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Review

Overview on probiotics and their impact in commercial poultry production

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ABSTRACT

Probiotics are live microbial feed ingredients that have a beneficial effect on health. Probiotics have great capacity to stimulate the growth of essential microorganisms, and reduce the load of pathogenic microorganisms. Thus, improving the intestinal microbial balance of the host and lowering the risk of gastrointestinal diseases. Probiotics have antimutagenic, anticarcinogenic, hypocholesterolemic, antihypertensive, antiosteoporosis, and immune modulatory effects. *Lactobacillus*, *Bifidobacterium, Leuconostoc, Enterococcus, Lactococcus, Bacillus, Saccharomyces, Aspergillus* and *Pediococcus* species are most commonly used probiotics in poultry production. The supplementation of probiotics to chicken improves feed-intake, feed conversation ratio (FCR), growth performance, meat quality, egg production, egg quality and have cholesterol lowering potential in poultry products. Despite the wide uses, probiotics thought to be harmful to debilitate and immune compromised populations in an accurate dosage of administration. Hence, precaution should be taken while applying these ingredients. Therefore, the aim of this review is to discuss about probiotics and their impact in commercial poultry production.

Keywords: Probiotics, commercial poultry, performance, egg quality, hypocholesterolemia.

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INTRODUCTION

A probiotic was defined as a live microbial feed supplement that beneficially affects the host animal by improving its microbial intestinal balance and stimulates the growth of beneficial microorganisms and reduces the amount of pathogens thus improving the intestinal microbial balance of the host. Intake of probiotic lowers the risk of gastro intestinal diseases by stimulating the growth of beneficial microorganisms, supplementation if probiotics alleviates the problem of lactose intolerance, the enhancement of nutrients bioavailability, and prevention or reduction of allergies in susceptible individuals (Chiang and Pan, 2012).

Probiotics are new green additives developed in recent years and are defined as mono or mixed cultures of living microorganisms that beneficially affect the host animal by modulating gut micro biota in commercial poultry production (Meng, 2010). Probiotics have been shown to reduce disease risk, maybe through a reduction in the proliferation of pathogenic species, maintaining micro biota balance in the gut and increasing resistance to infection (Sarangi, 2016). In addition, probiotic application has been reported in the poultry production with an emphasis on their influence on the growth performance of chickens and their carcass composition (Mikulski et al., 2012).

Recent evidence showed that various dietary and microbial supplements can influence host immunity against enteric disease prompted us to investigate the role of a commercial probiotic on coccidiosis. This probiotic consists of live *Pediococcus acidilactici,* which belongs to the homo fermentative gram positive bacteria that able to grow in a wide range of pH, temperatures and osmotic pressures, and thus able to colonize and inhabit the digestive tract. Some commercial bacteria have been found to enhance development of both the intestinal epithelia and the gastrointestinal lymphoid system (Jerzsele et al., 2012; Wondwesen and Moges, 2017).

A balanced microbial population would support the inherent defense mechanisms of a healthy intestinal tract, resulting in better control of intestinal pathogens and probiotics play an important role in stabilizing the intestinal ecosystem of animals by enhancing nutrient digestibility, increasing performance and competing with pathogenic bacteria in the intestine (Jerzsele et al., 2012). Administration of bacteria belonging to the *Bacillus* genus has beneficial effects in several conditions, like enteritis caused by *Escherichia coli*, *Salmonella enterica* or *Clostridium perfringens* (Jerzsele et al., 2012; Rahman et al., 2013). Decreased *C. perfringens* were reported by Jerzsele et al. (2012). Thus, the aim of this review is to discuss the impact of probiotics in commercial poultry production.

PROBIOTICS: OVERVIEW

Definition

Probiotics are viable bacterial or fungal cultures which are able to enhance the balance of intestinal flora and exercise valuable effects on the individual in which it has been administered. Probiotics are group of dietary products that can be incorporated in animal and poultry rations to raise performance or reduce pathogenic bacteria and probiotics can be categorized in to probiotic drugs, probiotic foods (food ingredients and dietary supplements) and direct feed microbial (probiotics for animal use). They are either single or multiple live microbial cultures which promote health benefit to the hosts. They are nonpathogenic and nontoxic in nature, when administered through the digestive route is favorable to the host's health (Wondwesen and Moges, 2017).

Histories of probiotics

The characteristics, actions, effects and importance of probiotics have merits in ancient history. Thousands of years ago, a Roman naturalist named Pliney the elder recommended and storage drinking of fermented milk to treat intestinal problems. Fermented foods are also mentioned in the Bible and the sacred books of Hinduism. Climates in the Middle East and Asia favored the souring of milk products, which were recommended for intestinal illness. This represented the therapeutic use of probiotics, even before the bacteria contained within them were recognized. Many of the same soured milk products are still being consumed today (Patra et al., 2011).

Route of administration

There are various methods for administering probiotic preparations to chickens. It can be given as a powder, capsule, liquid suspension and spray. The amount and interval between doses may vary. Probiotics may be given only once or periodically at daily or weekly intervals. The way of administration and timing are the main factors which affect the effectiveness of probiotic supplementations. Administration of probiotics via the feed, compared to administration in the drinking water, result in a higher rate of average daily gain. Besides, the supplementation of probiotics during early life is of great importance to the host because harmful bacteria can modulate expression of genes in intestinal epithelial cells. So this can create a favorable habitat and they have high survival ability and multiply fast in the conditions within the poultry gut. They have important properties like acid tolerance, bile tolerance and a strong adhesive capability with the digestive tract of the poultry (Wondwesen and Moges, 2017).

The effectiveness of a probiotic supplement depends upon what it contains. A good probiotic should have different character and, functions like: adherence to host epithelial tissue, elimination or reduction of pathogen, production of acids, hydrogen peroxide, antagonism to pathogen growth, non-pathogenic, non-carcinogenic and improvement of intestinal microflora and probiotic bacteria produce antimicrobial substances like volatile fatty acids and bacteriocins and have the ability to reduce pH that limit the growth or survival of pathogenic microbes (Hume, 2011). Bacteriocins are a small class of secreted peptides or proteins produced by bacteria that kill closely related bacterial strains by permeabilizing their cellular membranes or delay essential enzymes (Florent et al., 2011).

CLASSIFICATION OF PROBIOTICS

There is an array of microorganisms used as probiotics, which can be classified as follows:

Bacterial vs non-bacterial probiotics

With the exception of certain yeast and fungal probiotics, most of the micro-organisms used are bacteria. Examples of bacterial probiotics are several species of *Lactobacillus* (Mookiah et al., 2014), *Bifidobacterium* (Pedroso et al., 2013), *Bacillus* and *Enterococcus* (Mountzouris *et al*., 2010). Non-bacterial (yeast or fungal) probiotics include *Aspergillus oryzae* and *Candida pintolopesii* (Daskiran et al., 2012).

Spore forming vs non-spore forming probiotics

Although non-spore forming *Lactobacillus* and *Bifidobacterium* strains predominated initially, spore forming bacteria are now used such that *Bacillus subtilis* and *Bacillus amylo liquefaciens* (Ahmed et al., 2014).

Multi-species probiotics vs single-species probiotics

The microbial composition of probiotic products ranges from a single strain to multi-strain or species compositions. Examples of multi-species probiotics are PoultryStar ME (contains *Enterococcus faecium*, *Lactobacillus reuteri*, *L. salivarius* and *Pediococcus acidilactici*) (Giannenas *et al.*, 2012). PrimaLac (contains *Lactobacillus* spp, *E. faecium,* and *Bifidobacterium thermophilum* and Microguard (contains various species of *Lactobacillus, Bacillus, Streptococcus, Bifidobacterium* and *Saccharomyces* (Rahman et al., 2013). Single species probiotics include *Saccharomyces servisia* and *E. faecium*.

Allochthonous probiotics vs Autochthonous probiotics

The microorganisms used as probiotics which are normally not present in the gastrointestinal tract (GIT) of animals are referred to as allochthonous (e.g. yeasts), while the microorganisms normally present as indigenous inhabitants of the GIT are referred to as autochthonous probiotics such that *Lactobacillus* and *Bifidobacterium* (Abdel-Raheem et al., 2012).

PROBIOTIC MICROBES AND THEIR CHARACTERISTICS

These microorganisms are nonpathogenic and are not related to bacteria causing diarrhea. They cannot transfer antibiotic-resistance genes and maintain genetic stability. Probiotic microbes can resist gastric acid, bile, and digestive enzymes and can attach to the intestinal wall and fight off pathogens. They have anti-mutagenic effects and play a role in reducing serum cholesterol. Probiotic microbes also stimulate the immune system without causing inflammation and have anti-cancer effects. In addition, they can increase bowel movement, maintain the health of mucus, and improve the bioavailability of food components (Aziz et al., 2017).

Methods of administration of probiotics

There are four different methods for administering competitive exclusion preparations (probiotic):Treatment of individual birds practically, there exist four different ways of treating birds individually 1) Introducing the treatment material into the crop by tube and syringe, 2) Introducing the treatment material into the beak using hypodermic syringe fitted with a beaded needle, 3) Allowing each chick to drink from the tip of a pipette, 4) Dipping the beak of the bird the treatment material (Aziz et al., 2017).

Labeling of probiotics use in animal feed

Label in the packaging of commercial probiotic products should provide information about content, positive effects of the products, date of expiry, dose rates, and contraindications. However, commercial probiotics are often inadequately or incorrectly labeled and suggested that an ideal probiotic label "should state the organisms that are present to the strain level, correctly spell and identify the contents, state the number of live organisms, and guarantee that the stated number would be present at the time of expiry" (Weese and Martin, 2011).

Another piece of essential information that should be present on the label is the dose rate to be used for different categories of animals. This was often neglected on the labels and few studies have examined the quality and authenticity of probiotics labeling and found that the labeling of commercial probiotics was very poor. The common errors in the labeling were failing to mention specific names of microorganisms in the product, failing to give number of viable microorganisms in the product, giving conflicting information, not mentioning expiry date, and misspelling the microbial name (Weese and Martin, 2011).

Mode of probiotic action

Different probiotics exert their effects through various mechanisms not yet fully understood and presumed to be due to their action either in the gastro intestinal lumen or the wall of the GIT. The mechanism of action of these feed additives appears to be different (Fajardo et al., 2012). Probiotics help to prevent and control gastro intestinal pathogens and/or improve the performance and productivity of production animals through various mechanisms. Closely related strains may differ in their mode of action there are increasing numbers of spore forming bacterial strains being used as probiotics. A small proportion of ingested spores are believed to germinate in the intestine of animal However, it is not clear whether the germinated spores or the spores in its ingested form exert beneficial effects on the host (Lodemann, 2010).

Risks associated with probiotics

Although microorganisms used as probiotics in animal feed are relatively safe, precautions must be taken to protect animals, humans and the environment from potentially unsafe microorganisms. Theoretically, risks associated with the use of probiotics in animal feed are as follows: Infection (gastro intestinal or systemic) of the animal fed the probiotic, infection (gastro intestinal or systemic) of the consumers of animal products produced by animals fed probiotics, Transfer of antibiotic resistance from probiotics to other pathogenic microorganisms, release of infectious microorganisms or noxious compounds to the environment from the animal production system, infection (gastro intestinal or systemic) of the handlers of animal or animal feed, Skin and/or eye and/or mucus membrane sensitization in the handlers of probiotics, detrimental metabolic or toxic effects in the host due to the production of toxins by the microorganisms contained in probiotics, hyper stimulation of the immune system in susceptible hosts (Doron and Snydman, 2015).

Assessment of risk for probiotics

The microorganisms considered for use as probiotics in animal diets should be assessed against the above-mentioned risks. The microorganism under consideration need to be identified to strain level and the particular strain of microorganism should not have been associated with any infection in humans or animals. Similarly, the putative probiotic should not harbor transferable antibiotic resistance genes. Microorganisms which either produce toxins or cause hyper stimulation of the immune system in the host are generally not suitable for probiotics (Shanahan, 2012).

Safety of probiotics and potential public health risks

The safety of probiotics is discussed in general terms and is not specific to those used in animal feed. The possibility of probiotics used in poultry feed entering the human food chain cannot be ruled out. However, there is very little information available about the risk of human food “contamination” with probiotics used in animals. The microbial genera and species used as probiotics in poultry feed are generally considered safe. The most serious risk posed by probiotic microbes in feed are, first, transfer of antibiotic resistance due to the presence of transmissible antibiotic resistance genes/determinants in some probiotic bacteria; and second, infections from the probiotic microorganisms and presence of enterotoxins and emetic toxins in probiotic bacteria. Most publications relating to probiotics deal with their efficacy rather than safety. Most of the information about the safety of probiotics is based on *Lactobacillus* and *Bifidobacterium* (Hempel et al., 2011; Shanahan, 2012).

Therefore, more research is required in relation to the safety of probiotics. Shanahan (2012) highlights the limitations of claims made about the safety of probiotics in general, and especially the safety of any particular probiotic. According to Shanahan (2012) safety assessment and information on a particular probiotic strain cannot be generalized to similar probiotics (even with a different strain of the same species), as each probiotic requires safety and risk assessment on a case by case basis. The adverse effects and the severity of the effects of a probiotic could be context specific and depend on the susceptibility (immunity) and physiological state of the host (animal or human). Therefore, probiotic strains deemed to be safe in certain conditions may not be safe in other conditions. No probiotic can be regarded as 100% safe or with zero risk, as is the case with drugs (Hempel et al., 2011; Shanahan, 2012).

Public awareness about the risk from probiotics is limited. There is a need for proper risk benefit analysis and communication of this to the user/consumer of the probiotic. The contamination of probiotics with unwanted microbes or substances is an important safety and quality issue as with the safety and quality of probiotic microorganisms, and sometimes, hazards associated with contaminants may be a more important issue than the specific quality of the probiotics (Shanahan, 2012). Although there are many publications on the safety of probiotics, the evidence available is not enough to address all the safety issues and precludes a declaration of probiotics as universally safe or unsafe (Hempel et al., 2011).

IMPACT OF PROBIOTICS IN COMMERCIAL POULTRY PRODUCTION

Effects of probiotics on meat quality

Few studies have examined the effects of probiotics on carcass yield and quality in poultry. Marketable carcass yield or ready to cook quantity of carcass at day 42 was increased concurrently with increased growth rate and improved feed use efficiency with the use of the commercial probiotic and *E. faecium* in drinking water and a mix of the spore-forming bacterium *B. subtilis* and a yeast *S. cerevisiae* in feed (Abdel-Rahman et al., 2013). *E. faecium* in drinking water at the rate of 2 g per 100 birds per day increased ready to cook carcass weight and overall body weight (BW) gain at day 42 (Abdel-Rahman et al., 2013). In contrast, did not find any difference in carcass yield, growth rate and feed use efficiency of birds at day 42 treated with a commercial probiotic containing *B. subtilis* (Afsharmanesh and Sadaghi, 2014).

Water holding capacity of poultry meat was increased in birds fed with the probiotic *B. coagulans* (Zhou et al., 2010). The tenderness of the meat was also improved in probiotic treated birds in the same study using a local breed of meat-type chicken in China. Using another probiotic (*S. cerevisiae*), found no improvement in tenderness in breast meat of commercial broilers. However, both the probiotics had positive effects on growth rate and FCR (Zhao *et al.,* 2013) found differences in meat quality of Ross broiler chicks between two different probiotics. The intramuscular fat content in breast muscle was increased by 3.6% in birds treated with probiotic *C. butyricum,* while there was no effect with the probiotic *E. faecium* (Zhao et al., 2013).

The effect of probiotics on the relationship between carcass quality and yield is unclear. It is due to an effect on muscle or due to improved growth performance *and* the inconsistencies in the response may be due to the differences in probiotic strains and or the breed of birds used. Examined the effect of probiotics on the microbiology and gustatory factors of broiler meat and showed that the consumption of probiotics enhances the quality of meat before and after freezing and increase in the score of meat quality factors, including appearance, texture, succulence, and wholesomeness in broilers fed with probiotic (lacto-saccharose). However, flavor and taste showed lower scores and neither probiotics nor antibiotics affect sensory properties (color and smell intensity, unnatural taste, tenderness, succulence, wholesomeness, color property), and general properties of the thigh and breast meat (Getachew, 2016).

Stimulation of body immune system

Immune resulting from the exposure of intestine to various forms of antigen, such as pathogenic bacteria and protein in feed, is important in young animals' defense against intestinal infections. The birds treated with *Lactobacillus reuteri* further showed ideal and deeper cryptal villa which improve T cell function responses and increase the secretion of the IgM anti-*Salmonella* antibody (Sabiqaa et al., 2013).

Probiotics are reported to have also anti-mutagenic, anti-carcinogenic, hypo-cholesterolemic, antihypertensive, anti-osteoporosis, and immune modulatory effects. Intake of probiotic lowers the risk of gastrointestinal diseases by stimulating the growth of beneficial microorganisms. Supplementation of probiotics alleviates the problem of lactose intolerance. It also helps the enhancement of nutrients bioavailability, and prevention or reduction of allergies in susceptible individuals (Chiang and Pan, 2012).

Effects on growth performance

Increase in BW gain in broilers fed with probiotics *Lactobacillus*, *Bifidobacterium*, coliforms, and *Clostridium* species (Song, 2014) have suggested that probiotic supplementation improved performance of broilers (Nikpiran et al., 2013). The *pax* and *Saccharomyces cerevisiae* had positive effects on performance of Japanese quails (Zhang and Kim, 2014). Increase in BW gain in chicken fed with multi strain probiotics reported that significantly higher BW is recorded on broiler flocks that received probiotics (Mansoub, 2010) reported significant increase in BW of broilers fed with *Lactobacillus acidophilus* and *Lactobacillus* cases. The supplementation of probiotics includes *Lactobacillus acidophilus, Bacillus, Lactobacillus subtilis*, *Saccharomyces cerevisiae* and *Aspergillus oryzae* (Amer and Khan, 2012).

Probiotics have enhanced the growth rate in broilers better than avilamycin (Zhang and Kim, 2014). However, the general applicability of the probiotic approach as an alternate for avilamycin is not yet well established. Probiotics ranging from non-spore forming to spore formers and yeast have been evaluated for their potential to improve growth rates in commercial poultry production (Shim et al., 2012; Bai et al., 2013; Afsharmanesh and Sadaghi, 2014).

In many cases the improvement in growth rate in the probiotic treated birds was associated with increased feed intake (FI) (Lodemann, 2010; Lei et al., 2013) and improved feed use efficiency (Shim et al., 2012; Zhang and Kim, 2014) compared with untreated birds. Therefore, increased digestibility of feed resulting in improved feed use efficiency could be one of mode of actions for improved growth rate. Also, the differences in performance between treated and untreated birds may be due to a change in microbial populations in the GIT resulting increased production of SCFA and immune modulation (Zhao et al., 2013). Increased growth rate has also been associated with increased villas height, which increases absorption of nutrients from the intestine. In contrast, some probiotics did not improve growth in broiler (Hung et al., 2012).

Hypocholesterolemic potential

The cholesterol level of serum significantly decreased in groups supplemented with probiotics in assimilation of cholesterol by *Lactobacillus* compared to control group fed with basal diet. The same study also reported that there is a significant decrease in the serum level of triglycerides between control group and groups treated with *Lactobacillus acidophilus* and *Lactobacillus casei* supplemented in broiler diet in combination with water or alone (Mansoub, 2010). Supplementation of probiotic *Bacillus licheniformis* and *Bacillus subtilis* decreased egg yolk cholesterol and serum cholesterol levels in Brown-Nick layer hybrids and fat digestion rate is linked to the rate of gallbladder acids in digestion latex and subsequently the lipid concentration. *Lactobacillus acidophilus* and *Lactobacillus casei* in diet or water cause a decrease in gallbladder acids in digestion latex and this resulted in a reduction in the ability of fat digestion and therefore decreasing lipid level of blood (Getachew, 2016).

Prevention of enteric pathogens

The public health risk from zoonotic pathogens of poultry like Salmonella and Campylobacter and antibiotic resistance is increasing with intensification of the poultry production in developing countries and imprudent use of antibiotics in commercial poultry production systems and In addition, other enteric diseases of poultry, like necrotic enteritis and coccidiosis cause huge economic losses to the industry (Bera et al., 2010; Skinner et al., 2010). The change in the commercial poultry production systems which result in delayed colonization of the gastro intestinal mucosa by healthy microflora may be one of the reasons for the increasing incidence of enteric pathogens and the virtually sterile environment immediately post hatch makes it possible for opportunistic pathogens to colonize the intestine probiotics may prevent or control such enteric pathogens (Crhanova et al., 2011).

Effects on egg production and quality

The highest hen-day production and egg weight in layers supplemented with Liquid Probiotics Mixed Culture (LPMC) containing two type microorganisms, *Lactobacillus* and *Bacillus* species (Raka et al., 2014). Probiotic bacteria mixed culture to maize basal diet improved commercial poultry day egg production. Similarly, in barley based diets, addition of probiotic bacteria increased egg size but there were no differences in feed intake, feed conversion ratio (FCR) and egg specific gravity in layers and supplementation probiotic *Bacillus licheniformis* and *Bacillus subtilis* increased egg production and decreased percentages of damaged egg in Brown-Nick layer hybrids (Tarekegn, 2016).

On the other hand, indicated that significant higher egg production was recorded in Hyline layers supplemented with probiotic *Saccharomyces cerevisiae* (Saadia and Nagla, 2010). While probiotics can affect the production, FCR and quality of eggs in egg laying hens. Studies showing increase in egg production with supplementation of diets with probiotics (Gallazzi et al., 2009) in contrast with those showing no effect on egg production (Mikulski et al., 2012). Similarly, there are variable effects of probiotics on FCR in laying commercial poultry. One of the most promising effects of probiotics on egg quality is the consistent reduction of cholesterol in egg yolk. Yolk cholesterol has been reduced by lactic acid bacteria (Capcarova et al., 2010).

Effects on feed intake

Poultry are the cheapest source of animal protein, contributing significantly to supplying the growing demand for animal food products around the world (Farrell, 2013). The consumption and trade in poultry products is increasing rapidly as the human population increases, making it the second largest source of meat after pork (FAO, 2014). Probiotics can improve broiler chicken growth rates (Lei et al., 2013; Afsharmanesh and Sadaghi, 2014; Mookiah et al., 2014; Zhang and Kim, 2014) and control or prevent enteric diseases, including salmonellosis (Tellez et al., 2012; Biloni et al., 2013), necrotic enteritis (Jayaraman et al., 2013).

Rise in feed and water consumption is recorded in laying hens fed with Liquid Probiotics Mixed Culture (LPMC) containing two type microorganisms, *Lactobacillus* and *Bacillus* species (Raka et al., 2014). Supplementation of probiotic *Lactobacillus* cultures did not influence the FI, egg production or egg mass of hens throughout the 48-week period (Zhang and Kim, 2014). Increase body in FI in chicken feed with multi strain probiotics compared with that in control group fed basal diet (Saadia and Nagla, 2010) reported FI values of different treated groups were approximately similar and lacked significance with layer flock that feed with Saccharomyces cerevisiae. Probiotic (*Saccharomyces cervisiae*) supplementation of broilers had significantly increased feed consumption (Babazadeh et al., 2011). Probiotics did not have any significant positive effect on broilers FI, BW and FCR and *S. cerevisiae* significantly increased FI in Japanese quails (Nikpiran et al., 2013).

CONCLUSIONS

Probiotics have a number of beneficial effects in poultry production. According to different studies, provision of probiotics improves feed intake, feed conversation ratio, stimulates growth rate, increases egg production and have hypocholesteronemic effects on poultry products. However, some studies reported that there is nothing significant effect of feeding probiotics on feed intake, growth performance and egg production. Despite the wide use of probiotics in poultry production, an accurate dosage of administration has yet to be established. It can be mixed into water and feed with different dosages. The dense growth of poultry increases the risk of various microbial infections such as *Salmonella, Campylobacter* and *C. perfringens*. Antibiotics are widely used to improve growth factor and prevent and treat various infections. The presence of antibiotic residuals in meat and egg, followed by antibiotic resistance, threaten the health of consumers. Considering this increasing trend of antibiotic consumption and the ever-increasing prevalence of antibiotic resistance, alternative compounds such as probiotics and prebiotics are being employed today. Their consumption as nutritional supplements in poultry diet is expanding due to their health promoting effects, such as increasing growth, improving eggs, fortifying the immune system and enhancing the health status.

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