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Usage of probiotics in poultry industry

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Review Article

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Abstract

Probiotics are beneficial live microorganisms that are found naturally and are used to improve human, animal, or avian health issues. These germs include bacteria, fungus, and yeasts. Probiotics have been shown to enhance feed conversion efficiency, growth performance, immunological responses, and the ability of poultry to fight enteric pathogens in addition to increasing egg production of layers. Probiotics work through three main mechanisms: the generation of antibacterial compounds, the competitive exclusion of harmful microbes, and the host's immune system regulation. Probiotics from the genera Lactobacillus, Bifidobacterium, Bacillus, Micrococcus, Enterococcus, Streptococcus, Pediococcus, Saccharomyces, and Aspergillus are typically utilized in poultry feed. Antibiotics are now commonly found as residues in animal by-products because of their use in suppressing or eliminating undesirable organisms as well as enhancing growth performance which may lead to antibiotic resistant microorganisms. The replacement of antibiotics with probiotic in poultry industry has become an area of great importance for public health concerns. The present article reviews the beneficial properties and prospective applications of probiotics on health and production performances in poultry.

Keywords: *Probiotics, maicroorganism, poultry, immunity.*

Introduction

The term ‘probiotics’ is derived from Greek word “probios”, meaning “for life”. It's a beneficial microbe that colonize in the stomach rapidly to supress harmful bacteria from multiplication and this enhance the Animal, avian, and human health status . Probiotics are widely utilized in animal production systems to enhance immune responses, feed conversion efficiency, and production performances, particularly in cattle and poultry. Also animals have been fed with probiotics as a safe growth enhancer **Cavalheiro *et al.* (2015); Lan *et al.* (2017)**. A variety of microbial species like Lactobacillus, Enterococcus, Bacillus, Escherichia, Bifidobacterium, Streptococcus, Lactococcus, and Saccharomyces have been used as probiotics. Bacillus, Enterococcus, Saccharomyces, and recently Lactobacillus have been extensively used probiotics for livestock while Lactobacillus and Bifidobacterium species have been commonly used for humans **Simon *et al.* (2001); Kawakami *et al.* (2011)**. A cocktail of selected bacteria of Lactobacilli, Streptococci, and Bacillus are known to be beneficial probiotics. Several theories have been put to clarify exact mode of

action of probiotics **Ahmad (2003); Ng *et al.* (2009)**. Probiotics help the microbial environment of a bird's gastrointestinal tract by eleminating dangerous bacteria. Probiotics fight with the pathogens for the intestinal receptors that are essential for the attachment and growth of the bacteria, thus fast colonization of these useful microorganisms stops the growth of pathogens in the gut.

Also probiotic inhibit the pathogenic bacteria by production of antibacterial substances, competition for nutrients, and the stimulation of immunity **Bal *et al.* (2004); Rowghani *et al.* (2007)**. This review aims to summerize the basic principles and uses of probiotics, their valuable effects on poultry health, immunity and production, It also explains the probiotic colonization in the gastrointestinal tract, metabolism, and mode of action for improving poultry health and performance.

Historical background of probiotics

In 1965, **Lilley and Stillwell** described probiotics as microorganisms that help in the proliferation of useful bacteria in the gastrointestinal tract **Vila *et al.* (2010)**. This definition is opposite to antibiotic which inhibit the bacteria growth by producing antibacterial substances **Wang *et al.* (2019)**. Another scientists described probiotics as live microorganisms that when administraded in sufficient amount give health benefits to the host **Morelli and Capurso (2012)**. Furthermore, probiotic benefits and purposes are specific for each strain and other reactions may be induced in the host after probiotic ingestion **Morelli and Capurso (2012)**.

Probiotics can be extracted from different sources like fermented foods, milk or the gut microflora of different animals **Fontana *et al.* (2013)**. Lactobacillus, Bifidobacteria, Streptococcus, Saccharomyces, Pediococcus, , are the most commercially used probiotics in the poultry feed industry **Guarner and Malagelada (2003); Azad *et al.* (2018).** Lactic acid producing bacteria are popular for animals, poultry and humans use because they can enhance the ability for lactose digestion for lactose-intolerant individuals, decrease intestinal infections, prevent certain cancers, and lower serum cholesterol levels **Vieco-Saiz *et al.* (2019)**. Bifidobacteria can attack malignant cells, decrease blood ammonia, and cholesterol levels and produce many B vitamins **Gibson and Roberfroid (1995)**. *Bacillus licheniformis* can produce bacitracin antibiotic under either aerobic or anaerobic conditions **Anthony *et al.* (2009); Smialek *et al.* (2018)**.

Properties of an ideal probiotic

An ideal probiotic should be safe, non pathogenic, non toxic, genetically stable, isolated from individuals of species for which they are used, contain adequate number of viable microorganisms, replicate in short period and, withstand gut environment like pH variations and bile concentrations. It should be able to attach to intestinal epithelium, colonize in the intestine, persistent among gut microflora, stimulate immunity, enhance growth performance, produce antimicrobial compounds, resist antibacterial secretions, and not carry antibiotic resistant genes. Also it should be resist adverse condition of temperature and humidity during manufacturing, processing, storage, and have good sensory properties **Markowiak and Śliżewska (2018).**

Commonly used microbes as probiotics

The most commonly used probiotics contain one or a mixture of harmless microbes but multistrain probiotics had more beneficial effects in addition to Probiotic yeast can enhance the growth of beneficial bacteria by producing an intestinal pH range that is proper for their growth **Tabidi *et al.* (2013); Konieczka *et al.* (2022).**

The microbes generally used for developing probiotics are *Lactobacillus fermentum, L. plantarum*, *L. reuteri, L. salivarius*, *L. casei*, *L. rhamnosus, L. paracasei*, *Streptococcus thermophilus, Streptococcus salivarius, Bifidobacterium longuma, Bacillus licheniformisa*, *Bacillus subtilis, Enterococcus faecium*, *Saccharomyces pastorianusa, Saccharomyces cerevisiae*, *Lactococcus* lactis, *Pediococcus pentosaceus*, *Pediococcus acidilactici*, and *Aspergillus oryzae* **EFSA (2017); Fesseha *et al.* (2021); Fathima *et al.* (2023).**

Many commercial multi-strain probiotics like PrimaLac which contain Lactobacillus spp., *Enterococcus faecium*, and *Bifidobacterium thermophilum* Poultry Star ME that contain *Enterococcus faecium*, *Lactobacillus salivarius, Lactobacillus reuteri, and Pediococcus acidilactici,* Bifilac that include *Clostridium butyri-*

cum, Lactobacillus sporogenes, *Bacillus mesentericus,* and *Streptococcus faecalis,* and Microgaurd that have different species of Lactobacillus, Saccharomyces, Bacillus, Streptococcus and Bifidobacterium **Lambo *et al*. (2021).**

Mode of action of probiotics

Probiotics keep the balance of beneficial microflora in the poultry gut leading to efficient growth, feed conversion, production performance, and stimulation of poultry immunity to fight pathogens. The mode of action of probiotics in poultry includes establishment of healthy gut microflora, improvement of digestion, and nutrients' utilization, competition for nutrients with pathogens, production of antibacterial agents, neutralization of toxins, reduction in ammonia production, competitive exclusion of harmful pathogens, decreases pH, and stimulation of innate and adaptive host immunity system (figure 1) **Jin *et al*. (1997); Patterson and Burkholder (2003); Ng *et al.* (2009); Hajati and Rezaei (2010); Ogbuewu *et al*. (2022).**

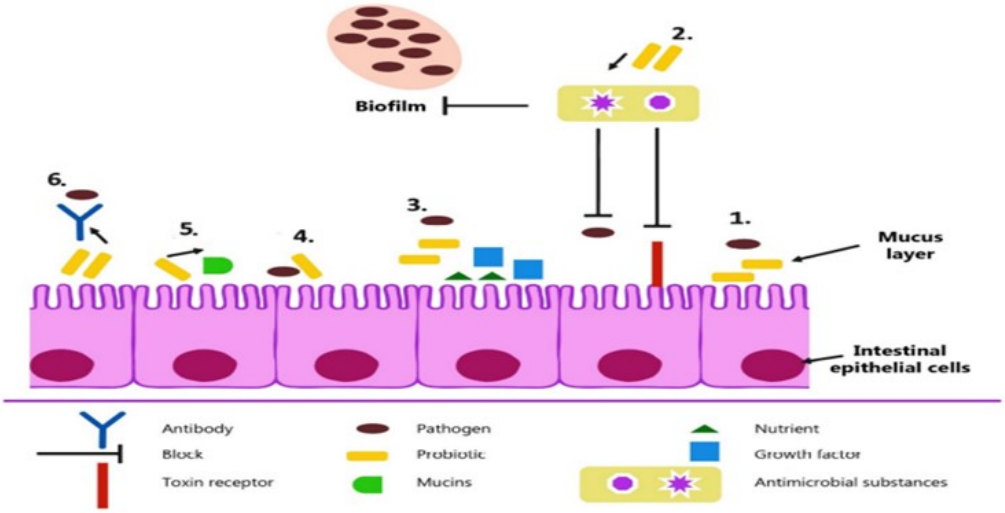

Figure (1). Modes of action of probiotic. (**1**) Competition for receptors. (**2**) Release of antibacterial products. (**3**) Growth stimulation (**4**) Attachment to intestinal mucosa. (**5**) Enhancement of mucin secretion. (**6**) Stimulation of immunoglobulin A production. **El-Hack *et al.* (2020).**

Applications of probiotics in poultry

Lactic acid bacteria based probiotic can be used for prevention and treatment of Salmonella infection in poultry. Also addition of probiotics to diet Improved egg production, body weight, and performance of layers and turkeys **Alkhalf *et al*. (2010); Hajati and Rezaei (2010); Dhama and Singh (2010); Hernandez-Patlan *et al*. (2020).**

Commercial probiotics which contain *Lactobacillus plantarum* and *casei, Saccharomyces cerevisiae, Carnobacterium divergens*, and *Lactococcus lactis* increase the growth rate of broilers and reduce Campylobacter spp count in the GIT and the resulting carcasses after processing under field conditions **Smialek *et al.* (2018)**.

Probiotics are active against foodborne pathogens such as *E. coli* **La Ragione *et al.* (2004),** *Clostridium perfringens* **Ramlucken *et al.* (2020),** *Yersinia enterocolitica* **Bujalance *et al.* (2014),** *Staphylococcus aureus* **El Kholy *et al.* (2014),** and *Listeria monocytogenes* **Olnood *et al.* (2015)** that affect poultry health and their meat.

Probiotic colonization in the gastrointestinal tract

A healthy gut microflora improves the health status of bird and eliminates harmful bacteria. The gut of newly hatched chicks is particularly sterile and begins to acquire microorganisms from the surrounding ecology. At this time chicks may get infected because harmful bac-

teria may increase more quickly than the useful bacteria. However, after that the microflora attains balance between favorable and harmful bacteria but when this balance affected by environmental stress or infectious pressure, the need for probiotic feeding is highly recommended to reduce their adverse effects **Dhama *et al*. (2011); Abdelqader *et al*. (2020)**.

Probiotic colonization extends along the alimentary tract from the beak to the colon and depends on a number of factors, including the microbial strain's stability, and survival, its relationship to the host, dosage and frequency of use, stress level, the host's health and age, and genetic makeup **Simon *et al.* (2004); Mason *et al.* (2005)**.

The mucous cover of the gastrointestinal tract, which covers the intestinal epithelial lining of as well as the surfaces of the caecum and colon, is a significant environment where microbes are prevalent and serve as a source of nutrients for bacteria **Jacobsen *et al.* (1999)**. A potential probiotic's ability to stick to the surfaces of mucous and epithelial cells is one of the key selection factors to prevent sticking of pathogens, for example *lactobacillus*-based probiotics reduced salmonella colonization when administrated from 1 to 7 days of chicks age **Rojas and Conway (1996); PenhaFilho *et al.* (2015)**.

Improving digestion, meat and egg quality, and nutrients utilization

Probiotics produce lactic acids, protease, lipase, and amylase which improve digestion, absorption, and metabolism of carbohydrates, proteins, fats and vitamins in the feed resulting in enhancement of growth, body weight gain, and feed conversion ratio. study An Egyptian studies showed probiotics restore cecal microbial equilibrium after IBD infection **Mosa *et al.* (2024)** and addition of *Lactobacillus acidophilus*(1gm/kg ration) improve final body of different broiler breeds in comparison to control groups **Omar (2014),** Also addition of *Lactobacillus salivarius* and *Lactobacillus reuteri* to chicken feed significantly enhanced their growth in addition to reduction of harmful bacteria **Dhama and Singh (2010); Kibrnesh *et al.* (2024)**. Lactobacillus and Bifidobacterium, two forms of facultative anaerobes that render the gut environment suitable for obligatory anaerbes which ferment carbohydrates and proteins resulting in lactic and volatile fatty acids which absorbed and metabolized by the bird and subsequently contribute in host energy requirements **Fooks and Gibson (2002); Chichlowski *et al*. (2007).**

Probiotics supplementation enhances chicken meat quality, flavor and taste by decreasing its fat and cholesterol content and elevating its content of total amino acids, inosinic acid and fresh flavor amino acids **Hossain *et al.* (2012); Ahmed *et al*. (2015); Hascík *et al*. (2020),** Also probiotics can improve egg production and egg quality parameters like egg shell thickness and weight of laying hens and laying quails, as well as reduction of the egg yolk cholesterol level **Mikulski *et al*. (2012); Sobczak and Kozłowski (2015); Zeweil *et al*. (2016).**

Previous study have showed that the addition of *Bacillus subtilis* to chicken ration can result in better levels of serum phosphorus, calcium and digestive enzymes like Amylase, Lipase, and Trypsin, enhanced bone mass, liver weight, and improved brightness values of thigh and breast meat, in addition to enhanced flavor and quality of broiler chicken meat **Mohammed *et al.* (2021); Abd El Latif and Omar (2023).**

Combating pathogens and diseases

Imbalance of the intestinal microflora caused by environmental or pathogenic stresses make physiological distubances in the host like improper digestion, poor nutrients absorption, loss of appetite, and diarrhea in addition to immune suppression and economic losses for poultry industry. So regular supplementation of probiotic is recommended to keep healthy and balanced microflora and subsequently improve health and productivity of poultry **Pal and Chander (1999); Dhama *et al*. (2008)**.

Probiotics prevent bacterial colonization by competitive exclusion mechanism, which include prevention of pathogen adhesion to its receptors, competition for the nutrients, production of antibacterial substances and reduction of toxin bioavailability **Hernandez-Patlan *et al*. (2020).**

Probiotic bacteria physically prevent opportunistic and pathogenic bacteria from colonizing in the intestinal tract by blocking its receptor, enhance epithelial barrier and stimulate mucin se-

cretion by epithelial cells which aid in mucosal immunity **Bermudez-Brito *et al*. (2012).** Also Yeast probiotic like *Pichia guilliermondii* bind efficiently to pathogenic bacteria preventing their attachment to enterocytes, then rapidly cleared from the gut **Cardozo *et al*. (2018).**
Probiotic bacteria make intestinal environment unfavorable for pathogens colonization by competition for the nutrients preventing them from acquiring energy for proliferation **Vieco-Saiz *et al.* (2019*).***
Probiotics produce antibacterial substances like bacteriocins, hydrogen peroxide, and organic acids such as lactic acid. Lactic acid bacteria produce Bacteriocins and lactic acids, Bacteriocins are antimicrobial peptides that kill pathogenic bacteria but not affect microflora while lactic acids lower the gut pH generating unsuitable condition for Pathogenic bacteria like *E. coli, Listeria monocytogenes and* Salmonella , Also Lactic acid producing probiotics have the ability to neutralize enterotoxins and mycotoxins **Wang *et al*. (2015); Liao and Nyachoti (2017); Peng *et al*. (2018); Hernandez-Patlan *et al*. (2020).**
Probiotics have the ability to inhibit poultry pathogens such as *E. coli*, *Salmonella Typhimurium, Salmonella Enteritidis, Listeria monocytogenes, Clostridium perfringens*, *Campylobacter*, and *Eimeria sp*. **Chateau *et al.* (1993); Stern *et al*. (2001); Dalloul and Lillehoj (2005).**
Previous study found that dietary supplementation of 1.0 x 10^9 colony forming unit (cfu) of *Saccharomyces cerevisiae var. boulardii* per kg of feed for broiler chickens challenged with *Salmonella enteritidis* improve their growth performance and inhibit Salmonella growth in addition to improvement of cecal Bifidobacterium and Lactobacillus spp. counts compared to challenged birds without yeast supplementation **Mountzouris *et al.* (2015)**. Lactobacilli can suppress pathogenic bacteria like *E. coli Salmonella*, and *Clostridium perfringens* **Kizerwetter -Swida and Binek (2005)** and *Lactobacillus, Pediococcus* and *Saccharomyces* probiotics decrease incidences of coccidiosis significantly **Dalloul *et al.* (2005); Lee *et al.* (2007)**. Spray probiotic of *Lactobacillus* and *Bacillus* could decrease pathological lesions and virus shedding after Avian influenza H9N2 infection **Rasaei *et al*. (2023)**.

Enhancement of Immunomodulation
Probiotics showed immunomodulatory effects by activation of innate and acquired immune responses resulting in protection of chicks against various infectious agents specially immunosuppressive diseases like infectious bursal disease (IBD), chicken anemia (CAV), Marek's disease and mycotoxicosis and subsequently secondary bacterial infections **Koenen *et al.* (2004); Dhama and Singh (2010); Cox and Dalloul (2015); Wang *et al.* (2021).** Probiotics enhance innate immunity by stimulation of mucous secretion and improvement of the function of intestinal epithelial barrier which protect the internal body tissues from enteric pathogens, toxins, and foreign antigens that present in the gastrointestinal lumen **Ng *et al*. (2009); Bermudez-Brito *et al*. (2012).** An animal experiment reported that *Lactobacillus brevis* ZLB004 can suppress the intestinal inflammation by down-regulation of the proinflammatory cytokines TNF-α and IL-8 **Li *et al*. (2016).** Probiotic mixture of *Lactobacillus plantarum and Clostridium butyricum* could elevate immunoglobulin A and G levels in broiler chickens **Han *et al*. (2018).** Another study reported the ability of probiotics to increase interferon gamma production significantly in splenocytes of chickens immunized with the cpg adjuvant WIV H9N2 **Alqazlan *et al*. (2021)**. Probiotics could improve antibody titers against many chicken viral infections like Newcastle disease, IBD, and CAV. **Talebi *et al*. (2008); Tomczyk *et al.* (2024)**.

Significant benefits and suggestions
Probiotics can maintain healthy gut microflora of poultry and should be given to their feed in newly hatched chicks, during stressful conditions and during antibiotic therapy or as an antibiotic replacement. These can protect chicks from diseases like early mortality, gastrointestinal disturbances and enteric infections leading to improvement of bird productivity and reduction of economic losses **Patterson and Burkholder (2003); Boirivan and Strober (2007); Dhama and Singh (2010).**
Probiotics keep healthy intestine, increase digestibility, and nutrients absorption, efficiency

inhibit growth of pathogenic microbes, enhance feed conversion and growth rate, prevent enteric disorders due to bacterial invasions, improve egg fertility and hatchability, enhance egg production and quality, fertility and hatchability of eggs, and reduces yolk cholesterol concentration, significantly help lowering of chick mortality, reduce ammonia in litter, reduce effects of enterotoxins and mycotoxins, stimulates immune system, thus making birds less susceptible to diseases; reduces stress during several conditions such as vaccination, antibiotic therapy, transportation, and change of feed, Also it strengthen skeletal muscle system of birds, augment effects of vaccines and drugs, and reduce carcass contamination **Jin *et al.* (1997); Fuller (2001); Patterson and Burkholder (2003); Dhama and Singh (2010); Halder *et al.* (2024).**

Antibiotics are frequently used in poultry as growth promoters and to kill pathogenic bacteria. However illegal or continuous use of subtherapeutic doses of antibiotics may result in development of antibiotic resistant bacteria, antibiotic residues in poultry products, and destruction of beneficial bacteria which cause intestinal disturbances **Dhama *et al.* (2008); Alagawany *et al.* (2018).**

Probiotics can prevent diarrhea and help to maintain the necessary intestinal microbiota balance without impairing the effectiveness of drugs and should be given before infection and after antibiotic therapy for regenerating the beneficial microflora. Commercial probiotics are available in the market as powder or liquid feed supplements and consist of a single strain of bacteria and/or a single strain of yeast or a mixture of them. Ideal multi-strain probiotic should contain a sufficient number of organisms like *Lactobacillus casei*, *Lactobacillus acidophilus, Lactobacillus bulgaricus*, *Bacillus subtilis, Streptococcus faecium, Sacchromyces cerevisiae* or other type of beneficial microbes, generally about 10^7 to 10^9 cfu/kg feed **Vegad (2004); Dhama and Singh (2010), Sanders *et al.* (2019).**

Conclusions

Probiotics were given to poultry feed to improve the growth, maintain the balance of bacteria in the avian gut, stimulate immunity, and decrease the occurrence of gastrointestinal diseases in the flocks resulting in improvement of poultry production.

Probiotics work better as a or growth promoter than antibiotics because they are less expensive, don't leave residues in the poultry meat or eggs and, don't cause health hazards to humans. More studies are required to optimize the effect of different probiotic strains on gut microbiome and for combating of different avian pathogens to improve poultry health and productivity, and reduce dependence on antibiotics.

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