DEVELOPMENT OF ARTIFICIAL RUMEN WITH THE FUNCTIONS OF MECHANICAL DIGESTION AND CIRCULATION OF DIGESTA

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Introduction

Many attempts have been made to measure the ability of the ruminant to convert low-quality roughage into high-quality products. The production is due mainly to microorganisms, and many artificial rumens have been developed to duplicate physiological characteristics in the rumen (Hannah et al., 1986; Hoover et al., 1976; Teather and Saur, 1988). However, there are many difficulties in simulating the functions of the rumen and the symbiotic relationships between bacteria and protozoa. The current paper describes an computer-controlled artificial rumen which have the following characteristics: A) Mechanical digestion unit, which enables the direct inoculation of rumen contents into the fermenter without squeezing through cloth before inoculation. B) Herical circulation unit which is designed to simulate the differential flows for liquids and sedimented solids including protozoa in the rumen. C) Automatic feeder with twelve chambers, which is designed to accommodate fine concentrates and the roughage up to 2.5 cm in length. D) Herical rake out unit, which discards the sedimented contents in the outlet port to keep the same liquid level in the fermenter. E) Small working volume of the fermenter, which enables to start the incubation of several artificial rumens with the same inoculum from a canulated animal.

Materials and Methods

A schematic diagram of the small artificial rumen with 280 ml of working volume is shown in figure 1. The fermenter is equipped with mechanical units listed below: A) Mechanical digestion gear unit: The unit is composed of three gears. Two small gears revolve clockwise and counterclockwise at 2 rpm around a large inner gear, normally, at 30 minutes intervals with a 5-seconds intermission. The gear unit is set approximately 5 mm deep in water to obtain effective trituration of roughage. When the roughage in the inoculum is long and hard, the reversible stroke is shortened to several seconds, gradually increasing to normal revolution rate according to the computer programming. B) Circulation unit: The helical blade fitted through the "T" shaped overflow duct

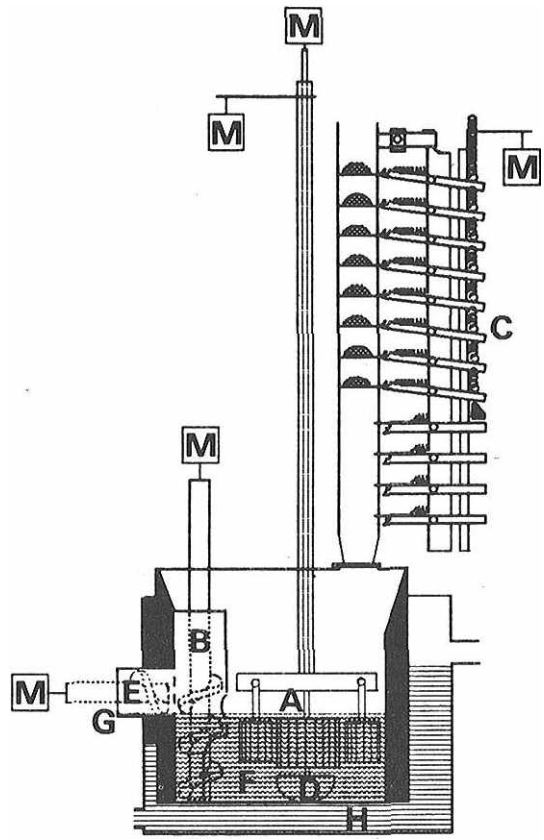

Figure 1. General schematic of artificial rumen. A, mechanical digestion gear unit; B, herical circulation unit; C, automatic feeder; D, stirring brade; E, herical rake out blade; F, fermentor; G, overflow port; H, water bath; M, motor.

turns clockwise at 5 rpm to help the overflow of sedimented component. When the blade turns counterclockwise, light density roughage floating on the liquid is sent to the bottom of the fermenter. C) Automatic feeder: The feeder has twelve chambers (35 x 35 mm, 30 mm in height) which can store concentrates and roughage up to 2.5 cm in length. The feeding time is controlled with an ordinary timer or computer. On feeding time, shutter on the fermenter opens first. Then the ladder chain with the hook at the end disconnects the latch of the feed chamber shutter. The feed falls down into the fermenter and the shutter of the fermenter closes. D) Stirring blade: Stirring blade is connected to the inner gear of the mechanical digestion unit. The blade turns at 0.5 rpm but can be increased to 60 rpm to mix the fermenter contents prior to sampling. E) Herical rake out blade: Another herical blade is fitted through the outlet of the "T" shaped tube to scrape out the sedimented materials which is piled up in the outlet and increase the working volume of the fermenter. The fermenter is placed in a 1.5 l water jacket to maintain temperature at 39°C. Carbon dioxide is introduced and mineral buffer solution (Weller and Pilgrim, 1974) with urea added at 0.5 g/l was infused at 0.29 ml/min^{-1} to give a liquid dilution rate of 1.5 day^{-1}. The fermenter was supplied with the ground hay (0.325 g), ground soybean meal (0.09 g) and rice starch (0.08 g) every hour. Rumen contents were withdrawn through the fistula shortly before the feeding (12 h after the preceding feeding) from sheep. Sheep were given on a diet of 300 g chopped hay and 150 g commercial dairy formula feed at 10:00 and 22:00, respectively.

Results and Discussion

Rumen contents with chopped roughage obtained shortly before the morning feeding were well digested with mechanical digestion gear unit in a fermenter after three days of incubation. Squeezing procedure of inoculum with surgical gauze or cheese cloth could be eliminated for the microbial study in vitro. Drive of the helical circulation unit affected the number of protozoa removed from the fermenter. When the helical convection unit was driven for 5 min/hr, the number of protozoa removed from the fermenter decreased to 70% of the continuous driving. When the helical circulation unit was driven continuously, the protozoa removed from the fermenter was about 2-4 times higher during 15-30 min after feeding than those of 0-15, 30-45, and 45-60 min. Protozoa populations were maintained at $2x10^5$ cells/ml for a week when the helical circulation unit was driven during 0-15 min after feeding. Automatic feeder could supply various substrates from fine particle to 2.5 cm long roughage. However, mechanical digestion gear unit locked when the fermenter was supplied with 0.73 g of 1 cm orchard grass every hour. The flocks of protozoa sedimented were affected by the shape and the speed of the stirring blade. Very dense flocks of protozoa were observed when the small stirring blade turns very slowly (< 10 rpm). The herical rake out blade was helpful for keeping the same liquid level. Without the blade, sudden overflow with a rush was observed.

(Key Words: Ruminant, Continuous Culture, Fermentation)

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