

A BAMN Publication
**DIRECT-FED MICROBIALS (PROBIOTICS)
IN CALF DIETS**



Introduction

This guide is published by the Bovine Alliance on Management and Nutrition (BAMN) which is comprised of representatives from American Association of Bovine Practitioners (AABP), American Dairy Science Association (ADSA), American Feed Industry Association (AFIA) and United States Department of Agriculture (USDA). The purpose of this publication is to provide the dairy industry with information relative to direct-fed microbials. An animal's digestive system digests and absorbs nutrients from food. However, an animal's gastrointestinal tract is constantly challenged by large numbers of bacteria, viruses, and protozoa found in feed, bedding, and the environment. The gastrointestinal tract has a sophisticated system to counter these potential pathogens consisting of physical, chemical, and immunological lines of defense. Beneficial bacteria (commensal) are an important part of this system.

Commensal bacteria:

- Ferment carbohydrates and produce short-chain fatty acids. Short-chain fatty acids reduce intestinal pH and inhibit the growth of some pathogens. Short-chain fatty acids also promote the growth of intestinal cells and may affect cell differentiation, thereby improving digestion and absorption.
- Provide a barrier effect against pathogens by competitive exclusion, meaning commensal species compete for the same sources of nutrients as potential pathogens. When the commensal bacteria out-compete other bacteria, they effectively restrict the growth of potential pathogens.
- Interact with the animal's immune system. Bacteria in the intestine promote the development of the immune system (both structure and function) in young animals. They also signal the immune system to produce immunoglobulins and other components to maintain the competence of the immune system.

Pathogens, stress, metabolic upset, the use of antimicrobials, and other causes can upset the balance of intestinal bacteria, which may impair digestion and make the animal more susceptible to disease. Thus, providing the animal with bacteria that assists in establishment (or reestablishment) of a normal bacterial profile can help maintain optimal animal performance.

How direct-fed microbials work

Bacteria colonize the intestine of an animal in its first days of life. During normal fermentation, beneficial bacteria produce organic acids: lactic, acetic, or butyric, which lower intestinal pH and inhibit growth of potential pathogens.

Some species of bacteria produce special antimicrobial compounds called bacteriocins, which inhibit the growth of pathogens in the intestine. Recent research also suggests that intestinal bacteria improve the barrier effect of intestinal mucosa and interact directly with the immune system, strengthening the system and protecting the calf against pathogen invasion.

Stress induced by weaning, transportation, changes in diet or weather, or treatment with antimicrobials can negatively affect the normal microflora in the intestine. When normal intestinal microflora are impaired, intestinal defensive mechanisms are upset, making the calf more susceptible to disease.

Direct-fed microbials (probiotics) defined

The terms direct-fed microbials and probiotics are used interchangeably. Probiotics are feed additives that contain microbial species that are considered to be non-pathogenic normal flora. A probiotic is defined as "*a live microbial feed supplement which beneficially affects the host by improving its intestinal microbial balance*" (Heyman and Ménard, 2001). Probiotics are also referred to as "*direct-fed microbials*." The U.S. Food and Drug Administration (FDA) defines direct-fed microbials as "*...products that are purported to contain live (viable) microorganisms (bacteria and/or yeast).*"

Direct fed microbials (or probiotics) refer to living organisms and should not be confused with prebiotics, compounds that promote the growth of gut bacteria (e.g., yeast culture, oligosaccharides) but are not living organisms. It is believed that gut bacteria have requirements for specific nutrients that may not be adequately provided by the animal's diet. Therefore, feeding these nutrients may promote the growth of gut bacteria, thereby improving the microbial profile in the gut.

Synbiotics contain both a probiotic and prebiotic, which work together to promote healthy intestinal flora.

Direct-fed microbials are regulated as feed ingredients by the American Association of Feed Control Officials (AAFCO) and FDA. Both AAFCO and FDA recognize a list of microorganisms appropriate for use in animal feeds. This list is published in the annual *Official Publication* of AAFCO.

Bacteria in direct-fed microbial products are normally listed on the product label under their scientific name (e.g., *Lactobacillus acidophilus*), followed by the content of organism in the product. The content is normally listed as *colony forming units*, or cfu per pound, ounce, or gram of product. See Figure 1 for an example of a feed label containing a direct-fed microbial. Ingredients refer to nutritive and non-nutritive items that are not direct-fed microbials. The figure uses an example of *L. acidophilus*; other organisms may be used in various products.

All organisms in an animal feed must be listed on the label with a guaranteed minimum number of live (viable) organisms per pound, ounce, or gram of feed.

Most direct-fed microbial products utilize one or more of several types of bacteria (Figure 2). Some of these bacteria are commonly used in direct-fed microbial products used specifically for calves, while some are used for other species. Some direct-fed microbial products contain viable yeast and other fungi (ex: *Saccharomyces cerevisiae*, *Aspergillus oryzae*) in addition to bacteria.

Research results

According to USDA's National Animal Health Monitoring System's (NAHMS) Dairy 2007 study, 20.0 percent of dairy and heifer operations used direct-fed microbials for preventive purposes, an increase from the 14.4 percent that did so in 2002.

Use of direct-fed microbials in humans and animal species such as young pigs has been widely reported in the scientific literature. Numerous studies have shown that humans or animals fed direct-fed microbials have altered intestinal bacterial populations, improved resistance to disease, reduced shedding of pathogens when challenged orally, increased intestinal immunity, reduced disease symptoms, and improved health. However, research on the effects of direct-fed microbials on young calves is much less clear. The following is a summary of published studies that have evaluated various direct-fed microbial formulas in the diet of unweaned calves.

Abe et al. (1995) reported that performance was improved (decreased scouring and improved growth) when probiotic bacteria (*Lactobacillus acidophilus* and *Bifidobacterium pseudolongum*) were fed. Timmerman et al. (2005) fed two different direct-fed microbial formulations to 1- to 2-week old veal calves in four different experiments. Results from all four experiments suggested that direct-fed microbials increased growth and feed efficiency in calves during the first two weeks. This appeared to be especially true when calves were stressed and disease incidence was significant. Ellinger et al. (1980) reported that feeding *L. acidophilus* to calves decreased the content of fecal coliforms, which may be related to presence of scours. Finally, Adams et al. (2008) suggested that a novel direct-fed microbial (*Propionibacterium jensenii* 702) resulted in greater body-weight gain, not only during the milk feeding period (the bacterium was added to milk), but also after weaning.

Figure 1. Example label for a feed product containing a direct-fed microbial*.

Net Weight Shown On Bag
Blue Bird Direct-Fed Product

Contains a source of live (viable), naturally occurring microorganisms

GUARANTEED ANALYSIS:
Lactic acid bacteria.....200 billion CFU/lb (list each organism in order of predominance) OR
Lactobacillus acidophilus..... 10 billion CFU/lb

INGREDIENTS: (Each ingredient must be specifically named in accordance with names and definitions adopted by AAFCO. Collective terms as approved by AAFCO may be used where applicable.)

DIRECTIONS FOR USE: (Directions for use and guaranteed analysis must be stated in the same units.)

Manufactured by:
Company Name

*Source: Direct-fed Microbial, Enzyme & Forage Additive Compendium. <http://www.microbialcompendium.com/reg.pdf>. Accessed 12/10/10.

Figure 2. Examples of bacteria used in direct-fed microbial products for calves.

- *Lactobacillus acidophilus*
- *L. lactis*
- *L. plantarum*
- *L. casei*
- *Bacillus subtilis*
- *B. licheniformis*
- *Enterococcus faecium*
- *Bifidobacterium bifidum*
- *B. longum*
- *B. thermophilum*

On the other hand, Harp et al. (1996) reported that feeding direct-fed microbials to dairy calves challenged with *Cryptosporidium parvum* had no effect on fecal scores or oocyst shedding. Others (Abu-Taroush et al., 1996; Jenny et al., 1991; Morrill et al., 1995; Higginbotham et al., 1998) also reported that direct-fed microbials had no effect on the health or growth of calves. Morrill et al. (1977) fed *L. acidophilus* and *L. lactis* added to milk, incubated for 24 hours, then fed to calves. These authors reported reduced starter intake and a trend for looser stools than calves fed non-cultured milk. Finally, Cruywagen et al. (1996) reported no significant effect of adding *Lactobacillus acidophilus* to young milk-fed calves. It is likely that variation in responses is a function of interactions between diet, the degree of the pathogen challenge and other stressors.

To summarize these research findings, most data suggest that improvements in animal performance (increase in body-weight gain, efficiency) may be limited in young, milk-fed calves. Rather, it appears that direct-fed microbials may be most useful under specific conditions whereby calves are exposed to immune or management challenges that may disrupt the intestinal environment. Under stress conditions, direct-fed microbials may reduce the risk or severity of scours caused by an upset in the normal intestinal flora of calves.

Using direct-fed microbials on-farm

Although direct-fed microbial products may, in theory, improve gut microflora, application on the farm can be more challenging. Direct-fed microbials are most commonly added to a calf's liquid diet, i.e., milk or milk replacer. Adding direct-fed microbials to pelleted feeds is difficult, as temperatures and pressures used in pelleting generally kill most organisms. Most direct-fed microbial products for calves are sold as feed additives, which are added to milk or milk replacer just prior to feeding, while others are administered as gels, pastes, or boluses. Although some products contain purified strains of individual organisms, most products are a combination of several species of bacteria and yeast and other fungi. Typical feeding rates range from one or two grams to several ounces per day.

Considerations when using direct-fed microbials on-farm

Strain selection. Most published research has been conducted with well defined individual strains or limited combinations of bacteria. Most modern direct-fed microbial products are combinations of several bacteria, and sometimes yeast, which make it difficult to determine what organism, if any, contributes to an improved response. Further, different strains of specific organisms (e.g., *Lactobacillus acidophilus*) may respond differently to other strains in the intestinal environment. Companies marketing direct-fed microbial products should research specific organism(s) in the product.

Storage. All direct-fed microbial products contain living organisms. Therefore, the manner in which products are manufactured, shipped, stored, and handled is very important. Conditions that can kill direct-fed microbials include storage for long periods, high temperatures, low temperatures, direct sun, high humidity, oxygen, presence of mineral premixes, and others. Over time, organisms will die and product effectiveness will be lost. Be sure to follow the manufacturer's recommendations for storing direct-fed microbial products. Many commercial laboratories test for total counts of viable organisms; however, monitoring growth of specific species of bacteria is more difficult.

Water. Chlorination, temperature and mineral content of water may affect viability of direct-fed microbials.

Mixing with milk replacer. Be sure to follow the manufacturer's recommendations on including in milk replacer, since high water temperatures used with some milk-replacer formulations (particularly those used in the veal industry) may kill some direct-fed microbial products.

Antimicrobials. Antimicrobials in milk replacer or waste milk may interfere with the action of direct-fed microbial products. In addition, use of ionophores (Bovatec[®] or Rumensin[®]) may interfere with the action of some direct-fed microbial products.

Pasteurization. All direct-fed microbial products should be added to waste milk only after pasteurization and after the milk has cooled to feeding temperature.

Quality assurance. It is difficult to determine whether or not the bacterial products you are purchasing are viable (alive). Private laboratories conduct total-plate counts for bacteria and yeast/molds, which may not accurately reflect viable bacteria counts. Many direct-fed microbial products contain several types of organisms, some of which are more sensitive to storage conditions than others. Therefore, it is difficult to determine which organisms are alive in a sample of direct-fed microbials tested for total cell counts.

Cost Benefit. Since there is wide variation in the cost of direct-fed microbials, a cost-benefit analysis is recommended when deciding to introduce direct-fed microbials as a feed additive.

Summary

Adding direct-fed microbials to milk or milk replacer may support calf intestinal integrity and overall health. Most research has reported little effect of direct-fed microbials on animal growth or feed efficiency. Rather, improved intestinal bacterial flora may reduce the risk of diarrhea, particularly when animals are exposed to significant immunological, environmental or other stressors.

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Publication Date 2011

AGN10P40599