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DIRECT FED MICROBIAL AND FUNGAL ADDITIVES IN RUMINANTS

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Introduction

Before birth, developing animals are sterile in the womb of their mothers. Upon birth, the digestive tracts of all animals are naturally colonized by a variety of microorganisms. Under healthy and non-stressful conditions, "beneficial" microflora colonizes the rumen and lower gut in a symbiotic relationship with the host. Beneficial rumen and gut microorganisms supply nutrients to the host, aid in digestion of dietary nutrients, and compete with potential pathogens. There is good evidence that the bacterial and fungal probiotics are effective in the manipulation of rumen development and function. More recently, growing concern over the use of antibiotics and other growth stimulants in animal feeds, the potential risk of antibiotic residues appearing in meat and milk, and the need for a food supply that is perceived as safe by consumers, has prompted many livestock producers to explore alternative strategies to enhance the overall health and performance of their herd or flock. Direct-fed microbials (DFM), or probiotics as they traditionally have been called, is one such naturally occurring product that has been incorporated into livestock diets in an attempt to accomplish this objective. DFM, particularly yeast cultures, stimulate growth of rumen bacteria in contrast to ionophores and antibiotics, which are toxic to selective bacteria. Although the total microbial population is increased with DFM supplementation, the cellulolytic and lactic acid utilizing bacteria are stimulated preferentially. Other yeasts and yeast cultures, such as brewers yeast, have been used as supplements in animal feeds for years, primarily due to their high protein and vitamin content.

Direct Fed Microbial

Term direct-fed microbial to describe microbial-based feed additives to fed animals and multitude of claims have been made for various DFM products and combinations.

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1. Improved growth rates by suppression of clinical infections.
2. Improved utilization of feed by promoting digestion of previously indigestible feedstuffs or by increasing the efficiency of existing digestive processes.
3. Improved milk production by dairy cows.
4. Improved animal health by stimulation of the immune system, or increasing the resistance to infectious diseases by direct antagonism.

To be effective, a DFM should meet the following criteria:

1. Be a strain capable of exerting a beneficial effect on the host animal.
2. Be non-pathogenic and non-toxic.
3. Be present as viable cells, preferably in large numbers, although minimum effective dose is unknown
4. Be capable of surviving and metabolizing in the gut environment, e.g., resistant to low pH, organic acids, bile salts, and digestive enzymes.
5. Be stable and capable of remaining viable for long periods under storage and field conditions.

Bacterial DFM

In general, most would agree that DFM based on bacteria must be “live.” Thus, they must survive processing, storage and the gut environment. *Lactobacillus acidophilus*, *L. casei, Enterococcus diacetylactis*, and *Bacillus subtilis* are commonly used as DFM products for ruminants. These organisms appear to have little effect on ruminal fermentation (Ware *et. al.,* 1988) and the site of action from these organisms appears to be in the lower gut but solid and repeatable data is lacking. Initial research with these organisms in ruminants was first centered on “stressed” animals with the general assumption that feeding beneficial organisms would decrease or prevent intestinal establishment of pathogenic microorganisms (Vandevoorde *et al.,* 1991). In ruminants, feeding *lactobacillus*-based DFM to young calves fed milk, calves being weaned or shipped cattle (Jenny et al., 1991) because these conditions were often classified as times of high stress. Calves fed *L. acidophilus* have been reported to have reduced incidence of diarrhea (Beecham *et al*., 1977) and reduced counts of intestinal *coliform* bacteria (Bruce *et al*., 1979). *Megasphaera elsdenii* (ME) is the major lactate-utilizing organism in the rumen of adapted cattle fed high grain diets. However, when cattle are abruptly shifted from a high-forage to high-concentrate diet, the numbers of ME are often insufficient to prevent lactic acidosis. Addition of ME has also experimentally prevented acidosis in steers (Robinson *et al*., 1992). Development of this organism for feedlot cattle, and perhaps high producing dairy cows, should be continued with emphasis on optimizing dose and timing of administration. Success with such an organism could allow feedlot producers to decrease the time it takes to adapt cattle to a high concentrate diet. It could also be useful by reducing chronic acidosis in lactating cows.

Fungal DFM

A variety of mechanisms have been put forth to explain changes in ruminal fermentations and improvements in performance when ruminants are fed fungal-based DFM. For example, yeast may have a buffering effect in the rumen by mediating the sharp drops in rumen pH, which follows feeding. Martin and Streeter (1995) suggested that fungal cultures improve the use of lactate by the ruminal organism *Selenomonas ruminantium* by providing a source of dicarboxcylic acids (e.g., malic acid) and other growth factors. Thus, yeast may help to buffer excess lactic acid production when ruminants are fed high concentrate diets. The effects on buffering are subtle; as added yeast cannot prevent lactic acidosis if the rumen is challenged with a diet rich in fermentable carbohydrates (Aslan *et al*., 1995). However, a higher pH may be one reason for the finding of increased numbers of rumen cellulolytic bacteria and improvements in fiber digestion with fungal cultures (Arambel *et al*., 1987).

DFM for young ruminants

The primary action of DFM appears to be related to enhanced development of rumen function by minimizing growth of pathogenic bacteria, increasing desirable microbial populations in the gut, and facilitating fiber digestion. Live bacteria are required for these processes to occur, meaning the organisms must be capable of surviving processing, remain viable during storage, tolerate the low pH found in the stomach, and then colonize in the gut.

DFM for adult ruminants

There is a tremendous amount of skepticism surrounding the use of DFM in adult ruminant diets. Lactating dairy cows has involved dietary supplementation with either *Aspergillus oryzae* or *Saccharomyces cervisiae*. *Aspergillus oryzae* is a fermentation extract produced from a selected strain of enzyme producing *Aspergillus oryzae*. It has its main effect in the rumen, increasing the population of cellulolytic bacteria, shifting VFA fermentation patterns by a reduction in the proportion of propionate relative to acetate and an increase in butyrate, and stabilizing rumen pH.

Feeding *Saccharomyces cervisiae* tends to result in a reduction in rumen ammonia levels, implying increased growth of rumen bacteria. There were significant increases in dry matter intake, milk production, milk fat percentage and milk protein percentage.

The response to yeast culture appears to be greater when supplemented to lactating cows in early lactation as opposed to cows in mid- or late-lactation. The response in milk yield increases as the ration of forage to concentrate in the diet decreases.

Practical Considerations for DFM

Direct-fed microbial products are available in a variety of forms including powders, pastes, boluses, and capsules. In some applications, DFM may be mixed with feed or administered in the drinking water. However, use of DFM in the latter manner must be managed closely since interactions with chlorine, water temperature, minerals, flow rate, and antibiotics can affect the viability of many organisms. Non-hydroscopic whey is often used as a carrier for bacterial DFM and is a good medium to initiate growth. Bacterial DFM pastes are formulated with vegetable oil and inert gelling ingredients. Some fungal products are formulated with grain by-products as carriers. Some DFM are designed for one-time dosing while other products are designed for feeding on a daily basis. However, there is little information comparing the efficacy of administering a DFM in a single massive dose compared to continuous daily dosing. Tolerance of DFM microorganisms to heat is important since many feeds are pelleted. In general, most yeast, *Lactobacillus*, *Bifidobacterium,* and *Streptococcus* are destroyed by heat during pelleting. In contrast, bacilli form stable endospores when conditions for growth are unfavorable and are very resistant to heat, pH, moisture and disinfectants. Thus, bacilli are currently used in many applications that require pelleting. Over-blending can sometimes compensate for microbial loss during pelleting, but this is not an acceptable routine practice.

SUMMARY

The specific role for many DFMs has not been defined. Animals that have been stressed have a greater response to DFM supplementation than do normal, healthy animals. Thus, until more information is available regarding specific applications, the primary role for supplemental DFM would be following periods of high stress, such as:

1. Neonatal calves
2. Post weaning
3. Following shipping
4. During periods of heat stress
5. During the early postpartum period
6. Following metabolic disorders

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