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Rumen Manipulation: A Potential Technique to Ensure High Livestock Production

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ARTICLE ID: 36

Introduction

Fungi, bacteria, and protozoa dominate the anaerobic rumen microbes that break down the ligno-cellulosic diet that the ruminants consume. Because they are mostly kept on low-quality roughage and graze on degraded range land, ruminants in poorer nations have poor productivity and nutrient consumption. Therefore, controlling rumen fermentation is essential to maximize ruminal fermentation, which will enhance animal productivity and nutrient uptake. The available rumen manipulation options include genetically modifying already-existing bacteria in the rumen environment, introducing naturally occurring or genetically modified foreign microbes into the rumen, and using chemical additives that specifically influence rumen microbes. Therefore, defaunation of rumen protozoa results in a decrease in ruminal methane generation as well as an increase in protein outflow in the gut, improving animal growth and feed conversion efficiency. Boost fibrolytic activity: Since rumen bacteria are the only organisms that can break down cellulose and hemicellulose, the only way to increase the breakdown of fiber in high lignocellulosic feeds is to manipulate lignocellulosic linkages. Given the availability of feed resources, greater attention needs to be paid to controlling rumen fermentation in order to boost cellulolytic activity and maximize the use of low-grade roughage, which is going to improve the efficiency of livestock.

Rumen Manipulation

Increasing ruminant productivity (the production of milk, meat, and wool) and optimizing feed consumption are two key components of manipulating ruminal fermentation. The goal of ruminal fermentation manipulation is to increase processes that are advantageous to the host and eliminate, reduce, or modify processes that are detrimental.

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Why is Manipulation Vital?

- **Boost fibrolytic activity:** Since rumen bacteria are the only organisms that can break down cellulose and hemicellulose, the only way to increase the breakdown of fiber in high lignocellulosic feeds is to manipulate lignocellulosic linkages.
- **Boost the production of microbial proteins**: The majority of the amino acids that enter the duodenum come from microbial proteins. Thus, it is important to enhance the rumen's microbial protein synthesis.
- **Reduction in proteolysis:** Since the processes of hydrolyzing feed protein, deaminating amino acids, and recycling ammonia for microbial protein synthesis all need energy, it is best to avoid having the rumen break down protein and deamininate amino acids.
- **Preventing acidosis:** In animals fed a high grain diet, it is possible to regulate the amount of lactic acid in the rumen liquid to prevent acidosis and the subsequent inhibition of feed utilization.
- **Novel microbes:** In high-producing ruminants, the quality of the protein is crucial. It is possible to engineer microbes to produce peptides from amino acids and provide them to animals through their intestines.
- **Plant toxin metabolism:** It is possible to control rumen fermentation to effectively use feeds that contain antinutritional ingredients as tannin, saponin, mimosine, etc

Methods of Rumen Manipulation

In general terms, there are two categories into which rumen manipulation techniques can be divided: genetic and non-genetic. In an effort to increase animal output, attempts have been undertaken to use gene transfer and manipulation to create genetically modified rumen microorganisms. Nevertheless, there has been very little/spoken success in the field of genetically modifying rumen bacteria. Physical means (dietary manipulation), appropriate drugs, or feeding microbes (probiotics) can all be used to manipulate the rumen without affecting its genetic makeup.

Genetic Manipulation

- It has been investigated to introduce different genes into gut microbes and to improve the ability of the naturally occurring bacteria in the rumen to perform specific functions or to add new ones through genetic modification.

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- The genetically altered microbes can either break down lignins and fibrous parts of feed, or they can break down toxins, provide necessary amino acids, lessen the amount of methane produced in the rumen, and withstand acidity.
- Similar to the prior approach, introducing novel species or strains of microorganisms into the intestine has a tremendous potential to boost feedstuff digestibility and enhance animal productivity.

Non-Genetic Manipulation

Probiotics:

The rumen microbial flora provides fermentation and chemical reactions that aid in the digesting process in ruminants. The rumen and intestinal microbiota, which are vital to the health of the animal, have been identified over the past ten years as the primary variables to control for the animal's growth and performance. Unfortunately, the growth of unwanted bacteria continually threatens their homeostasis, which is bad for the animals' performance and well-being. To improve rumen metabolic activity and hence overall animal production, live microbial cultures (probiotics)—fungi, yeast, and bacteria—are being attempted as natural feed additions these days. Probiotics have been shown to improve animal growth and resistance to disease, as well as to be a cost-effective dietary supplement. Microbial feed additives have also been shown to improve ruminant nutrition, with an additional 7–8% improvement in live weight gain and milk production.

the following are possible benefits of probiotic use in farm animals:

- Fostering growth
- Increased feed conversion effectiveness
- Improved nutrition absorption by regulation of the growth and development of gut epithelial cells
- Enhanced vitamin synthesis, calcium metabolism, and carbohydrate metabolism
- Neutralization of substances that are detrimental to nutrition, such as phytic acid and trypsin inhibitors
- Synthesis of microbial enzymes, thereby makes up for the host's inadequate intestinal enzyme activity
- Getting rid of or managing gut microbes that cause clinical or subclinical illnesses
- Intestinal stimulation of both specific and nonspecific immunity

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Impact of feeding probiotics on the performance of animals

- **Digestibility of nutrients**: There have been stated to be numerically significant improvements.
- **Production of milk:** Animals given yeast showed a positive reaction in terms of dry matter, organic matter, crude protein, and fiber in their milk.

Fixing Concentrate to Roughage Ratio

Feeding crop residue and dry grasses that are high in structural carbohydrates promotes microbial fermentation in the rumen, which in turn increases the population of methogenic bacteria in the rumen, which in turn increases the production of methane. Methane generation is a waste of dietary energy; methane production can be decreased by adding concentrate to a diet high in straw. Feeding urea molasses block as a lick to ruminants has improved the rumen environment and provided readily available nutrients for the growth of cellulolytic bacteria, which has reduced methane production in the rumen.

Dietary minerals (UMMB) or supplements containing starch rich concentrate, ionophores such as monensin/rumensin, and antibiotics can enhance the function of the rumen. These supplements have the advantageous effect of lowering methane production while also clearly increasing livestock productivity. Urea is recyclable and provides the rumen microorganisms with nitrogen. Both feed grade and fertilizer grade urea are utilized in the feeding of ruminants. In a compound ration, it can be administered through feed combined with other feed ingredients. Another usage for urea is as liquid nitrogen, which is achieved by dissolving it in water and providing the ruminants with it as drinking water. An alternative formulation would be a multinutrient feed block made of urea and molasses bound together with a binder.

Additive Feed Used to Manipulate Rumen Function

- Ionophores
- Drugs
- Anti-bodies
- Herbal Preparation
- Micro-nutrients

Commercially available feed additives known as ionophores are known to increase animal productivity. They work by altering the rumen microbial population through ion

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transfer across cell membranes. While the dairy industry has not used ionophores much, it has been used extensively in the beef industry to improve feed efficiency and control coccidiosis. For example, ionophores like monensin may have benefits for dairy cattle, such as improved energy metabolism, increased milk production, and altered milk components. Lasolasid has been observed to inhibit proteolytic activity, deamination, and methanogenesis, which is said to increase propionate production. Consequently, it improves the ruminant sector's efficiency of feed utilization.

Bypass Nutrients

- Feeding nutrients that are either liberated or protected is an indirect method to control rumen activity. Feeding such nutrients causes the lower digestive system to become the site of nutrient digestion instead of the rumen. The general goals are to improve the duodenum's supply of amino acids and lessen the rumen's attack on dietary protein by proteolytic enzymes.
- Bypass protein stimulates milk production nearly always due to its effect on feed intake, and depending on nutrient imbalances, it may also lead animals to mobilize their bodily reserves. High-fat, high-protein diets that provide long-chain fatty acids and high protein for post-ruminal digestion may help prevent this.
- Without significantly affecting feed intake or, consequently, milk output, passing starch or altering the rumen to increase propionate production can inhibit body reserve mobilization because they balance nutrients for milk production.The efficiency of energy consumption is enhanced, nevertheless, since it balances the nutrients needed for milk production.
- Fiber digestion in the rumen is slowed down when bypass fat is fed. This lowers the synthesis of acetic acid. In order to keep animals' supplies of long-chain fatty acids intact, protected fat feeding is done in the rumen. A weight of fat provides 2.25 times more energy than a weight of carbs or protein. Boost the energy density of your diet in relation to unit weight. preserve the rumen's ability to produce acetic acid.

Defaunation

- A process known as "defaunation" results in an animal known as a "defaunated animal" when its rumen becomes free of rumen protozoa.

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- Animal growth and feed conversion efficiency are enhanced when rumen protozoa are eliminated through defaunation, which decreases ruminal methane generation and enhances protein outflow in the intestine.

Methods of Defaunation

Defaunating animals and obtaining a ruminant animal devoid of rumen ciliate protozoa can be done in a few different methods. The many defaunation techniques are:

- **Isolation of neonates:** Taking neonates away from their mothers at birth and keeping them always isolated from the adult ruminant animals. After two or three days of birth, the newborn animals should be separated.
- **Chemical treatment:** Sodium lauryl sulfate, manoxol, and copper sulphate are the compounds that have been used extensively to defaunate animals. Animals' rumens are exposed to chemicals intended as defaunating agents through rumen fistulas or stomach tubes**.**
- **Dietary Manipulation:** The ciliate protozoa are very responsive to pH changes in the rumen. When the rumen pH drops below 5.8 or below 5.0, the ciliate protozoa are totally eradicated and their activity is negatively impacted. Offering high-energy feed, particularly cereal grains like barley and maize, to animals that have been dehydrated for a full day result in an acidic environment in the rumen, with a pH of less than 5.0. The animal becomes defaunated because of these pH drops in the rumen, which totally eradicate the ciliate protozoa.

Conclusion

Rumen is an anaerobic, naturally fermenting system that may be primarily controlled by changing the microflora's composition. The rumen can be easily manipulated to increase output by defaunting the animals with indigenous flora, tree leaves, or agricultural industry waste. One of the main areas of focus for rumen manipulation in the near future will be the introduction of naturally occurring microorganisms from one species' digestive tract to another for the effective breakdown of plant toxins and for the efficient use of nutrients. Great biotechnological potential exists when rumen microorganisms are genetically modified for effective ruminal fermentative digestion.