

Dietary Pattern Effects Of Probiotics On Health And Productivity Of Livestock...Review The Field Studies

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Abstract:

The long-term use of antibiotics has led to the emergence of drug resistance, threatening the health of animals and consumers alike and harming the environment. Therefore, researchers have been working on the use of beneficial microorganisms or substances that can benefit these microorganisms for proper functioning, called probiotics and prebiotics, as well as the synergistic interactions called synbiotics. Probiotics act as a nutritional supplement; they are live therapeutic agents that enhance immunity, reduce the need for antibiotics, and decrease the incidence of infections and diseases. Probiotics achieve internal balance in the microbial ecosystem, improving the microbial ecology of the digestive tract, which enhances feed conversion efficiency. This promotes healthy growth and enhances milk production. Probiotic supplements have also been shown to improve cognitive behavior and reduce stress. This review presents previous field studies about probiotics, prebiotics, and synbiotics, and discusses their potential as a promising nutritional model for maintaining livestock health, increasing production, and protecting consumer and environmental health. Furthermore, this study identifies the criteria for these substances to be adhered to.

Keywords: Probiotics, Prebiotics, Synbiotics, Nutrition, livestock health

INTRODUCTION

Continuous population growth requires increased availability of plant and animal food. Therefore, scientists are seeking solutions that enable increased food production rates while simultaneously reducing costs, meeting the highest quality and safety standards, and ensuring consumer and environmental protection. Animal production is in contact with consumer nutrition and health, as animal intestinal pathogens, such as *Campylobacter*, *Salmonella*, *Listeria*, *Yersinia*, and *Clostridia*, represent a direct source of food contamination and the cause of numerous zoonosis diseases (2,3). The extensive development of livestock husbandry methods has led farmers to use feed additives that ensure superior growth rates, protect animal health from infectious pathogens, and improve other production parameters, such as feed metabolic efficiency and the quality of meat, milk, and eggs. The main reason for using these additives is to achieve effects similar to those of growth promoters such as antibiotics, which were banned by the European Union on January 1, 2006 (1).

The intestine contains a complex and dynamic microbial ecosystem with several key functions. The first and most important function is the ability of this ecosystem to protect the host from intestinal disorders. Unfortunately, the ability of natural bacteria to combat intestinal infections is not always effective. Adding other bacteria (probiotics) to the intestinal microflora has been shown to support and help treat infections. The use of probiotics dates back more than 100 years, specifically to Metchnikoff (8). The modern global economy and intense market competition have led to the need to introduce new technologies for animal nutrition. Numerous scientific reports confirm the positive impact of probiotics on ruminant's health, particularly about protection against pathogens, stimulating the immune response, and increasing production capacity. Scientific and technological developments have even led to the use of prebiotics with probiotics or synergized support effects, which are called synbiotics. The action of prebiotics can be likened to the effect of sugars used in fermenting grass, with less methane released compared to fermenting feed without sugars. Furthermore, energy-rich feed increases feed intake by ruminants and reduces feed retention time, thus reducing methane emissions. Manipulating rumen fermentation involves the use of a variety of chemicals that influence the microbial community in the rumen, potentially reducing methane production and increasing reductive acetate formation. The end product of carbon dioxide and hydrogen is acetate, not methane. This can reduce greenhouse gas emissions and improve the energy efficiency of feed (6).

This review presents previous field studies about probiotics, prebiotics, and synbiotics, and discusses their potential as a promising nutritional model for maintaining livestock health, increasing production, and protecting consumer and environmental health. Furthermore, this study identifies the criteria for these substances to be adhered to.

Definition of Probiotic

The term "probiotic" comes from two Greek words: "bios" and "pro," meaning "for life, current definition was formulated in 2002 by the Food and Agriculture Organization and a World Health Organization expert as "carefully selected strains of live microorganisms that when used in sufficient quantities, it provides probiotics, the health benefits microorganisms (29). The most important criteria are:

1- Microorganisms used in the production of probiotics must be isolated from animals belonging to the species for which they are intended to be used, to demonstrate their health benefits, especially species-specific. Therefore, the obtained biological materials must be as adapted as possible to the digestive conditions of these animal species (35).

2- To enhance the effectiveness of probiotics, the appropriate bacterial strains must be selected with the correct dosage.

3- Probiotics added to feed must be resistant to the temperatures and pressures used in treating processes, as well as to humidity and the influence of harmful substances (such as heavy metals or mycotoxins) during feed preparation, handling, and, especially, storage (22).

4- It is essential to assess the safety and health risk levels of the strains used in probiotic preparation and ensure that they contain an appropriate number of live cells. They should have a beneficial effect on host health, which may also include stimulating growth, enhancing digestive functions such as cholesterol and lactose metabolism, and boosting immunity against pathogens such as *Helicobacter pylori* and *Candida albicans*, in addition to containing anti-mutagenic and anti-cancer properties (23).

Probiotics: the mechanism of action

The mechanism of action of probiotic microbes as feed additives is not yet fully understood. However, it has been found that these microorganisms adhere to the digestive tract wall and can survive under adverse conditions, promoting the stability and protection of the intestinal ecosystem. They also influence the digestive and metabolic processes, as well as the immune response. Therefore, the properties of probiotics can be summarized in their ability to improve animal health, increase productivity, and enhance immunity by restoring the function of the mucosal barrier in the digestive tract and improving intrinsic immunity through increased antibody production and Phagocytic activity. The lumen of the gastrointestinal tract contains essential nutrients and beneficial microorganisms, as well as pathogenic microorganisms, toxins, and some foreign antigens. The epithelial cells of the intestinal mucosa selectively establish a permeable barrier between the environment of the lumen and body tissues. This barrier represents the host's first line of defence against harmful microbes in the gastrointestinal tract (intestinal innate immunity), but factors such as stress or disease conditions can disrupt this barrier. Probiotics enhance the function of the intestinal barrier by modulating the phosphorylation of cytoskeletal proteins and narrowing junction proteins, increasing the effectiveness of intestinal interactions and cellular stability. It's worth noting that probiotics can suppress the immune response in other conditions, such as allergies and autoimmune diseases. Studies have also shown that probiotics can stimulate microflora in the intestines (32, 37).

Probiotics products: A live microorganisms

Probiotic products may contain one or more selected microbial strains. It should be noted that the microorganisms used as food supplements in the European Union are predominantly bacteria, often Gram-positive bacteria belonging to the following genera: *Bacillus*, *Enterococcus*, *Lactobacillus*, and *Streptococcus*. Some fungi and yeast strains are also used as probiotics, such as *Saccharomyces cerevisiae* and *Kleuveromyces* (37).

Bacteria belonging to the genera *Lactobacillus* and *Enterobacter* are normal microorganisms in the gastrointestinal tract of animals and are typically found in large quantities, ranging from 10^7 to 10^8 CFU/g and 10^5 to 10^6 CFU/g, respectively. Although most of the microorganisms mentioned are safe for the host, some can cause problems. For example, *Enterobacteriaceae* may be involved in transmitting antibiotic resistance, while *Bacillus cereus* produces diarrheal and emetic toxins. The

recommended dosage for most probiotics is 109 CFU/kg of feed. Off-the-shelf probiotic formulations for animals typically contain one, two, or more strains of microorganisms (4).

Probiotics: In animal husbandry

The use of probiotics in animal nutrition is linked to their proven effectiveness in modifying the gut microbiota and maximizing the utilization of the feed provided, leading to weight gain and improved growth rates in various animals, such as turkeys, poultry, pigs, sheep, goats, cows, and horses. Also, probiotics have significant benefits for digestion, particularly in cellulite breakdown and microbial protein synthesis. In a study in sheep, the use of probiotics in late pregnancy and lactation resulted in increased weight gain in lambs, while experimental results indicated that the use of probiotics in animal nutrition improved the quantity and quality of milk, meat, and eggs (fat and protein). In a study of cows, the fungus *Aspergillus oryzae* was added to corn rations, which led to an increase in milk protein content. In newly weaned young farm animals, the main expected effect of probiotics is a reduction in the incidence of diarrhea. The use of probiotics in combating diarrhea is one of the most studied aspects. The absence of side effects is also an important factor (19, 34). The most important reasons for using probiotics are shown in Figure (1), The two most important purposes of probiotics in livestock feed are to balance beneficial microbes in the gastrointestinal tract, which plays a critical role in its health; and to stimulate the host immune response, such as stimulating peripheral blood mononuclear cells (PMBCs) and cytokines, and producing a series of immune regulatory molecules by intestinal cells when stimulated by bacteria. Or, to inhibit pathogenic bacteria by producing a variety of substances that inhibit both Gram-positive and Gram-negative bacteria. These inhibitory substances include organic acids, hydrogen peroxide, and bacteriocins, thereby improving the animal's immunity and increasing disease resistance (27, 33, 9, 20). Beneficial probiotic strains of *Lactobacillus* have been isolated from the vaginal tract and mammary gland of cows, and from the oral cavity of newborn calves. Strains isolated from the vaginal tract have been shown to produce hydrogen peroxide, while strains capable of producing organic acids have been isolated from the mammary gland. Competitive exclusion of microorganisms is an important method for the prevention of intestinal diseases caused mainly by *Escherichia coli* and *Salmonella* to prevent and control of diarrheal syndromes in newborns, as an alternative to previously used antibiotics. Probiotics are also used as a nutritional technology to support animal health during difficult physiological periods, or to alleviate psychological stress such as pregnancy, postpartum, or when dietary patterns change (19). Probiotic bacteria may have a direct effect on pathogenic bacteria through their presence in the intestine and the secretion of antimicrobial substances, such as secretion of a protein called BIF, secreted by *B. longum* BL 2928, which is effective against Gram-negative bacteria, as it inhibits the interaction between *E. coli* and epithelial cell lines. It inhibits the interaction between *E. coli* and human epithelial cell lines. *Bifidobacterium* strains (CA1 and F9) secrete a lipophilic compound with potent antimicrobial activity against *S. typhimurium* SL1344 and *E. coli* 1845 (30). Laboratory studies have shown the effectiveness of lactic acid bacteria in eliminating or inactivating pathogenic bacteria. Laboratory studies on cell lines have helped study how probiotics adhere to the intestinal epithelium. These cell lines have different phenotypic characteristics in the intestinal epithelium and have been widely used, particularly in humans. Their use is explained by the fact that they mimic the intestinal barrier that pathogenic microorganisms must cross to infect the body, and then reach the systemic circulation to reach different parts of the body (21).

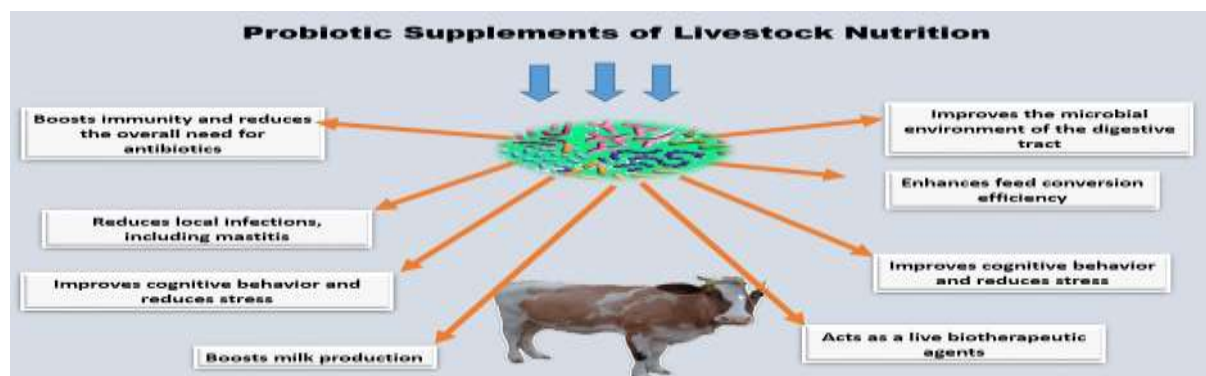


Figure 1: Importance of probiotic supplements in livestock nutrition

Probiotics for bovine

In bovine, the primary purpose of using probiotics is to prevent and control gastrointestinal disorders especially, diarrhea in newborns, lactation period, through the influence of rumen nutrient metabolism, and stimulate the activity of rumen microorganisms, helping to maintain health and improve production performance. For more than 30 years, numerous scientific papers have demonstrated that live yeast improves the health and productivity of ruminants as a natural alternative to influence animal performance. The reported effects include increased feed intake, milk production, and body weight gain (28). The study suggested the benefit of yeast in manipulating rumen fermentation and ruminant productivity. *Saccharomyces cerevisiae* was found to have a growth effect on bacterial communities, whose mechanism of action in the rumen is to improve digestion and reduce acidity. Yeast also provides some vitamins necessary for growth and development (7). Gastrointestinal disorders (diarrhea) are the leading cause of morbidity and mortality in newborn calves. Several studies have demonstrated the effectiveness of probiotics in treating these syndromes, observing their effect in restoring the digestive flora to normal function (10). They also found that vaginal lactic bacteria isolated from cows, instead of traditional antibiotic treatment, were used as a probiotic to treat postpartum uterine infections in cows (25). The specificity of feeding dairy cows large amounts of acidic silage and concentrates leads to the formation of organic acids that exceed the rumen's natural buffering capacity, leading to a pH drop below (6). Ruminant acidity causes discomfort in cows, loss of appetite, and a decrease in digestibility and milk production. Probiotics are bioregulators that can prevent a drop in rumen pH by increasing the utilization of lactic acid by some rumen bacteria (5). Postpartum carbohydrate intake often leads to the establishment of high amounts of organic acids in the rumen that exceed its buffering capacity, leading to a pH drop. It was found that its administration by feeding the microorganism *Prevotella bryantii* (25A) in these animals leads to normalization of rumen pH and then re-establishment of normal digestion (18).

Probiotics for ovine

In sheep, probiotics are particularly used to prevent and combat pathological conditions arising from digestive imbalances. The development of pathogenic bacteria and digestive metabolic disorders are associated with an imbalance in the gut microbiota. Probiotic bacteria in the gut can prevent the adhesion of pathogenic bacteria by providing a barrier between the pathogen and the intestinal epithelium. Adding *Streptococcus faecalis* bacteria to the daily diet has been found to improve gut health. Introducing intestinal bacteria such as *L. faecium*, *L. acidophilus*, *L. casei*, *L. fermentum*, and *L. plantarum* into the diet of lambs infected with *E. coli* resulted in a reduction the presence of pathogenic strains, in addition to improved growth performance and meat production (24).

Bacteria and yeast can play a role in restoring the balance of gut bacteria by stimulating the microbiota. This effect is demonstrated in a study that found administering *Sacharomyces cerevisiae* (strain CNMC 1-1077) may stimulate the growth and activity of cellulose-degrading bacteria in lambs (12,13). Three strains were used, either individually or in combination, in young sheep during the pre-rumination phase: *Kluiveromyces marximanus* NRRL-3234, *Saccharomyces uvarum* ATCC-9080, and *Saccharomyces cerevisiae* NCDC-42. The effect of probiotics on rumen fermentation in sheep was measured by direct rumen administration of *Saccharomyces cerevisiae* (50 mg/day) and *Aspergillus oryzae* (3 g/day). Both probiotics and protozoa stabilized rumen pH after feeding, maintaining pH at approximately 6 for a prolonged period. Ammonia nitrogen concentration increased significantly in the presence of protozoa and probiotics (24).

Prebiotics

They are natural products used as feed additives. They are a group of different nutrients, such as pectin, cellulose, and xylan. Prebiotics do not require complete digestion, metabolism, or conversion rather, they stimulate targeted metabolic processes, resulting in health benefits for the host ecosystem. Prebiotics include non-absorbable carbohydrates (oligosaccharides and polysaccharides), peptides, proteins, and lipids. Legumes, fruits, and grains are natural sources of prebiotics (31).

A commonly used prebiotics are Gluco-oligosaccharide, fructose-oligosaccharide (FOS), trans-galacto-oligosaccharide (TOS), glyco-oligosaccharide, lactulose, xylooligosaccharide, stachyose, raffinose, and lactitol, malto-oligosaccharide. When these substances reach the large intestine, they become nutritional substrates for beneficial intestinal bacteria (36).

The biological properties of prebiotics

- 1- Undigested (or only partially digested)
- 2- Not absorbed in the small intestine
- 4- Not fermented by bacteria in the oral cavity and are well fermented by beneficial intestinal bacteria
- 4- Not fermented by potential pathogens in the intestine (38)

When designing prebiotics, it is essential to determine the appropriate dosage, as an overdose of prebiotics can lead to gastrointestinal disturbances, flatulence, and diarrhea. The advantages of prebiotics include their long-term use as a preventative measure, and they do not cause any harmful side effects as with antibiotics (16).

Principles for Selecting Prebiotics:

To identify a substance and prove it is a potential prebiotic, we must know its source, origin, purity, and chemical composition. Prebiotics must meet the safety standards required by all countries. They must be generally safe, be available in an appropriate dosage, have minimal side effects, be free of contaminants and impurities, and not negatively affect the gut microbiota (11). The basic criteria for classifying food ingredients as prebiotics:

- 1- The prebiotic must be resistant to digestion in the upper gastrointestinal tract.
- 2- The prebiotic reaches the large intestine, where it is selectively fermented by the targeted beneficial gut bacteria, thereby positively impacting the gut microbiota.
- 3- The fermentation process must lead to metabolic changes, including improved immune system function (14).

Synbiotics

The term "synbiotic" refers to the production of a combination of probiotics and prebiotics, instilling the probiotic in the gastrointestinal tract and enhancing its survival through the presence of selective activators. Synbiotics possess properties of both probiotics and prebiotics and were designed to overcome some of the potential difficulties probiotics face in surviving in the gastrointestinal tract. Probiotics positively influence intestinal balance, while prebiotics provide energy and nutrients for the probiotic bacteria. Therefore, the appropriate combination of both components in a single product ensures a significantly better effect than using either the probiotic or prebiotic alone. The health-promoting effects of synbiotics in modulating the gut microbiota in animals appear promising (17).

CONCLUSION

Animal farming has entered an era in which the use of antibiotics or other pharmaceutical products has become increasingly undesirable, especially after their ban in the European Union as a feed supplement. Probiotics are primarily used in livestock to treat various gastrointestinal disorders, particularly during difficult physiological periods such as pregnancy, postpartum, and newborns, or when feeding patterns change according to the season. Given the limited clinical trials, we recommend further clinical studies on the use of probiotics to treat various gastrointestinal disorders in farm animals.

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