MICROBIAL FEED ADDITIVES FOR DAIRY CATTLE

by

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The rumen of a dairy cow represents a complex ecosystem, and researchers and nutritionists have been attempting to manipulate this ecosystem through the use of various additives for many years. These additives have consisted of nutrients, micronutrients, enzymes, buffers, metabolic agents, antibiotics and microbials. This paper will briefly address the topic of utilizing direct-fed microbials in the rations of dairy cows.

THE "PROBIOTIC" RATIONALE

During the past 30 years, there has been a great deal of interest in using antibiotics as a method to control the rumen fermentation and to alter the flora of the intestines. However, in recent years, antibiotic additives have come under increasing scrutiny, primarily due to pressure from consumer groups. As a result of this, more emphasis has been placed on maintaining the well-being of animals by adding beneficial organisms to their digestive tracts, rather than exposing the animals to antibiotics. This approach has been termed "probiotic", meaning literally "for life". In 1989 the FDA accepted a purpose statement from the National Feed Ingredients Association which replaced the term "probiotics" with "direct-fed microbials" (DFM), defined as "a source of live (viable) naturally-occurring micro-organisms".

The intestinal tract is sterile at the time of birth, but is inoculated with micro-organisms from the dam's vagina and from the environment. Bacteria and protozoa exist in the normal animal in various symbiotic and parasitic relationships, and these relationships remain relatively stable until they are disrupted by exposure to antibiotics, feed changes, or stress, such as shipping, overcrowding, disease or early lactation. Pathogenic bacteria may become established in the gut and can cause diarrhea, other gastrointestinal disorders and reduced animal performance.

The original hypothesis behind adding DFM bacteria to the ration was to overwhelm and out-compete the pathogens in the gut. However, several alternative modes of action have been proposed, which will be explained later. DFM's also encompass fungal additives such as Saccharomyces (yeast) and Aspergillus, which appear to have a ruminal mode of action rather than intestinal as the bacteria do. The fungi are generally used to enhance animal performance rather than to

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combat a disease or stress situation that already exists. Table 1 lists the organisms that are approved for use as DFM's.

Table 1. Genera of organisms approved by the FDA for use in direct-fed microbials.

Aspergillus	Lactobacillus
Bacillus	Pediococcus
Bacteroides	Propionibacterium
Bifidobacterium	Saccharomyces
Leuconostoc	Streptococcus

THE USE OF SACCHAROMYCES AND ASPERGILLUS IN DAIRY RATIONS

Saccharomyces cerevisiae (SC) has been investigated for its potential effects on milk production ever since Eckles and Williams published a report in 1925 (10). The research has centered mainly on lactational responses, but trials have also demonstrated performance responses in growing calves (1, 27). Table 1 summarizes lactation responses in a number of trials. Many investigators and dairy managers report an increase in dry matter intake when SC is added to the ration. It is possible that the increased production is due largely to this increase in dry matter intake. Some investigators have demonstrated improvements in digestibility of various ration components with SC supplementation and increases in cellulolytic bacteria numbers in the rumen (41).

Table 2. Effect of Saccharomyces cerevisiae on milk production. (Adapted from Kung, 1991 (30)) Note that not all responses are statistically significant.

Reference	Production response, kg/d
Boland, 1986 (6)	+3.2
Didley, 1986 (9)	+1.8
Hoyos et al., 1987 (20)	+1.5
Arambel & Kent, 1988 (3)	-1.4
Bax, 1988 (5)	+2.4
Harris & Lobo, 1988 (21)	+1.0
Quinonez, et al., 1988 (36)	+1.4
Erdman & Sharma, 1989 (11)	-0.7
Gunther, 1989 (19)	+4.9
Huber et al., 1990 (26)	+0.8
Williams et al., 1990 (42)	+2.0
Wohlt et al., 1990 (43)	+1.2
Herrera-Saldana et al., 1991 (23)	+1.9

The rumen environment is not conducive to fungal growth. Arambel and Tung (2) demonstrated that SC numbers did not increase under "in vitro" conditions. However, Dawson and Newman (7) suggested that SC replication was indeed occurring in the rumen. It should be noted that replication is probably not necessary for metabolic activity in the rumen environment. It appears to be the enzymes and metabolites that are either secreted or autolyzed from live cells or released from dead cells and their growth medium that exert the effect of SC additives.

Another fungus that has been used as a supplement for dairy cows more recently is Aspergillus oryzae (AO). Research results are somewhat mixed (see Table 2), and are similar to those obtained from inclusion of SC. As with SC, AO appears to stimulate rumen bacterial growth and efficiency (17), improving bacterial protein yield from the rumen. The effects of both SC and AO may be due to increases in numbers of rumen cellulolytic bacteria and improvements in cellulose digestion (4, 13), and SC may reduce the drop in rumen pH associated with feeding (12). Gomez-Alarcon (18) also demonstrated a tendency for body temperatures to be lower when AO was added to the ration.

Table 3. Effect of Aspergillus oryzae on milk prouction. (Adapted from Kung, 1991 (30).) Note that not all responses are statistically significant.

Reference	Production response, kg/d
Harris, et al., 1983 (21)	-0.4
Van Horn et al., 1984 (38)	+1.1
Huber et al., 1985 (24)	+1.7
Huber et al., 1986 (25)	+0.9
Marcus et al., 1986 (31)	+1.7
Wallentine et al., 1986 (39)	+3.6
Gomez-Alarcon et al., 1988 (15)	+1.7
Kellems et al., 1988 (29)	+1.1
Denigan et al., 1990 a (8)	-0.1
b	+0.3
Sievert and Shaver, 1990 (37)	+0.3

THE USE OF BACTERIA IN DAIRY RATIONS

There has been interest in the use of lactic acid bacteria (LAB) since the Russian scientist Metchnikov (32) noted that Bulgarians who consumed large amounts of LAB-cultured dairy products had lowered incidence of disease and longer life spans. LAB may act in the intestines through several mechanisms: 1) Suppression of undesirable bacteria by production of antibacterial compounds, competition for

nutrients or competition for adhesion sites; 2) alteration of microbial metabolism by increasing or decreasing certain enzyme activities; 3) stimulation of immunity by increasing antibody levels or increasing macrophage activity.

There has been great interest and research in utilizing LAB in farm animals other than dairy, but the data in dairy cows and calves is limited. Gilliland (14) and Pioneer (34) demonstrated reduced incidences of scours and improvements in performance in growing calves. Ware et al. (40) and Jaquette et al. (28) reported an increase of 1.8 kg daily milk production with the addition of LAB cultures to the ration. In a field trial (35) heifers and cows peaked at -0.3 and +3.4 kg milk per day relative to controls when LAB was added.

FUTURE CONSIDERATIONS

It is important to note that there are distinct differences among DFM's offered by various manufacturers. Even though two feed tags may both list Saccharomyces cerevisiae, Aspergillus oryzae or Lactobacillus acidophilus as additives, there are differences in the strains that each company has developed for their product, and these may translate into variations in performance. In the upcoming years, new strains will continue to be developed, perhaps with differing biological activities. The potential also exists to use genetic engineering techniques to develop organisms with new functional capabilities, such as increased enzyme production, providing protection against disorders of the GI tract or even production of nutrients.

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