

The Effect of Probiotics on Animal Health

REVIEW

Nicolae Corcionivoschi¹, Dan Drinceanu², Ioan Mircea Pop³, Deirdre Stack¹, Lavinia Ștef²,
Călin Julean² Billy Bourke¹

¹*The Children's Research Centre, Crumlin Road, Dublin 12 and The School of Medicine and Medical Science,
University College Dublin, Dublin, Republic of Ireland*

²*Banat's University of Agricultural Sciences and Veterinary Medicine, Faculty of Animal Sciences and
Biotechnology, Timisoara, Romania*

³*"Ion Ionescu De La Brad" University of Agricultural Sciences and Veterinary Medicine, Iasi, Romania*

Abstract

The mechanisms of action of probiotic bacteria and their effect in combating digestive disorders in humans and animals has been demonstrated and supported in numerous scientific studies. Probiotic bacteria are used in a wide range of nutritional techniques in order to support the host organism during physiological strain, to reduce stress due to technology and to combat diarrheal syndromes (occurring naturally or pharmacologically induced). Based on a rich bibliographic material, this paper presents the role of probiotic bacteria to equilibrate the beneficial microbial population and in bacterial turnover by stimulating the host immune response via specific secretions (eg. bacteriocins) and competitive exclusion of potentially pathogenic germs in the digestive tract (Salmonella, E. coli). In the same context, this review presents the basic studies on the effect of probiotic bacteria in health maintenance for the main species of farm animals: pigs, poultry, cattle and sheep.

Key words: probiotic bacteria, mechanisms, farm animals

1. Introduction

The intestine harbours a complex and dynamic microbial ecosystem that has several major functions. The first and the most important function is represented by ability of this ecosystem to protect the host from intestinal disorders. Unfortunately the ability of natural flora to fight intestinal infections is not always effective. Supplementation of intestinal microflora with probiotic bacteria was proven to support and help treating infections at that level. Probiotic therapy is back dated over 100 years ago to Elie

Metchnikoff [1]. Studies show that commercial probiotic consumption often increases specific intestinal microflora, but usually not the total count of bacteria found in the intestine. The effects on animal health are summarised in figure 1.

The main arguments for the use of probiotics in preventing and combating digestive disorders in animals are:

(i) Their role on the balance and multiplication of the beneficial microbial population in the gastrointestinal tract that has a very important role in the "digestive health" [2]; these food supplements have been demonstrated to alter the pre-existing intestinal flora so as to provide an advantage to the host. As we have previously stated probiotics are able to influence the function and composition of the intestinal microbiota. These effects are mainly metabolic in nature at

* Corresponding author: Nicolae Corcionivoschi
The Children's Research Centre, Crumlin Road, Dublin
12, Republic of Ireland, Tel: +35314096597,
Fax: +35314550201, nicolae.corcionivoschi@ucd.ie

specific sites with specific metabolic activity (eg. in the gut) [3].

(ii) Stimulation of the host response such as stimulating specific proliferative response of PMBC (peripheral blood mononuclear cells [4]; Most of immune mechanisms are extremely important in inflammatory diseases at the intestinal level. Probiotics have the ability to shape the immune system by their physiological action in the intestines. Upon colonising in the gut they will trigger an immune response because the intestinal cells can produce a series of immunoregulatory molecules when stimulated by bacteria. In piglets it was shown that the ratios of peripheral blood mononuclear cells (PBMC), cytokine production of PBMCs have an effect on vaccination responses. In this context some recent literature shows that *B. cereus var. toyoi* alters the immune status as well as functionalities of systemic immune cell populations [5].

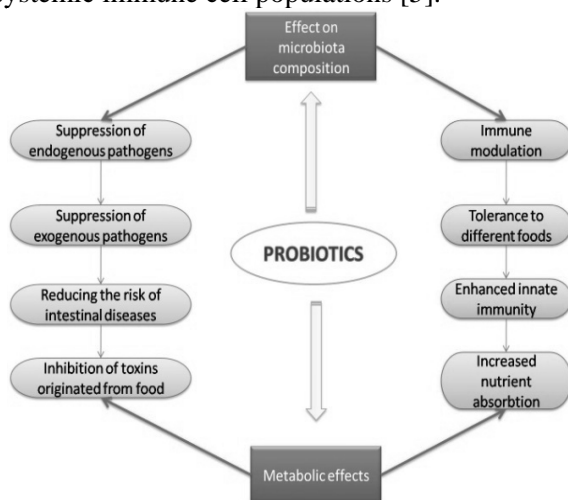


Figure1. Probiotics effect on animal health

(iii) Inhibition of the potential pathogenic bacteria by producing a variety of inhibitory substances to both Gram-positive and Gram-negative bacteria. These inhibitory substances include organic acids, hydrogen peroxide and bacteriocins [6]. Acetic acid has the strongest inhibitory effect with an inhibitory activity on both bacteria and yeast. Studies on gastric epithelial cells shows that higher concentrations of organic acids dramatically decrease the viability of *H. pylori*. It was also shown that organic acids could inhibit *H. pylori* adhesion and invasion of gastric cells [7]. Beneficial probiotic strains of *Lactobacillus* were isolated from the vaginal tract and mammary

gland of adult heifers and oral cavities of newborn calves. It was shown that the strains isolated from the vaginal tract produce more hydrogen peroxide than the strains isolated from the vaginal tract, while those able to produce organic acid were isolated from both environments. In comparison only a few strains were able to produce bacteriocins and were isolated only from the mammary gland and faeces, but not from the vaginal tract [8].

Competitive exclusion is an important way to prevent intestinal diseases mainly caused by *E. coli* and *Salmonella*, as an alternative to antibiotics that were used as growth promoters. Probiotics are already used as a nutritional technique to support the host organism during difficult physiological periods, to attenuate technological stress or to prevent and combat diarrheal syndromes [9]. Probiotic bacteria may have a direct effect on pathogenic bacteria through their physical presence in the intestine or secretion of antimicrobial substances. Secretion of antimicrobial products is one of the most studied components participating in anti-pathogenic activity of probiotic bacteria. A protein called BIF, secreted by *B. longum* BL 2928, is only known to be active against gram-negative bacteria [10]. It inhibits the interaction between *E. coli* and human epithelial cell lines [10]. *Bifidobacterium* strains (CA1 and F9) secrete a lipophilic compound with a strong antimicrobial activity against *S typhimurium* SL1344 and *E. coli* 1845 [11]. In vitro studies have shown that lactic acid bacteria are effective in removing or stopping the activity of pathogenic bacteria. Studies in vitro with human cell lines have helped to investigate how probiotics adhere to the intestinal epithelium. These cell lines have different phenotypic characteristics in the intestinal epithelium, have been widely used especially in humans [12]. Their use has its explanation in the fact that mimics the intestinal barrier that pathogenic microorganisms must pass in order to infect and then systemic circulation to reach various parts of the body [13].

Probiotics for swine

In pigs probiotic bacteria can have a positive influence on gut microbiota balance, intestinal epithelium integrity and the appropriate maturation of the gut-associated tissue. The frequency of gastrointestinal disorders in pigs is

significantly influenced by physiological state as follows: (i) in the first few days after birth the digestive tract of piglets is firstly colonised, via contamination from the mother and from the environment, with useful microorganisms like lactic acid bacteria, *Enterobacteriaceae* and *Streptococcus*, (ii) after introducing dry food there is an increase in the number and density of anaerobes, creating a microbiota that can protect against pathogens by forming a line of defence at the mucosal level [14].

Weaning is a complex transition period in which piglets are separated "brutally" from the mother, there are significant changes in the feeding technology and also they encounter a switch from liquid feeding (milk) to dry feeding with low digestibility. Weaning at a younger age (21 days) in the intensive rearing of pigs exacerbate the overall level of stress in immature animals.

In the weaning period the most promising effects of the use of probiotics are related to the competitive exclusion of pathogenic bacteria. Competitive exclusion of pathogens can be used efficiently to farm animals after treatment with antibiotics to prevent infection with *Salmonella* during especially because the host microflora is in recovery. This concept involves administration of non-pathogenic bacterial cultures (one or more strains) in order to reduce colonization or presence of pathogenic bacteria in the intestine [15].

The occurrence of gastrointestinal disorders immediately after weaning is the main cause of economic loss that occurs in the pig farming industry in the EU and is expected to count for about 17% of all piglets born. A mix of four lactobacilli isolated from weaning pigs can reduce anaerobe counts in the gut causing as a secondary effect a decrease in diarrhea. Supplementation of a diet with *L. sobrius* improves the body-weight gain of weaned pigs orally challenged with ETEC K88 despite with no effect on diarrhoea [16]. Supplementation with *Lactobacillus rhamnosus* GG in weaning pigs showed a trend to more ETEC excretion in faeces. Administration of live yeast (*Saccharomyces cerevisiae* spp. *boulardii*) to weaned pigs for 3–4 weeks improves growth performance post weaning, villus height, epithelial cell proliferation and the numbers of macrophages at various sites of the small intestine [17].

Sows and gilts in advanced stages of pregnancy and lactation are passing through a critical period when due to a limited food ingestion capacity, it

may be difficult to cover the nutritional requirements for milk production [18]. Interestingly, supplementing the sows with *Escherichia faecium* strongly decreases the incidence of diarrhoea in piglets in the first week post weaning [19]. It also reduces the level of cytotoxic (CD8 +) T-cells in the jejunal epithelium of the piglets [20].

Probiotics for poultry

In birds it is estimated that the influence of digestive microflora on digestion, productivity and health condition is more obvious than in other monogastric species. Probiotics are used mainly to help ensure health status by maintaining the digestive microbial balance and reducing potential pathogenic bacteria which have the effect of improving performance and productivity (growth, increases in egg production, feed conversion).

Intestinal disorders in birds are highlighted by diarrheal syndromes of different intensities which can trigger sensitive periods of growth (in the first days after hatching) or they are caused by stress of technological nature (mainly food factors: imbalanced nutrition, high bacterial and fungal presence).

Probiotics are mainly used in birds aiming to prevent and combat digestive disorders based on competitive exclusion of potentially pathogenic bacteria (*Salmonella*, *Escherichia coli*, *Clostridium perfringens*), antimicrobial secretions (bacteriocins), the stimulation of an immune response that contributes to the maintenance or reinstallation of "intestinal health" [21]. In the United States in the year 2006 it was estimated that 1.4 million people contracted salmonellosis. This represents 42% of all diseases of food origin, raising a massive research interests aimed at reducing or eradicating *Salmonella* contamination of poultry and their products. We pursued this line of inquiry by a study performed on young chickens infected with *Salmonella enteridis* (10^4 CFU) one hour after various doses of a culture of *Lactobacillus* (FM-B11) [22]. Thus, it is found that after hatching, the usual way to control this pathogen consists in the administration of an oral *Lactobacillus* live culture (10^6 and 10^8) resulting in a significant decrease in the presence of *Salmonella enteridis* in chicks.

Bacteriocins produced by *Escherichia coli* are also predicted to have role in preventing *Salmonella*

infection. Recent studies have shown that strains of *Lactobacillus salivarius* isolated from chicken intestine produce bacteriocins with antagonistic activity against Gram-positive bacteria and *Campylobacter jejuni* [21].

Regarding the specific immunity is known to affect the chicks ability to resist pathogenic infection which is determined mainly by the condition of the intestinal mucosa of chickens. Following a study by Haghghi *et al.*, [23] it has been found that by administering a probiotic mixture consisting of *Lactobacillus acidophilus*, *Bifidobacterium bifidum* and *Streptococcus faecalis* there was an increase in the natural antibody production in the serum and gut for some antigens. It was also found that probiotics may induce changes in the gastrointestinal tract in terms of histological structure and regulation of mucus secretion [24]. Dietary inclusion of a microbial feed additive (*L. salivarius* and *L. reuteri*) slightly increased the growth performance and improved intestinal nutrient absorption with an associated improvement intestinal architecture [25].

Probiotics can be used successfully when broilers are fed with feed containing mycotoxins. As seen in some studies, food supplementation with 10 mg/kg feed of *Saccharomyces boulardii* significantly mitigate the effect of decreasing haemoglobin and total protein (albumin, globulin) in chickens whose diet contained ochratoxin A at levels of 0.5 ppm [26].

Probiotics for cattle

In bovines the use of probiotics has the main purpose of preventing and combating digestive disorders (especially diarrhea in livestock during lactation), to influence the ruminal metabolism of nutrients and to stimulate activities to ruminal microorganisms which helps maintain health and improve productive performance. For over 20 years numerous scientific papers showed that live yeast improves health and productivity of ruminants as a natural alternative to influence animal performance. The reported effects are: increased food intake [27], milk production [28] and body weight [27]. The usefulness of yeast cultures in manipulating ruminal fermentation and ruminant productivity has been suggested in numerous studies [29]. It was found that *Saccharomyces cerevisiae* has a growth effect on

bacterial populations which is based on their mechanism of action of the rumen. Another beneficial effect refers to the fact that yeasts make available the necessary vitamins for growth and development [30].

Digestive disorders (diarrhea) are the leading cause of morbidity and mortality in newborn calves. The efficacy of probiotics in the treatment of these syndromes has been certified by numerous studies that observed the effect of probiotics in restoring the digestive flora [31]. In lights of the finding that traditional antimicrobial treatment of uterine infections in cows post-partum does not always provide resettlement for treated animals, vaginal lactic bacteria, isolated from cows, can be used as the probiotics to treat those infections in cattle [32].

Specificity of feeding dairy cows with large amounts of silage and concentrates with an acidic potential leads to the formation of organic acids that exceed the natural buffering capacity of the rumen which results in a decrease of pH to values below 5. Ruminal acidosis cause cows discomfort, anorexia, reduced digestibility and milk production. Probiotics are bioregulators that can prevent reduction of ruminal pH by increasing the use of lactic acid by some ruminal bacteria [33]. Ingestion of high amounts of carbohydrates after parturition often leads to identification of high quantities of organic acids in rumen which exceeds the buffering capacity leading to a drop in pH. It was found that administration by feeding the micro-organism *Prevotella bryantii* (25A) in these animals results in normalization of ruminal pH and then reinstalling the normal digestion [34].

Probiotics for sheep

In sheep, use of probiotics is directed especially to prevent and combat pathological conditions which arise from digestive imbalance.

The administration of probiotics together with prebiotics helps correct imbalances in bacteria, provides energy and helps in rehydration to reduce recovery time from stress or in disease treatment in sheep.

This imbalance can be mainly caused by:

- development of pathogenic bacteria;
- disturbed digestive metabolism associated with an imbalance of digestive flora;

A probiotic bacterium in the intestine prevents attachment of pathogenic bacteria by applying a barrier effect at the interface between the pathogen and intestinal epithelial tissue. Thus it was found that the supplementation of *Streptococcus faecium* or of a mixture of *Streptococcus faecium*, *L. acidophilus*, *L. casei*, *L. fermentum* and *L. plantarum* in the diets of lambs, infected with *E. coli*, led to a reduction in the presence of pathogenic strains at this level with an improvement in growth performance and meat production [35, 36].

probiotics were proved to be effective [30]. To diversify the probiotic yeasts [37] three strains were assessed (individually and in combination): *Kluyveromyces marximianus* NRRL-3234, *Saccharomyces uvarum* ATCC-9080 and *Saccharomyces cerevisiae* NCDC-42 in young sheep during the pre-ruminant stage. It was shown following this experiment that it is not necessary to use these strains in combination. The best results, with no statistical significance, were obtained with *Saccharomyces cerevisiae* in regards to food intake and nutrient digestibility and ruminal fermentation characteristics.

The effect of probiotics on the ruminal fermentation in sheep and was measured by direct administration, in the rumen, of *Saccharomyces cerevisiae* (50 mg / day) and *Aspergillus oryzae* (3 g/day). The experiments were carried out on animals whose rumen was first defaunated and then re-faunated. It was found that probiotic bacteria can stimulate bacterial growth but reduced the overall population of cellulolytic bacteria. Separate administration of probiotic bacteria in the presence of protozoa resulted in the reduction of redox potential values. However administration in combination had a stimulating effect on this parameter. Both probiotics and protozoa stabilized ruminal pH after feeding, keeping the site at around 6 for a long time. Ammonia nitrogen concentration was significantly increased in the presence of protozoa, and probiotics have increased ammonia nitrogen only in re-faunated sheep. The concentration of methane and hydrogen gases was higher in re-faunated animals. Probiotics had a clear effect on the mixture of VFA [38].

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Bacteria and yeasts can play a role in re-balancing the digestive flora, which is the effect of stimulating microbiota. This effect can be exemplified by a study which found that the administration of *Sacharomyces cerevisiae* (CNMC strain 1-1077) may stimulate the development and activity of cellulolytic bacteria, especially in lambs. Such an effect is beneficial for preventing bacterial imbalance that may occur in the rumen. Therefore in the methodology of combating infectious disease syndromes

2. Conclusion

Animal husbandry has entered the era when the use of antibiotics or other pharmaceutical products is increasingly unwelcome. Antibiotics are a special category and they were actually banned by the EU as a nutritional supplement. In livestock probiotics are used mainly to treat various digestive disorders, especially during difficult physiological and technological periods. Because of a lack of clinical trials it is difficult to make specific recommendations about how and when probiotics should be used in treating various digestive disorders in farm animals.

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