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Replacement of Soybean Meal with Cassava Pulp Mixed with Urea Gelatinizes (Caspurea) in Concentrate Diets of Beef Cattle

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Abstract: This research aimed to study the effects of cassava pulp mixed with urea Gelatinizes (Caspurea) on productive performance of Thai native x Brahman beef cattle. Four yearling Thai native x Brahman beef cattle with average live weight of 154.7±26.8 kg were used in a 4×4 Latin square arrangement of treatments with 4 periods, each period consisted 21 days. The treatments were 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 total dry matter intake (5.5, 5.5, 5.2 and 5.3 kgDM day^{-1}; $p>0.05$) was not significantly different among dietary treatments. DM digestibility (71.2, 72.1, 71.2 and 67.7%; $p<0.01$) was lowest in 75% replacement diet. DM digestibility decreased linearly ($p<0.01$) and quadratically ($p<0.01$) as the level of Caspurea increased. Ruminal ammonia-N concentration (8.5, 8.8, 9.5 and 13.3 mg%; $p<0.01$) was highest in 75% replacement diet and increased linearly ($p<0.01$) and quadratically ($p<0.01$) with increasing the level of Caspurea. Moreover, linearly ($p<0.01$) and quadratically ($p<0.01$) decreases in TVFAs (127.4, 123.6, 119.8 and 96.4 mM L^{-1}; $p<0.01$) observed were (total volatile fatty acid) reflecting increases in level of Caspurea. Increase in level of Caspurea caused linearly ($p<0.01$) decrease in bacteria (2.6, 2.5, 2.5 and 2.4×10^{10} cell mL^{-1}) and protozoa populations (2.2, 2.2, 2.1 and 1.9×10^{5} cell mL^{-1}). Nitrogen absorption (65.5, 64.7, 60.6 and 57.7 g day^{-1}) were also lowest in 75% replacement diet ($p<0.01$) however, among 0, 25 and 50% replacement groups were not differ. With increasing the level of Caspurea, N absorption was decreased. Nitrogen retention (%N intake) (24.1, 23.6, 25.3 and 13.6%N intake) tended to increase in 50% replacement diet ($p = 0.05$) while, in 0, 25 and 50% replacement diet groups were not differ, moreover, N retention tended to decreased linearly ($p = 0.08$) as the level of Caspurea increased. Blood urea nitrogen (22.5, 23.2, 23.3 and 24.6 mg%; $p<0.01$) was highest in 75% replacement diet and BUN increased linearly ($p<0.01$) with increasing the level of Caspurea. These results indicated that 50% replacement diet by Caspurea for soybean meal in concentrate has positive effects on Thai native x Brahman crossbred beef cattle production.

Key words: Caspurea, soybean meal, CP, cassava pulp, urea, beef

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 efficiently 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 >13% Crude Protein (CP), thus ammonia from non Protein Nitrogen (NPN) in these rations is not utilized by rumen microorganisms (Roffler and Satter, 1973). Utilization of urea rations for milk production has been improved by use of a mixture of gelatinized starch and urea, processed through an extruder cooker (Jittakot, 1999). During processing at high temperature and pressure, the starch mixed with urea gelatinizes, forming a homogeneous mass (Starea), which decomposes slowly in the rumen, gradually releasing urea and thus, supplying the bacteria simultaneously with ammonia and energy for protein synthesis. 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 production performance of Thai native x Brahman beef cattle and utilization of dietary nitrogen with various levels of cassava pulp mixed with urea Gelatinizes (Caspurea) replacement for soybean meal in the concentrate.

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MATERIALS AND METHODS

Four crossbred (Thai native x Brahman) male beef cattle were used in the research. The animals were randomly assigned in a 4×4 Latin square design with 4 periods, each period consisted 21 days. 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 were fed concentrate (14% CP) at 2.0% BW, twice daily at 08.00 and 17.00. Each animal was housed in an individual pen and free access to clean water all times. Daily collection of urine and faeces were made in the last 7 days of each period. Urine of individual animals was collected in 200 mL of 20% H_2SO_4 to keep the final pH of the urine <3 all times in a container. It is essential to acidify the urine to prevent bacterial activity. After recording the weight, urine was diluted 4 times to prevent precipitation of uric acid during storage. Duplicate urine samples of 50 mL were taken and stored at -20°C until analysis. 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 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 ruminal fluid sampling. Rumen fluid was collected at 0, 3 and 6 h post feeding 5 mL of 6 N HCl was added to 50 mL and jugular blood was collected at 0, 3 and 6 h post feeding and placed into heparinized vacationer tubes and centrifuged at 2500× g for 15 min. Both rumen fluid and blood were stored at 5°C, until analysis. Live weights of each animal were measured before feeding at the beginning and at the end of each feeding period (21 days). Urea treated rice straw and concentrate were sampled every 2 weeks and the composites sample were analyzed for NDF, ADF and ADL contents (Goering and Van Soest, 1970), DM, ash and crude protein were determined by the methods of AOAC (1990). Neutral detergent fiber, acid detergent fiber, acid detergent lignin of feeds and faeces were determined by the methods of Goering and Van Soest (1970) and dry matter, ash, crude protein and ammonia nitrogen were determined by the methods of AOAC (1990). Rumen fluid TVFA concentration was determined by titration technique of Briggs *et al.* (1957). Acetic, propionic and butyric acid concentrations were determined by GC (Hewlett Packard GC system HP6890 A; Hewlett Packard Avondale, PA).

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

RESULTS AND DISCUSSION

The composition of the diets is shown in Table 1. Variation in CP analyzed within concentrates was small (approximately 14% CP) and were 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 indicated that concentrate intake increased quadratically ($p<0.05$) as the levels of Caspurea increased. Total dry matter intake (5.5, 5.5, 5.2 and 5.3 kgDM day^{-1}; $p>0.05$) was not significantly different among dietary treatments. The results indicated that Caspurea and intimate mixture of gelatinized starch and urea, improved palatability of urea-containing rations. These results agree with that reported by Stiles *et al.* (1970), who found that Starea improved palatability of urea-containing rations.

The effect of diet on feed digestibility is shown in Table 3. These results indicated the DM and CP digestibility of the diet containing Caspurea at 75% replacement for soybean meal was lower ($p<0.01$) than other diets. DM digestibility (71.2, 72.1, 71.2 and 67.7%) was lowest ($p<0.01$) in 75% replacement diet. DM digestibility decreased linearly ($p<0.01$) and quadratically ($p<0.01$) as the level of Caspurea increased. Moreover, OM and CP digestibility decreased linearly and quadratically ($p<0.05$) as the levels of Caspurea increased. These data indicated that urea nitrogen from Caspurea was utilized less efficiently than nitrogen from Soybean Meal (SBM). Increase in level of Caspurea from 50-75% caused decrease in digestibility, it is possible that low efficient incorporation of N for microbial growth and activity. When urea is broken down into ammonia in the rumen, the ammonia may be absorbed into the blood stream of the ruminant. The liver will convert the ammonia into urea, which may be excreted or reabsorbed into the stomach contents. However, if the rate of ammonia absorption exceeds the capacity of the liver to convert it to urea, ammonia will accumulate in the animal's blood possibly resulting in ammonia toxicity. In order to avoid the possibility of ammonia toxicity while using Caspurea as a NPN source of nitrogen in ruminant feed, the use of Caspurea as a feed supplement has been limited to 50% replacement for SBM. Susmel reported that SBM is very high biological value and have been used as a true protein source for ruminant, it has been suggested that matching supply of energy and N supply in the rumen may improve microbial growth and activity. However,

Table 1: Feed formulation and chemical composition of dietary treatment

	Caspurea:Soybean meal			
Feed stuffs	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%)			
DM	90.5	90.2	90.4	89.9	51.5
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

Table 2: Effect of dietary treatments on feed intake

	Caspurea:Soybean meal					Contrast*	
Items	0:100	25:75	50:50	75:25	SEM	L	Q
Feed intake (kgDM day^{-1})							
Concentrate	1.99	1.98	1.99	2.02	0.01	0.056	0.029
Roughage	3.50	3.50	3.20	3.30	0.14	0.200	0.598
Total intake	5.50	5.50	5.20	5.30	0.14	0.257	0.497
Total intake (%BW)	3.70	3.60	3.40	3.50	0.09	0.083	0.787
Total intake (g kg^{-1} BW$^{0.75}$)	127.90	127.50	119.90	124.90	2.93	0.119	0.700

SEM = Standard Error of the Mean, *Orthogonal polynomial contrast, L = Linear and Q = Quadratic

Table 3: Effect of dietary treatments on nutrient intake, digestibility and BW change

	Caspurea:Soybean meal					Contrast*	
Items	0:100	25:75	50:50	75:25	SEM	L	Q
Nutrient intake (kg day^{-1})							
NDF	2.7	2.7	2.5	2.6	0.06	0.436	0.546
CP	0.53	0.53	0.51	0.51	0.01	0.140	0.537
Digestibility (%)							
DM	71.2^{a}	72.1^{a}	71.2^{a}	67.7^{b}	0.59	0.005	0.009
NDF	61.8^{a}	62.9^{a}	61.2^{a}	55.1^{b}	1.13	0.005	0.021
CP	76.9^{a}	76.9^{a}	75.3^{a}	70.3^{b}	0.52	0.001	0.003
Body weight (kg)							
Initial weight	146.1	146.1	146.3	146.0	-	-	-
Final weight	157.5^{a}	157.0^{a}	157.8^{a}	154.8^{b}	0.59	0.094	0.033
Body weight change (kg day^{-1})	0.54^{a}	0.52^{a}	0.55^{a}	0.42^{b}	0.02	0.014	0.034

^{a,b}Means within a row with different superscripts differ ($p<0.05$), SE = Standard Error of the Mean, *Orthogonal polynomial contrast, L = Linear, Q = Quadratic

Helmer *et al*. (1970) reported that cows receiving either soybean meal or Starea as the protein supplement were no differences between rations for apparent digestibility of DM, CP, ADF or cellulose.

Body weight change (0.54, 0.52, 0.55 and 0.42 kg day^{-1}) was increased ($p<0.05$) by 50% replacement diet, moreover, decrease linearly ($p<0.05$) in BW change reflected increases in level of Caspurea (Table 3). Body weight change was lowest when Caspurea replacement for SBM in concentrate at 75% was fed, while those 0, 25 and 50% Caspurea replacement for SBM rations showed similar BW. The results indicated that soybean meal has very high biological value for ruminant production, resulting in a decrease in average daily gain when Caspurea level was increased from 50-75%. These results agree with the report of Susmel, who found that SBM had the high essential amino acid and biological value for ruminant. 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. The average change in body weight showed that dairy cows fed urea lost significantly more weight than those fed SBM or Starea. Differences in weight gains were not statistically significant between the SBM 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 showed in Table 4. Ruminal pH increased linearly and quadratically ($p<0.01$) as level of Caspurea increased and was highest when Caspurea replacement for SBM in concentrate at 75% was fed.

Ruminal ammonia-N concentrations (8.5, 8.8, 9.5 and 13.3 mg%) were highest ($p<0.01$) in 75% replacement diet and increased linearly ($p<0.01$) and quadratically ($p<0.01$) with increasing the level of Caspurea (Table 4). The results showed that NH_3-N concentrations were highest when Caspurea replacement for SBM in concentrate at 75% was fed while those 0, 25 and 50% Caspurea replacement for SBM rations were lower ($p<0.01$) than in 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 SBM fed group. It is possible that low efficient capture of N for microbial protein synthesis occurred. These data indicated that urea nitrogen from Caspurea was utilized less efficiently than nitrogen from SBM. Increase in level of Caspurea from 50-75% caused increase in ammonia in the rumen. It is possible that high level of NPN in Caspurea leading to the accumulation of ammonia in the rumen.

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.

Table 4: Effect of dietary treatments on rumen fermentation

	Caspurea:Soybean meal					Contrast*	
Items	0:100	25:75	50:50	75:25	SEM	L	Q
pH (h-post-feeding)							
0	7.0^{c}	7.0^{c}	7.2^{b}	7.3^{a}	0.01	0.001	0.015
3	6.4^{c}	6.5^{b}	6.6^{b}	7.1^{a}	0.01	0.001	0.001
6	6.7^{d}	6.8^{c}	6.9^{b}	7.2^{a}	0.01	0.001	0.001
Mean	6.7^{b}	6.8^{b}	6.8^{b}	7.2^{a}	0.07	0.001	0.066
NH_3-N (mg%)							
0	7.9^{c}	7.5^{d}	9.0^{b}	12.9^{a}	0.08	0.001	0.001
3	9.4^{d}	9.6^{c}	9.8^{b}	13.9^{a}	0.01	0.001	0.001
6	8.1^{d}	8.9^{c}	9.5^{b}	13.2^{a}	0.01	0.001	0.001
Mean	8.5^{c}	8.8^{c}	9.5^{b}	13.3^{a}	0.19	0.001	0.001

^{a,b,c,d}Means within a row with different superscripts differ ($p<0.05$); *Orthogonal polynomial contrast, L = Linear and Q = Quadratic

Reported by Kolver *et al.* (1998) that decreases in ammonia concentration were the results of a more efficient capture of N for microbial protein synthesis. Moreover, Helmer *et al.* (1970) have shown that slower hydrolysis of urea results in more efficient incorporation of urea N into microbial protein. Ruminal NH_3-N concentration at 0, 3 and 6 h post feeding found that ruminal NH_3-N concentrations at 3 h post feeding were increased similar in all dietary treatments. The data in this research indicated that ruminal fermentation was 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 decreased indicating a more 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 and 2 h. However, Davis and Stallcup (1967) reported that 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 that peak rumen NH_3-N for Starea rations at 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 1-2 h was 12.8 for 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; Schmidt *et al.*, 1973; Thompson *et al.*, 1972). 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. These findings agree with many workers 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 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, 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).

Total VFA concentrations in the rumen are presented in Table 5. Total volatile fatty acid (127.4, 123.6, 119.8 and 96.4 mM L^{-1}; $p<0.01$) were significantly among dietary treatments, decreased linearly ($p<0.01$) and quadratically ($p<0.01$) when the level of Caspurea increased from 50-75%. The lowest ($p<0.01$) concentration recorded was on animals fed 75% replacement diet. The low concentration of VFA probably reflecting asynchronous diet, resulting in decreased ruminal end product (Kim, 2001). Moreover, Witt *et al.* (1999) reported that higher VFA concentration might have been related to the microbial population in 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. VFA concentration at 3 h post feeding was increased similar in all dietary treatments. However, the molar proportions of acetic, propionic and butyric acids (mol/100 mol) were not

Table 5: Effect of dietary treatments on volatile fatty acid concentrations

	Caspurea:Soybean meal					Contrast*	
Items	0:100	25:75	50:50	75:25	SEM	L	Q
h-post-feeding							
Acetic acid (mol/100 mol)							
0	68.0	67.0	66.9	65.8	2.37	0.457	0.671
3	69.9	70.0	68.8	71.9	0.75	0.110	0.169
6	72.1	67.9	71.0	72.0	1.45	0.672	0.133
Mean	69.9	68.3	69.0	70.0	1.85	0.981	0.369
Propionic acid (mol/100 mol)							
0	15.0	18.9	14.9	15.0	2.08	0.673	0.367
3	23.0^{ab}	24.9^{a}	25.1^{a}	19.8^{b}	1.44	0.187	0.039
6	22.0^{a}	21.8^{a}	22.0^{a}	18.7^{b}	0.77	0.031	0.095
Mean	20.0	21.9	20.6	17.8	2.36	0.231	0.098
Butyric acid (mol/100 mol)							
0	7.9	7.8	7.1	7.0	0.59	0.733	0.427
3	11.9	10.8	13.9	13.1	0.86	0.133	0.949
6	9.8^{b}	10.9^{ab}	12.0^{a}	12.0^{a}	0.57	0.015	0.398
Mean	9.9	9.8	10.9	11.1	1.43	0.240	0.986
TVFAs (mM L^{-1})							
0	101.2^{a}	100.9^{a}	100.7^{a}	86.1^{b}	0.62	0.001	0.001
3	142.2^{a}	140.4^{a}	139.5^{a}	114.0^{b}	0.66	0.001	0.001
6	139.0^{a}	129.4^{b}	119.2^{c}	89.0^{d}	0.27	0.001	0.001
Mean	127.4^{a}	123.6^{a}	119.8^{a}	96.4^{b}	4.87	0.001	0.050

^{a,b,c}Means within a row with different superscripts differ ($p<0.05$); *Orthogonal polynomial contrast, L = Linear and Q = Quadratic

different. The data in this research indicated that ruminal fermentation was 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 VFA concentration was decreased indicating a more 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 4 h post-feeding. While, the total VFA concentrations and that acetic acid was 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) that Starea and SBM rations result in higher amount of total VFA than urea. Propionate concentration was similar in SBM and Starea rations and higher in urea rations.

Haskins *et al*. (1967) reported that no relationship of nitrogen source to molar percentages of VFA's, however, Davis *et al*. (1957) found that 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 that higher proportions of acetate and butyrate have been depressed compared to controls whereas propionate and 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 Blood urea nitrogen (22.5, 23.2, 23.3 and 24.6 mg%) was highest ($p<0.01$) in 75% replacement diet than other treatments. BUN increased linearly ($p<0.01$) with increasing the level of Caspurea. These data indicate a slower rate of ammonia release 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 at 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 in to urea in the liver. Moreover, Sinclair *et al*. (1993) also reported that animals offered energy and nitrogen asynchronous diet had high blood urea nitrogen.

Blood urea nitrogen concentration at 3 h post feeding was increased similar in all dietary treatments. The data in this research indicated that ruminal fermentation was greatest at the 3 h post feeding; rumen ammonia may have been absorbed into portal blood and incorporated in to urea in the liver. However, at the 6 h post feedings BUN was decreased indicating a more excreted in the urine. (Sinclair *et al*., 1993; Witt *et al*., 1999). Schmidt *et al*. (1973) reported that blood NH_3-N level were 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^{-1} 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 the 30 mM L^{-1} rumen fluid necessary to result in a rise in 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, reported by Jones *et al*. (1974) that the highest blood urea nitrogen was with the SBM ration. Reducing dietary crude protein content resulted in lower BUN.

Table 6: Effect of dietary treatments on microbial population and blood urea nitrogen

	Caspurea:Soybean meal					Contrast*	
Items	0:100	25:75	50:50	75:25	SEM	L	Q
Blood urea nitrogen (mg%)							
0	20.4^{c}	21.0^{c}	22.3^{b}	23.2^{a}	0.15	0.001	0.647
3	23.7^{c}	24.3^{b}	24.1^{bc}	26.0^{a}	0.10	0.001	0.003
6	23.3^{b}	24.2^{a}	23.5^{b}	24.6^{a}	0.10	0.001	0.438
Mean	22.5^{b}	23.2^{b}	23.3^{b}	24.6^{a}	0.39	0.001	0.451
Bacteria ($\times 10^{10}$ cell mL^{-1})	2.6^{a}	2.5^{a}	2.5^{a}	2.4^{b}	0.02	0.001	0.008
Protozoa ($\times 10^{5}$ cell mL^{-1})	2.2^{a}	2.2^{a}	2.1^{a}	1.9^{b}	0.04	0.002	0.079

^{a,b,c,d}Means within a row with different superscripts differ ($p<0.05$); *Orthogonal polynomial contrast, L = Linear and Q = Quadratic

Table 7: Effect of dietary treatments on nitrogen balance

	Caspurea:Soybean meal					Contrast*	
Items	0:100	25:75	50:50	75:25	SEM	L	Q
Urine N (g day^{-1})	45.1	44.8	40.2	46.6	4.51	0.999	0.190
Urine N (g kg^{-1} BW $^{0.75}$)	1.0	1.0	0.9	1.1	0.06	0.969	0.286
Feces N (g day^{-1})	19.6^{b}	19.3^{b}	19.8^{b}	24.4^{a}	0.63	0.002	0.009
N absorption (g day^{-1})	65.5^{a}	64.7^{a}	60.6^{b}	57.7^{b}	1.12	0.002	0.405
N retention (g day^{-1})	20.5^{a}	19.8^{a}	20.4^{a}	11.2^{b}	2.18	0.088	0.213
N absorption (%N intake)	76.9^{a}	76.9^{a}	75.3^{a}	70.3^{b}	0.52	0.001	0.003
N retention (%N intake)	24.1^{a}	23.6^{a}	25.3^{a}	13.6^{b}	2.85	0.052	0.099

^{a,b}Means within a row with different superscripts differ ($p<0.05$); *Orthogonal polynomial contrast, L = Linear and Q = Quadratic

Rumen microbe populations are presented in Table 6. Increases in level of Caspurea caused decreased linearly ($p<0.01$) in bacteria and protozoa populations. The lowest ($p<0.01$) population recorded was on animals fed 75% replacement diet.

The levels of Caspurea replacement for soybean meal in concentrate had a significant influence upon both total bacteria and protozoa populations ($p<0.01$), which were lowest in 75% replacement diet. It is possible that 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*., 1990). Sinclair *et al*. (1993) and Kim (2001) reported that higher synchronizing rate of degradation of dietary energy and N release in the rumen beneficially increased microbial protein synthesis. Therefore, high soluble N in diets and cassava starch possibly affected the rumen microbe population. Microbial biomass, net 15N incorporation into cells, volatile fatty acid production increased linearly with increasing levels of cassava inclusion in diets (Sommart *et al*., 2000).

Nitrogen balance study is shown in Table 7. Urinary N excretion was similar across treatment, however, fecal N excretion increased linearly and quadratically ($p<0.01$) as level of Caspurea increased and was highest when Caspurea replacement for soybean meal in concentrate at 75% was fed. N absorption decreased linearly ($p<0.01$) as level of Caspurea increased and was lowest when Caspurea replacement for soybean meal in concentrate at 75% was fed. Decreases in N absorption were the results of increased fecal N excretion. Nitrogen absorption (65.5, 64.7, 60.6a and 57.7 g day^{-1}) were also lowest ($p<0.01$) in 75% replacement diet, however, among 0, 25 and 50% replacement groups were not differ. With increasing the level of Caspurea, N absorption was decreased. Nitrogen retention (%N intake) (24.1, 23.6, 25.3 and 13.6%N intake) tended to increase in 50% replacement diet ($p = 0.05$) while, in 0, 25 and 50% replacement diet groups were not differ. Moreover, N retention tended to decreased linearly ($p = 0.08$) as the level of Caspurea increased. N excretion increase, indicating that asynchronous diet decrease N capture in the rumen and N utilization in beef cattle (Sinclair *et al*., 1993).

CONCLUSION

The results indicated that Caspurea used as a protein source replacement for soybean meal at 25 and 50% in ration were unaffected feed intake, BW change, blood metabolites, rumen microbe populations, end-products of ruminal fermentation, digestibility and nitrogen balance. Therefore, this study suggests that Caspurea would replace for soybean meal not >50%. Based on this research, Caspurea can be used as a protein source in Thai Native x Brahman beef cattle ration especially, when fed on urea-treated rice straw as roughages.

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