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# METHANE AND PROTEIN FROM BEEF CATTLE MANURE

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## Introduction

Dwindling supplies of conventional fossil fuels have prompted renewed interest in recovering energy through the bioconversion of waste organic materials. The large quantities of manure produced in confinement feedlots and the need to manage this manure effectively make feedlots a logical choice for assessing the feasibility of recovering methane and protein through anaerobic fermentation.

Research at MARC is designed to determine the technical and economic feasibility of recovering methane and protein from beef cattle manure.

Sepcific objectives are to:

(1) Develop design criteria for optimum production of methane and protein through anaerobic fermentation of beef cattle manure,
(2) Develop efficient methods to recover high protein biomass from the fermented residue,
(3) Evaluate the nutritional value of the biomass as a livestock feed,
(4) Determine the capital and operational costs and energy, manpower, and safety requirements for methane fermentation systems associated with livestock operations.

This project was initiated in 1976 and is jointly funded by the U.S. Department of Agriculture, Agricultural Research Service, and the U.S. Department of Energy through the Solar Energy Research Institute.

## Anaerobic Fermentation

**MICROBIOLOGY.** Anaerobic fermentation is a biological process in which organic matter decomposes without oxygen to yield methane. The phenomenon occurs naturally when organic material remains without oxygen under conditions amenable to microbial processes. Such conditions prevail in many natural environments ranging from pond sediments to the gastrointestinal tract of animals. Use of the methanogenic process for generating energy from organic residues requires an understanding of the mechanisms involved and the factors affecting these mechanisms.

**BIODEGRADABILITY.** Because anaerobic fermentation is a biological process, the biodegradability of the material being fermented affects the product yield. We found that the roughage content of cattle rations affects the biodegradability of the manure.

Manure from cattle fed a ration of 91% corn silage and 40% corn silage produced 80% and 60%, respectively, the amount of methane produced by manure from cattle fed 7% corn silage. We have also shown that the age of manure and amount of such foreign material as dirt and bedding can reduce the methane yield by 30 to 50%. Thus, we estimated that the maximum amount of methane that can be produced from fresh manure from finishing cattle is 5.5 ft of methane/pound of organic matter. Old manure or manure from cattle fed high roughage rations would produce about one-half to two-thirds this amount.

## Methane Production Rate

Although our research on biodegradability shows the maximum amount of methane that can be produced from cattle manure, it is not practical to extract the maximum amount because of the long fermentation time and larger fermentor volume required. Thus, it is important for researchers to predict the methane production rate under different fermentation conditions. We have developed an equation that predicts the methane production rate (in cubic feet of methane/cubic feet of fermentor/day) based on the biodegradability and concentration of manure being fermented, the fermentation time, and two kinetic parameters. Using this equation, we found that the highest methane production rate occurrs at 60° C. Rates at 30, 35, 40, 45, 50, 55, and 65° were 42, 52, 64, 78, 92, 89, and 52% of the rate at 60°. We also found that methane production is inhibited when manure concentration exceeds 5 lb of organic matter/cubic feet. Thus, to achieve high methane production rates, while maintaining stable fermentation, we recommend operating fermentors between 50 to 55°, manure loading rate of 1 lb of organic matter/cubic feet of fermentor/day, and retention time of 5 days.

## Energy Requirement

Our studies have shown that the major energy requirement for operating fermentors between 50 to 55° C was for heating the fermentor. About 37% of the energy produced by the system was needed for heating. This amount was reduced to 20% when half of the effluent heat was recovered to help heat the manure entering the fermentor. The next main energy user was for mixing the manure and fermentor contents. Mixing amounted to 7% of the total energy production when the mixers were run continously. Mixing energy can be reduced substantially when intermittent mixing is used. Continuous mixing produces, at most, only a 10% higher methane production rate than mixing 2 hr/day. Energy required to pump the manure into and out of the fermentor accounted for about 4% of the total energy produced. Thus, the energy required to operate the fermentation systems accounts for about 30 to 50% of the energy produced.

## Feeding Fermentor Effluent

Using the fermentor effluent as a feed ingredient for livestock appears to have merit, although some technical

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problems must be solved. Dried centrifuged effluent can be fed at a level up to 10% of the dietary dry matter and not change the use of the diet components by the animal. Disadvantages of feeding dried centrifuge effluent are that more than one-half of the nitrogen is not captured by centrifugation, and capital and energy costs needed to install and operate the centrifuge and drying systems are high. Eliminating the drying process would retain more nitrogen, but storing the wet centrifuged solids would be a problem. Mixing the total fermentor effluent into a ration has the advantage of using most of the nutrients. However, the amount of moisture in the effluent limits the amount of effluent that can be mixed into a total ration. The major effects of feeding fermentor effluent have been a decreased apparent digestibility of dry matter, nitrogen, ash, and gross energy in sheep and decreased total ruminal fatty acid concentrations before and after feeding in steers.

## Economics

Economic studies show that methane can be economically produced at moderate plant sizes (between 3 to 7 tons of dry matter/day) when farmer-constructed and operated systems are used. Commerical "turn-key" systems are only economical at sizes greater than 25 tons of dry matter/day. This means that farmer-constructed and operated systems are economical for confined-beef feedlots between 1,000 to 2,000 head without an effluent feed credit and about 300 head with an effluent feed credit of $70/ton. Commercial "turn-key" systems are only economical for confined feedlots larger than 8,000 head without effluent feed credit and between 1,000 to 2,000 head with an effluent feed credit of $70/ton. For dirt feedlots, the economical feedlot sizes must be at least twice as large because of the lower biodegradability of the manure and contamination with dirt and debris.