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Rumen Manipulation to Improve Animal Productivity

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Introduction

Anaerobic rumen microorganisms mainly bacteria, protozoa and fungi degrade ligno-cellulosic feeds consumed by the ruminants. The ruminants in developing countries are predominantly maintained on low grade roughage and grazing on degraded range land resulting in their poor nutrient utilization and productivity. Hence, manipulation of rumen fermentation was tried during last two decades to optimize ruminal fermentation for improving nutrient utilization and productivity of the animals. Modification of rumen microbial composition and their activity was attempted by using chemical additives those selectively effect rumen microbes, introduction of naturally occurring or genetically modified foreign microbes into the rumen and genetically manipulation of existing microbes in the rumen ecosystem. Accordingly, rumen protozoa were eliminated by defaunation for reducing ruminal methane production and increasing protein outflow in the intestine, resulting in improve growth and feed conversion efficiency of the animals. Further, Interspecies trans-inoculation of rumen microbes was also successfully used for annulment of dietary toxic factor. Additionally, probiotics of bacterial and yeast origin have been used in animal feeding to stabilize rumen fermentation, reduced incidence of diarrhoea and thus improving growth and feed conversion efficiency of young stalk. It is envisaged that genetic manipulation of rumen microorganisms has enormous research potential in developing countries. In view of feed resource availability more emphasis has to be given for manipulating rumen fermentation to increase cellulolytic activity for efficient utilization of low grade roughage.

Some of the Major Objectives of Rumen Manipulation are:

a. **Enhance fibrolytic activity:** To increase the fibre degradation mainly through manipulation of lignocellulosic bonds in high lignocellulosic feeds as the rumen microbes are the only degraders of cellulose and hemicellulose,

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b. **Increase microbial protein synthesis:** Major portions of the amino acid reaching the duodenum are of microbial protein origin. Therefore, attempts should be made to maximize microbial protein synthesis in the rumen.

c. **Reduction in proteolysis:** Hydrolysis of feed protein, deamination of amino acids and reutilization of ammonia for microbial protein synthesis are all energy consuming process, hence the degradation of protein and deamination of amino acids in the rumen should be discouraged.

d. **Reduction in methanogenesis:** Methane generation in the rumen is a wasteful process as 5-10% of GE intake of ruminants is converted in to methane. The provision of an alternate hydrogen sink in the rumen may help in increasing digestible energy (DE) availability for production.

e. **Prevention of acidosis:** In high grain fed animals, the evel of lactic acid can be controlled to avoid acidosis and inhibition of feed utilization due to lowered pH of the rumen liquor.

f. **Shifting acetate to propionate production:** In fattening beef/lambs the production of propionate in the rumen at the expense of acetate may be helpful.

g. **Novel microbes:** The quality of protein is important in high producing ruminants. Microbes, can be tailored to synthesize the amino acids in the form of the peptides and supply to the animals in the intestine.

h. **Metabolism of plant toxins:** Rumen fermentation can be manipulated for efficient utilization of feeds which contain anti nutritional factors viz. tannin, saponin, mimosine etc.

i. Synthesis of useful secondary metabolites.

Methods of Rumen Manipulation

- Broadly the methods of rumen manipulation can be classified in two i.e., genetic manipulation and non genetic manipulation.
- In genetic manipulation, attempts were made to develop genetically engineered rumen microbes by gene transfer/manipulation technique to enhance the animal productivity.
- However success in the field of genetic manipulation of rumen microbes is very poor/sporadic.

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- Non genetic manipulation of the rumen can be done by physical methods (dietary manipulation) and by using suitable chemicals or feeding microbes (probiotics).

Genetic Rumen Manipulation

- The potential of application of molecular techniques in achieving the goals of rumen manipulation are enormous
- These techniques could allow the introduction or increase of desired activities such as cellulolysis and detoxification or reduction of undesirable activities such as proteolysis, deamination and methanogenesis.
- For this purpose, one approach would be to select the desirable gene and to express them in predominant rumen bacteria. Naturally present microorganisms in the rumen can be genetically modified to enhance their capacity of defined functions or to add new functions.
- The problems with the establishment of genetically engineered rumen bacteria are too many and very complex. In addition to the scientific and technical problems involved in the establishment of these bacteria in the rumen, the existing regulations about the release of genetically engineered microbes in the atmosphere is also a limitation.
- The genetically modified microorganisms are either able to digest fibrous components and lignins of forage, or degrade toxins, synthesize essential amino acids, reduce ruminal methane production and tolerate acids.
- The second approach would be to introduce new species or strains of microorganisms into the gut.
- The best example of the successful introduction of a new organism (not genetically modified) in the rumen was the introduction of bacteria that was capable of degrading 3- hydroxy-4 (1H)-pyridone (DHP) into Australian ruminants (Wallace, 1994).

Non-Genetic Rumen Manipulation

Microbial feed additives (probiotics)

Use of live microbial cultures (probiotics) is being tried now a days as natural feed additives for enhancing rumen metabolic activity and thereby overall animal production. Supplementation of different probiotics (fungi/yeast and bacteria) resulted in improved nutrient status and productivity of the ruminants under certain conditions.

The utilization of probiotics in farm animals may contribute in the following aspects:

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- Growth promotion,
- Improved feed conversion efficiency,
- Better absorption of nutrients by control of gut epithelial cell proliferation and differentiation,
- Improved metabolism of carbohydrate, calcium and synthesis of vitamins,
- Neutralization of anti nutritional factors i.e., trypsin inhibitor, phytic acid etc,
- Microbial enzyme production, compensating for deficient intestinal enzyme activities of the host,
- Elimination or control of intestinal microorganisms producing sub clinical or clinical diseases,
- Stimulation of non specific and specific immunity at the intestinal level.

In calves, administration of probiotics may be most effective under the following circumstances:

- After birth
- Before and after transportation
- At weaning
- Following over eating or antibiotic administration.

Administration of probiotics in livestock may be most effective under following conditions:

- After birth to encourage the early establishment of beneficial rumen microflora,
- Following antibiotic treatment,
- In the presence of enteric pathogen such as E. coli, Salmonella, Coccidia,
- During environmental or mangemental stress.

In adult cattle, administration of probiotics may become more effective under the situation of:

- Ketosis,
- Antibiotic treatment,
- Bloat,
- Difficult calving.

Probitics for Neonatal Ruminant

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Application of microbial preparation for newborn animals includes dosing or drenching the animals soon after birth or inclusion of direct fed microbial products (DFM) in either milk or milk replacer.

Goals

Similar to those for non ruminants

1. Rapid adaptation to solid feed by accelerating the development of a normal adult intestinal microflora.
2. Avoiding the establishment of enteropathogens.
3. Stimulate the early development of rumen.

The primary goal of inoculating neonates with lactic acid bacteria is to establish a beneficial population of bacteria in the GI tract capable of competing successfully with pathogens. There is evidence of rapid rumen development and faster growth by additions of certain Lactobacillus bacteria in the animal's feed.

Probiotic for Growing Ruminant

Effect of probiotic feeding on rumen function

- **Rumen microbial population:** Yeast feeding has been found to be increase the total number of rumen bacterial population along with higher proportion of cellulolytic bacteria
- **The percentage of Entodiniomorphid:** protozoa decreased and Dasytricha increased in the rumen of yeast culture fed animal
- **Ammonia nitrogen:** Animals consuming yeast culture have lower ruminal ammonia nitrogen concentration and higher microbial protein synthesis.
- **Rumen enzyme profile:** The yeast supplementation in the diet increased the activity of carboxymethyl cellulase enzyme in the rumen of animals.
- **Oxygen scavenger:** Yeasts act as an oxygen scavenger int he rumen. During feed ingestion, some amount of oxygen enters the rumen along with feed and its adversely affect the rumen environment as well as growth of the rumen

Effect of probiotic feeding on animal performances

- **Nutrient digestibility**: Numerical significant improvements have been reported in digestibility .

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- **Milk production**: Positive response on milk production of dry matter, organic matter, crude protein and fibre in yeast fed animals.

Defaunation

- The process of making the rumen of animals free of rumen protozoa is called defaunation and the animal is called defaunated animal.
- Rumen protozoa elimination by defaunation reduces ruminal methane production and increases protein outflow in the intestine, resulting in improve growth and feed conversion efficiency of the animals.

Methods of Defaunation

There are several ways to defaunate the animals and to obtain a ruminant animal free from rumen ciliate protozoa. The different methods of defaunation are:

Isolation of newborn animals:

- Separation of newborn animals from their dams after birth and preventing them from any contact with the adult ruminant animals. The newborn animals should be separated 2 to 3 days after birth

Chemical treatment

- The chemicals which have been widely used to defaunate the animals are copper sulphate, manoxol and sodium lauryl sulphate.
- Chemicals which are used as defaunating agent are introduced in the rumen of animals either orally by a stomach tube or through rumen fistula.

Dietary manipulation

- The ciliate protozoa are very much sensitive to change in rumen pH. The activity ciliate protozoa is adversely affected when the pH of the rumen fall below 5.8 and the rumen pH fall below 5.0, the ciliate protozoa are be completely eliminated. Therefore, offering high energy feed (especially cereal grains like barley, maize to the starved (for 24 hours) animals, creates acidic condition in the rumen and rumen pH fall below 5.0.
- These falls in rumen pH eliminate the ciliate protozoa completely and the animal becomes defaunated.

Area of Future Research

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- Screening of non-conventional animal feeds specially tree leaves for anti-protozoal activity.
- Standardization of defaunation method for its implication at farmer's level.
- New species/ strains of microorganism should be screened to use as probiotic.
- Mechanism of action of probiotic should be studied thoroughly.
- Reduction in methanogenesis to improve availability of digestible energy and reduce environmental pollution.
- Production of suitable strain of recombinant microorganisms and their propagation in the rumen for efficient detoxification of plant toxins, reduction in methanogenesis, higher cellulolysis, reduced ruminal proteolysis (deamination).

Conclusions

Rumen is a natural fermentative anaerobic system which should be manipulated essentially by altering the composition of rumen microflora. There is ample scope to manipulate the rumen by feeding local plants or tree leaves or agro industrial by products to defaunate the animals for improving its productivity. Introduction of naturally occurring microorganism from digestive system of one species to another species for efficient degradation of plant toxins as well as for efficient utilization of nutrients will be one of the major thrust area in near future for rumen manipulation. Genetically manipulation of rumen microorganism for efficient ruminal fermentative digestion has an enormous biotechnological potential.However, in India, more emphasis should be given for manipulating the rumen to increase cellulolytic activity for efficient utilization of low grade roughage.