DIGESTIBILITY OF NEUTRALIZED UREA-TREATED RICE STRAW AND NITROGEN RETAINED IN CROSSBRED HOLSTEIN STEERS

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Summary

The experiment was carried out to study the digestibility of nutrients in the neutralized urea-treated rice straw when it was fed singly or in combination with concentrates. A total of 8 crossbred Holstein steers were randomly allocated in a 4 × 4 Latin square design consisted of 4 treatments, in which the neutralized straw/concentrates ratio on DM basis varied as 100/0, 90/10, 80/20 and 70/30. The results indicated that the digestibility of DM, ether extract and NFE, and TDN and DE of the diets tended to increase with an increase in the level of concentrates. Regression analysis showed that the values of intercepts should be used for estimating DM digestibility, TDN and DE of neutralized straw, when it was fed with concentrates. Digestibilities of crude fiber, NDF and ADF tended to be higher when it was fed singly than when fed with concentrates. Digestibilities of organic matter and CP were not so much changed with the increasing level of concentrates. Although the animals singly fed the neutralized straw showed positive body weight gain and N balance, it should be necessary to supplement the concentrates to get more body weight gain and N-balance in the crossbred Holstein steers.
(**Key Words:** Digestibility, N-balance, Neutralized Straw, Crossbred Steer)

Introduction

Rice straw is widely produced in the tropical regions and commonly used as an animal feed, however, the straw is not suitable for dairy cattle feeding because of its low nutritive value. Urea treatment of rice straw increased crude protein (CP) content and dry matter (DM) digestibility to some extent (Jayasuriya and Perera, 1982; Wanapat et al., 1982; Promma et al., 1985), however, the increased CP was reduced by exposing the treated straw to the open air because of the evaporation of free ammonia. Promma et al. (1994) recently demonstrated that the neutralization of free ammonia in the treated straw with sulfuric acid well fixed ammonia and could stabilize CP content of the treated straw. Moreover, the neutralization increased the *in vitro* DM digestibility of the treated straw, and the neutralized straw could be stored as a dry form for 3 months without a large loss of CP. The CP content of dried neutralized 6% urea-treated rice straw was 12.3% on DM basis, and even after 3 months of storage it was kept at a level as high as 9.1%. The major fraction of increased CP was in the form of ammonium sulfate, and if this compound could be effectively utilized by dairy cattle, it might be used as a useful roughage for the dairy cattle.

In order to investigate the possibility of effective use of the neutralized urea-treated rice straw to the dairy cattle, nutrient digestibility and energy content of the treated straw were determined using the crossbred Holstein steers. The utilization of energy and CP was also estimated by measuring the body weight gain and nitrogen balance.

Materials and Methods

A total of 8 6-7 month-old crossbred (50% blood level) Holstein steers with average body weight of 135 kg were used in this experiment. They were dewormed prior to the experiment. In a 4 × 4 Latin square design, 2 animals were used as a representative of one experimental unit and they were randomly allocated into 4 treatments for 4 periods. Each period consisted of 10 days for preliminary feeding and 10 days for collection of excreta. Feces and urine were collected separa-

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tely, and the total outputs were recorded everyday. Ten percent of daily excrements were accumulatively stored in a freezer throughout the experiment. When urine was collected, 100 ml of 9 N sulfuric acid was used as a preservative.

The neutralized straw was fed with concentrates at ratios of 100/0, 90/10, 80/20 and 70/30 respectively on DM basis, and the total amount of the mixed rations was fixed to 3.0 kg DM/day, so that the plane of nutrition was raised accordingly. The amounts of neutralized straw to be fed singly were designed to cover the maintenance levels of TDN and CP, which were estimated by the equation of NRC (1988) with the assumption that TDN of neutralized straw was approximately 50 % on DM basis. During the experimental periods, feeds were given twice a day at a constant amount, and feed residues, if remained, were weighed and checked on DM content. Water was given at a constant volume of 30 l/day during the collection period. Calcium- and phosphorus-free mineral vitamin blocks were supplied as a free choice.

Neutralized 6% urea-treated rice straw used in this experiment was prepared as follows: 1,000 kg of rice straw was sprayed with 1,000 l of water containing 60 kg urea, and kept airtight using polythene sheets for 21 days. The stack was then opened, and the straw was immediately sprayed with an acid-molasses solution, which contained 40 kg of conc. sulfuric acid and 100 kg of molasses in 500 l of water, and mixed well using a turning machine, then the straw was again kept airtight with polythene sheets for another 24 hours. The neutralized urea-treated rice straw thus produced was sun-dried for approximately 8 hours with regular turning. Dried neutralized straw was then baled using a baling machine. The baled neutralized straw was stored under roof throughout the experiment.

The concentrate mixture used in this experiment was prepared once a week by mixing 45% rice bran, 27% ground corn, 5% soybean oil meal, 20% kapok seed oil meal, 3% mineral mixture and 10 g/100 kg of vitamin mixture. The mineral mixture contained (in %) Ca 17.5, P 7.3, Na 13.5, S 2.1, (in PPM) Zn 2,071, Cu 986, Mn 5, 900, Co 41.4, Se 4.5 and I 6.8, and the vitamin mixture contained A 10^6 IU/kg, D 300,000 IU/kg and E 80 g/kg.

Daily rations were checked on DM content, and proximate analysis was performed weekly. Samples of feces collected everyday were mixed thoroughly and dried in an oven at 60℃, then the chemical analysis was performed. DM, organic matter (OM), CP, ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE) were analyzed by the method of AOAC (1975), and neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by the method of Goering and Van Soest (1970). For the analysis of CP in the feces and urine, fresh samples were used to avoid the loss of nitrogen in drying. GE content of feeds and feces was determined using a bomb calorimeter (Shimadzu model CA-3P).

Data of digestion trial and nitrogen balance were statistically analyzed by the method of variance analysis in a 4 × 4 Latin square design. The differences between treatment means were checked by Duncan's new multiple range test (Steel and Torrie, 1984). The data of digestibility, TDN, DE and N-balance obtained in the trials using the mixed rations were subjected to the regression analysis in order to estimate the digestibility of neutralized urea-treated straw.

Results and Discussion

The chemical compositions of dried neutralized urea-treated rice straw and concentrates used in this experiment are shown in table 1. It was shown that when neutralized straw was produced in the practical scale, the average CP content obtained from weekly analysis throughout the experimental period was 10.2% on DM basis. This value was lower than the average value of 12.3% which was obtained in the laboratory scale experiment (Promma et al., 1994). In order to compare the contents of nutrients other than CP with those previously indicated by Promma et al. (1994), the values shown in table 1 were recalculated on CP-free DM basis, and the following values were obtained (in %); Ash 21.9, EE 1.8, NFE 36.4, CF 39.8, NDF 65.8 and ADF 51.3. EE content was very similar in both experiments, but NFE showed lower value but Ash, CF, NDF and ADF showed higher values than those previously obtained in the laboratory scale experiment (Promma et al., 1994). Such differences might be due to the different set of rice straw used or to the different effect of neutralization in the practical scale in this experiment and the laboratory scale in the previous experiment. The concentrates used in this experiment had 16.5% of CP and 19.8 MJ GE/kg, which were both in the normal range for dairy cattle feeding. The other nutrients in the concentrates were also in the normal range.

TABLE 1. CHEMICAL COMPOSITION (DM %) OF NEUTRALIZED 6% UREA-TREATED RICE STRAW AND CONCENTRATES FED TO CROSSBRED HOLSTEIN STEERS (Mean ± SE, N=8)

	Neutralized straw	Concentrates
DM (fresh %)	89.3 ± 2.9	89.9 ± 2.6
Ash	19.7 ± 0.3	9.7 ± 0.5
OM	80.3 ± 0.5	90.3 ± 0.4
CP	10.2 ± 0.3	16.5 ± 0.4
EE	1.6 ± 0.2	9.7 ± 0.8
NFE	32.6 ± 2.2	54.5 ± 1.6
CF	35.8 + 1.4	9.7 + 0.6
NDF	59.2 ± 4.2	20.1 ± 1.1
ADF	46.2 ± 1.6	15.3 ± 1.0
GE (MJ/kg)	15.9 ± 0.1	19.8 + 0.1

The results of the digestion trials are given in table 2. Since Schneider and Flatt (1975) described that the digestibility of roughages could be estimated using the regression equation which was calculated with the digestibilities of mixed rations, the regression analysis was performed using the data of table 2, and the results are shown in table 3. As seen in table 2, DM digestibility was not significantly different among the diets containing 0, 10, 20 and 30% concentrates, however, the regression was significant as indicated in table 3 when calculated with the data of mixed rations. This means that the value of intercept, 54.1%, would be better to use instead of the value obtained with the 100/0 ration, 56.0%, for the calculation of DM digestibility of neutralized straw when it was fed with concentrates. OM digestibility showed a significant difference between the 70/30 and 80/20 rations, but the regression analysis showed no significant trend. The digestibilities of EE and NFE were significantly decreased when the level of concentrates was reduced, and consequently the regressions were significant. This means that the values of intecept, 47.5% and 47.9%, respectively, might be applicable as the digestibility of EE and NFE of the straw. The digestibilities of CF, NDF and ADF tended to increased with a decrease in the level of concentrates, particularly that of ADF was significantly higher in the single feeding of straw. According to the regression analysis, however, no significant trend was observed, and the average values of 75, 67 and 66% in CF, NDF and ADF, respectively, could be used for the mixed rations. The digestibility of CP showed some fluctuations among the diets, and no significant regression was obtained. TDN and DE were both increased with the increase in the level of concentrates, and the regressions were significant. The values of the intercepts, however,

TABLE 2. DIGESTIBILITY OF NUTRIENTS, TOTAL DIGESTIBLE NUTRIENTS, DIGESTIBLE ENERGY VALUE AND NITROGEN BALANCE (N=8)

Straw/concentrates	70/30	80/20	90/10	100/0	SEM
Digestibility (%)					
DM	57.8	57.2	55.2	56.0	1.0
OM	64.2[b]	59.7[a]	61.5[ab]	62.6[ab]	1.1
CP	52.7	54.2	49.5	47.7	2.7
EE	73.2[c]	66.2[bc]	56.4[b]	38.2[a]	4.4
NFE	58.0[c]	54.2[b]	51.4[ab]	49.4[a]	1.0
CF	74.2[a]	76.0[ab]	75.8[ab]	79.3[b]	1.1
NDF	65.0[a]	66.9[ab]	68.2[ab]	72.1[b]	1.5
ADF	65.6[a]	66.2[a]	65.4[a]	71.2[b]	1.1
TDN (%)	56.6[c]	54.4[bc]	51.4[ab]	50.5[a]	1.0
DE (MJ/kg)	10.3[b]	9.8[b]	9.3[a]	9.2[a]	0.2
N-balance (g/day)	18.8[c]	15.4[bc]	11.3[ab]	7.6[a]	1.6

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

TABLE 3. REGRESSION ANALYSIS[1] OF THE DATA GIVEN IN TABLE 2 (N=8)

	Intercept Y (x = 0)	Coefficient of X	R^2	RSD[2]	Significance levle of regression
DM (%)	54.1	0.13	0.53	1.8	0.008
OM (%)	59.4	0.12	0.24	4.1	0.260
CP (%)	48.9	0.16	0.28	4.5	0.170
EE (%)	47.5	0.91	0.57	10.7	0.003
NFE (%)	47.9	0.34	0.69	3.0	<0.001
CF (%)	76.9	−0.10	0.28	2.4	0.180
NDF (%)	69.0	−0.12	0.17	5.6	0.430
ADF (%)	65.5	0.01	0.03	3.4	0.890
TDN (%)	48.9	0.27	0.82	1.5	<0.001
DE (MJ/kg)	8.7	0.05	0.76	0.4	<0.001
N-balance (g/day)	6.8	0.47	0.39	9.2	0.060

[1] X: ratio of concentrates, Y: digestibility, energy value or nitrogen balance.
[2] RSD: residual standard deviation.

were a little lower than those obtained in the single feeding of straw (table 2).

When the digestibilities and energy values of concentrates were estimated using the regression equations, they were 67% in DM, 138.5% in EE, 81.9% in NFE, 75.9% in TDN and 13.7 MJ/kg in DE. These values were almost reasonable except for the case of EE. The residual standard deviation for EE was very high, which indicated the big variation of the data, and some other effects such as fat and protein contents of the diets would be associated with as discussed by Schneider and Flatt (1975).

The N-balance seemed to be increased by the increased level of concentrates, although the significance level was a little higher than the level of 0.05, and even by the single feeding of neutralized straw, positive N-balance was observed in the crossbred Holstein steers. It might be interpreted from this fact that the steers could well utilize the non-protein nitrogen such as ammonium sulfate present in the neutralized straw, which was produced by the neutralization of ammonia with sulfuric acid. De Aliva (1985) indicated that N-balance would be increased with an increase in CP level of the diet. In the present experiment, the digestible CP level was increased by the supplementation of concentrates and subsequently N-balance was increased as discussed later.

The actual DM intake and levels of digestible CP, CF and TDN are shown in table 4. The animals offered neutralized straw alone maintained or slightly increased their body weight during 10 days of the experimental period, since they consumed more TDN than the maintenance level by 10 percent, and their N-balance were positive. The animals given neutralized straw with concentrates also gained body weight according to the level of concentrates, since the plane of nutrition increased with the same order. The amounts of neutralized straw given to the animals were not always consumed completely, and the actual level of neutralized straw in the diet was calculated to be 89% and 79% instead of 90% and 80%, respectively. According to the observation, the refusal straw was mostly the top part or finely ground part of the straw, and these parts were considered to be not palatable. Consumed TDN and digestible CP were increased with the level of concentrates, and directly resulted in an increase in the plane of nutrition and N-balance. TDN content of neutralized straw was around 50%, which was very similar to the assumed value. The density of both TDN and CP of the rations was increased with an increase in the ratio of concentrates, and the density of CF was contrary. Although the steers maintained their body weight with the single feeding of neutralized straw, neutralized straw alone is not enough to optimize the growth of dairy cattle and supplementation of concentrates is inevitable. What planes of nutrition in terms of TDN, CP and CF are most suitable to optimize the

TABLE 4. DRY MATTER INTAKE AND PLANE OF NUTRITION (N=8)

Straw/concentrates	70/30	80/20	90/10	100/0
Mean BW (kg)	134.7	134.4	136.1	136.3
BW change (kg/10 days)	1.6	1.4	1.3	0.8
DM intake (kg/day)				
Neutralized straw (A)	2.1	2.3	2.5	2.6
Concentrates	0.9	0.6	0.3	0.0
Total (B)	3.0	2.9	2.8	2.6
% of live weight	2.2	2.2	2.1	1.9
A/B (%)	70.0	79.3	89.3	100
TDN intake (kg/day)	1.71	1.58	1.45	1.31
Plane of nutrition[1]	1.4	1.3	1.2	1.1
Digestible CP intake (g/day)	190	179	149	129
N-balance (g/day)	18.8	15.4	11.3	7.6
Level of nutrients (DM %)				
TDN	56.6	54.4	51.4	50.5
CP	12.0	11.4	10.9	10.2
CF	28.3	30.7	33.3	35.8

[1] Kg TDN consumed/kg TDN for maintenance.

growth of dairy cattle must be further investigated.

It can be concluded from the results that neutralized 6% urea-treated rice straw had 54% DM digestibility, 50% TDN and 9 MJ DE/kg. The CP content of neutralized 6% urea-treated straw was 10% on DM basis and its digestibility was around 48% irrespective of the level of supplemented concentrates. Although the increased CP in the neutralized straw is non-protein nitrogen, the animals can utilize it efficiently. Hence, neutralized urea-treated rice straw could be used as a preserved feed for supporting the production of growing crossbred Holstein cattle during the dry season.

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