EFFECT OF CASPUREA AS A PROTEIN SOURCE REPLACEMENT FOR SOYBEAN MEAL IN DIETS ON PERFORMANCE OF THAI NATIVE X BRAHMAN BEEF CATTLE

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Abstract

This experiment aimed to study the effects of Caspurea (cassava pulp-urea) on the productive performance of Thai Native × Brahman beef cattle. Four Thai Native × Brahman beef cattle (approximately 365 days of age and average live weight of 154.7 ± 26.8 kg) were used in a 4 × 4 Latin square arrangement of treatments with four 21-d periods. The treatments were the levels of Caspurea replacement for soybean meal in concentrate at 0, 25, 50, and 75%. Concentrates were formulated to contain 14% CP and were fed at 2.0% BW. All animals were fed *ad libitum* urea-treated rice straw as roughage. The results showed that the total dry matter intake (5.5, 5.5, 5.2, and 5.3 kgDM/d; $P > 0.05$) was not significantly different from other dietary treatments. Dry matter digestibility (71.2, 72.1, 71.2, and 67.7%; $P < 0.01$) was the lowest in 75% replacement diet and ruminal ammonia-N concentration (8.5, 8.8, 9.5, and 13.3 mg%; $P < 0.01$) was the highest in 75 % replacement diet. Moreover, the total volatile fatty acid (127.4, 123.6, 119.8 and 96.4 mM; $P < 0.01$), the bacteria population [2.6, 2.5, 2.5 and 2.4 ($\times 10^{10}$ cell/ml)], the protozoa population [2.2, 2.2, 2.1, and 1.9 ($\times 10^{5}$ cell/ml)] and nitrogen absorption (65.5, 64.7, 60.6, and 57.7 g/d) were also lowest in 75% replacement diet ($P < 0.01$), but were not different from 0, 25, and 50% replacement groups. The nitrogen retention (%N intake) (24.1, 23.6, 25.3, and 13.6 g/d) tended to increase in 50% replacement diet ($P = 0.05$) while, in 0, 25, and 50% replacement diet groups were not different. Blood urea nitrogen (22.5, 23.2, 23.3, and 24.6 mg%; $P < 0.01$) was the highest in 75% replacement diet and the average daily gain (0.54, 0.52, 0.55, and 0.42 kg/d; $P < 0.05$) was linearly decreased by Caspurea replacement diet. These results indicate that 50% of the replacement diet by Caspurea for soybean meal in concentrate has positive effects on crossbred Native × Brahman beef cattle production.

Keywords: Urea, Caspurea, soybean meal, Thai Native-Brahman beef cattle

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Introduction

Urea has been utilized as a supplemental nitrogen source for beef cattle rations when natural protein supplements are expensive. However, urea is utilized less efficient than natural plant proteins such as soybean meal for beef production (Helmer and Bartley, 1971). It has been suggested that rumen ammonia concentrations accumulate when dry matter of the ration contains more than 13% crude protein (CP), thus, ammonia from non protein nitrogen (NPN) in these rations is not utilized by rumen microorganisms (Roffler and Satter, 1973). The utilization of urea rations for milk production has been improved by the use of a mixture of gelatinized starch and urea, processed through an extruder cooker (Jittakhot, 1999). Rumen ammonia concentrations were reduced when this mixture was incubated with rumen microorganisms (Helmer *et al.*, 1970). The objectives of this research were to compare the production performance of Thai Native x Brahman beef cattle and the utilization of dietary nitrogen with various levels of Caspurea replacement for soybean meal in the concentrate.

Materials and Methods

Four Thai Native x Brahman crossbred male beef cattle were used in the experiment. The animals were randomly assigned in a 4×4 Latin square designs with four 21-d periods. The dietary treatments were as follows: Caspurea replacement for soybean meal in concentrate at 0, 25, 50, and 75%. All animals were fed *ad libitum* of urea-treated rice straw and concentrate (14% CP) at 2.0% BW, twice daily at 08.00 am. and 05.00 pm. Each animal was housed in an individual pen and given free access to clean water at all times. Daily collection of urine and faeces was made on the last 7 days of each period. The urine was collected approximately 5% of the total stored in a container with 100 ml of 10% H_2SO_4 (final pH $\approx$ 3). It is essential to acidify the urine to prevent bacterial activity. Each urine collection of each period was diluted 4 times to prevent precipitation of uric acid during storage. The samples were stored at - 20^{o}C until they were analysed. Daily faeces collected in each period were bulked, mixed and a 5% sub sample was taken. The samples of faeces were oven dried and ground (1 mm Screen) for the determination of DM, ash, OM, NDF, ADF, and N content. Rumen fluid and jugular blood were collected on the last day of each period. Ruminal pH was measured immediately after the ruminal fluid sampling process.

Rumen fluid was collected at 0, 3, and 6 h post feeding approximately 50 ml with 5 ml of 6 N HCl.The jugular blood was collected at 0, 3, and 6 h post feeding and placed into heparinized vacationer tubes and centifuged at 2,500 $\times$ g for 15 min. Both rumen fluid and blood were stored at 5^{o}C until they were analysed. Live weights of each animal were measured before feeding at the beginning and at the end of each feeding period (21 d). Urea-treated rice straw and concentrate were sampled every two weeks and the composited sample was analyzed for NDF, ADF, and ADL contents (Goering and Van Soest, 1970). DM, ash and crude protein were determined by the methods of AOAC (1985). Neutral detergent fiber, acid detergent fiber, acid detergent lignin of feeds and faeces were determined by the methods of Georing and Van Soest (1970) and dry matter, ash crude proteins were determined by the methods of AOAC (1985).

Rumen fluid TVFA concentration was determined by titration technique of Briggs *et al.* (1957) and by GC (Hewlett Packard GC system HP6890 A; Hewlett Packard Avondale, PA). Acetic, propionic and butyric acid concentrations were determined by GC (Hewlett Packard GC system HP6890 A; Hewlett Packard Avondale, PA). NH_3 –N contents were determined by the methods of Bromner and Keeney (1965).

Statistical Analyses

All data obtained from the experiment were subjected to the analysis of variance using Proc. GLM (SAS, 1996) and treatment means were statistically compared by Duncan’s New Multiple Range Test (Steel and Torries, 1980). The data were also subjected to the General Linear Models (GLM) procedure for orthogonal polynomial analysis of SAS (SAS, 1996).

Results and Discussion

The composition of the diets is shown in Table 1. The variation in CP analyzed within concentrates was small (approximately 14% CP) and was slightly higher than those formulated. The high Caspurea (75% replacement) rations contained slightly higher NDF than other diets.

The effect of diet on feed intake is shown in Table 2. These results indicate that the concentrate intake increased quadratically ($P < 0.05$) as the levels of Caspurea increased. Caspurea, and the intimate mixture of gelatinized starch and urea improved the palatability of urea-containing rations. These results agree with those reported by Stiles *et al*. (1970), who found that Starea improved the palatability of urea-containing rations.

The effect of diet on feed digestibility is shown in Table 3. These results indicate that the DM and CP digestibility of the diet containing Caspurea at 75% replacement for soybean meal was lower than that of other diets ($P < 0.01$). Moreover, the DM, NDF and CP digestibility decreased linearly and quadratically ($P < 0.05$) as the levels of Caspurea increased. These data indicate that urea nitrogen from Caspurea was utilized less efficiently than nitrogen from soybean meal. Susmel *et al*. (1989) reported that soybean meal has a very high biological value and has been used as a true protein

Table 1. Feed formulation and chemical composition of dietary treatment

Feed stuffs	Caspurea : Soybean meal 0:100	25:75	50:50	75:25	
Caspurea	0.0	3.8	7.5	11.2	
Cassava pulp	50.0	50.0	50.0	50.0	
Rice bran	15.0	15.0	15.0	15.0	
Soybean meal	18.0	14.2	10.5	6.8	
Palm meal	13.0	13.0	13.0	13.0	
Molasses	1.0	1.0	1.0	1.0	
Urea	0.8	0.8	0.8	0.8	
Sulfur	0.2	0.2	0.2	0.2	
Lime stone	0.5	0.5	0.5	0.5	
Salt	0.5	0.5	0.5	0.5	
Mineral mix	1.0	1.0	1.0	1.0	
Total	100.0	100.0	100.0	100.0	
Chemical composition (%)					Urea treated rice straw
DM	90.5	90.2	90.4	89.9	51.5
	......................% DM				
OM	92.6	91.2	90.6	89.9	90.1
NDF	14.5	15.4	16.2	16.8	69.1
ADF	8.2	8.7	8.9	9.3	46.3
ADL	3.3	3.5	3.6	4.3	8.6
Ash	7.4	8.8	9.4	10.1	9.9
AIA	1.2	1.3	1.5	1.4	1.6
CP (%)	14.1	14.1	14.1	14.0	6.9

DM = dry matter, OM = organic matter, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin, AIA = acid insoluble ash, CP = crude protein source for ruminants. It has been suggested that a matching supply of energy and N supply in the rumen may improve microbial growth and activity. However, Helmer *et al*. (1970) reported that cows receiving either soybean meal or Starea as the protein supplement showed no differences between rations for the apparent digestibility of DM, CP, ADF or cellulose.

The average daily gain (ADG) decreased linearly and quadratically ($P < 0.05$) as the level of Caspurea increased (Table 3). ADG was the lowest when Caspurea replacement for soybean meal in concentrate at 75% was fed while those 0, 25, and 50% Caspurea replacement for soybean meal rations showed similar ADG. The result indicate that soybean meal has a very high biological value for ruminant production, resulting in a decrease in average daily gain when Caspurea level was fed higher than 50%. These results agree with the report of Susmel *et al*. (1989), who found that soybean meal had the high essential amino acid and biological value for ruminant. Helmer *et al*. (1970)'s results have shown that the slower hydrolysis of urea results in more efficient incorporation of urea nitrogen into microbial protein. However, the daily gains of the steers fed urea and Starea were not different. The average change in body weight

Table 2. Effect of dietary treatment on feed intake

Items	Caspurea : Soybean meal				SEM	Contrast*	
	0 : 100	25 : 75	50 : 50	75 : 25		L	Q
Feed intake(kgDM/d)							
Concentrate	1.99	1.98	1.99	2.02	0.01	0.06	0.03
Roughage	3.53	3.51	3.20	3.34	0.14	0.20	0.60
Total intake	5.52	5.49	5.19	5.36	0.14	0.26	0.50
Total intake (%BW)	3.66	3.65	3.42	3.54	0.09	0.08	0.79
Total intake (g/kgBW$^{0.75}$)	127.97	127.51	119.91	124.92	2.93	0.12	0.70

*SEM = standard error of the mean, * Orthogonal polynomial contrast L = linear and Q = quadratic*

Table 3. Effect of dietary treatment on nutrient in take, digestibility and ADG

Items	Caspurea:Soybean meal				SEM	Contrast*	
	0 : 100	25 : 75	50 : 50	75 : 25		L	Q
Nutrient intake (kg/d)							
NDF	2.71	2.72	2.53	2.66	0.06	0.44	0.55
CP	0.53	0.53	0.51	0.51	0.01	0.14	0.54
Digestibility (%)							
DM	71.20^a	72.11^a	71.24^a	67.66^b	0.59	0.01	0.01
NDF	61.86^a	62.89^a	61.16^a	55.14^b	1.13	0.01	0.02
CP	76.92^a	76.98^a	75.31^a	70.33^b	0.52	0.01	0.01
Body weight (kg)							
Initial weight	146.10	146.10	146.30	146.00	-	-	-
Final weight	157.50^a	157.00^a	157.80^a	154.80^b	0.59	0.09	0.03
ADG (kg/d)	0.54^a	0.52^a	0.55^a	0.42^b	0.02	0.01	0.03

*[a,b] Means within a row with different superscripts differ ($P < 0.05$), SE = standard error of the mean, ADG = average daily gain, *Orthogonal polynomial contrast, L= linear and Q = Quadratic*

showed that dairy cows fed urea lost significantly more weight than those fed soybean meal or Starea. Differences in weight gains were not statistically significant between the soybean meal and Starea fed animals. On the other hand, Starea and soybean meal rations were consumed in sufficient quantities to support high production and to maintain or increase body reserves.

Ruminal pH data are shown in Table 4. Ruminal pH increased linearly and quadratically ($P < 0.01$) as the level of Caspurea increased (Table 4) and was the highest when Caspurea replacement for soybean meal in concentrate at 75% was fed.

Rumen NH_3-N concentration increased linearly and quadratically ($P < 0.01$) as the level of Caspurea increased (Table 4). The results showed that NH_3-N concentrations were the highest when Caspurea replacement for soybean meal in concentrate at 75% was fed while those of 0, 25, and 50% Caspurea replacement for soybean meal rations were lower than in the 75% replacement. It is possible that true protein was hydrolyzed slower than Caspurea. If this were the case, then one would expect ruminal ammonia of the high NPN (75% Caspurea) fed group to be higher than that of the soybean meal (SBM) fed group. It is also possible that the low efficient capture of N for microbial protein synthesis occured. Davis and Stallcup (1967) observed more alkaline rumen pH when urea was fed due to the high concentration of ammonia and the low VFA production. As reported by Kolver *et al*. (1998), decreases in ammonia concentration were the results of a more efficient capture of N for microbial protein synthesis. Moreover, Helmer *et al*.'s results (1970) have shown that the slower hydrolysis of urea results in more efficient incorporation of urea N into microbial protein.

Ruminal NH_3-N concentration at 3 h post feeding were increased in all dietary treatments. The data from this experiment indicate that ruminal fermentation was the greatest at the 3 h post feeding. Higher NH_3-N concentration at 3 h post feeding might have been related to the microbial population in the rumen that increased at the same time. However, at the 6 h post feedings, its decrease indicated a larger capture of N for increased microbial protein synthesis (Sinclair *et al*., 1993).

In contrast, Roman-Ponce *et al*. (1974) reported that rumen ammonia N (NH_3-N) concentration was higher for all rations at 1 h after feeding than 2 h (28.2 and 19.0 mg%). Rumen ammonia was similar for Urea and Starea rations but higher than SBM at 1 h and 2 h. However, Davis and Stallcup (1967) reported

Table 4. Effect of dietary treatment on rumen fermentation

Items	Caspurea : Soybean meal				SEM	Contrast*	
	0 : 100	25 : 75	50 : 50	75 : 25		L	Q
pH (h-post-feeding)							
0	7.04^c	7.02^c	7.19^b	7.29^a	0.01	0.01	0.02
3	6.42^c	6.52^b	6.55^b	7.06^a	0.01	0.01	0.01
6	6.73^d	6.82^c	6.92^b	7.22^a	0.01	0.01	0.01
Mean	6.73^b	6.78^b	6.89^b	7.19^a	0.07	0.01	0.07
NH_3-N (mg%)							
0	7.91^c	7.48^d	9.02^b	12.92^a	0.08	0.01	0.01
3	9.42^d	9.64^c	9.82^b	13.85^a	0.01	0.01	0.01
6	8.11^d	8.92^c	9.52^b	13.21^a	0.01	0.01	0.01
Mean	8.48^c	8.83^c	9.45^b	13.33^a	0.19	0.01	0.01

^{a,b,c,d} *Means within a row with different superscripts differ ($P < 0.05$),* * *Orthogonal polynomial contrast L= linear and Q= quadratic* the peaks of ammonia concentration in rumen contents 2 or 3 h after feeding either SBM, Urea or SBM + Urea rations. Thompson *et al*. (1972) found peak rumen NH_3-N for Starea rations 90 min after feeding. Although rumen NH_3-N values for Urea and Starea were not significantly different at either 1 or 2 h., the decline in NH_3-N from 1 to 2 h was 12.8 mg% for which is Urea and 6.4 mg% for Starea, suggesting a slower hydrolysis for Starea than Urea rations, which is in agreement with Stiles *et al*. (1970) and Schmidt *et al*. (1973). Many researchers (as these data confirm) have obtained higher ammonia contents after feeding with Urea than SBM rations (Davis and Stallcup, 1967; Freitag *et al*., 1968; Thompson *et al*., 1972; Schmidt *et al*., 1973). Stiles *et al*. (1970) observed lower rumen ammonia content in the Starea-fed cows than urea-fed cows. Others (like these data) failed to find lowering of rumen ammonia with Starea as compared to Urea (Schmidt *et al*., 1973) but did find a slow decline in rumen ammonia with Starea after feeding which agreed with these results. Coombe *et al*. (1960) pointed out that there was a relationship between rumen pH and ammonia concentration which depended on quantities of VFA. Bloomfield *et al*. (1963) also indicated that increasing pH increased ammonia absorption and that low rumen pH was associated with high VFA absorption. These findings agree with many researchers because rumen pH and VFA followed the above patterns, e.g. lower rumen pH observed for SBM and Starea rations resulted in higher VFA concentrations, with the Urea rations having the opposite effect. The correlation between the rumen pH and VFA was 0.8. Davis and Stallcup (1967) also observed more alkaline rumen pH when Urea was fed due to the high concentration of ammonia and the low VFA production. SBM and Starea were associated with high VFA production and with more acid rumen pH. Schmidt *et al*. (1973) reported that at the 1.5 h sampling time, the ruminal ammonia levels in animals fed urea or Starea were not different, perhaps indicating that Starea was hydrolyzed slower than urea (Stiles *et al*., 1970). If this were the case, then one would expect ruminal ammonia of the urea fed group to be higher than that of the Starea fed group prior to the initial post-feeding sample. Helmer *et al*. (1970) have shown that slower hydrolysis of urea results in more efficient incorporation of urea nitrogen into microbial protein. However, the daily gains of the steers fed urea and Starea were not different. Rumen ammonia levels in animal fed urea and Starea were higher than those for animals fed SBM and TSBM until the 3.5 h (urea) and 5.5 h (Starea) sampling times. There were no differences in the levels of rumen NH_3-N in animals fed the SBM diets. Moreover, high rumen ammonia has been associated with higher content of SBM or crude protein in rations (Freitag *et al*., 1968).

The total VFA concentrations in the rumen concentration decreased linearly ($P < 0.01$) as the level of Caspurea increased. The lowest concentration recorded was on animals fed 75% replacement ($P < 0.01$) (Table 5). The lowest concentration of VFA probably reflecting asynchronous diet, resulting in the decrease of ruminal end product (Kim, 2001). Moreover, Witt *et al*. (1999) reported that the higher VFA concentration might have been related to the microbial population at the same time as optimum pH. Moreover, Davis and Stallcup (1967) observed more alkaline rumen pH when urea was fed due to the high concentration of ammonia and the low VFA production. The molar proportions of acetic, propionic and butyric acids at 0, 3, and 6 h post feeding are presented in Table 5. The VFA concentration at 3 h post feeding increased similarly in all dietary treatments. However, the molar proportions of acetic, propionic and butyric acids (mol/100 mol) were not different. The data from this experiment indicate that the ruminal fermentation was the greatest at the 3 h post feeding. Higher VFA concentration at 3 h post feeding might have been related to the microbial population in the rumen that increased at the same time. However, at the 6 h post feedings, it decreased indicating a greater capture of C-skeleton for increased microbial protein synthesis (Sinclair *et al*., 1993; Witt *et al*., 1999). The result agrees with the report of Stiles *et al*. (1970), who reported that the rumen VFA concentration usually peaked at 4 h post-feeding while the total VFA concentration and that acetic acid were the highest for the Starea-fed animals. The molar proportions of propionic, iso-butyric and iso-valeric acids were significantly greater for those fed the control ration.This finding was similar to those reported by Roman-Ponce *et al.* (1974) whose results show that Starea and SBM rations result in a higher amount of the total VFA than urea. The propionate concentration was similar in SBM and Starea rations, but higher than in Urea rations.

Haskins *et al.* (1967) reported that these was no relationship between the nitrogen source to molar percentages of VFA's but Davis *et al.* (1957) found more acetate and greater A/P ratios in rumen fluid from SBM than from urea-supplemented cattle. Moreover, the mechanism for the decreased A/P ratios in rumen fluid of steers receiving high sulfur diets may involve a more efficient, sulfur-dependent metabolic pathway. Whanger and Matrone (1966) offered evidence of propionate synthesis via the acrylate pathway from lactate, a compound utilized poorly by animal tissue. This system taps a supply of energy otherwise deficient in rations which are inadequate in sulfur and provides an additional source of propionate thereby improving the overall efficiency of the diet.

However, Holter *et al.* (1971) also found higher proportions of acetate and butyrate that have been depressed compared to controls whereas propionate and the total VFA's were increased markedly in rations containing SBM (Davis *et al.*, 1957; Hutjens and Schultz, 1971).

Blood urea nitrogen concentrations are presented in Table 6. BUN Blood urea nitrogen

Table 5. Effect of dietary treatment on volatile fatty acid concentrations

Items	Caspurea : Soybean meal				SEM	Contrast*	
	0 : 100	25 : 75	50 : 50	75 : 25		L	Q
h-post-feeding							
Acetic acid (mol/100 mol)							
0	68.01	67.02	66.88	65.79	2.37	0.46	0.67
3	69.89	70.01	68.78	71.87	0.75	0.11	0.17
6	72.12	67.88	71.03	72.01	1.45	0.67	0.13
Mean	70.00	68.30	68.89	69.89	1.85	0.98	0.37
Propionic acid (mol/100 mol)							
0	15.01	18.89	14.92	15.02	2.08	0.67	0.37
3	22.99[ab]	24.91[a]	25.11[a]	19.78[b]	1.44	0.19	0.04
6	22.02[a]	21.78[a]	21.98[a]	18.69[b]	0.77	0.03	0.10
Mean	20.01	21.86	20.67	17.83	2.36	0.23	0.10
Butyric acid (mol/100 mol)							
0	7.88	7.79	7.12	7.03	0.59	0.73	0.43
3	12.01	10.81	13.87	13.16	0.86	0.13	0.95
6	9.77[b]	10.86[ab]	12.01[a]	11.85[a]	0.57	0.02	0.40
Mean	9.89	9.82	11.00	10.68	1.43	0.24	0.99
TVFAs (mM/l)							
0	101.16[a]	100.88[a]	100.74[a]	86.12[b]	0.62	0.01	0.01
3	142.16[a]	140.41[a]	139.51[a]	113.97[b]	0.66	0.01	0.01
6	138.97[a]	129.36[b]	119.22[c]	88.97[d]	0.27	0.01	0.01
Mean	127.43[a]	123.55[a]	119.82[a]	96.35[b]	4.87	0.01	0.05

[a,b,c] *Means within a row with different superscripts differ ($P < 0.05$), * Orthogonal polynomial contrast L = linear and Q = quadratic*

concentrations increased linearly ($P < 0.01$) as the level of Caspurea increased (Table 6) and was higher in the animals fed 75% replacement than other diets. These data indicate a slower rate of ammonia release and/more complete uptake of the NH_3-N for microbial protein synthesis when SBM rather than urea was the N source. These increases reflect the higher concentrations of ammonia in the rumen of these animals indicating that a high NPN intake in the diet may cause imbalances between N and energy supply to rumen microorganisms and ammonia concentrations increase (Shabi *et al*., 1998), ammonia may have been absorbed into portal blood and incorporated into urea in the liver. Morover, Sinclair *et al*. (1993) also reported that the animals offered energy and nitrogen with an asynchronous diet had high blood urea.

The blood urea nitrogen concentration at 0, 3, and 6 h post feeding showed that the blood urea nitrogen concentration at 3 h post feeding increased similarly in all dietary treatments. The data from this experiment indicate that the ruminal fermentation was the greatest at the 3 h post feeding, rumen ammonia may have been absorbed into portal blood and incorporated into urea in the liver. However, at the 6 h post feedings decrease indicated a more excreted in the urine (Sinclair *et al*., 1993; Witt *et al*., 1999). Schmidt *et al*. (1973) reported that the blood NH_3-N level was only slightly higher when urea was used as a nitrogen source than when SBM, TSBM or Starea were used as the nitrogen sources (1.2 and 1.1 µg NH_3-N/ml blood). An increase in blood NH_3 levels would not be expected since the rumen NH_3 concentrations at the 1 h sampling time were approximately one-half of the 30 mM/liter rumen fluid which is necessary to result in a rise in the peripheral blood ammonia. Blood urea nitrogen reached its peak concentration approximately 1 h after the rumen ammonia peak irrespective of supplemental nitrogen source. At 2.5 h, BUN was lower in the animals fed Starea than for those fed urea and, except for the 0 and 12 h samples, the levels for the animals fed Urea and Starea were higher than those for SBM and TSBM fed groups. These data indicate a slower rate of ammonia release and/or more complete uptake of the NH_3-N for microbial protein synthesis when SBM rather than Urea was the nitrogen source. In contrast, Jones *et al*. (1974) reported that the highest blood urea nitrogen was with the SBM ration. Reducing dietary crude protein content resulted in lower BUN.

Rumen microbe populations are presented in Table 6. Bacterial population decreased linearly and quadratically ($P < 0.01$) as the level of Caspurea increased. The lowest population recorded was on animals fed 75% replacement ($P < 0.01$). Protozoa population decreased linearly and quadratically ($P < 0.01$) as the level of Caspurea increased. The lowest population recorded was on animals fed 75% replacement ($P < 0.01$).

The levels of Caspurea replacement for soybean meal in concentrate had a significant influence upon both total bacteria and protozoa population ($P < 0.01$) and was lowest in 75% replacement. It is possible that the lower synchronizing rate of degradation of dietary energy and N release in the rumen beneficially increased rumen microbe population and microbial protein synthesis (Herrera-Saldana *et al*., 1989). Sinclair *et al*. (1993) and Kim (2001) reported that the higher synchronizing rate of degradation of dietary energy and N release in the rumen beneficially increased microbial protein synthesis. Moreover, Jouaney and Ushida (1999) reported that ruminal protozoa growth depends on a high rate of soluble sugars and starches in the ration. Therefore, high soluble N in diets and cassava starch possibly affected the rumen microbe population. Microbial biomass, net ^{15}N incorporation into cells, and volatile fatty acid production increased linearly with the increasing levels of cassava inclusion in diets (Sommart *et al*., 2000).

The results of the N balance study are shown in Table 6. Urinary N excretion was similar across treatments, but fecal N excretion increased linearly and quadratically ($P < 0.01$) as the level of Caspurea increased and was highest when Caspurea replacement for soybean meal in concentrate at 75% was fed, but N absorption decreased linearly ($P < 0.01$) as the level of Caspurea increased and was lowest when Caspurea replacement for soybean meal in concentrate at 75% was fed. The decreases in N absorption were the results of increased fecal N excretion. The increase of N excretion indicates that asynchronous diet decreases N capture in the rumen and N utilization in beef cattle (Sinclair *et al*., 1993). Moreover, N retention (%N intake) tended to decreased linearly (P = 0.05) as the level of Caspurea increase.

Conclusions

The results indicate that Caspurea as a protein source replacement for soybean meal at 25 and 50% in ration did not affect feed intake, average daily gain, blood metabolites, rumen microbe populations, end-products of ruminal fermentation, digestibility, and nitrogen balance. However, the cattle performances were higher at replacement level of 50% Capurea in ration than other levels. Therefore this study suggests that Caspurea could replace soybean meal at not more than 50%. Based on this experiment, Caspurea can be used as a protein source in Thai Native × Brahman beef cattle ration especially when fed on urea-treated rice straw as roughage.

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Table 6. Effect of dietary treatment on microbial population, blood urea nitrogen and nitrogen balance

Items	Caspurea : Soybean meal				SEM	Contrast*	
	0 : 100	25 : 75	50 : 50	75 : 25		L	Q
Blood urea nitrogen (mg%)							
0	20.36^{c}	21.02^{c}	22.32^{b}	23.22^{a}	0.15	0.01	0.65
3	23.69^{c}	24.26^{b}	24.14^{bc}	25.99^{a}	0.10	0.01	0.01
6	23.29^{b}	24.20^{b}	23.45^{b}	24.62^{a}	0.10	0.01	0.44
Mean	22.45^{b}	23.16^{b}	23.30^{b}	24.61^{a}	0.39	0.01	0.45
bacteria ($\times 10^{10}$ cell/ml)	2.59^{a}	2.53^{a}	2.52^{a}	2.35^{b}	0.02	0.01	0.01
Protozoa ($\times 10^{5}$ cell/ml)	2.21^{a}	2.19^{a}	2.13^{a}	1.94^{b}	0.04	0.02	0.08
N balance							
Urine N (g/d)	45.05	44.77	40.21	46.62	4.51	0.99	0.19
Urine N (g/kgBW$^{0.75}$)	1.01	1.02	0.94	1.06	0.06	0.97	0.29
Feces N (g/d)	19.57^{b}	19.28^{b}	19.79^{b}	24.36^{a}	0.63	0.01	0.01
N absorption (g/d)	65.51^{a}	64.72^{a}	60.63^{b}	57.74^{b}	1.12	0.01	0.41
N retention (g/d)	20.51	19.83	20.42	11.20	2.18	0.09	0.21
N absorption (%N intake)	76.90^{a}	76.89^{a}	75.30^{a}	70.31^{b}	0.52	0.01	0.01
N retention (%N intake)	24.09	23.61	25.32	13.59	2.85	0.05	0.10

[a,b,c,d] *Means within a row with different superscripts differ (P < 0.05),* [*] *Orthogonal polynomial contrast L = linear and Q = quadratic*

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