Application of lactic acid bacteria, yeast and bacillus as feed additive in dairy cattles

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Abstract

Probiotics act positively on rumen feed digestion and ruminant production as feed additive, these additives are diverse and exerting their action through different mechanisms. This review gives an overview of the probiotics feed additive and summarizes the current status of lactic acid bacteria, yeast and Bacillus which are the most common used feed additive to improve milk performance and health in dairy cattle. This yields a comprehensive idea of the reviewed studies on lactic acid bacteria, yeast and Bacillus to enhance further research in dairy cow industry.

Key words: Lactic acid bacteria, yeast, Bacillus, feed additive.

Introduction

Probiotics, defined as “live microbial feed supplements” which beneficially affect the host animal by improving its microbial balance have been proposed for several decades 1-5. The most commonly used probiotics in dairy cattle often fall into three categories according to the category of microorganism: (1) yeast preparation; (2) lactic acid bacteria preparation; (3) Bacillus preparation. These probiotics are primarily targeted for enhancing intestinal health, improving milk production and feed conversion efficiency 6, 7. Dietary supplementation of appropriate amount microecological preparation cannot only improve and optimize the microecological environment in rumen, but have no drug resistance due to abuse antibiotic and drug residues in animal 8.

In recent years, many microecological preparations were used widely in animal production as “rumen microecological regulator” in ruminant animals. Generally speaking, these probiotics can be used as “green” feed additive to improve production, feed efficiency, intestinal health and safety of dairy production 9-11.

One purpose of this review is to summarize the current status of lactic acid bacteria, yeast and Bacillus which are most common used as feed additive in dairy cattles. In addition, microecological preparations were used widely as feed-additive in poultry enterprise, which are one of the most promising alternatives to antibiotics, therefore, the other purpose of this paper is offering support to some extent for researchers to explore alternatives to antibiotics.

Yeast: Yeast products are most widely utilized in the dairy industry 12. Yeast cells in the rumen create better conditions for the growth of anaerobic cellulolytic bacteria by using the traces of available oxygen on the surfaces of freshly ingested feed, and stimulate their attachment to cellulose particles 13, 14. The mechanism that yeasts can improve rumen bacterial growth and protein synthesis, bacterial enzymatic activities, digestion of fibre, voluntary feed intake and animal production can be explain as Fig. 1 describes.

Yeast preparations are often fed as live or dead products with or without fermentation extracts as feed additives. Desnoyers et al. 15 reported that yeast supplementation increased DMI, milk yield, and fat-corrected milk, it also increased rumen pH and VFA concentrations, and decreased the rumen lactic acid concentrations. In addition, application of yeast culture in diet of dairy cattle at mid-lactation also has good effects on increasing milk production and improving milk quality 16, 17. Yeast preparations are also used in in vitro fermentation, researchers have found that addition of Saccharomyces cerevisiae to fermentations decreased lactate accumulation and methane production. In vivo studies show that Saccharomyces cerevisiae increased DMI and milk production 18, 19. Collectively, the evidence supports the fact that yeast preparation improves milk production and production efficiency in dairy cows.

Lactic acid bacteria: Lactic acid bacteria (LAB) are characterised by their production of lactic acid and are predominant participants in many industrial and artisanal plant, meat and dairy fermentations. The most widely used probiotic strain in the cattle industry belongs to Lactobacillus 20. Many studies are concerning on in vitro fermentation to explore the effects of lactic acid bacteria inoculants on in vitro digestibility and improve nutritive value of forage 21, 22.
At the rumen level

- O2 uptake
- Micronutrient supply (peptides, vitamins, malate)
- Glucose uptake (competition with bacteria)
- Lactic acid metabolism by bacteria
- pH stabilization
- Lactate-utilizers, cellulolytic bacteria (protozoa, fungi)
- Polysaccharide depolymerases
- Rate of OM digestion

At the animal level

- Feed intake
- Remove of toxicants (chemicals, pathogens)
- Risk of acidosis
- Energy and amino acid supply
- Health disorders
- Improved animal productivity

*Figure 1. Proposed model to describe the action of yeast in the rumen and consequences for ruminants.*

Lactobacillus plantarum, Enterococcus faecium, and various Pediosoccus species are often added to forage crops at the time of ensiling to improve the ensuing fermentation. Liu et al. found that compared to untreated corn silage, corn silage treated with LAB can increase the milk yield, simultaneously increasing the milk protein and total non-fat solids content of milk significantly (p<0.05). In in vivo studies, Jiang et al. found that dietary supplementation of Lactobacillus can significantly increase the milk production compared control group, and reduce the count of somatic cells. Besides, Lactobacillus culture has the ability to reduce mastitis, it may be link to stimulation of the immune response through up-regulation of interleukin-1 (IL-1) and IL-8 in the mammary gland. Bacillus: At present, Bacillus is used for dairy industry as microecological additive mainly including Bacillus subtilis, Bacillus licheniformis and Bacillus subtilis natto. Researchers found that Bacillus subtilis supplementation had no significant effect on rumen fermentation characteristic, duodenal microbial N flow and ruminal apparent nutrient digestibility (p>0.05), and had no effect on milk yield and milk protein. Moreover, other researchers found that Bacillus subtilis spores not only increased antibody level and T cell responses to a co-administered antibody antigen, but also broadened them. These characteristics of Bacillus subtilis are very important for dairy cattle to enhance their health and milk safety. Adding Bacillus licheniformis into the diet for calves increased average daily gain of calves in the trial of 0-8 weeks and body structure index at the end of the trial. Meanwhile, Bacillus licheniformis supplementation increased milk yield and milk protein compared with control group, but percentage of milk fat and lactose was not significantly different between treatments (p>0.05). In addition, in vivo studies, Bacillus licheniformis increased ruminal apparent nutrient digestibility of neutral detergent fibre, acid detergent fibre, and organic matter (p<0.05), it also increased microbial crude protein flow into duodenum (p<0.05), total VFA, and acetate concentration in ruminal fluid, but decreased the ammonia nitrogen concentration in ruminal fluid.

In term of Bacillus subtilis natto, a culture of Bacillus subtilis natto promotes development of the rumen in calves, it makes rumen covering with more soft, flexible, tongue-like papillae at rumen wall. Meanwhile, researchers reported that Bacillus subtilis natto spores were able to survive in rumen and alter rumen fermentation pattern. However, the spores cannot permanently colonize in the gastrointestinal tract of Holstein dairy cows. Other researchers also found that Bacillus subtilis natto fermentation product was effective in increasing lactation performance of early lactation dairy cows. These studies demonstrate that B. subtilis natto alters rumen fermentation pattern and has a positive effect on lactation performance through promoting development of the rumen.

Conclusions

We are sure that the probiotics will be used as widely as the prebiotics for animal production, since probiotics have the similar function as prebiotics. Taking this review into consideration, we can conclude that supplementation of lactic acid bacteria, yeast and Bacillus, respectively, improve animal performance, stimulate immune response and maintain dairy cattle health as the functional amino acids. As the relationships among them are still not fully understood, their combined application are not discussed in this review. Probiotics, at least in some cases, improve the efficiency of milk production in dairy cows. In recent years, with the development of molecular methodologies, advance in molecular methodologies will offer a more precise analytic approach to analysis the rumen microflora and the intestinal microbial ecosystem which can help us understand the mode of action better.
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