PRODUCTION RESPONSES OF CROSSBRED HOLSTEIN MILKING COWS FED UREA-TREATED RICE STRAW AT THREE DIFFERENT FIBER LEVELS

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Summary

The experiment was conducted to determine the effect of different fiber levels on milk production of crossbred Holstein milking cows fed urea-treated rice straw (UTS) as a roughage. Eight cows were allotted into 2 squares of 4 cows each with 4 treatments by a balanced design. The treatments were 17%, 22%, and 24% crude fiber (CF) diets and Thai feeding system (free choice of roughage and 1 kg of concentrates/2 kg of milk) as a control. Body weight change was not significantly different among the treatments during the experiment. Milk production (4% FCM) and milk protein content were not different among the treatments, but milk fat content was low in the 17% CF group and high in the control group. Cows fed the 17% CF diet consumed less UTS and more concentrates than the others, and consequently total DM intake was not different among the treatments. The feed conversion ratio was significantly higher in the control. Feed cost per kg milk was lowest in the control and highest in the 17% CF diet. The fiber content of the diet would be more than 17%, preferably 22-24% for normally producing Thai crossbred Holstein cows when the UTS was fed as a main roughage source.

(**Key Words**: Production, Fiber Levels, Urea-Treated Straw, NRC Recommendation, Crossbred Cows)

Introduction

The crossbred Holstein cattle has been used for milk production in the developing countries for more than 20 years. In the tropical conditions feeding is the major factor for milk production particularly during the dry season. Attempts have been intensified in utilizing urea-treated rice straw for supporting the productivity of ruminants during that critical period. Promma et al. (1985a, 1985b) indicated that the crossbred Holstein milking cows could produce 8.8-9.0 kg of 4% FCM per day by *ad libitum* feeding of urea-treated rice straw supplemented with concentrates. In Thailand, most farmers have followed the traditional feeding method of the dairy cattle, which is free choice of roughages with an additional supply of concentrates at a level of 1 kg per 2 kg of milk production. This method has been accepted throughout the country as a practical one. However, problems of inadequate or surplus nutrient supply were often seen under this method.

According to Promma et al. (1993), crossbred Holstein heifers fed the urea-treated rice straw diet containing 22-30% crude fiber or 33-46% ADF showed a good growth response (500 g gain/day), when the diet contained standard levels of TDN and CP recommended by NRC (1988), but the reduction of TDN and/or CP to 90% those of the standard, growth rate was depressed. Lofgren and Warner (1970) reported that feeding milking cows with 17% crude fiber (CF) or 19% ADF maintained a normal level of milk fat production. Crude fiber level of the cow diet of approximately 16% was recommended for maintaining milk fat content at satisfactory level (Thomas and Rook, 1983). Woodford (1984) also demonstrated that fiber content of the ration at 18.6% ADF maximized milk production with normal milk fat content. According to NRC (1981), heat stress is the main factor to limit the dry matter intake of feed in the hot climate. Sutardi (1991) suggested, therefore, that milking cows raised in the tropics need more input of TDN and CP than those recommended by NRC (1988). Strategy for increasing feed intake should

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be considered, preferably use of good quality roughages. Apart from other crop residues, urea-treated rice straw was proved to be the roughage that ruminants showed high feed intake (Wanapat, 1985).

The objective of this experiment was to investigate the effect of different fiber levels of urea-treated rice straw diets on milk production and milk composition of crossbred Holstein milking cows under the standard requirement of NRC. The results were compared with that of the traditional feeding system, and factors associated with milk production were also discussed.

Materials and Methods

The crossbred Holstein milking cows (75% of Holstein blood) were used to study the effect of dietary levels of fiber on milk production. The animals were arranged by the method of balanced design (Cochran and Cox, 1957). The experiment was conducted within two squares consisted of 4 treatments × 4 periods per each square. Each experimental period was 30 days. Each of the experimental animals was designed to get all 4 treatments within 120 days. Since the resting period could not be given during the lactation, the measures and animals were adjusted with the residual effects. After passing peak of production, 8 cows were randomly placed into 2 squares consisting of 4 animals per one square. Cows in the first square were in the first lactation period and those of the second square were in the second lactation period. Cows in each square were similar in stage of lactation, previous milk record, age and body size as shown in table 1. The animals were individually tethered in stalls with free access of water and free choice of mineral lick. Milking was done twice a day at 05 : 00 h and 15 : 00 h by a milking machine.

TABLE 1. PREVIOUS RECORDS OF EXPERIMENTAL ANIMALS

Square	Cow no.	Age		Body wt. at beginning	Lactation	Days after parturition	Milk yield	
							Before starting	Previous lactation
		year	month	kg		days	kg/day	kg/day
1	1	2	6	359	1st	75	12.1	–
	2	2	5	351	1st	81	12.9	
	3	2	5	284	1st	90	9.6	–
	4	2	5	334	1st	84	8.4	–
2	5	3	6	438	2nd	81	13.2	8.9
	6	3	6	393	2nd	78	13.8	9.2
	7	3	7	434	2nd	93	12.9	9.5
	8	4	0	410	2nd	69	14.8	10.3

Cows were designed to get 4 treatments, being 17%, 22% and 24% crude fiber (CF) diets and *ad libitum* feeding control. Urea-treated rice straw (UTS) and concentrate supplements as shown in table 2 were used to meet the NRC standard (1988) and having the desired levels of CF. The computer program developed by Promma et al. (1990) was used in formulating the diets using data from chemical analysis (table 3) and the production record of each cow. Mineral mixture contained 17.5% of Ca, 7.2% of P, 1.9% of S and adequate amounts of trace minerals. Vitamin mixture contained 10^8 IU/kg of A, 300,000 IU/kg of D and 80 g/kg of E which was given in extra and the amounts were also calculated to meet the requirements. The composition of the concentrate supplements used in the 17%, 22% and 24% CF diets were shown in table 3 together with that for the control treatment. The cows were given calculated amounts of UTS and concentrates according to the recommendation of the computer program, but those of the control were given UTS *ad libitum* and 1 kg of concentrates per every 2 kg of milk production. For all treatments, feeds were given twice a day, concentrates at 07 : 30 h and 14 : 30 h and UTS

TABLE 2. COMPOSITION OF CONCENTRATE SUPPLEMENTS

Treatments Ingredients (%)	17% CF	22% CF	24% CF	Control
Ground corn	69.7	66.4	63.1	50.0
Soybean meal	28.3	31.1	34.1	6.0
Rice bran	–	–	–	10.0
Kapok meal	–	–	–	25.0
Rape seed meal	–	–	–	6.0
Mineral mixture	2.0	2.5	2.8	3.0
Vitamin mixture (g/100 kg)	4.1	5.2	5.6	15.0
Cost (Baht/kg)	5.63	5.86	6.09	4.62

at 08 : 00 h and 15 : 00 h. The residue of UTS were weighed every day and checked on dry matter content. Body weight changes of cows were calculated from the measurements of 3 consecutive days at the initial and final of each period.

Treatment or rice straw was conducted by exposing rice straw with water and urea at the ratio of 100 : 100 : 6 on weight basis. Treatment was done under airtight condition by covering with polythene sheets and left for at least 21 days before use. Urea-treated rice straw was removed from the stack and cut into 20 cm prior to the feeding, and fed without aeration.

UTS and concentrates were randomly collected every week, and dry matter (DM), crude ash (CA), crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE) were analyzed by the AOAC standard method (1975). Acid detergent fiber (ADF) of the feed was analyzed by the method of Goering and Van Soest (1970). Protein content of UTS was obtained from fresh samples. Total digestible nutrients (TDN) contents of all feeds were indirectly calculated from the metabolizable energy contents using the equations of Moe and Tyrrell (1976) to convert to TDN. The estimation of metabolizable energy was done by the gas test method (Menke et al., 1979) using the rumen liquor obtained from the crossbred Holstein cows fed the similar test feed (UTS and concentrates). Milk samples were collected once a week from two consecutive morning and afternoon milkings, and protein and fat contents were determined by the titration method and Gerber method, respectively. Calculation of the feed cost was based on the price of feed ingredients (Baht/kg as feed basis) at the experiment, such as, urea-treated straw 1.0, ground corn 3.4, soybean meal 11.5, rice bran 3.9, kapok meal 5.1, rape seed meal 5.5, mineral mixture 7 and vitamins 400.

Data of treatment effects, such as body weight change, DM intake of UTS and concentrates, milk yield, milk composition, feed conversion ratio (FCR) and feed cost were statistically analyzed by the analysis of variance of balanced design (Cochran and Cox, 1957). Residual effects were tested and used for adjusting the treatment means. The differences between treatment means were determined by Duncan's new multiple range test (Steel and Torrie, 1960).

Results and Discussion

The chemical composition of the feeds used in this experiment is given in table 3. The DM basis TDN content of UTS calculated from the estimated ME values was 53.7%, which was very close to the result obtained by the digestibility trial using the crossbred Holstein bulls (Promma et al., 1993), being 54.1% on DM basis. The TDN contents of other feed ingredients were on their normal range. Some variations were seen in DM and CP contents of UTS with regard to the method of covering the treated straw stack; some moisture together with ammonia gas could escape through the overlapping parts of polythene sheets.

The performance of crossbred Holstein milking cows fed different levels of CF is presented in table 4. Body weight changes during 30 days were not statistically different among the treatments, however, most of the cows fed the control diet

TABLE 3. CHEMICAL COMPOSITION OF FEEDS

Feeds	DM (fresh %)	CP	CF	ADF	TDN
			DM%		
Urea-treated straw	69.1 ± 15.1[1]	7.9 ± 1.4	38.6 ± 1.8	51.1 ± 2.8	53.7
Ground corn	88.9 ± 1.9	9.7 ± 1.2	3.0 ± 0.7	5.4 ± 0.4	88.7
Soybean meal	89.6 ± 3.0	48.1 ± 2.5	9.3 ± 0.5	13.2 ± 0.8	88.2
Rice bran	90.1 ± 3.9	14.3 ± 1.2	12.4 ± 3.4	16.8 ± 4.2	74.0
Kapok meal	88.4 ± 1.9	42.1 ± 3.2	28.8 ± 1.9	42.1 ± 4.7	62.4
Rape seed meal	92.0 ± 2.6	40.6 ± 1.6	8.9 ± 0.8	16.5 ± 2.9	76.0
Concentrate supplement					
For 17% CF diet	88.6 ± 2.1	18.0 ± 1.4	4.3 ± 0.4	6.8 ± 0.5	77.3
For 22% CF diet	89.1 ± 2.7	19.2 ± 1.3	4.5 ± 0.3	6.7 ± 0.4	76.9
For 24% CF diet	88.8 ± 2.5	20.1 ± 0.8	4.4 ± 0.3	7.1 ± 0.3	76.7
For control diet	88.9 ± 3.1	19.6 ± 1.3	9.5 ± 0.6	14.5 ± 0.8	68.8

[1]Mean ± SD (N = 16).

TABLE 4. PERFORMANCE OF CROSSBRED HOLSTEIN COWS FED DIFFERENT LEVELS OF CRUDE FIBER

Treatments	17% CF	22% CF	24% CF	Control	SEM
Body weight change (kg/30 days)	−2.1	2.3	4.1	−4.4	4.32
4% FCM yield (kg/head/day)	12.3	12.4	12.3	12.0	0.35
Milk fat content (%)	3.76[a]	3.92[ab]	3.79[ab]	3.94[b]	0.06
Milk protein content (%)	3.19	3.10	3.09	3.03	0.01
Dry matter intake					
UTS (kg/head/day)	3.93[a]	5.89[b]	5.69[b]	5.80[b]	0.16
Concentrate (kg/head/day)	6.68[c]	5.48[b]	5.30[a]	6.00[b]	1.85
Total (kg/head/day)	10.61	11.37	10.99	11.80	0.36
Total (% of body weight)	2.9	3.1	2.9	3.1	0.1
Concentrates/UTS ratio	1.70	0.93	0.93	1.03	0.23
FCR (kg feed/kg milk)	0.88[a]	0.93[a]	0.89[a]	0.99[b]	0.02
Feed cost (Baht/kg milk)	3.89[c]	3.70[bc]	3.53[ab]	3.37[a]	0.09

FCM: Fat corrected milk, FCR: Feed conversion ratio.
Mean with different superscripts within row differ at $p < 0.05$.

lost their body weight. The cows fed the control diet consumed more CF and less TDN than the other groups as shown in table 5, although the concentrates/UTS ratio was almost similar to that of the 22% and 24% CF diet groups. Milk production was not different among the treatments, however, there was significant differences in milk fat production; the 17% CF diet produced lower fat milk and the control diet higher fat milk. This should be due to the higher CF content in the control diet and the lower content in the 17% CF diet, since Bondi (1987) mentioned that diets rich in roughage lead to an increased ratio of acetic to propionic acid, which in case of milking cows, is accompanied by an increase in fat content of milk. No significant difference was found in milk protein content among the treatments.

The cows given the 17%, 22% and 24% CF diets were planned to consume all amount of UTS and concentrate supplements offered, however, some cows particularly those fed the 24% CF diets consumed not completely the UTS given. The intake of UTS was lower in the 17% group but not different among the 22% CF, 24% CF and control groups. The dry matter intake of the concentrate supplements was significantly increased by the feeding of 17% CF diet and

decreased by the feeding of 24% CF diet. Consequently, total dry matter intake was not so much different among the treatments, being 2.9%, 3.1%, 2.9% and 3.1% of the body weight in the 17% CF, 22% CF, 24% CF and control groups, respectively. Feed conversion ratio was significantly higher in the control group and the other groups did not show any significant difference in feed conversion ratio. Feed cost per kg of milk production was significantly higher in the 17% CF group, followed by the 22% CF and 24% CF groups, and the feed cost of the control diet was lowest.

Since some cows consumed not completely UTS given as stated before, the real nutrient contents of the given diets were calculated and the results are shown in table 5. It was clearly shown that the 17% and 22% CF groups consumed the expected amounts of CF, however, the 24% CF group consumed less CF than expected, being 22% instead of 24%. The CF content of the control diet, on the other hand, was estimated to be about 24%. The contents of ADF in the diets were almost proportional to the CF contents. When these values were compared to the NRC recommendation, the CF content of the 17% CF diet met the recommendation but the other diets were higher in CF than the recommendation, and the ADF content was higher in all the diets than in the NRC recommendation. The increasing rate of the CF content was 0%, 30%, 30% and 40%, and that of the ADF was 10%, 41%, 42% and 54% in the 17%, 22%, 24% CF and control groups, respectively.

TABLE 5. ACTUAL NUTRIENT CONTENTS OF THE DIETS

Treatments	17% CF	22% CF	24% CF	Control	NRC[1]
TDN consumption (kg/day)	7.3	7.4	7.4	7.2	7.4
CP consumption (kg/day)	1.51	1.52	1.52	1.63	1.65
CF content (%)	17.0	22.1	22.1	23.8	17.0
ADF content (%)	23.2	29.7	29.9	32.5	21.0

[1]NRC recommendation (1988) for 11-13 kg/day of milk production.

The actual consumption of TDN and CP was shown to be a little lower than the NRC recommendations. The reduction rate in TDN in the 17-24% CF groups was 0-1.3% and that in CP was 7.9-8.5%. The reduction rate in the control group was 2.7% in TDN and 1.2% in CP. It was seen from this result that in the crossbred Holstein cows any negative effect was not shown on the performance of production even though the CP consumption was reduced by 8% of the NRC recommendation. The previous report of Promma et al. (1993) showed that the reduction of protein level in the UTS diets caused less negative effect on the growth of crossbred Holstein heifers than the reduction of TDN level. More experiments are necessary to identify the optimum CP requirement of the crossbred milking cows. Although the CP consumption of the control group was close to the NRC recommendation, the performance was not specifically superior to the other groups but tended to show lower performance in body weight change, milk yield and milk protein production. Regarding this, two particular factors could be pointed out in the concentrate supplements; CF content was high, being 9.5% compared to 4.3-4.5% of the others, and TDN content was low, being 69% compared to 77% of the others. Nevertheless, 22-24% of CF content in the diet could show as good performance as the recommended CF content of 17% for crossbred Holstein milking cows. It could be concluded from the result that feeding the crossbred Holstein milking cows with urea-treated rice straw can be effectively done by ration formulation management, however, the levels of TDN, CP and CF contents in the diet should be controlled carefully. It would be recommended to have 100% level of TDN and CP of the NRC recommendation, and 22% CF. The traditional feeding system also gave a good result, but the formulation of the concentrates should be done carefully.

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