

Effect of Feeding Frequency on Eating Behavior Patterns and Amount of Intake of Hay in Steers

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Abstract

This experiment studied the effect of feeding frequency on eating behavior of roughage. Four steers (average body weight 200kg) were used for this experiment. Two treatments were set according to the daily frequency of hay feeding (twice feeding (8 : 20, and 17 : 20) and 3-times feeding (8 : 20, 12 : 00 and 17 : 20) treatments). Diurnal analyses of meal and rumination period were conducted over four periods : from 8 : 20 to 11 : 19 (period 1), from 12 : 00 to 17 : 19 (period 2), from 17 : 20 to 20 : 59 (period 3) and from 21 : 00 to 8 : 19 on the next day (period 4). Daily hay intake did not differ with the feeding frequency of hay. There was no difference between the treatments in the time spent on meals. The hourly time spent on hay meals **did not differ between treatments in periods 1 and 4.** The hourly time spent on meals of hay fed at 12 : 00 in the 3-times feeding treatment in period 2 was slightly higher, and the time fed at 17 : 20 in period 3 was significantly ($P < 0.05$) lower than that in the twice feeding treatment. In the morning feeding, there were no differences in time spent on meals in each 10 minutes period after the end of concentrate eating between the treatments. In the evening feeding

(at 17 : 20), the time spent on meals of 3-times feeding treatment rapidly decreased starting 20 minutes after the end of concentrate eating. The time spent on meals in 3-times feeding treatment after the periods of 20 minutes was significantly ($P < 0.05$) lower than that of the twice feeding treatment.

Introduction

Feeding is one of the important factors for planning the management system of farms. Rations fed to cattle normally consist of concentrate and roughage in farms. Roughage does not compete with human food resources. Thus, it would be more desirable for roughage intake to be increased without changing production level of cattle. To increase roughage intake, we conducted some experiments to understand the effect of feeding methods of diet on roughage intake (with reference to the amount of⁶⁾ and timing of concentrate offerings⁷⁾, and feeding sequence of concentrate and roughage⁴⁾. In these reports, eating behavior of roughage was analyzed with the meal state theory³⁾ to define cattle eating demands, and the effect of feeding methods on roughage eating was shown.

Eating is activated by the feeding of diets. Increments of daily feeding frequency from one to

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four times a day for sheep affected to the amount of daily intake¹⁾. On the other hand, Hayasaka et al²⁾, had reported that time spent on eating and diurnal eating patterns were not changed by increasing feeding frequency from twice to four times a day for cows. It was thought that the effect of increasing of feeding frequency on roughage eating might be changed by the timing of roughage feeding, because demand of eating changes within a day.

To increase roughage intake, from the aspect of eating behavior analysis, it is necessary to clear the effect of feeding stimuli on roughage eating. Therefore, this experiment studied the effect of feeding frequency on the eating behavior of roughage (not only daily based, but also just after feeding).

Materials and Methods

Four steers (average body weight 200kg) were used for this experiment, and offered pelleted composition and first cutting long grass hay. The chemical concentrate and gross energy content of each diet is shown in Table 1. Concentrate was given to all steers about 75g / MBS / d, and offered twice a day (08 : 20 and 17 : 20). Two treatments were conducted according to the daily frequency of hay feeding. Hay was offered at 08 : 20 and 17 : 20 in the treatment of twice feeding, and at 08 : 20, 12 : 00 and 17 : 20 in the 3-times feeding treatment. Hay was fed *ad libitum* to ensure a 10% weighback in every feeding.

Table 1. Chemical composition and gross energy content of diets

| Diet | Concentrate | Hay |
|-------------|-------------|------|
| DM, % | 86.3 | 87.1 |
| CP, DM% | 17.1 | 11.1 |
| NDF, DM% | 19.7 | 74.2 |
| ADF, DM% | 7.8 | 43.9 |
| GE, MJ/kgDM | 18.7 | 18.9 |

The experimental period of each treatment was 11 days. On the last day of each treatment, the eating and ruminating activities were recorded a video recordar and jaw movement recording system. For each eating bout, the time of beginning and the ending of eating bouts of hay were recorded as well as rumination bouts. Intervals between hay eating bouts were classified as a within-meal interval or a between-meal interval according to the results of our previous reports (the criterion for hay meal length of was 4 minutes, and the criterion for rumination period length was 15 minutes)³⁾. 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 length of rumination period was also defined as the time from the start of the first rumination bout to the end of last rumination bout (min).

Diurnal analyses of meal and rumination periods were conducted over four periods, from 08 : 20 to 11 : 19 (period 1), from 12 : 00 to 17 : 19 (period 2), from 17 : 20 to 20 : 59 (period 3) and from 21 : 00 to 8 : 19 on the next day (period 4). Changes of time spent on meals of hay in 10 minutes periods after the end of concentrate eating and after the hay offering (feeding at 12 : 00 in the 3-times feeding treatment) were examined within 60 minutes. The comparisons between the averages were carried out using Wilcoxon-Mann-Whitney's two sample test⁴⁾.

Results

Table 2 shows the dry matter intake of concentrate and hay in each treatment. All concentrate fed was eaten. Daily hay intake did not differ with the frequency of hay feeding.

Table 2. Dry matter intake of concentrate and hay

| Feeding frequency | 2 | 3 | S.E. |
|------------------------|------|------|------|
| Concentrate, gDM/MBS/d | 74.0 | 74.5 | 0.8 |
| Hay, gDM/MBS/d | 26.3 | 28.7 | 2.3 |

Table 3 shows the daily time spent on meals of hay, daily number of meals, rate of hay eating and rumination behavior in each treatment. All the steers ate concentrate initially within 15 minutes after a simultaneous feeding of concentrate and hay (08:20 and 17:20). There was no difference in the time spent on meals and the daily number of rumination periods between the treatments. The

daily number of meals, the rate of eating and time spent on rumination periods in the 3-times feeding treatment were slightly higher than that in the twice feeding treatment. The latent periods of rumination (the period from morning (08:20) and evening feeding (17:20) to start first rumination) in the 3-times feeding treatment was slightly lower than that in the twice feeding treatment.

Table 3. Daily eating behavior and rumination

| Feeding frequency | | 2 | 3 | S.E. |
|---|----------|-------|-------|------|
| Meal | | | | |
| Time, | min/d | 278.4 | 273.0 | 28.6 |
| Number, | meals/d | 14.3 | 18.5 | 1.5 |
| Rate of eating, | kgDM/min | 4.9 | 6.5 | 0.6 |
| Rumination | | | | |
| Time, | min/d | 399.6 | 442.8 | 29.2 |
| Number, | period/d | 13.5 | 12.8 | 0.6 |
| Latent period of rumination ¹⁾ , min | | 193.7 | 154.8 | 30.6 |

1) Period from morning (08:20) and evening (17:20) to start of first rumination.

Table 4 shows the diurnal variation in the hourly time spent on meals and on rumination periods. The hourly time spent on meals of hay was not different between treatments in period 1 and 4. In period 2, the hourly time spent on meals of hay in the 3-times feeding treatment was slightly higher, while in period 3, it was significantly ($P < 0.05$)

lower than that in the twice feeding treatment. The hourly time spent on rumination periods of 3-times feeding treatment in period 2 was slightly higher than that of twice feeding treatment. In other periods, there were no differences between treatment

Table 4. Time spent on meals of hay and rumination in each periods

| Feeding frequency | 2 | 3 | S.E. |
|---|-------------------|-------------------|------|
| Time spent on meals of hay (min/h) | | | |
| Period 1 (08:20-11:59) | 23.6 | 23.3 | 3.2 |
| Period 2 (12:00-17:19) | 9.3 | 12.7 | 1.5 |
| Period 3 (17:20-20:59) | 24.7 ^a | 16.5 ^b | 0.6 |
| Period 4 (21:00-08:19) | 4.6 | 4.9 | 0.9 |
| Time spent on rumination period (min/h) | | | |
| Period 1 (08:20-11:59) | 4.0 | 3.9 | 1.3 |
| Period 2 (12:00-17:19) | 16.0 | 21.1 | 1.9 |
| Period 3 (17:20-20:59) | 6.1 | 8.0 | 2.6 |
| Period 4 (21:00-08:19) | 25.3 | 24.5 | 3.7 |

a, b: Significantly different ($P < 0.05$)

Changes of time spent on meals of hay in 10 minutes periods after the end of concentrate eating and after the hay offering (feeding at 12:00 in the

3-times feeding treatment) within 60 minutes are shown in Figure 1. In the morning feeding, there was no differences in time spent on meals per 10

minutes between the treatments. In the evening feeding (at 17 : 20), the time spent on meals of 3-times feeding treatment rapidly decreased starting 20 minutes after the end of concentrate eating. The time spent on meals of the 3-times feeding treatment after periods of 20 minutes was

significantly ($P < 0.05$) lower than that of the twice feeding treatment. In the 12 : 00 feeding of the 3-times feeding treatment, the time spent on meals just after hay feeding was lower than that in the morning (8 : 20) and evening (17 : 20) feeding.

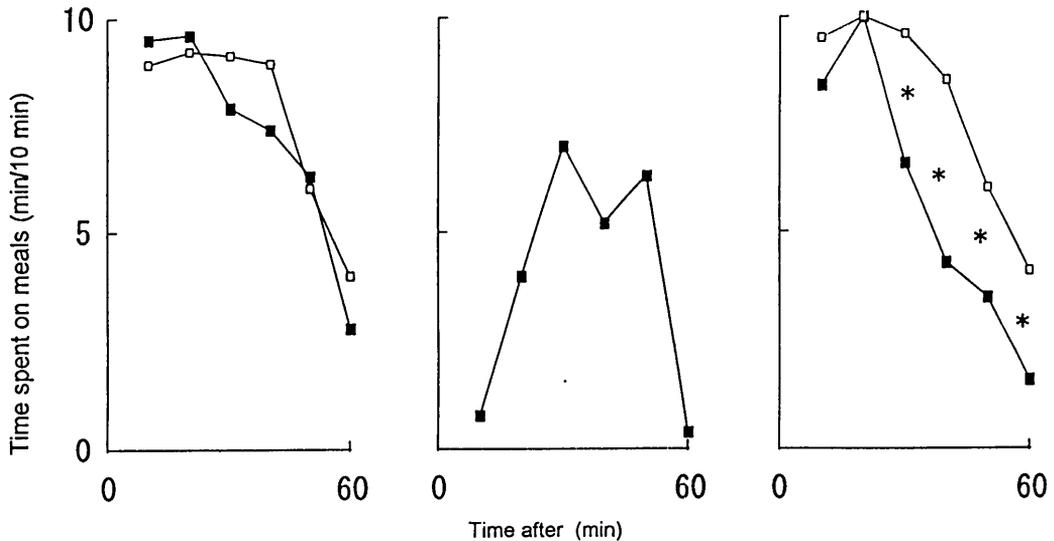


Figure 1. Changes of time spent on meals of hay in 10-minute periods with time after end of concentrate eating (a, c) and time after hay offering (b). Open square is twice feeding treatment (hay was offered at 8 : 20 and 17 : 20 with concentrate). Closed square is three times feeding treatment (hay was offered at 8 : 20 and 17 : 20 with concentrate, and offered 12 : 00 alone), Asterisk indicates that average in same period was significantly ($P < 0.05$) different between treatments.

Discussion

Offering diets is one of the greatest stimuli to eating behavior of cattle. Therefore, increments of frequency of feeding were believed to result in increasing feed intake. However, Hayasaka et al²⁾ reported that time spent on eating and diurnal eating patterns were not changed by increments of feeding frequency from twice to four times for cows. From the present experiment, time spent on roughage meals and the amount of roughage intake was not changed by increments of feeding frequency from twice to three times. These results of time spent on eating in the present experiment matched the report by Hayasaka et al²⁾.

Concerning the diurnal eating pattern, in the present experiment, there was a slight effect of increments of feeding frequency on the eating pattern of roughage (more time spent on meals in

period 2 in the three times feeding treatment). This was the evidence that feeding was a stimuli for eating. However, the eating pattern just after feeding at 12 : 00 (fed hay alone) was considerably different than the morning and evening feeding (fed hay with concentrate), and it was at a lower level.

There were only 3 hours and 40 minutes from morning feeding (8 : 30) to afternoon feeding (12 : 00), and 4 hours and 20 minutes from afternoon feeding to evening feeding. Lower meal activity and higher rumination activity were shown from after 3 hours to the next feeding in our previous report (same concentrate feeding level and twice feeding of hay)⁵⁾. In the 3-times feeding treatment, afternoon and evening feeding might fall within the period of rumination activity, not eating activity. From these results, the interval between feedings should be considered to try to increase roughage intake by

increment of feeding frequency.

It was concluded that increasing the feeding frequency did not effect daily hay intake, but the diurnal pattern of hay eating behavior just after feeding was changed by increments of feeding frequency in the present feeding treatment.

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要 約

4頭の去勢牛を繰り返し用い、以下の実験を実施した。処理区は、乾草の給与回数により、2回給与区と3回給与区とした。採食行動および反芻の日内変化は、1日を4つの期間（期間1から期間4）に分け、検討した。1日当りの乾草摂取量および採食時間に処理間差は認められなかった。1時間当りの採食時間は、期間1および期間4では両処理間に差は認められなかった。3回給与区における昼の乾草給与後の期間2での1時間当たりの採食時間は、2回給与区に比べやや高く、夕方の乾草給与後の期間3での1時間当たりの採食時間は、2回給与区に比べ有意に低かった。朝の乾草採食開始（濃厚飼料採食終了）後60分間の採食時間変化に、乾草給与回数の影響は認められなかった。夕方の乾草給与後の採食時間変化では、3回給与区で濃厚飼料採食終了20分後から乾草採食時間が急激に低下し、2回給与区に比べ有意に低かった。