

## Effect of Mixing Diets and Sequence of Feeding on the Amount of Intake, Time Spent Eating and Changes of Eating Behavior with Time after Feeding in Steers

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### Abstract

Thirty six steers were used to study the effect of both offering mixed rations and the sequence of feeding on feed intake and eating pattern. Steers were given pelleted concentrate and chopped hay twice daily. In FH treatment, steers were first fed hay for 40 minutes from 7:30 and 19:30, and then fed concentrate for 40 minutes. In FC treatment, hay and concentrate feeding was done in reverse order. In MIX treatment, hay and concentrate were mixed and offered 80 minutes from 7:30 and 19:30. Dry matter intake/metabolic body size in MIX treatment was tended to be less than that in FH treatment, and not differed with FC treatment. The time spent eating in MIX treatment was almost equal to that in FH treatment, and longer than that in FC treatment. In both separate feeding treatments, the eating behavior ratio of the first fed diet decreased beginning 20-25 minutes after feeding. In MIX treatment, the ratio decreased beginning 35-40 minutes after feeding. The ratio of the second fed diet in FC treatment decreased beginning 15-20 minutes after feeding, and that in FH treatment decreased beginning 20-25 minutes after feeding. From 15-20 minutes after feeding to the end of the feeding period, the eating behavior ratios of first fed hay were significantly higher than those of second fed hay. The ratios of concentrate in all periods were the same, regardless of sequence of feeding. The absolute value of the regression coefficient in the MIX treatment was lower than that of both diets in FH and FC treatments. The absolute value of hay was lower than that concentrate in FH and FC treatment.

**Key Words:** mixing diets, sequence of feeding, eating behavior, steers.

To eliminate or reduce labor, the cow housing system was changed from one of individuals to one of groups. In group feeding, cows were offered mixed rations to prevent selective eating. There have been many reports about the effects on feed intake, milk yield and rumen fermentation of offering mixed rations. Some reports pointed out that dry matter intake was not influenced by mixing<sup>1,2,10</sup>. However, other reports suggested that feed intake increased by offering a mixed ration<sup>4,5</sup>.

In separate feeding, which was compared with mixed feeding, feed intake was affected by sequence of feeding<sup>9</sup>. There has not been much other work on

sequence of feeding, apart from Voight et al.'s report<sup>9)</sup> dealing with cellulose digestion. The study of eating behavior was necessary to investigate the effect of mixing and sequence of feeding on feed intake.

The time spent eating and the rate of eating for the entire feeding period were investigated in some reports<sup>7,8)</sup>, but little information has been available with respect to the changes of eating behavior over time after start of feeding.

This study was conducted to study the effect of offering a mixed ration and sequence of feeding on feed intake and eating pattern. The eating pattern was investigated by time spent eating during a period of 5 minutes, which was divided according to the time after feeding.

### Materials and Methods

The animals used were 36 six-month-old Holstein steers. The average weight of the steers was approximately 190 kg. Steers were given pelleted concentrate and chopped hay twice daily. Table 1 shows chemical compositions and gross energy content of concentrate and hay. In the FH treatment, the steers were first fed hay for 40 minutes from 7:30 and 19:30, and then fed concentrate for 40 minutes from 8:10 and 20:10. In FC treatment, hay and concentrate feeding was done in reverse order. In MIX treatment, hay and concentrate was mixed and offered for 80 minutes from 7:30 and 19:30. Steers were each assigned to one of three treatments, so there were 12 steers in each treatment. The diets offered were over 110% of the amount of intake.

Table 1. Chemical composition and gross energy content of diets

	Dry Matter	CP <sup>1)</sup>	NDF <sup>2)</sup>	ADF <sup>3)</sup>	GE <sup>4)</sup>
	%	(% of DM basis)			MJ/kg DM
Concentrate	87.1	16.4	16.3	5.4	16.6
Hay	87.4	11.3	47.3	29.8	16.3

1) Crude protein, 2) Neutral detergent fiber, 3) Acid detergent fiber, 4) Gross energy.

The duration of one treatment was a week. On the last day of each week, the time spent eating and amount of feed intake were recorded. Four video cameras were used to record the time spent eating. The duration of feeding, 80 minutes, was divided into 16 periods. Thus one period was 5 minutes. The eating behavior ratio was the percentage of time spent eating during several 5-minute periods. The ratio started decreasing at the periods that were significantly ( $P < 0.05$ ) different from the initial period after offering. The linear regression of the ratio on the time after feeding was calculated in the range from the period that was the preceding of starting period of the ratio decreasing to the period that was end of feeding.

Tukey's procedure<sup>6)</sup> was used to compare the average of the different treatments and the average ratio of eating behavior of different periods.

## Results and Discussion

Table 2 shows the amount of feed intake, the time spent eating and the rate of eating. Dry matter intake/metabolic body size in MIX treatment tended to be less than that of FH treatment, and did not differ from that in FC treatment. Time spent eating in MIX treatment was approximately equal to that in FH treatment, and was significantly ( $P < 0.05$ ) longer than that in FC treatment. The amount and time spent eating for hay intake in FH treatment were significantly ( $P < 0.05$ ) greater than those in FC treatment. Rate of eating was approximately the same.

**Table 2.** Dry matter intake, time spent eating and rate of eating in steers

	FH	FC	MIX	S. E. <sup>1)</sup>
DM intake (g/kg <sup>0.75</sup> /day)	123	109	111	3.7
Hay	30 <sup>a</sup>	20 <sup>b</sup>	—	1.3
Concentrate	93	89	—	3.0
Time spent eating (min./day)	125 <sup>a</sup>	108 <sup>b</sup>	121 <sup>a</sup>	2.8
Hay	68 <sup>a</sup>	52 <sup>b</sup>	—	1.4
Concentrate	58	56	—	1.7
Rate of eating (DMg/min.)	49	53	48	2.2

1) Standard error, a, b  $P < 0.05$

In our previous study<sup>9)</sup>, DM intake and time spent eating were greater in steers offered diets separately, in which hay was fed first, then concentrate was fed. The results of DM intake and time spent eating in this study agreed with those of our previous study<sup>9)</sup>. The DM intake and the time spent eating of separate feedings, which was usually compared with mixing feeding, changed with a change in feeding methods, such as sequence of feeding. Some reports concluded that the amount of DM intake increased when the mixed ration was offered<sup>4,5)</sup>. On the other hand, some reports pointed out that offering the mixed ration had no effect on DM intake<sup>1,2)</sup>. In this study, the amount of DM intake did not increase by mixing of diets.

The changes of eating behavior ratio according to time after feeding are shown in Fig. 1 and Table 3. Eating behavior ratio immediately after feeding was approximately 100% in all treatments. In both the separate feeding treatments, eating behavior ratio of the first fed diet (hay in FH, concentrate in FC) decreased from period 5 (20–25 minutes after feeding). In MIX treatment, there was approximately 100% at period 5, and the eating behavior ratio decreased from period 8 (35–40 minutes after feeding). From period 5 to 8, the eating behavior ratios in MIX treatment were highest, and those in FH treatment were higher than those in FC treatment.

At the beginning of period 9, the second fed diet (concentrate in FH, hay in FC) was offered. After period 9, the eating behavior ratio was almost 100% in

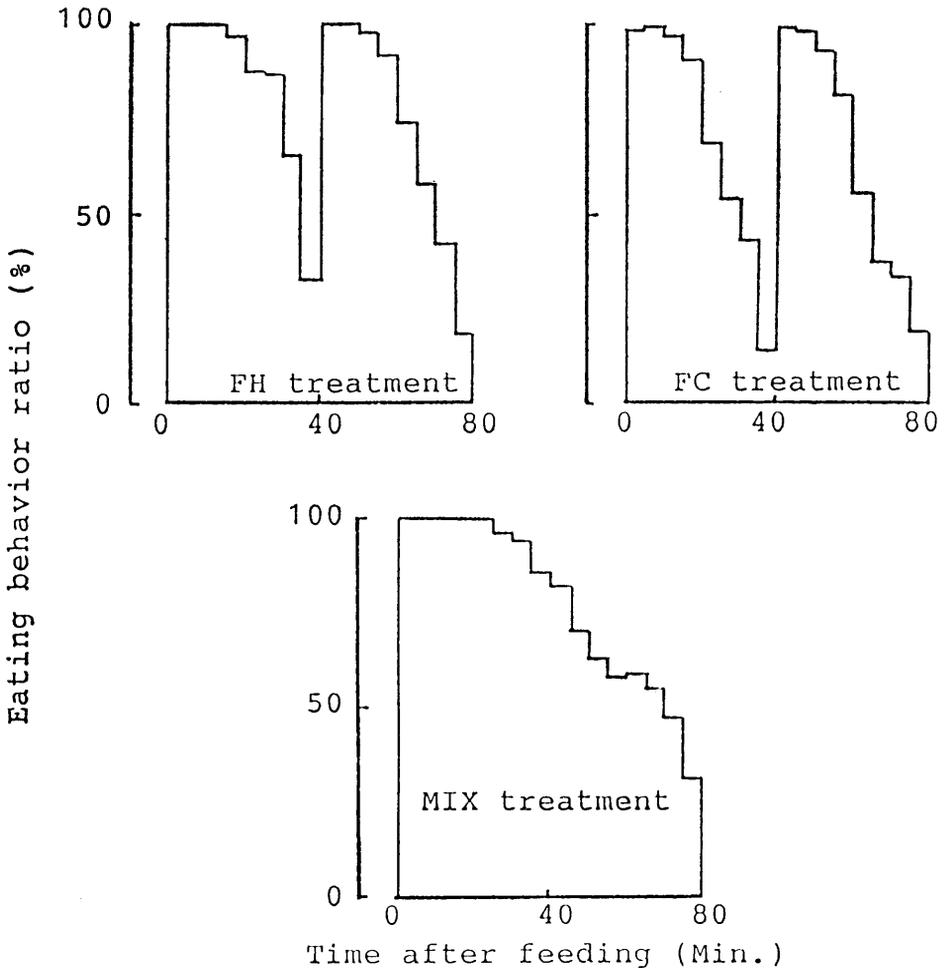


Fig. 1. Changes of eating behavior ratio according to time after feeding. The duration of feeding, 80 minutes, was divided 16 periods that was 5 minutes. Eating behavior ratio was percentage of time spent eating in 5 minutes period.

FH and FC treatment. The ratio of hay in FC treatment decreased from period 12, and that of concentrate in FH treatment decreased from period 13. In MIX treatment, there was no re-offering, and the ratio decreased from period 9. From period 9 to period 12, the ratios in MIX treatment were significantly ( $P < 0.05$ ) less than those in FH and FC treatment.

Eating behavior changes with time of access to and re-offering of the diets<sup>7,8</sup>. In separate feeding treatments, time of access to each diet was 40 minutes. In mixed feeding treatment it was 80 minutes. This was why the eating behavior ratio started to decrease later in mixed feeding than in separate feeding.

Table 4 shows the effect of sequence of feeding on the eating behavior ratio with time after each diet offering in separate feeding. From period 3 to period 8, the eating behavior ratios of first fed hay (FH treatment) were signif-

**Table 3.** Eating behavior ratio according to time after feeding in each treatment

5 minutes period	FH	FC	MIX	S. E. <sup>1)</sup>
	%			
Period no. 1 ( 0- 5 <sup>2)</sup> )	99.2	98.7	99.8	0.5
2 ( 5-10)	99.9	99.3	100.0	0.2
3 (10-15)	99.7	97.2	99.9	1.2
4 (15-20)	97.4 <sup>ab</sup>	89.7 <sup>a</sup>	99.9 <sup>b</sup>	2.5
5 (20-25)	86.7 <sup>ab</sup>	68.1 <sup>a</sup>	99.9 <sup>b</sup>	5.4
6 (25-30)	87.4 <sup>a</sup>	54.8 <sup>b</sup>	96.4 <sup>a</sup>	4.9
7 (30-35)	64.9 <sup>a</sup>	42.9 <sup>b</sup>	93.8 <sup>c</sup>	3.5
8 (35-40)	32.4 <sup>a</sup>	13.9 <sup>b</sup>	85.6 <sup>c</sup>	3.7
9 (40-45) <sup>3)</sup> )	100.0 <sup>a</sup>	99.2 <sup>a</sup>	81.5 <sup>b</sup>	2.2
10 (45-50)	99.7 <sup>a</sup>	97.3 <sup>a</sup>	75.0 <sup>b</sup>	2.3
11 (50-55)	97.5 <sup>a</sup>	93.4 <sup>a</sup>	63.1 <sup>b</sup>	3.6
12 (55-60)	92.2 <sup>a</sup>	81.2 <sup>a</sup>	57.8 <sup>b</sup>	3.2
13 (60-65)	73.5 <sup>a</sup>	55.2 <sup>b</sup>	59.1 <sup>ab</sup>	4.6
14 (65-70)	57.6 <sup>a</sup>	37.7 <sup>b</sup>	55.1 <sup>ab</sup>	5.2
15 (70-75)	42.4	33.0	47.4	5.5
16 (75-80)	18.6	19.1	31.5	4.3

1) Standard error.

2) Range of period. There were minutes from the time of first fed diet offering. Just time of first figure was not included, and time of second figure was included in the periods.

3) Second fed diet were offered (FH and FC treatment). a, b, c P<0.05

**Table 4.** Eating behavior ratio according to time after concentrate and hay feeding

5 minutes period	Hay		Concentrate		S. E. <sup>1)</sup>
	1st	2nd	1st	2nd	
No. 1 ( 0- 5 <sup>2)</sup> )	99.2	99.2	98.7	100.0	0.5
2 ( 5-10)	99.3	97.4	99.3	99.7	0.8
3 (10-15)	99.7 <sup>a</sup>	93.5 <sup>b</sup>	97.3 <sup>ab</sup>	97.5 <sup>ab</sup>	1.3
4 (15-20)	97.4 <sup>a</sup>	81.2 <sup>b</sup>	89.7 <sup>ab</sup>	92.2 <sup>a</sup>	2.6
5 (20-25)	86.7 <sup>a</sup>	55.3 <sup>b</sup>	68.1 <sup>ab</sup>	73.5 <sup>a</sup>	5.7
6 (25-30)	87.5 <sup>a</sup>	37.7 <sup>b</sup>	51.0 <sup>c</sup>	57.7 <sup>c</sup>	5.9
7 (30-35)	64.9 <sup>a</sup>	33.1 <sup>b</sup>	43.0 <sup>b</sup>	42.4 <sup>b</sup>	5.0
8 (35-40)	32.4 <sup>a</sup>	19.2 <sup>b</sup>	14.0 <sup>b</sup>	18.6 <sup>b</sup>	4.1

1) Standard error.

2) Range of period. There were minutes from the time of first or second fed diet offering. Just time of first figure was not included, and time of second figure was included in the periods. a, b, c P<0.05

icantly ( $P < 0.05$ ) higher than those of second fed hay. The ratios of concentrate in all periods did not differ, regardless of sequence of feeding.

Voight et al.<sup>9)</sup> described that cellulose digestibility in the forestomach increased when chopped ryegrass was fed first and barley or corn grain fed second. They did not investigate the dry matter intake and time spent eating. In our previous study<sup>9)</sup>, we concluded that the dry matter intake and time spent eating hay were affected by sequence of feeding, but not those of eating concentrate. The results of this study confirmed our previous conclusion, and suggested that the difference in sequence of hay feeding appeared from 15 minutes after feeding.

The regressions of eating behavior ratio on the time after feeding are shown in Table 5. In all treatments, the regression coefficient was higher than 0.90, and significant ( $P < 0.05$ ). The absolute value of the regression coefficient in MIX treatment was smaller than that of both diet in FH and FC treatment. The absolute value of the regression coefficient of hay was significantly ( $P < 0.05$ ) smaller than that of concentrate in FH and FC treatment. There was no difference in the regression coefficient of both diets, regardless of sequence of feeding.

Table 5. Regressions of eating behavior ratio on the time after feeding

Treatment Diet		Regression Equations <sup>1)</sup>	r
FH	Hay	$Y = -3.04X + 157$	-0.923*
	Concentrate	$Y = -3.57X + 155$	-0.997*
FC	Concentrate	$Y = -3.53X + 151$	-0.987*
	Hay	$Y = -3.05X + 129$	-0.982*
MIX	Mixed ration	$Y = -1.23X + 133$	-0.979*

1) Y: eating behavioral ratio (%).

X: time after feeding (minutes).

\*  $P < 0.05$

Based on the results presents above, dry matter intake and the time spent eating were not affected by the mixing of diets, but the effect of mixing of diets on eating pattern after feeding was not clear because the time of access to the diets was different between mixed and separated feeding. In the separate feeding, we confirmed the previous conclusion and suggested that the difference due to sequence of feeding appeared from 15 minutes after hay feeding.

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## 要 約

本試験では、36頭のホルスタイン種去勢牛を用い、乾草と配合飼料を個別給与した場合と混合給与した場合の採食量および採食時間を比較するとともに、その際の採食行動について、飼料給与後の時間経過に伴う変化に着目し検討した。処理区は、分離給与であり乾草、配合飼料の順で給与したFH区、給与順序がFH区と逆のFC区および混合飼料を給与したMIX区とした。いずれの処理区も、1日2回、7:30および19:30より各80分間飼料を給与した。FHおよびFC区では、最初の飼料給与40分後に飼料を入れ換えた。MIX区における代謝体重当たりの乾物採食量は、乾草から先に給与したFH区に比べ少ない傾向にあり、配合飼料を先に給与したFC区とほぼ等しかった。MIX区における採食時間は、FH区とほぼ等しく、FC区に比べ長かった。採食行動割合は、いずれの処理区においても飼料給与直後（分離給与の場合は飼料を入れ換えた直後も含む）は、ほぼ100%であった。MIX区の採食行動割合は、飼料給与35~40分後の期間から減少した。FH区における採食行動割合の減少開始は、いずれの飼料でも20~25分後の期間であった。FC区での減少開始は、給合飼料で20~25分後、乾草で15~20分後の期間であった。配合飼料における採食行動割合および減少開始までの時間に、給与順序による差は認められなかった。乾草の採食行動割合は、給与10分以降FH区の方がFC区に比べ高く、その差は15分以降で特に大きかった。減少開始以降の時間と採食行動割合から、いずれの処理区においても有意な一次回帰式が得られた。回帰係数の絶対値は、MIX区でFH区およびFC区に比べ小さかった。乾草における回帰係数は、配合飼料に比べ小さかった。以上のことから、配合飼料と乾草の混合により必ずしも採食量や採食時間は変化しないこ

とが示された。また、分離給与における飼料給与順序により採食量および採食時間が変化することが確認された。さらに、給与順序による採食行動の変化は、乾草給与 15 分後から顕著となることが示された。