EFFECT OF FEEDING NEUTRALIZED UREA-TREATED RICE STRAW ON MILK PRODUCTION OF CROSSBRED HOLSTEIN COWS

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Summary

The response of crossbred Holstein milking cows to the neutralized urea-treated rice straw feeding was investigated. Rice straw was treated with 6% urea for at least 21 days and further with sulfuric acid for overnight to complete the neutralization. The neutralized straw was then sun-dried and its feeding value was compared with that of the dried non-neutralized urea-treated straw. They were fed to the cows with concentrates either by the ration formulation based on the nutrient requirements for milk production recommended by NRC or by the traditional way in which straw was fed *ad libitum* and concentrates at 1 kg/2 kg of milk poduction. The results showed that milk production as well as milk composition of cows were not different between neutralized and non-neutralized straw. The feeding of the neutralized straw could significantly reduce the supply of protein-rich feed such as soybean oil meal, and it was demonstrated that ammonium sulfate in the neutralized straw could be utilized as effective as the plant origin protein. The results also suggested that if the traditional feeding method is applied to the dairy cattle, protein content of the supplementing concentrates should be increased to meet the requirement.

(**Key Words**: Milk Production, Neutralized Straw, Crossbred Cows)

Introduction

Fixation of CP content of urea-treated rice straw was successfully done by neutralizing free ammonia in the treated straw with sulfuric acid, and the CP of dried neutralized straw remained at 9.12% even if it was kept for 3 months (Promma et al., 1994a). The results of the digestion trial reported by Promma et al. (1994b) indicated that DM digestibility of neutralized straw estimated with crossbred Holstein steers was 54-56%, and TDN and DE were calculated to be 48.9-50.5% and 8.7-9.2 MJ/kg, respectively. Single feeding of neutralized straw showed a positive N-balance in steers, and N-balance was increased when concentrates were added to the straw. Although this new idea of neutralization of urea-treated rice straw with sulfuric acid has just developed, there might be a possibility for using neutralized straw to alternate preserved conventional roughages for dairy cattle during the dry season. The CP content of neutralized urea-treated straw is stable, while that of non-neutralized urea-treated straw was reported to be reduced when it was exposed to the open air. The report of Promma et al. (1994b) showed that single feeding of neutralized straw could only maintain the body weight of animals although the neutralized straw had 10.2% of CP and 50% of TDN. Similarly, to the urea-treated rice straw, therefore, the crossbred milking cows should be fed the neutralized urea-treated straw with a certain amount of concentrate supplements to provide enough energy, protein, minerals and vitamins.

In Thailand, a traditional feeding method has been practiced, which was based on an *ad libitum* feeding of roughages along with 1 kg of concentrates/2 kg of milk produced. According to Promma et al. (1993), feeding the urea-treated rice straw by the ration formulation tended to support better milk production than by the traditional feeding method.

In order to examine the benefit of feeding the dried neutralized urea-treated rice straw on milk production of crossbred Holstein cows, this experiment was carried out by comparing the dried neutralized and non-neutralized urea-treated rice straw under both the traditional and ration formulation feeding managements.

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Materials and Methods

A total of 8 cossbred Holstein milking cows having the records of milk production, age and stage of lactation shown in table 1 were used in this experiment. The cows were dewormed and checked on health conditions prior to the experiment. All experimental animals have passed the peak of lactation and they were allotted into 2 squares of a balanced design (Cochran and Cox, 1957). The cows in the first square were in the first lactation, and those in the second square were in the second and third lactations. Each square was composed of 4 treatments × 4 periods. Since the resting period could not be given during the lactation. the arrangement of treatments was planned to investigate the residual effects of treatments. Each period consisted of 20 days, and each cow was offered every treatments within 80 days. The treatments were as follows: (1) urea-treated rice straw (rationing), (2) neutralized urea-treated rice straw (rationing), (3) urea-treated rice straw (traditional), (4) neutralized urea-treated rice straw (traditional).

TABLE 1. PREVIOUS RECORDS OF EXPERIMENTAL ANIMALS

Square	Cow no.	Age (y)	Age (m)	BW at start (kg)	Lactation	Days after parturition	Milk yield just before starting (kg/day)
	1	2	3	367.5	1st	100	14.0
1	2	2	6	373.0	1st	51	13.5
	3	2	3	341.0	1st	40	13.5
	4	2	3	315.0	1st	32	12.5
	5	4	8	375.0	3rd	114	13.0
2	6	4	7	363.0	3rd	42	16.0
	7	4	6	403.0	2nd	66	16.0
	8	3	10	455.5	2nd	124	13.0

Cows in the treatments 1 and 2 were given the formulated diets to meet the standard requirements of NRC (1988) but containing 28-30% ADF (rationing). Based on the production records and the chemical composition of feeds which was later shown in table 3, the diets were formulated every week using the computer program developed by Promma et al. (1990). Cows in the treatments 3 and 4 were given the straw *ad libitum* and the concentrate mixture at a level of 1 kg/2 kg milk produced (traditional). All animals were given the concentrates at 08:00 and 15:00 hour so as to completely consume the given concentrates within 30 minutes. Thereafter, the straw was given at 08:30 and 15:30 hour. DM contents of feeds given and refusals were measured every day. Cows were adequately supplied with water and a lick block of minerals throughout the experiment. Animals were weighed at the initial and final days of each period. Milking was done twice a day at 05:30 hour and 15:30 hour using a milking machine. Milk samples from each cow were collected every 10 days for checking fat and protein contents, which were measured by Gerber and titration methods, respectively.

Treatment of rice straw with 6% urea was done in a concrete bunker silo, the capacity of which was 3 tons of dried rice straw. The straw was placed in the silo by 6 layers, 500 kg each, and each layer was sprayed with urea water (30 kg of urea in 500 l of water) using a spraying machine. The top of silo was covered with plastic sheets to provide an airtight condition, and bundles of rice straw were put on the plastic sheets to make shade. The treatment of straw lasted at least 21 days. A certain amount of treated rice straw was taken out from the silo every day and dried on the floor for approximately 6 hours. Dried treated straw was then fed to the animals of the treatments 1 and 3.

The neutralized urea-treated straw was made as follows: Just after being taken out from a silo, a pile of 87.5 kg urea-treated straw was sprayed with 25 l of a sulfuric acid-molasses solution using a sprinkling can. The straw was well mixed using a forage folk, covered with plastic sheets and left for overnight to complete neutralization. Then the straw was dried on the floor and fed to the animals of the treatments 2 and 4. An amount of sulfuric acid used here was calculated just to neutralize 3/4 of free ammonia in the treated rice straw. The free ammonia in the treated rice straw was determined by the distillation method (AOAC, 1975). The amount of sulfuric acid thus calculated was dissolved in 25 l of water together with 5 kg of molasses.

A concentrate mixture was formulated as shown in table 2 to contain 14% CP and 71% TDN on air dry basis. In the treatments 1 and 2, the concentrate mixture was supplemented with soybean oil meal and the mineral mixture shown in table 2 to meet the CP, TDN and Ca requirements, however, in the treatments 3 and 4, only the concentrate mixture was fed. The contents of DM, Ash, CP, ether extract (EE), NFE and CF in the feeds were determined by the method of AOAC (1975), and ADF and NDF were measured by the method of Goering and Van Soest (1970).

Data of milk production, milk composition, feed intake, feed conversion ratio (FCR) and body weight change were statistically analyzed by the method of variance analysis in a balanced design (Cochran and Cox, 1957). The interaction of main effects was tested by the variance analysis in a 2 × 2 factorial design. Duncan's new multiple range test was used for checking the difference between treatment means (Steel and Torrie, 1960).

TABLE 2. FORMULATION OF CONCENTRATE MIXTURE (%)

Ingredients	Composition
Rice bran	19.3
Ground corn	51.9
Soybean oil meal	8.0
Kapok oil meal	16.4
Mineral mixture[1]	4.4
Vitamin mixture[2], g/kg	15.0

[1] Contained: (in %) Ca 13.4, P 6.5, Na 14, Cl 19.2, S 2.6, Mg 3.5; (in PPM) Zn 1,800, Cu 300, Mn 1,800, Co 7, Se 12 and I 80.

[2] Contained: A 10^6 IU/kg, D 300,000 IU/kg, E 80 g/kg.

Results and Discussion

The chemical composition of feeds used in this experiment is shown in table 3. CP content of the dried non-neutralized straw was 6.4%, and it was not so much different from the value previously reported by Promma et al. (1994a), however, CP content of the dried neutralized straw was 9.5% which was a little lower than the values previously reported (Promma et al., 1994a; Promma et al., 1994b). Since the amount of sulfuric acid was restricted to fix 3/4 of the ammonia present in the fresh urea-treated straw in order to ensure no sulfuric acid remained, a part of ammonia present as a free state might be lost during the treatment. Assuming that the CP of untreated straw (3.3% on DM basis) was not changed during the urea treatment, the CP as ammonium salts could be calculated to be 3.1% (48.4% of total CP) in the non-neutralized straw and 6.2% (65.3% of total CP) in the neutralized straw. The contents of CF, NDF and ADF of the neutralized straw were not so much different from the previous results of Promma et al. (1994b). TDN value of the neutralized straw, 48.9%, and that of the non-neutralized straw, 49.5%, were adopted from the results of Promma et al. (1994b) and Promma et al. (1982), respectively. The chemical compositions of the soybean oil meal and the concentrate mixture were in a normal range.

The milking performance as well as body weight change of cows fed the neutralized and non-neutralized straw are shown in table 4. Since no interaction was detected in all items, only the main effects could be discussed. As seen in the table, cows fed the rationing diets tended to lose their body weight by 0.12-0.13 kg/day and those fed the diets in a traditional way gained their body weight by 0.2 0.7 kg/day, although no significant difference was found among the treatments. Straw DM intake was significantly higher in the cows fed in the traditional way than in those fed the rationing diets. It was observed that most of the cows fed the rationing diets ate over the given straw during the day time, while the traditionally fed groups consumed the straw freely and the remainings were seen in the next moring. In this experiment, body weight was measured in the morning at 07:30 hour, which possibly resulted in body weight loss in the rationing groups and body weight gain in the traditional groups as

TABLE 3. CHEMICAL COMPOSITION (DM %) AND ENERGY VALUE OF FEEDS[1] USED (Mean ± SE, N = 8)

Composition	Non-neutralized urea-treated straw	Neutralized urea treated straw	Soybean oil meal	Concentrate mixture
DM, fresh (%)	88.7 ± 0.5	88.9 ± 0.5	89.6 ± 0.1	88.9 ± 0.2
Ash	18.8 ± 0.4	18.5 ± 0.3	7.8 ± 0.2	7.7 ± 0.2
CP	6.4 ± 0.2	9.5 ± 0.3	43.1 ± 1.3	15.1 ± 0.3
Ammonium salt	3.1 ± 0.2	6.2 ± 0.3		
EE	1.6 ± 0.1	1.6 ± 0.1	3.1 ± 0.3	6.9 ± 0.2
NFE	38.1 ± 0.5	36.3 ± 0.6	37.5 ± 1.8	62.6 ± 0.3
CF	35.1 ± 0.6	34.1 ± 0.6	8.5 ± 0.5	7.7 ± 0.3
NDF	62.4 ± 1.3	59.1 ± 1.3	16.5 ± 0.8	28.8 ± 1.4
ADF	44.8 ± 1.1	43.9 ± 0.9	12.9 ± 0.6	13.2 ± 1.4
TDN	49.5[2]	48.9[2]	84.7[3]	76.8[3]

[1] CP content of untreated straw was 3.3 ± 0.2%.
[2] Adopted from the report of Promma et al. (1982) and Promma et al. (1994b).
[3] Estimated value using an equation of Fonnesbeck et al. (1984).

TABLE 4. MILKING PERFORMANCE OF CROSSBRED HOLSTEIN COWS GIVEN NON-NEUTRALIZED AND NEUTRALIZED 6% UREA-TREATED RICE STRAW (N = 8)[1]

Feeding	Rationing		Traditional		SEM
Neutralization	Non	Neutralized	Non	Neutralized	
BW change (kg/day)	−0.12	0.13	+0.7	+0.2	0.2
Milk yield (kg FCM/day)	13.4[b]	13.0[ab]	12.4[a]	12.6[a]	0.2
Milk fat (%)	3.8	3.8	3.9	3.8	0.1
Milk protein (%)	3.2	3.2	3.1	3.1	0.1
DM intake (kg/day)					
Straw	6.1[a]	6.3[a]	7.3[b]	7.2[b]	0.2
Concentrates (A)	6.8[c]	6.3[b]	5.7[a]	5.9[a]	0.1
Soybean oil meal	1.5[b]	0.9[a]		–	0.1
Concentrate mix	5.2	5.3	5.7	5.9	–
Mineral mix	0.1	0.1	–	–	–
Total (B)	12.9	12.6	13.0	13.1	0.2
% of BW	3.4	3.4	3.4	3.5	0.1
A/B	52.7[b]	50.0[b]	43.9[a]	45.0[a]	1.0
FCR (kg DM/kg FCM)	0.96[a]	0.97[a]	1.05[b]	1.04[b]	0.02

[1] No interaction was detected in all items ($p > 0.05$).
[abc] Within rows, means with different superscripts differ ($p < 0.05$).

discussed before.

Milk production of cows expressed as 4% FCM was not different between the feeding of neutralized and non-neutralized straw, however, the cows of rationing groups tended to produce more milk than those of traditional groups. The contents of milk fat and milk protein were not different among the treatments, being 3.8-3.9% in milk fat and 3.1-3.2% in milk protein, both of which were quite in normal ranges of crossbred Holstein cows.

As seen in table 3, dried neutralized straw contained higher CP than dried non-neutralized straw. For the ration formulation, therefore, the diet containing neutralized straw would require less protein supplements than that containing non-neutralized straw. This is the reason why the non-neutralized straw diet contained more soybean oil meal. The total DM intake as well as the DM intake on body weight basis were not different among the treatments, and consequently FCR was better in the rationing groups than in the traditional groups.

In table 5, TDN and CP intake of each group as well as the efficiency of TDN and CP for milk production are indicated. Although no significant difference in total TDN intake was found among the treatments, TDN intake from straw was higher in the traditional groups, which, in turn, TDN intake from concentrates was higher in the rationing groups. Since the efficiency of TDN utilization for milk production was not different among the treatment, being 0.62-0.64 kg TDN/kg FCM, levels of TDN intake from both straw and concentrates had no effect on milk production.

TABLE 5. INTAKE OF TOTAL DIGESTIBLE NUTRIENTS AND CRUDE PROTEIN BY COWS (N = 8)[1]

Feeding	Rationing		Traditional		SEM
Neutralization	Non	Neutralized	Non	Neutralized	
TDN intake (kg/day)					
Total	8.25	8.00	7.91	8.12	0.11
Straw	3.05[a]	3.09[a]	3.63[b]	3.53[b]	0.08
Concentrates	5.20[d]	4.91[c]	4.28[a]	4.59[b]	0.09
CP intake (kg/day)					
Total	1.82[c]	1.79[c]	1.31[a]	1.59[b]	0.05
Ammonium salt	0.19[a]	0.39[b]	0.23[a]	0.45[b]	0.02
Efficiency (kg/kg FCM)					
TDN	0.62	0.62	0.64	0.64	0.02
CP	0.14[b]	0.14[b]	0.11[a]	0.12[a]	0.01

[1] No interaction was detected in all items ($p > 0.05$).

[abc] Within rows, means with different superscripts differ ($p < 0.05$).

Total CP intake of cows was higher in the rationing groups than in the traditional groups, and this might reflect the difference in milk production. In both groups, the intake of CP as the form of ammonium salts was higher in the neutralized straw feeding than in the non-neutralized straw feeding, but no difference in milk production was found between them. It means that the increased intake of non-protein nitrogen by feeding the neutralized straw did not show any ill-effect in the milk production as easily realized by the efficiency of CP utilization. Since total DM intake and FCR were not different between the neutralized and non-neutralized straw groups when fed by the rationing method, it can be considered that ammonium sulfate in the neutralized straw was utilized as effective as the plant origin protein for milk production. The result of Promma et al. (1994b) indicated that the crossbred Holstein steers fed the neutralized straw could utilize the ammonium sulfate effectively, since the N-balance was positive even if the neutralized straw was fed singly. The report of sobczak et al. (1962) also demonstrated that milk production of cows was not depressed by substituting the oil cake with ammonium sulfate. The reduction of plant origin protein sources such as soybean oil meal from the diet might reduce the cost of milk production.

Finally, the actual nutrient contents of the diets were calculated to compare with the NRC requirements, and the figures are shown in table 6. As seen in the table, TDN content of the diets formulated by the ration formulation method was close to the value of NRC recommendation (1988), but it was higher than that of the diets fed traditionally. Lower TDN content of the diets for the traditional groups might increase the intake of straw, and the total TDN intake was not different among the groups. CP contents of the rationing diets were higher than the NRC recommendation by some 2%, but that of the diet for traditional feeding with non-neutralized straw was lower than the recommendation. Consequently, the cows could not take enough CP, which resulted in lower milk production. Although the milking cows could utilize the ammonium salts as effectively as protein, CP content of the concentrates used for the traditional feeding should be increased to get an increased milk production. CF and ADF contents in the rationing diets were shown to be as designed but higher than the NRC recommendations. CF and ADF contents in the traditional feeding method were further higher, but such a high fiber content did not affect milk fat content.

TABLE 6. ACTUAL NUTRIENT CONTENTS (DM %) OF THE DIETS (N = 8)

Feeding	Rationing		Traditional		SEM	NRC
Neutralization	Non	Neutralized	Non	Neutralized		
TDN	64.1[b]	63.7[b]	61.4[a]	61.6[a]	0.5	63.0
CP	14.1[c]	14.9[d]	10.2[a]	12.1[b]	0.2	12.0
CF	20.8[a]	21.6[a]	23.2[b]	22.1[ab]	0.5	17.0
ADF	28.1[a]	29.1[a]	31.1[b]	29.9[ab]	0.5	21.1

[abcd] Within rows, means with different superscripts differ ($p < 0.05$).

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