutral detergent fiber; ADF: acid detergent fiber and ADL: acid detergent lignin.**
[3/] **Estimated: NFE = 100-(CP+CF+EE+Ash).**
[4/] **Estimated: NSC = 100-(CP+NDF+EE+Ash).**
[5/] **Estimated: Hemicellulose = NDF-ADF,** [6/] **Estimated: Hemicellulose = ADF-ADL.**

carbohydrate (NSC) and varied NDF among those diets. NSC was dramatically increased as the level of cassava chip increased in the diets. The differences among concentrate mixed diets in NSC, NDF and fiber components can be related to differences in the ingredients used in diet formulation (Table 1).

Chemical composition of fresh elephant grass (FEG) is presented in Table 2. Elephant grass contained 10.64% CP (1.7% N). Similar values for FEG have been previously reported by Mpairwe *et al*. (1998); Kabi *et al*. (2005). The relatively high levels of CP and low level of ADL in FEG suggest its suitability for goat, in terms of feed intake and digestibility, which have a limited rumen capacity to use highly lignified feeds. Nevertheless, the nutritive value of FEG may depend on cultivar, age of plant, plant density, the plant part, soil fertility, harvestingfrequency, season and climate.

Voluntary feed intake

The effects of levels of urea on feed intake of growing goats are presented in Table 3. Feed intake was statistically unaffected by treatments. Overall mean feed intake in terms of total DMI, % BW g/kgBW$^{.75}$, was similar for all dietary treatments, averaging a total DMI 706.7g/day. The data indicated that levels of urea had no effect on feed intake in growing goats. Goats fed a control diet had higher values of total DMI than those of the experimental groups, although the differences were not significant (P> 0.05). This is probably due to high urea-based diets being unfavoured as feed for goats compared with the control diet and also agreed with a published report by Wanapat *et al*. (2004). Also,not all goats were willing to eat grain containing so much urea (Skjevdal, 1981). While, high levels of cassava chip (CC) in diets had no effect on feed intake by growing goats. These data supported

Table 3. Effect of varying levels of urea on feed intake and nutrient intake (g/d) in growing goat fed on fresh elephant grass.

Attribute	Dietary treatment (% urea) [1/]				SEM	Contrasts		
	T1(0)	T2(1)	T3(2)	T4(3)		L	Q	C
DMI, kg/d								
Elephant grass, g/d	332.5	320.0	317.5	325.0	0.01	0.83	0.71	1.00
%BW	1.52	1.45	1.47	1.50	0.08	0.96	0.79	0.92
g/kg $W^{0.75}$	32.98	31.53	31.73	32.41	1.61	0.93	0.77	0.94
Concentrate, g/d	405.0	375.0	380.0	368.0	0.02	0.53	0.82	0.76
%BW	1.83	1.68	1.73	1.68	0.09	0.53	0.70	0.63
g/kg $W^{0.75}$	39.70	36.52	37.43	36.41	2.06	0.51	0.72	0.65
Total DMI, g/d	737.5	695.0	697.5	692.5	0.01	0.46	0.64	0.76
DMI, %BW	3.35	3.14	3.20	3.19	0.09	0.65	0.63	0.70
DMI, g/kg $W^{0.75}$	72.60	68.05	69.16	68.81	1.97	0.57	0.60	0.69
BW change, g/d	14.0	14.0	14.0	11.0	0.03	0.63	0.73	0.95
BW change, %	12.71	12.98	12.71	10.39	1.74	0.65	0.66	0.86

[1/] **T1 = Level of urea 0%, T2 = Level of urea 1%, T3 = Level of urea 2%, T4 = Level of urea 3%,**
[a-b] **Means within the same row not sharing a common superscript are significantly different (P<.05)**
L = linear, Q = quadratic, C = cubic.
* **p<.05**
SEM = Standard error of the mean (n = 4)

earlier works (Zinn and DePeters,1991; Sommart *et al*., 2000) which reported that inclusion of cassava in diets resulted in satisfactory animal performance and no negative effects on animal health in finishing beef cattle and in lactating dairy cows. However, Hoover (1986) reported that providing a source of more degradable NSC can result in a substantial decrease in ruminal pH and fiber digestibility thus reducing feed intake.

Similarly, no significant (P>0.05) effect of urea level was detected for BW change, but BW change tended to be slightly lower for goats fed diets containing 3% urea compared with other treatmeants. This trend may be related to the higher DMI of control diets as compared with urea-based diets.

Rumen fermentation pattern

Rumen ecology parameters were measured for pH, NH_3-N and BUN. In addition, BUN was determined to investigate their relationship with rumen NH_3-N and protein utilization. The pattern of ruminal fermentation at 0 and 4 h post feeding and overall means are given in Table 4. Rumen fluid pH at 0 and 4 h post feeding were unchanged by dietary treatments, while at 4 h after the onset occurred. At this time, the pH values ranged from 6.32-6.42. The greatest drop in pH occurred in animals supplemented with increasing levels of CC in the diets, but all treatment means were within the normal range and the values were quite stable at 6.67-6.77, which has been reported as optimal for microbial digestion of fiber (Hoover, 1986) and also digestion of protein (6.0-7.0). Since the ruminal pH is partly regulated by the ammonia concentration in the rumen fluid, the variation in pH may be explained by the urea entering the rumen and being hydrolyzed by microbial ureases into CO_2 and ammonia (2-NH_3) (Van Soest, 1994). According to the reviews by Ørskov (1986) and Garrett (1996), cows with rumen fluid of pH above 5.8 were considered normal, while those between 5.0 and 5.8 may be suffering from subclinical acidosis. The relatively high rumen fluid pH obsevered in our study suggested that goats were not likely suffuring from subclinical acidosis.

Ruminal NH_3-N at 0 h post feeding was

Table 4. Effect of levels of urea and cassava chip in concentrate on rumen fermentation character istics in growing goat fed on fresh elephant grass.

Attribute	Dietary treatment (% urea)					Contrasts		
	T1(0)	T2(1)	T3(2)	T4(3)	SEM	L	Q	C
Ruminal pH								
0 h-post feeding	7.05	7.07	6.97	7.02	0.08	0.64	0.88	0.47
4	6.42	6.35	6.32	6.37	0.03	0.75	0.62	0.96
Mean	6.77	6.72	6.67	6.72	0.04	0.55	0.30	0.26
NH_3-N, mg/dL								
0 h-post feeding	9.14	9.49	8.78	8.78	0.68	0.81	0.91	0.81
4	11.79[bc]	10.22[c]	16.07[ab]	16.79[a]	1.26*	0.10	0.67	0.31
Mean	10.46[ab]	9.86[b]	2.42[ab]	12.78[a]	0.81*	0.52	0.96	0.54
BUN, mg/dL								
0 h-post feeding	17.87	16.99	16.18	16.18	0.59	0.48	0.81	0.92
4	19.40	21.56	19.54	21.36	1.14	0.67	0.93	0.38
Mean	18.64	18.53	17.86	18.77	0.67	0.97	0.76	0.78

[1/] **T1 = Level of urea 0%, T2 = Level of urea 1%, T3 = Level of urea 2%, T4 = Level of urea 3%,**
[a-c] **Means within the same row not sharing a common superscript are significantly different (P<.05)**
L = linear, Q = quadratic, C = cubic.
*** p<.05, ** p<.001**
SEM = Standard error of the mean (n = 4)

similar among treatments, but, except at 4 h post feeding and overall means were affected by treatments. Increased ruminal NH_3-N levels were found (P<0.05) as the level of urea increased in the diets (11.7 to 16.7 and 10.4 to 12.7 mg/dL, respectively). Rumen ammonia concentration was higher in goats supplemented with urea than in the control group (0% urea). Wallace (1989) observed that supplementation with urea at 30g/kg of DM caused a higher concentration of ruminal NH_3-N and increased the bacterial numbers and activity in sheep receiving barley diets. Nevertheless, the rumen ammonia concentrations in all animals were within acceptable physiological ranges and should be adequate for microbial growth as the values were more than the optimum value required (10-30 mg%, Perdok and Leng, 1990) for increasing microbial protein synthesis, feed digestibility and voluntary feed intake (DelCurto *et al*., 1990) of low-quality forages. Concentrations of NH_3-N in ruminal fluid have been reported to decrease when 1) urea containing diets fed to nonlactating dairy cows were supplemented with molasses and starch (Fadel *et al*., 1987), 2) the nonstructural carbohydrate content of the diet was increased (MacGregor *et al*., 1983), or 3) the amount of starch digested in the rumen was increased (McCarthy *et al*., 1989).

Meanwhile, BUN concentration was not altered by treatments, averaging 18.4 mg/dL.It was close to the optimal level in normal goats which has been reported in the range of 11.2 to 27.7 mg/dL (Lloyd, 1982). The increases in rumen NH_3-N levels also resulted in increasing levels of BUN. Previous studies (Preston *et al*., 1965; Pfander *et al*., 1975; Karnezos *et al*., 1994) reported that concentrations of BUN are highly positively correlated to the level of ammonia production in the rumen. The urea content in the blood has been found to reach a maximum 3 h after feeding (Eggum, 1970) and is commonly considered to reflect the protein degradability, level of forage intake and N to energy ratio (Hammond *et al*., 1994) in ruminant diets. This would indicate that available rumen NH_3-N could be used and/or absorbed in the rumen for further synthesis (Table 4).

Blood metabolites

Blood glucose concentration at 0 and 4 h post feeding and overall means was similar (p>0.05) among dietary treatments, averaging 71.51 mg/dL (3.9 mmol/L) (Table 5). Blood glucose concentration taken prior to morning feeding of the goats tended to be lower than that taken at 4 h after the onset of feeding. All treatment means were within the normal range, which has been reportedas ranging from 50 to 75 mg/dL (2.77 to 4.16 mmol/L) (Kaneko,1980). Observed blood glucose concentrations were similar to those reported by Gelaye *et al*. (1990) and Turner *et al*. (2005). Other studies (Nelson and Guss, 1992; Radostits *et al*., 2000; Ramin *et al*., 2005) reported that the plasma concentration of glucose in ewes between as 13-92 mg/dL and averaging 63.3 mg/dL in cattle (Khan *et al*., 1998). The variation in blood glucose could affect on physiological status (Firat and Ozpinar, 1996) or disease conditions (Ford *et al*., 1990). Moreover, sampling is very important, as prior to morning feed, absorption of nutrients from the digestive tract was at minimum level (Hove and Halse, 1983). Glucose, as a source of energy, is necessary for production and reproduction performance (Radostits *et al*., 2000). Concentrations of specific blood components have been used to monitor nutrient status (e.g. serum glucose and BUN) (Hammond *et al*., 1994) in ruminants. Blood glucose and BUN level may serve as indicators for a goat's energy status. In the present experiment, these data indicate that goats consuming dietary the experimental treatments were in a normal energy status. This may be the possible reason for the lack of differences among diets and there were no deleterious effects on feed intake or the metabolism of the goats.

Packed cell volumn (PCV) at 0 h post feeding was similar among treatments; except at 4 h post feeding and overall means were affected by treatments, but all were within the normal range of 22-38 mg/dL (Lewis, 1976; Jain, 1993). Based on this study, it indicated that goats consuming high levels of urea (3% DM) with casava-based diets were unaffected in blood glucose and PCV. They also showed positive in energy status. Serum glucose has been shown to increase in high energy diet, while dramatically decreases in starvation and low energy diet (West, 1996).

Rumen microorganism population

Table 6 presents the rumen microorganism populations. Population of rumen microbes (bacteria,protozoa and fungal zoospores) were not affected (p>0.05) by treatments. Overall protozoal populations tended to be slightly greater between the 0 and 4 h post feeding in the urea-based diet with high levels of cassava chip compared with the control diet. Also, *Entodiniomorphs* sp. was higher than

Table 5. Effect of levels of urea and cassava chip in concentrate on blood metabolized characteristics in growing goat fed on fresh elephant grass.

Attribute	Dietary treatment (% urea) [1/]					Contrasts		
	T1(0)	T2(1)	T3(2)	T4(3)	SEM	L	Q	C
Blood glucose, mg/dL								
0 h-post feeding	69.62	68.07	72.22	67.95	2.25	0.95	0.70	0.39
4	76.07	71.77	75.42	71.00	2.11	0.54	0.98	0.40
Mean	72.85	69.91	73.82	69.47	2.00	0.70	0.84	0.36
PCV, mg/dL								
0 h-post feeding	30.75	28.75	29.50	29.50	0.55	0.58	0.42	0.52
4	29.00[a]	28.50[ab]	26.50[b]	27.00[ab]	0.66*	0.24	0.73	0.55
Mean	29.87[a]	28.22[ab]	28.00[b]	28.25[ab]	0.51*	0.34	0.55	0.96

[1/] **T1 = Level of urea 0%, T2 = Level of urea 1%, T3 = Level of urea 2%, T4 = Level of urea 3%,**
[a-b] **Means within the same row not sharing a common superscript are significantly different (P<.05)**
L = linear, Q = quadratic, C = cubic.
*** p<.05, ** p<.001 SEM = Standard error of the mean (n = 4)**

Table 6. Effect of levels of urea and cassava chip in concentrate on population of rumen microbs in growing goat fed on fresh elephant grass.

Attribute	Dietary treatment (% urea)					Contrasts		
	T1(0)	T2(1)	T3(2)	T4(3)	SEM	L	Q	C
Total direct count								
Bacteria (x10^{10}cell/ml)								
0 h-post feeding	1.56	1.90	1.86	1.82	10.97	0.47	0.40	0.72
4	1.54	1.88	1.86	1.89	12.11	0.26	0.45	0.66
Mean	1.55	1.89	1.86	1.85	11.30	0.35	0.42	0.69
Total Protozoa(x10^{6}cell/ml)								
0 h- post feeding	3.08	3.04	2.16	3.56	7.10	0.34	0.15	0.26
4	2.78	4.80	3.58	3.78	11.15	0.75	0.46	0.40
Mean	2.93	3.92	2.87	3.65	6.37	0.50	0.87	0.26
Holotrich sp. (x10^{5}cell/ml)								
0 h-post feeding	1.25	1.37	1.00	1.50	0.17	0.78	0.54	0.33
4	1.50	1.25	1.00	1.87	0.47	0.71	0.30	0.64
Mean	1.38	1.31	1.00	1.69	0.29	0.39	0.10	0.24
Entodiniomorphs sp. (x10^{6}cell/ml)								
0 h-post feeding	2.95	2.90	2.05	3.41	4.52	0.84	0.25	0.27
4	2.62	4.67	3.47	3.56	10.96	0.76	0.43	0.41
Mean	2.78	3.78	2.66	3.48	6.27	0.52	0.91	0.27
Fungal zoospores (x10^{6}cell/ ml)								
0 h-post feeding	2.45	2.54	1.95	3.05	4.29	0.36	0.78	0.41
4	2.74	1.60	2.73	2.74	7.99	0.42	1.00	0.13
Mean	2.59	2.07	2.34	2.89	5.40	0.78	0.57	0.59

[1/] T1 = Level of urea 0%, T2 = Level of urea 1%, T3 = Level of urea 2%, T4 = Level of urea 3%.
[a-b] Means within the same row not sharing a common superscript are significantly differen (P<.05)
L = linear, Q = quadratic, C = cubic.
*** p<.05, ** p<.001**
SEM = Standard error of the mean (n=4)

Holotrich sp. in the same treatment. This agrees with the finding of Chamberlain *et al*. (1985) and Jouany (1988) in which starch supplementation favoured the development of protozoa, in particular the entodiniomorphid species. Coleman (1986) also showed that the growth of protozoa was greatly enhanced by starch and without starch in the ration, protozoa density was low and the rates of digestion were reduced. The presence of protozoa in the rumen can also affect rumen fermentation of starch. Jouany and Ushida (1999) reported that the number of protozoa per ml rumen fluid depends on the rate of soluble sugars and starches in the ration and also on the pH. Moreover, if the ration is based on grain, protozoa engulfment of starch grains can modulate pH and protect the animal from acidosis (Russell and Hespell, 1981; McAllister *et al*., 1993). In the present study, protozoal numbers tended to be higher in goats fed high levels of cassava chip. More soluble carbohydrate would probably provide abetter niche for protozoal growth.

Conclusions

Based on this experiment, it could be concluded that higher levels of urea (3%) could be used with high levels of CC in concentrate without altering feed intake, rumen ecology, blood metabolites or animal performance when compared with control diets. Increasing levels of urea in the diet was associated with higher ruminal NH_3-N but did not affect physiology and was adequate for microbial

growth. It is a potential approach to exploiting the use of local feed resources. However, based on this data, it would be desirable to conduct further research on the use of cassava chips at a high level when synchronized with NPN (urea) to determine practical rations for finishing goats and dairy goats as well as using this approach for on farm research.

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