RATE OF PASSAGE OF DIGESTA IN YOUNG CALVES WEANED AT 6 WEEKS OF AGE

Ryozo OURA, Junjiro SEKINE, Masahiko OKUBO and Yasushi ASAHIDA

Animal Nutrition and Feeding Institute, Faculty of Agriculture, Hokkaido University, Sapporo 060

Received July 2, 1986

Introduction

One of characteristics in ruminants is the digestion of fiberous materials through the fermentation in the rumen. The digestion of fiber in the rumen is governed by such two main factors as the rate of passage of digesta through the rumen and the rate of degradation by ruminal microorganisms[9]. There are no observations concerning the ruminal passage rate in growing young calves developing their rumen.

The present study purposed to study passage rate of digesta through the digestive tracts for calves weaned at 6 weeks of age comparing with the rate determined by 14-month-old steers.

Materials and Methods

Two Holstein castrated male calves weighing about 50 kg were fitted with rumen cannula at 4 weeks of age. They subsisted on whole milk and were weaned at 6 weeks of age. After weaning, they were fed a ration consisting of 6 parts of concentrate and 4 parts of 1st cut orchardgrass hay to fulfil the metabolizable energy required for 0.5 kg of daily gain[1]. Table 1 shows chemical composition of feeds used in the present study.

Passage rate of digesta was determined at 7, 9, 13 and 17 weeks of age using the method described by OKUBO *et al.*[10]. Chromium impregnated cell wall constituents (Cr-CWC) shown by UDEN *et al.*[12] was prepared with CWC extracted from the same hay as fed to calves as a marker for the determination of passage rate of digesta. The rate of degradation of Cr-CWC in the rumen was tested by the following method. Samples of Cr-CWC ground through 1 mm screen were placed into the nylon bags (pore size, 48 μ). The bags were incubated in the rumen for 72 hours. Residuals of Cr-CWC

TABLE 1. Chemical composition of feeds

	DM[a]	OM	CP	CF	CWC	ADF	ADL
	%	% of DM					
Orchardgrass 1st cut hay	84.2	90.8	11.1	35.4	67.3	44.5	5.2
Calf starter	84.4	94.4	19.9	7.2	15.6	9.2	1.7
Growing mixture for steers	84.3	93.9	19.4	4.8	14.0	6.8	1.8

a) Each abbreviation represents as follows: DM, dry matter; OM, organic matter; CP, crude protein; CF, crude fiber; CWC, cell wall constituents; ADF, acid detergent fiber; ADL, acid detergent lignin.

were determined after 72 hours incubation. Chromium concentration in feces was analyzed by the method described by YOSHIDA *et al.*[13].

Two 14-month-old steers (245 kg live weight) fitted with rumen cannula were fed the same ration as fed to calves at such levels as 4 and 6 kg of daily allowance[1]. Determination of passage rate of digesta were conducted by the same manner as described in calves under two feeding levels.

Constants of passage rate were calculated by the following equation presented by GROVUM and WILLIAMS[7] :

$$Y = Ae^{-k_1(t-TT)} - Ae^{-k_2(t-TT)}$$

for $t > TT$, and for $t < TT$, $Y = 0$,

where Y represents chromium (Cr) concentration in fecal dry matter, t is time after administration of Cr in the rumen, A represents adjusted marker concentration of Cr in fecal dry matter, k_1 is the passage rate constant of the rumen, k_2 is the passage rate constant of the lower gut and TT is a calculated time for first appearance of marker in feces, that is transit time for the intestine.

Results and Discussion

Live weight (LW) of calves averaged 59.6 kg and 102.6 kg at 7 and 17 weeks of age, respectively. Daily gain from 7 to 17 weeks of age averaged 0.62±0.05 kg. Calves grew as intended and had no detrimental effects by the cannulation of the rumen.

Amounts of Cr-CWC incubated in the rumen for 72 hours were recovered 97% of the initial weight. Thus, Cr-CWC was little degraded in the rumen. The Cr-CWC satisfies the determination of passage rate of digesta.

Table 2 shows rates of passage of digesta determined by 6-week-weaned calves and 14-month-old steers together with dry-matter intake per unit of

TABLE 2. Means of dry-matter intake per liveweight (DMI/LW), passage rate constants for the rumen (k_1) and the lower gut (k_2), and transit times (TT) in 6-week-weaned calves and 14-month-old steers

	Age	DMI/LW	k_1	k_2	TT
	wk	g/kg	——— hr^{-1}	———	hr
Calf	7	17.2	0.038	0.094	13.8
	9	19.3	0.043	0.134	17.4
	13	22.6	0.042	0.131	11.9
	17	22.6	0.045	0.097	14.5
	mo.				
Steer	14	14.5	0.036	0.131	15.9
	14	20.0	0.053	0.140	14.5

live weight (DMI/LW) at the corresponding age. Passage rate constants through the rumen of 6-week-weaned calves increased with age from 0.038 hr^{-1} at 7 weeks to 0.045 hr^{-1} at 17 weeks of age. Dry-matter intake per unit of live weight also increased with age from 17.2 g/kg at 7 weeks to 22.6 g/kg at 17 weeks of age. In 14-month-old steers, k_1 increased from 0.036 hr^{-1} at the level of DMI of 14.5 g/kg to 0.053 hr^{-1} at 20.0 g/kg. Several workers reported that k_1 closely related to DMI in mature cattle and sheep[3~5, 8,11]. EVANS[4] found linear relationships between k_1 and the level of DMI/LW in sheep and cattle. Results of k_1 obtained by individual animals regressed on DMI/LW for both calves and steers as shown in figure 1. Following equations were obtained:

$$k_1 = 0.02330 + 0.00091\ \text{DMI/LW},\ r = 0.619 \text{ for calves}$$

$$k_1 = -0.01286 + 0.00332\ \text{DMI/LW},\ r = 0.979 \text{ for steers.}$$

No statistical significance was found in calves, while the equation for steers showed highly statistical significance ($P < 0.01$). The result obtained in steers agreed to those obtained in wethers fed lucern chaff[8]. Thus, k_1 changes with dry-matter intake in mature animals. Increase in k_1 of calves was associated with an increase in DMI/LW with age. ASAI and SASAKI[2] found that capacity of the rumen of 6-week-weaned calves increased from 171 ml/kg of LW at 8 weeks of age to 305 ml/kg at 13 weeks of age and stayed at constant level thereafter. The capacity of the rumen at 13 weeks of age or over corresponded to 1.8 times of that found at 8 weeks of age. Intakes of DM at 13 and 17 weeks of age increased by 1.3 times of that at 7 weeks

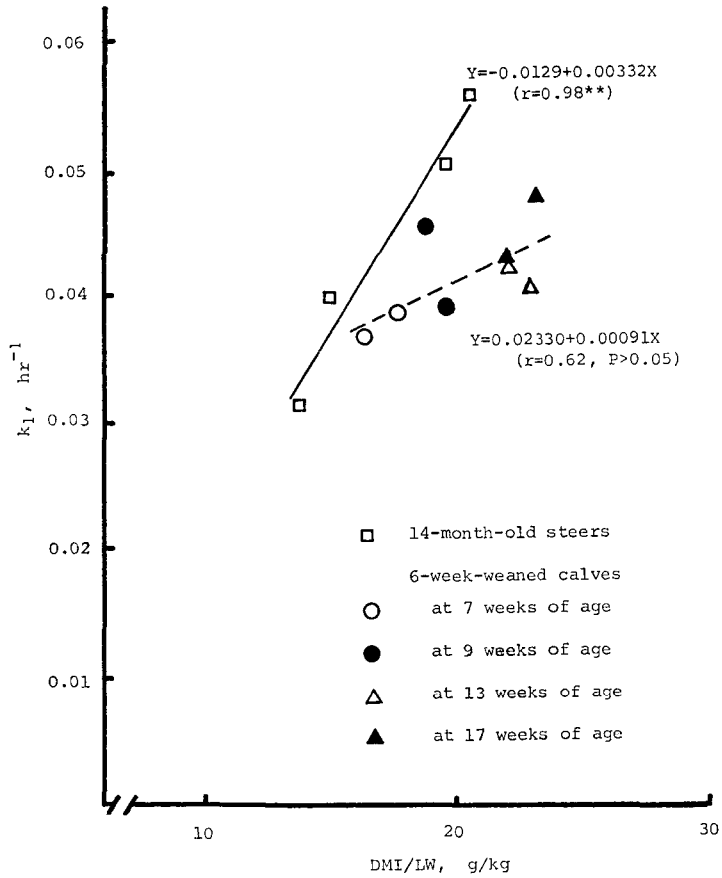

Fig. 1. Relationships of dry-matter intake per live weight (DMI/LW) to passage rate constant for the rumen (k_1) in 6-week-weaned calves and steers.

of age. Supposing the capacity of the rumen increased as found by ASAI and SASAKI[2], intakes of DM may not have increased per unit of the ruminal capacity. Thus, the regression equation for calves showed no statistical significance. When k_1 and DMI/LW were considered, both of them did not differ significantly at 13 and 17 weeks of age. Compared with k_1 for steers at high level of DMI/LW, calves at 13 and 17 weeks of age had lower k_1 than steers, even though DMI/LW was somewhat higher in calves than steers. Changes of k_1 with growth of calves, therefore, appeared to be simultaneously affected by other factors than dry-matter intake. Further study is required to clarify the relationship between capacity of the rumen and k_1.

Passage rate constants through the lower gut in calves increased from 0.094 hr^{-1} at 7 weeks of age to about 0.13 hr^{-1} at 9 and 13 weeks of age and decreased to 0.097 hr^{-1} at 17 weeks of age. In steers, k_2 slightly increased as feeding level increased. The values of k_2 in calves at 9 and 13 weeks of age were similar to that in steers at low level of feeding.

GROVUM and WILLIAMS[8] also determined k_2 and TT in wethers fed lucern chaff at increasing levels from 8.2 to 26.5 g DMI/kg LW. They found that k_2 increased and TT decreased with DMI/LW. The results of k_2 and TT obtained in steers agreed to the relations reported by GROVUM and WILLIAMS [8]. Those obtained in calves did not agree to the results presented by GROVUM and WILLIAMS[8]. Development of the rumen function in calves reached to a plateau level at 2 months of age when they consumed fair amounts of roughage[6]. The ruminal capacity has reached to a constant proportion to live weight at 13 weeks of age[2]. The qualitative and quantitative development of the rumen may have affected to the ruminal digestion which in turn influenced on the rate of passage of digesta through the lower gut. The present study, however, did not clarify the reason why k_2 of calves decreased at 17 weeks of age. Since the passage rate of digestible materials was difficult to interpret as described by MERTENS and ELY[9], mechanisms affecting digestibility which is a function of digestion and passage[9] are required for further study on the rate of digestion in the rumen of early weaned calves.

Summary

Passage rates of digesta through the digestive tracts were determined in 6-week-weaned calves at 7, 9, 13 and 17 weeks of age and in 14-month-old steers fed at 2 levels of a ration consisting of 6 parts of concentrate and 4 parts of 1st cut orchardgrass hay. Passage rate constants through the rumen (k_1) of calves increased with age from 0.038 hr^{-1} at 7 weeks to 0.045 hr^{-1} at 17 weeks of age. No significant relationship was found between k_1 and dry-matter intake in calves. In steers, k_1 linearly related to dry-matter intake ($P<0.01$). Passage rate constants through the lower gut (k_2) increased and transit time decreased with increased dry-matter intake in steers. In calves, k_2 increased from 0.094 hr^{-1} at 7 weeks to 0.13 hr^{-1} at 9 and 13 weeks, then decreased to 0.097 hr^{-1} at 17 weeks of age.

Literature Cited

1. AGRICULTURAL RESEARCH COUNCIL: The Nutrient Requirements of Ruminant Livestock. p. 31 and p. 118., Commonwealth Agricultural Bureaux, Slough, 1980

2. ASAI, T. and SASAKI, Y.: Studies on the anatomical development of digestive organs in the calf. *Tohoku Agric. Exp. Sta. Res. Bull.*, **40**: 209-224. 1970 (in Japanese)
3. COOMBE, J. B., DINIUS, D. A. and WHEELER, W. E.: Effect of alkali treatment on intake and digestion of barley straw by beef steers. *J. Anim. Sci.*, **49**: 169-176. 1979
4. EVANS, E.: An evaluation of the relationships between dietary parameters and rumen solid turnover rate., *Can. J. Anim. Sci.*, **61**: 97-103. 1981
5. GANEV, G., ØRSKOV, E. R. and SMART, R.: The effect of roughage or concentrate feeding and rumen retention time on total degradation of protein in the rumen., *J. agric. Sci., Camb.*, **93**: 651-656. 1979
6. GODFREY, N. W.: The functional development of the calf. II. Development of rumen function in the calf., *J. agric. Sci., Camb.*, **57**: 177-183. 1961
7. GROVUM, W. L. and WILLIANS, V. J.: Rate of passage of digesta in sheep. 4. Passage of marker through the alimentary tract and the biological relevance of rate-constants derived from the changes in concentration of marker in faeces., *Br. J. Nutr.*, **30**: 313-329. 1973
8. GROVUM, W. L. and WILLIAMS, V. J.: Rate of passage of digesta in sheep. 6. The effect of level of food intake on mathematical predictions of the kinetics of digesta in the reticulorumen and intestines. *Br. J. Nutr.*, **38**: 425-436. 1977
9. MERTENS, D. R. and ELY, L. O.: A dynamic model of fiber digestion and passage in the ruminant for evaluating forage quality., *J. Anim. Sci.*, **49**: 1085-1095. 1979
10. OKUBO, M., HANADA, M., SEKINE, J., MIURA, U. and ASAHIDA, Y.: The rumen degradability of protein for various feedstuffs., *J. Fac. Agr. Hokkaido Univ.*, **63**: 49-53. 1986
11. SHELLENBERGER, P. R. and KESLER, E. M.: Rate of passage of feeds through the digestive tract of Holstein cows., *J. Anim. Sci.*, **20**: 416-419. 1961
12. UDEN, P., COLUCCI, P. E. and VAN SOEST, P. J.: Investigation of chromium, cerium and cobalt as markers in digesta. Rate of passage studies., *J. Sci. Food Agric.*, **31**: 625-632. 1980
13. YOSHIDA, M., KOSAKA, K., HORII, S. and KAMEOKA, K.: A new procedure for the determination of chromic oxide with potassium phosphate reagent., *Japan. Poultry Sci.*, **4**: 24-29. 1967 (in Japanese)