Flow of Digesta Passing through the Duodenum in the Naturally Suckled Calves

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Many investigations have been reported on the course of digestion of milk and other diets in the alimentary tract of young calf. However, there is little or no experimental data derived from the naturally suckled calves. The naturally suckled calves receive milk from their dams relatively slowly three to six times for 24 hours, while the artificially suckled calves are fed a large amount of milk substitute once or twice a day and they are weaned at earlier age¹⁾. In recent more detailed investigations⁴⁻⁶⁾, it is known that the course of digestion in the abomasum and small intestine of the milk-fed calves is greatly influenced by the frequency of suckling, milk composition and age of calves. Therefore, it was presumed that the course of events during digestion in the alimentary tract of the naturally suckled calves might be different from that of the artificially suckled calves.

Accordingly, the purpose of the present experiment has been to elucidate the flow of digesta and nutrients passing through the duodenum of the naturally suckled calves equipped the duodenum cannula.

Materials and Methods

Animals: Three Japanese Black calves which were suckled by their dams were used. Their body weight and age at the beginning of this experiment were as follows: calf 1, 61 kg and 27 days; calf 2, 97 kg and 89 days; calf 3, 125 kg and 115 days. The calf 1 was a pre-ruminant and the other two were able to eat substantial quantities of roughage. The calves were inserted surgically a T-type cannula made of polyvinyl chloride pipe into the duodenum immediately posterior to the pylorus as described by MARKOWITZ²⁾. All calves recovered quickly and returned to normal food consumptions within 7 days after the operation.

Feeding: The calves were placed individually in digestion cages throughout the experimental period of 7 days. During this period, they were allowed to be suckled

自然哺乳子牛の十二指腸を通過する消化管内容物の流れについて: 久馬 忠・菊池武昭・高橋政義・滝沢静雄 (農林水産省東北農業試験場, 盛岡市 020-01)

by their dams at 9:00 and 21:00 hours twice a day, and the volume of milk intake was measured by the change of the body weight of each calf before and after suckling in the last 3 days of the experiment. Hay was freely given and the residue was also measured to record the hay intake. As a solid phase marker, chromic oxide encapsulated with gelatin was given in an oral dose of 2 g at 8:00 and 20:00 hours twice a day during the experimental period.

Sampling: At the end of experimental period, the collection of digesta flowing out from the duodenum cannula began 0.5 hr before the morning suckling and continued until 24 hr after the morning suckling. The digesta samples were collected intermittently into a polyethylene bag attached to the barrel of cannula. About 100 ml of digesta were usually obtained within 10 minutes. The digesta collected were not returned to the calves.

Analytical methods: After measuring the volume and pH of the digesta immediately after collection, the samples of digesta were freeze-dried to determine dry matter, and then the remainder was stored at -20°C for further analyses. The chemical compositions of digesta, milk and hay were analysed by the methods normally adopted. The concentration of Cr_2O_3 in digesta was determined by the method of STEVENSON and de LANGEN³⁾.

Results and Discussion

All calves remained in good health throughout the experiment. The mean intake of milk and hay for the last 3 days of the experiment were as follows: calf 1, 5.7 and 0; calf 2, 5.1 and 0.98; calf 3, 8.2 and 1.51 kg per day.

pH: Fig. 1 (a) shows the pH of the digesta flowing into the duodenum. In all calves, the pH of the digesta rose from a basal level of about 2 to 3.5–5.0 immediately after the suckling, and then returned to the basal level within 6 to 8 hours after the suckling. The similar patterns of the pH change have been reported by several workers^{4–6)} who studied on the calves given whole milk twice a day. The rise of the pH after suckling was possibly due to the rapid passage of milk whey which was excluded from milk curd in the abomasum.

The average pH (mean $\pm$ SD) of the digesta in calf 1, calf 2 and calf 3 were 2.9 ± 1.19 , 2.3 ± 0.52 and 3.1 ± 0.68 , respectively. The basal level of the pH in calf 1 was lower than those in calf 2 and calf 3, and the fluctuation of the pH in calf 1 was greater than in the others. It may be assumed that the pH of the digesta flowing into the duodenum was influenced with the dilution rate of hydrochloric acid secreted in the abomasum and the volume of effluents from the reticulo-rumen.

Digesta flow: Fig. 1 (b) shows the flow of digesta into the duodenum. The flow rate of digesta in all calves reached the highest 2 hours after suckling, and then decreased with the time after suckling. It is presumed that the rapid flow of digesta during the first few hours after suckling was due to a transient passage of the whey separated from milk clot in the abomasum. These results in the present experiment were similar to the observations of other workers^{4–6)}.

Digesta Flow Passing through Duodenum

Fig. 1. Diurnal changes in the pH (a), digesta flow (b), dry matter flow (c), nitrogen-free extract (d), crude-protein (e), and Cr_2O_3 flow (f), passing through the duodenum of the naturally suckled calves.

The flow pattern of dry matter flowing into the duodenum was similar to that of the flow of digesta, as shown in Fig. 1 (c). The rapid flow of dry matter immediately after suckling resulted from the transient flow of milk lactose, as described later.

The hourly flow rate of digesta (mean $\pm$ SD) in calf 1, calf 2 and calf 3 were 339 ± 150 , 1743 ± 174 and 1438 ± 198 ml/hr, respectively. The hourly flow rate of dry matter in calf 1, calf 2 and calf 3 were 35 ± 7.0 , 66 ± 6.0 and 101 ± 9.7 g/hr, respectively. The total flow of digesta in calf 1, calf 2 and calf 3 were 8.1, 41.8 and 34.5 kg/day, respectively. The total flow of dry matter in calf 1, calf 2 and calf 3 were 844, 1592 and 2412 g/day, respectively.

The flow rate of digesta and dry matter in the older calves were greater and

more continuous than the younger calf, and the total flow of digesta was about twice in calf 1 and about seven times in the two others as much as the amount of daily milk and hay intake. On the other hand, the amount of dry matter passing through the duodenum was between 117 and 94% of the daily dry matter intake. It is presumed that the increase in the flow of digesta passing through the duodenum was caused by the addition of a large amount of saliva and abomasal secretion, whereas the decrease in dry matter passage was probably due to the fact that the ingesta was digested and absorbed to some extent in the rumen.

Flow of nutrients: There was a rapid flow of NFE during the first few hours after suckling, as shown in Fig. 1 (d). The flowing pattern of NFE was similar to that of the dry matter, but the passage of NFE was more transient. This observation is in agreement with those of other workers⁴⁻⁶⁾ who observed using the artificially suckled calves. These results were consistent with the fact that lactose passed through the abomasum more rapidly than the other nutrients and very little was incorporated into milk clot.

The flow of crude protein passing through the duodenum was relatively constant over the 24-hour period in each calf, as shown in Fig. 1 (e). The flow of those nutrients decreased temporarily 2 hours after suckling and the greatest flow rate occurred 6 to 10 hours after suckling. The present results support the findings of the other workers that protein and fat flow gradually into the duodenum after suckling at a relatively constant rate because of clot formation in the abomasum⁴⁻⁶⁾.

Passage of Cr_2O_3 : Fig. 1 (f). shows the flow of Cr_2O_3 given as a solid phase marker. The concentration and flow rate of Cr_2O_3 showed the great fluctuation over a 24-hour period. After suckling, the flow rate of Cr_2O_3 showed a marked decrease and the greatest flow rate was observed 6 to 10 hours after suckling. The fluctuation in the flow rate of Cr_2O_3 in calf 1 was greater than that in the other calves. The recovery of Cr_2O_3 from the duodenal digesta in calf 1, calf 2 and calf 3 were 78, 81 and 108%, respectively. Therefore, it seemed that Cr_2O_3 was not a suitable marker to estimate the passage of dry matter in the duodenum by the spot sampling of digesta in the suckled calf.

The results in the present experiment showed that the flow of digesta passing through the duodenum in the naturally suckled calves were similar to that observed in the artificially suckled calves. However, if the calves had been allowed to suckle more frequently as seen in natural behavior, the flow pattern of digesta might have been different from the present observation.

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