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# Role of In-feed Probiotics on Performance and Health of Animals: A Review

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## Abstracta

Bacterial resistance and residual effects are the primary reasons for the prohibition of antibiotics incorporation as growth promoters in animal nutrition. Therefore, to date researchers and nutritionists are in searching of ideal alternatives to antibiotics which able to best optimize productivity without adverse effects. The utilization of microbial probiotics in farm animals feeding has become a popular approach in recent years and gains a scientific concern regarding their potentials and limitations. Probiotics are commonly defined as viable microorganisms that are used as feed additives in commercial livestock farming. Selected strains of bacteria, yeast and fungus (alone or in combination) which possess beneficial properties on digestive process or animal health are utilized in their preparations. These microbes in the digestive tracts of livestock have a profound influence on maintaining the balance of micro flora which can impact on the animal performance and health. Studies revealed that certain animal feed probiotics enhanced immunity, digestive efficiency and overall productivity without adverse effects to users and environment. However, these improvements in livestock performance have not been consistently achieved although several beneficial assertions have been documented. Moreover, the mode of action for probiotics is also continued as a chronic issue and still it is not fully explained. This review tries to summarize the information to date on the microbes of in-feed probiotics, their role in animal productivity and the possible modes of action.

**Keywords:** Antibiotics; Environment; In-feed probiotics; Micro flora; Mode of action

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## Introduction

Livestock production was the fastest growing agricultural sector in many parts of the globe and it was fundamental for sustainable production of high quality protein to meet up increasing demand of animal source food [1] Worldwide, 35 percent more demand for animal protein in the next 20 years is predicted (unpublished, Poultry boon for Hosne Ara). Human population growth, income improvement, globalization and urbanization are the foremost causes for the increased demand for animal origin foods [2]. The changing dietary pattern resulted in a shift from extensive to large scale commercial production of farm animals. In response to this, it becomes a basic issue among the scholars of the livestock industry to improve productivity of farm animals and to better secure consumer demand through utilizing scarce resources efficiently and thus generate income for a growing agricultural population in this quickly changing world. In fact better advancement in livestock management techniques, nutrition and health managements are the subsets for improvement in the productivity and performance of animals.

Review of different literatures showed that numerous advances in animal productivity have been demonstrated through the use of nutritional modifiers and inclusion of antimicrobial products in to livestock feed [3,4]. In this regard, antibiotics have been used for a long time as nutritional supplements to enhance the effectiveness of nutrients and exert their effects in the digestive process [5]. Although the primary use of antibiotics is in the treatment of infections, certain antibiotics in animal feed proved to improve feed efficiency and growth performance [5,6]. Although several beneficial effects proved, the problem with antibiotic usage in animal production is that it increases bacterial resistance and drug residues, and thus, decreased potency [5,7]. Therefore, the inclusion of in-feed antibiotics as growth promoters in livestock farming had been restricted in many parts of the world. The utilization of various feed additives and/ or substitutes in farm animals feeding had become a popular strategy in recent years. The most commonly practiced alternatives to antibiotic have been microbial probiotics and gain a scientific concern regarding their potentials and limitations [3,4].

According to FEFANA [8] probiotics are live microorganisms which confer a health benefit on the host when administered in adequate amounts. The inclusion of probiotics in feeds is designed to encourage certain strains of microbes in the digestive tracts of livestock at the expense of less desirable ones [6]. Review of literatures indicates that probiotic use in animal nutrition is widely accepted today. The microorganisms used in the preparations of probiotics are non-pathogenic, nontoxic and have beneficial effects on the digestive ecosystem and confer resistance to infection. The commonly used probiotic are genus *Lactobacillus, Bifidobacterium, Saccharomyces, Enterococcus, Streptococcus, Pediococcus, Bacillus* and *Leuconostoc* [3]. These microorganisms in the digestive tracts of livestock have a profound influence on the conversion of feed into end-products which can impact on the overall animal performance and health. Moreover, the microorganisms used in probiotics are approved for animal nutrition and would not adversely affect the health of probiotic users and environment [9]. The global demand for healthy livestock and antibiotic-free animal products from consumer had been driving demand for probiotics-based animal feed. The present review compiles existing knowledge on the various aspects of in-feed probiotics mainly on the microbes used in animal diets, their effects of application and possible mechanism of actions in farm animal nutrition.

## Microorganisms used as probiotics in animal nutrition

Most probiotic mixtures utilize one or more of several types of bacteria where as some preparations contain spore forming-fungi and yeast-based strains [10,11] reported that many commercial products recently use multi-strain probiotics, although the benefits of using more than one strain or species in a single product have not been clearly established. These microbial in-feed additives help in management of toxins, destruction of harmful bacteria, increased absorption of nutrients and effective digestion of fibers. According to [10] the most common microbial groups used as probiotics in animal feeds are *Aspergillus, Brevibacillus, Bifidobacterium, Candida, Clostridium, Escherichia, Enterococcus, Bacillus, Lactobacillus, Lactococcus, Pediococcus, Streptococcus, Saccharomyces, Megasphaera, Prevotella and Propionibacterium*. Mammals' age, diet, health and pathological status might be influenced by the percentage of individual/ various microbial groups [3].

# Role of Probiotics on Animal Performance and Health

## Probiotics and animal performance

These feed additives will improve animal production with minimal possible damage to the environment. Review of different studies show that the performance, digestion efficacy and the immune system of farm animals such as cattle, pig and poultry had been enhanced through the use of certain in-feed probiotic preparations. For instance, growth performance improvement in lambs was reported through the in-feed probiotics due to their actions on nutrient bioavailability [12]. The application of yeast (*Saccharomyces cerevisiae*) in the form of live culture, or dead cells with culture extracts, has also proved successful in beneficially modifying rumen fermentation [13]. Similarly observed enhancements for dry matter intake and weight gain by lactic-acid-producing bacteria through promoting the stability of the rumen flora [14,15]. However, improvements in performance have not been consistently achieved when feeding probiotics to feedlot cattle. Although [16] reported a 2% increase on the growth performance of feedlot cattle with L. acidophilus (strains NP45 and NP51) plus *Propionibacterium freudenreichii*, [17] indicated that performance was not greatly affected by feeding the same probiotics and strains.

The usefulness of probiotics in the nutrition of young pigs has been shown, although the results varied greatly from one another especially in relation to such indicators of production as growth and feed efficiency [18]. A study conducted in Germany on probiotic treatment (*E. faecium* NCIMB 10415) found no effect on performance of sows and piglets [19]. In this project the probiotic was fed to the sows during gestation and lactation and to piglets during the suckling period with creep feed and after weaning at day 28 for 6 weeks. However [20] improved weight gain and feed conversion on piglets fed Bacillus coagulans better than un-supplemented piglets. In recently published study, [21] demonstrated that the overall productivity of piglets had enhanced by probiotics, combination of B. *licheniformis & B. subtilis*, as shown in the Table 1.

Literature reports on the performance improvements through the administration probiotic in their diets have not been consistently achieved for chicken. Inclusion of probiotics in the diet of broilers at $4^{th}$, $5^{th}$ and $6^{th}$ weeks resulted in improved performance compared to the control group [21,22]. It had been reported that probiotics are utilized for reduced stress levels apart from improving performance. Lactobacillus cultures enhanced performance (BW gain and FCR) to broilers reared under temperature stressed conditions and also in turkeys reared under suboptimal conditions [23,24]. However, the study conducted [25] showed that feeding broiler chickens with the feed supplemented with a probiotic preparation LABYuc-Probio (containing in 1g, $4.7 \times 10^7$ of Lactobacillus bacteria, $2.0 \times 10^3$ of Saccharomyces cerevisiae yeasts and 50 mg of Yucca schidigera extract) did not result in significant changes in the body weight gains and feed utilization compared with a group of chickens

**Table 1.** Effect of a probiotic supplemented to piglets day 1 to 42 post weaning [20].

| Parameters | Control | Probiotic | Index |
|---|---|---|---|
| Number of piglets | 240 | 240 | - |
| Feed intake, g/d | 721 | 734 | 102 |
| Average Daily Gain, g/d | 454 | 484* | 107 |
| Feed Conversion Ratio, g/g | 1.59 | 1.52* | 96 |
| Dead/culled, % | 7.92 | 4.17 | 53 |
| *P<0.05 | | | |

receiving antibiotic feed with or without any additions. No significant differences in growth performance during 22-42 days between broilers fed the probiotic diet and those fed control diet [26]. In recently published study also performance of broiler breeder did not improved by *Lactofeed* and *Pediguard* probiotic preparations in their nutrition.

In general, the lack of response on animal performance for probiotics could be due to a number of factors, including differences in the microbes or strains used, duration and frequency of exposure, management of animals or impairment of animal performance by infectious agents, the conditions under which the experiment was carried out or variations in the surrounding environment [1,27].

## Effect of probiotics on animal health

The health benefits expected from ingested feed would depend on the state of digestive system and specifically up on the balance and composition of favorable versus harmful bacteria. Live probiotic microorganisms play important role in livestock health basically through their involvement for the balance of microbial groups in the host. In relation to this, probiotic action resulted protection against infectious agents due to enhanced immunological responses [28].

In-feed probiotics improve health in animals by promoting the stability of the rumen flora [15]. Literature reports on the effectiveness of probiotic applications in preventing or reducing the risk of ruminal acidosis are inconclusive, although inclusion of probiotics in beef cattle diets is perhaps the second most adopted practice after ionophores. This is because probiotic microbes promotes and favors the growth of lactateutilizers in rumen either directly by feeding lactate-utilizing or indirectly by feeding lactate-producers [14,29]. *Megasphaera elsdenii* inclusion also proved effective in acidosis prevention as [30] demonstrated that intraruminally drenching increasing ruminal pH and decreasing lactate concentrations. Feeding of *Lactobacillus* and *Enterococcus* reduced risk of acidosis for dairy cows. Similarly, yeast *S. cerevisiae* lessened the lactic acid concentration in the rumen of lactating Holstein cows [31,32]. However, these positive responses for probiotics in preventing the risk of ruminal acidosis or changes in digestive function are not always true. Found no effect of *S. cerevisiae* culture containing metabolites of yeast fermentation on ruminal fermentation [33]. Limited effects on ruminally cannulated steers fed with *Enterococcus faecium* with or without *S. cerevisiae* [14].

The most frequently observed effect of probiotics on the health of piglets is a reduction in the incidence rate of diarrhea and shortening of its duration, as well as a decrease in the mortality rate during the pre-weaning and peri-weaning period [34]. It was demonstrated that the best results are obtained when the probiotic is administered already on the first, or on the second day of life at the latest. That is why probiotics are administered to them after birth orally in the form of a special paste with the use of special dispensers [35]. An integrative study on the effects of a probiotic strain (*E. faecium* NCIMB 10415) fed to piglets during the suckling period with creep feed and after weaning at day 28 for 6 weeks also revealed that incidence of diarrhea was reduced significantly after weaning [19,21] also demonstrated that the survival rate of piglets had enhanced by probiotics (combination of *B. licheniformis* & *B. subtilis*) as shown in Table 1.

In relation to the use of probiotic preparation in poultry production, beneficial effects including disease prevention and/ or controlling infection are observed in certain studies. For instance, it was reported that a reduction of *coccidiosis* and the spread of disease. Used probiotics based on *E. faecium, B. animalis, L. reuteri* and *B. subtilis,* either alone or in mixture [36]. A study [37] also showed that supplementing feed with a probiotic preparation LABYuc-Probio® during the first week of rearing resulted in a significant reduction in the number of bacteria of the genus Clostridium in the fecal-urate excreta of chickens. However, T-cell-mediated immune response in broiler breeders was not improved by Lactofeed and Pediguard supplementation [38]. The probiotic preparations and the strains used vary considerably and may explain the differences found between these studies.

**Modes of Action of Probiotics**

The mechanisms by which probiotics provoke their beneficial effects on the host look a chronic issue and various hypotheses have been explained in the literatures. Promoting healthy gut microbiota [6,21] digestion and absorption of nutrients [21,39,40], antimicrobial activity [4,40,41] quorum sensing [21,41,42], colonization resistance [10] and stimulating the immune system [10,21,43] are among the possible modes of action related to best optimization of overall productivity in animals.

## Secretion of antimicrobial substances

Several studies showed that the effect of probiotics was through the secretion of antagonistic chemicals such as organic acids, inhibitory metabolites (reuterin), hydrogen per oxide and anti-bacterial substances termed bacitracin [4,40] These chemicals involved in the control of intestinal population weather directly by killing pathogens or by generating localized microenvironments unfavorable for pathogen establishment [4]. Organic acids (particularly acetic acid and lactic acid) have a strong inhibitory effect against Gram-negative bacteria [4]. Also they have been considered the main antimicrobial compounds responsible for the inhibitory activity of probiotics against pathogens. Many bacterial species, including lactic acid bacteria, bifidobacteria [41] and bacillus can produce several types of thermostable bacteriocins which have antimicrobial activity against a range of potential pathogens of animals including *Bacillus, Staphylococcus, Enterococcus, Listeria, and Salmonella species* [10,21,44] also demonstrated that probiotic strains belonging to the Bacillus *(B. licheniformis, B. subtilis A, B. subtilis B & B. cereus)* inhibit the growth *of Clostridium perfringens* type A in pigs.

## Effects on microflora composition

In-feed probiotics promote the stability of the rumen microflora as feed is a major cause of changes in the microbial composition, which may overpower their effect on the host. These is because the inclusion of probiotics in feeds is designed to encourage certain strains of microbes in the digestive tracts of livestock at the expense of less desirable ones [6]. Probiotics offer potentially safe and effective strategies for controlling harmful pathogens. It was stated that the digestive microflora in pigs had been mitigated beneficially by a Bacillus-based probiotic [21] who demonstrated in canulated pigs by providing a diet with and without combination of *B. licheniformis & B. subtilis*. Probiotic increased the number of beneficial bacteria like *Lactobacillus, Bifidobecterium and Bacteroides-Prevotella-Porphyromonas* as well as the butyrate producing *Roseburia and Clostridium cluster IV*. Another effect of probiotic feeding, especially in ruminants, is the stimulation of the growth of lactateutilizers which in turn metabolize lactate derived from rapid carbohydrate fermentation. Probiotics (specifically lactate-producing bacteria i.e. *Lactobacillus* and *Enterococcus*) may play a supportive role in the rumen as their presence helps the ruminal microenvironment to adapt to the presence of large quantities of lactic acid preventing or reducing the risk of acidosis in beef cattle [14].

### Increased digestibility and absorption of nutrients

The benefits expected from ingested feed would depend primarily on the state of digestive system and specifically up on the balance and composition of favorable versus harmful microbiota. The probiotic supplementation can be expected to decrease the epithelial turnover rate and increase the height of intestinal villi and the villi height: crypt ratio, thus increasing the surface area for nutrient absorption in poultry and in pig [21,39].

Increased digestibility of nutrients in diet may be due to increased enzyme activity in the intestine due to probiotics [45]. The ingested feed is mixed with digestive enzymes which will break down into small particles and then absorbed through the walls of the small intestine. The friendly bacteria of in-feed probiotics break down the ingested feed in to the smaller nutrients which then enter the blood stream and circulate to reach the cells to sustain the animal life [21]. It was reported that Lactobacillus probiotics altered the digestive enzyme activity in the digestive tract of poultry and pigs [10]. Bacteria, especially Bacillus spp., excrete exoenzymes into their environment with the aim of converting the nutrients present in their micro-environment to small molecules that can be transferred into the bacterial cell [21]. This means that they excrete all enzymes needed to convert fibers and proteins into absorbable molecules. It had also been reported that spore forming bacteria, like Bacillus *amyloliquefaciens*, produce extracellular enzymes including *α-amylase, cellulase, proteases and metalloproteases* which could increase nutrient digestion [45,46].

### Quorum sensing and competitive adhesion

Quorum sensing is a type of bacterial communication through secreting signaling-molecules [47]. According to [21] this type of communication between a lactic acid bacterium (La-5) and a pathogenic *E. coli* is known to change the pathogenesis of the E. coli so that colonization by the *E. coli* is prevented. On the other hand, the probiotic microbes like *B. licheniformis & B. subtilis* are reported to adhere on the intestinal epithelial sites of the host animal by competing for the attachment site [21]. This will prevent the adhesion of harmful pathogens like *E. coli* and *Salmonella species* to epithelial receptors. After one hour of incubation, it was found that the probiotic reduced the attachment of *E. coli* to the swine epithelium by 33%. The probiotic microorganisms [42,48] prevent colonization of harmful bacteria by competing for the attachment site in the digestive tract of the host.

### Additional mechanism of actions

Several studies have indicated immuno stimulatory effects of probiotics. [28] Probiotics enhanced immunological responses through restitution of intestinal barrier function. Most of the physical structures of the immune system are located in the gastro- intestinal tract, and comprises approximately 80% of the immune system [21]. In-feed probiotics could modulate the host immune response and increase serum immunoglobulin levels [10]. It has also been demonstrated that probiotics stimulate both innate and acquired immune functions [10,21,43] Also their action of enhancing the expression of genes involved in tight junction signaling is a possible mechanism to reinforce the intestinal barrier integrity [49].

## Conclusion

Reviews of different studies revealed affirmations for microbial probiotics in animal nutrition, although literature reports are still inconclusive. Nevertheless, certain in-feed probiotics plays a vital role in enhancing animal performance, digestion efficiency and immune system, and helps in delivering antibiotic-free animal products for consumers. Furthermore, the microorganisms used in probiotics are accepted for animal nutrition and do not adversely affect animal health, probiotic users and environment. Although different hypotheses have been suggested by researchers, the modes of action of probiotics are currently not yet well explained and it would be a worthy target for future research. The relatively high demand from animal sectors in this quickly changing world plus very good safety records of probiotics are expected to further exploit in-feed probiotics in the feed industry in the years to come. In general, the increasing demand for safe and healthy food, population growth and preservation of the environment, the adoption of advanced technologies probiotics would be ideal alternatives for antibiotics for the livestock industry.

## Conflict of Interest

Author declares that there is no conflict of interest.

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