

## Effects of amount of concentrate offering and its timing on characteristics of hay eating activity in steers

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### Abstract

The aim of this experiment was to study the relationships between feeding schedule and roughage eating behavior to establish efficient feeding methods for increasing roughage intake. Eight steers divided into two groups according to daily concentrate offering level per metabolic body size (MBS) (low level=30 g/MBS/day, high level=75 g/MBS/day). Three treatments were conducted according to the timing of concentrate offering in each group: 1) concentrate and hay were fed simultaneously, 2) concentrate was offered 2 hours after hay, and 3) concentrate was offered 4 hours after hay. In the low-level concentrate offering group, daily hay intake and characteristics of hay eating activity did not differ by timing of concentrate offering. On the other hand, in the high-level concentrate offering group, hay intake of the steers with a 4-hour time lapse was significantly lower than those of steers in other treatments, time spent on hay meal and meal length were decreased with the lengthening of hours between hay and concentrate offering. It was concluded that at high levels, of concentrate should be fed with hay in order to increase hay intake.

### Introduction

Amount of roughage intake of cattle is one of the most important factor for roughage utilization. Roughage produced on an own land has less impact on the environment than do imported concentrates, and roughage does not compete with human food sources. There are some reports regarding the relationship between roughage intake and characteristics of roughage (chemical composition or physical form)<sup>1,8)</sup>. However, there are a few reports regarding the relationships between roughage intake and daily feeding schedule of roughage.

Wierenga and Hopster<sup>7)</sup> reported that dairy cattle ate roughage frequently just after or before eating concentrate. If concentrate eating induces roughage eating, the schedule of concentrate feeding is affected by roughage eating patterns and roughage intake. Palmquist *et al.*<sup>4)</sup> reported that cows are more roughage when concentrate was offered 4 hours after roughage offering than when concentrate

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was offered simultaneously with roughage. However, Stanley and Morita<sup>5)</sup> observed no differences between separate and simultaneous feeding of concentrate and roughage. These reports about the effects of feeding schedule of concentrate and roughage on roughage eating dose not have behavioral aspects of eating and ruminating.

Information about eating and ruminating behavior is useful for examining the effects of feeding schedule on roughage intake. The aims of this experiment were to study the relationships between feeding schedule and roughage eating behavior or rumination behavior and to establish efficient feeding methods for increasing roughage intake.

### Materials and Methods

Eight steers (average body weight 185 kg) were used for this experiment and were offered pelleted concentrate and first-cutting long grass hay. The chemical composition and gross energy content of each diet are shown in Table 1. Steers were divided into two groups according to concentrate offering level; four steers of the low-level concentrate offering group were given about 30 g/MBS/day concentrate and four other steers were given about 75 g/MBS/day. Grass hay was offered twice daily (8:20 and 17:20) and was fed *ad libitum* to ensure a 10% weighback. Concentrate offering time was different for the following treatments. Three treatments were conducted according to the timing of concentrate offering in each group: 1) 0-hour treatment (concentrate and hay were fed simultaneously), 2) 2-hour treatment (concentrate was offered 2 hours after hay), 3) 4-hour treatment (concentrate was offered 4 hours after hay).

Table 1. Chemical composition and gross energy content

Concentrate level	Concentrate		Hay	
	30 g	75 g	30 g	75 g
DM, %	86.8	86.7	83.1	87.4
C P, DM%	21.5	20.2	68.9	68.0
NDF, DM%	22.8	20.2	68.9	68.0
ADF, DM%	14.4	7.5	47.0	41.8
G E, MJ/kgDM	18.0	18.9	17.6	18.5

The experimental period of each treatment was 11 days. On the last day of each treatment, the eating and ruminating activities recorded by video recorder and jaw movement recording system. For each eating bout, the time of beginning and the time of ending of eating bout of hay and rumination bout were recorded. Intervals between hay eating bout were classified as a within-meal interval or a between-meal interval according to the results of our previous reports (meal criterion length of hay was 4 minutes, and the criterion length of rumination period was 15 minutes<sup>3)</sup>). A meal of hay is defined as the period between two between-meal intervals. Therefore, a meal and rumination period consist of one or more eating bouts and rumination bouts. The meal length was defined as the time from the

start of the first eating bout to the end of last eating bout in one meal (min). The rumination period also was defined as the time from the start rumination bout to the end of the last rumination bout (min). The comparisons between averages were carried out using Wilcoxon-Mann-Whitney's two-sample test<sup>6)</sup>.

### Results and Discussion

Dry matter intake of concentrate and hay is shown in Table 2. There was no leftover at concentrate offering, and every steer ate the concentrate within 15 minutes. In every treatment of timing of concentrate offering, dry matter hay intake in the group of low-concentrate level was significantly ( $P < 0.05$ ) higher than that in group of high-concentrate level. In the low-level concentrate offering group, averages of hay intake did not differ by timing of concentrate offering. However, in the high-level group, dry matter hay intake of the 4-hour treatment was significantly ( $P < 0.05$ ) lower than the other treatments.

The time spent on, number of and length of meal and rumination period are shown in Table 3. In every treatment (timing of concentrate offering), time spent on hay meals was higher, number of meals was lower and average length of meals was higher in the low-level concentrate (30 g/MBS/day) group than those in the high-concentrate feeding group. In the high-level concentrate feeding group, time spent on hay meal and meal length decreased with the lengthening of hours

Table 2. Dry matter intake of concentrate and hay

Timing of conc. fed <sup>1)</sup>	0 hour		2 hour		4 hour	
	30 g	75 g	30 g	75 g	30 g	75 g
Concentrate, gDM/MBS/d	30.9 <sup>a</sup>	73.5 <sup>b</sup>	30.8 <sup>a</sup>	74.6 <sup>b</sup>	31.1 <sup>a</sup>	75.1 <sup>b</sup>
Hay, gDM/MBS/d	56.0 <sup>a</sup>	28.0 <sup>b</sup>	58.4 <sup>a</sup>	29.0 <sup>b</sup>	57.4 <sup>a</sup>	22.9 <sup>c</sup>

a, b, c: Differences between averages with a different letter are statistically significant ( $P < 0.05$ ).

1) Timing of concentrate offering.

Table 3. Time spent, number and length of meal and rumination

	0 hour		2 hour		4 hour	
	30 g	75 g	30 g	75 g	30 g	75 g
Meal						
Time, min./d	394 <sup>a</sup>	331 <sup>b</sup>	372 <sup>a</sup>	251 <sup>b</sup>	384 <sup>a</sup>	174 <sup>c</sup>
Number, /d	11 <sup>a</sup>	17 <sup>b</sup>	11 <sup>a</sup>	16 <sup>b c</sup>	11 <sup>a</sup>	14 <sup>c</sup>
Length, min./meal	35 <sup>a</sup>	21 <sup>b</sup>	34 <sup>a</sup>	16 <sup>c</sup>	35 <sup>a</sup>	13 <sup>c</sup>
Rumination						
Time, min./d	462 <sup>a</sup>	460 <sup>a</sup>	449 <sup>a</sup>	461 <sup>a</sup>	435 <sup>a</sup>	302 <sup>b</sup>
Number, /d	14	14	15	13	14	12
Length, min./rumination	33	33	31	35	31	27

a, b, c: Differences between averages with a different letter are statistically significant ( $P < 0.05$ ).

between hay and concentrate offering. However, in the group of low-level concentrate, there were no changes with the timing of concentrate offering. It was concluded that timing of concentrate feeding only effected the hay eating activity when concentrate feeding level was high.

Time spent on rumination periods, number of rumination periods and average length of rumination period showed similar values except the 4-hour treatment in the high-concentrate feeding group. The values of 4-hour treatment in the high-concentrate group were significantly ( $P < 0.05$ ) less than those of other treatments. This difference of characteristics of rumination periods might depend on changes of amount of daily hay intake.

There have been many reports about eating and/or rumination behavior (daily time spent on eating and rumination), but few reports defined or analyzed meal or rumination period. Thus, there was little information about the characteristics (number and length) of meal or rumination periods. Regarding meal length, daily roughage intake more closely related with meal length than with number of meals<sup>2)</sup>. In the present experiment, meal length was shortened and daily hay intake was decreased when the concentrate feeding level was increased. However, in every timing of concentrate offering, the number of meals was increased and daily hay intake was decreased when concentrate feeding level was increased. These results support the reports by Metz<sup>2)</sup>.

Comparison of meal length among treatments of timing of concentrate offering at high-concentrate level, daily hay intake was not different between 0-hour and 2-hour treatment, but meal length of hay was shorter in the 2-hour treatment than that in the 0-hour treatment. In our previous reports<sup>3)</sup>, we found that meal length was longer in the period just after feeding than that in the period from 3 hours after one feeding to the next. It was concluded that meal length of hay was prolonged by feeding stimulus of hay in our previous experiment. Wierenga and Hopster<sup>7)</sup> reported that milking cows ate roughage frequently just after or before concentrate eating. These results meant that concentrate feeding was a stimulus for roughage eating activity.

In the group of high-level concentrate of the present experiment, feeding stimulus of concentrate to hay eating activity might be higher in the 2-hour treatment than that in 4-hour treatment because of longer meal length in the 2-hour treatment. Changes of time spent on meals of hay in 10 minutes periods with time after the end of concentrate eating is shown in Fig. 1. It seems that time spent for meals just after concentrate eating decreased with prolonged interval time between hay and concentrate offering. In the 0-hour treatment, hay and concentrate were fed simultaneously, so we can not separate the effects of concentrate and hay feeding stimuli on hay eating activity. However, it was suggested that the effect of concentrate offering on hay eating activity when concentrate and hay were fed separately was smaller than that when diets were fed simultaneously.

The results described herein emphasize the importance of the concentrate level regarding the effect of interval time between concentrate and hay feeding on hay eating activity. It was concluded that at the low-concentrate feeding level, interval time between concentrate and hay offering do not effect meal character-

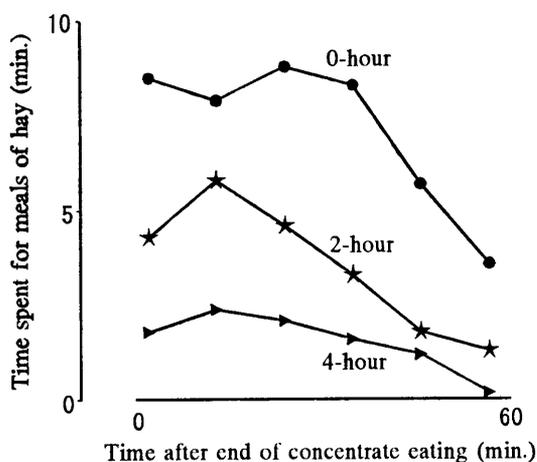


Fig. 1. Changes of time spent for meals of hay in 10 minutes periods with time after end of concentrate eating in the group fed by high-concentrate level (75 g/MBS/day).

istics, but at high concentrate level (low demand for hay), concentrate should be fed with hay so as to increase the amount of hay intake.

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### 要 約

8頭の去勢牛を濃厚飼料の給与量により、各4頭の2群に分け(低レベル30g/代謝体重/日, 高レベル75g/代謝体重/日), 以下の実験を実施した。処理区は、濃厚飼料と乾草の給与時刻間

隔により、0時間区、2時間区および4時間区の3処理区とした。濃厚飼料の低レベル給与時には、乾草の日採食量や、乾草の採食行動に、濃厚飼料の給与時刻による差は認められなかった。これに対し、高レベル給与時には、乾草の日採食量は、乾草の4時間後に濃厚飼料を給与した4時間区で、他の処理区に比べ有意に低かった。また、乾草の採食時間や採食期継続時間は、乾草と濃厚飼料の給与間隔の延長に伴い低下した。