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Review on Overview of Probiotics: Alternatives for Antibiotic Use in Poultry

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Abstract

Supplementation of probiotic as a mean to improve the health and performance of poultry has generated significant interest over the last few years. A driving force for the interest of probiotic is to eliminate the use of low dose antibiotics in poultry production. The extensive use of antibiotics in poultry with the purpose of promoting growth rate, increasing feed conversion efficiency and for the prevention of intestinal infections have led to an imbalance of the beneficial intestinal flora and the appearance of resistant bacteria. With increasing concerns about antibiotic resistance, there is increasing interest in finding alternatives to antibiotics for poultry production. To avoid the health hazards of antimicrobials drugs like antibiotics to human as well as poultry, probiotic has been used for as an potential substitute for antibiotics and been proved to be saved in poultry production system. This increased attention toward probiotic supplementation has generated an extensive body of research in the present day. The increase of productivity in the poultry industry has been accompanied by various impacts, including emergence of a large variety of pathogens and bacterial resistance. These impacts are in part due to the indiscriminate use of chemotherapeutic agents as a result of management practices in rearing cycles. This review provides a summary of the use of probiotics for prevention of bacterial diseases in poultry, as well as demonstrating the potential role of probiotics in the growth performance and immune response of poultry, safety and wholesomeness of dressed poultry meat evidencing consumer’s protection, with a critical evaluation of results obtained to date. Collectively this review found a strong evidence to suggest that probiotic supplementation may have an impact on the immune response, overall health and performance of poultry.

Keywords: Antibiotics, bacteria, disease control, probiotics, poultry, supplement

1. Introduction

The poultry industry has become an important economic activity in many countries. In large scale rearing facilities, where poultry are exposed to stressful conditions, problems related to diseases and deterioration of environmental conditions often occur and result in serious economic losses. Prevention and control of diseases have led during recent decades to a substantial increase in the use of veterinary medicines. However, the utility of antimicrobial agents as a preventive measure has been questioned, given extensive documentation of the evolution of antimicrobial resistance among pathogenic bacteria. So, the possibility of antibiotics ceasing to be used as growth stimulants for poultry and the concern about the side-effects of their use as therapeutic agents has produced a climate in which both consumer and manufacturer are looking for alternatives. Probiotics are being considered to fill this gap and already some farmers are using them in preference to antibiotics (Dalloul *et al.*, 2005).

During the last several decades, antibiotics have been widely used in the poultry industry to promote growth. Moreover, the extensive use of antibiotics has the possibility to generate antibiotic-resistant bacteria in animal products (Abdelqader *et al.,*2013). Usage of antibiotics as an animal growth promoter in animal diets have been banned or limited in many countries (Applegate *et al.,*2011). The great challenge of commercial poultry production is the availability of good quality feed with minimum cost on sustainable basis. Feed is the major component of the total cost of production in the poultry industry. Commercial poultry production ranks among the highest source of animal protein and the increase in the size of the poultry industry has been faster than other food-producing animal industries (Cengiz *et al.*, 2015).

With the current advent of excluding antibiotic growth promoters in poultry production in Europe and America, the issue of controlling enteric infections caused by pathogenic bacteria without the use of antibiotics becomes challenging. Mortality caused by infection is a big problem in the poultry industry. Such infections are responsible for reduced growth rates and consequent economic losses in poultry. Antibiotics are the main tools utilized to prevent or treat such infections in poultry house. Besides, antibiotics are also added to the feed as growth promoters and to accelerate the growth of healthy animals. Unfortunately, the long term and extensive use of antibiotics for veterinary purpose may eventually result in selection for the survival of resistant bacteria species or strain. In view of rising concerns on the extensive loss in poultry due to gastro intestinal problems in chick gut and implementation of strict laws to use of harmful synthetic drug or antibiotics, creates demand of an alternative disease control resources to enhance gut health and to reduce the use of AGPs (Cisek, 2014).

The utility of antimicrobial agents as a preventive measure has been questioned, given extensive documentation of the evolution of antimicrobial resistance among pathogenic bacteria and the concern about the side effects of their use as therapeutic agents has produced a climate in which both consumer and manufacturer are looking for alternatives. Probiotic are being considered to fill this gap and has been used as potential substitute for antibiotics in poultry (Dalloul *et al.*, 2005).

Adding the so-called beneficial bacteria to the digestive tract of poultry is not a new concept, however, a complete understanding of where, when and how to use them still has escaped us in its entirety. A strikingly crucial event in the development of probiotics was the finding that newly hatched chickens could be protected against colonization by Salmonella enteritidis by dosing a suspension of gut contents derived from healthy adult chickens (Cisek, 2014).

In broiler nutrition, probiotic species belonging to Lactobacillus, Streptococcus, Bacillus, Bifido bacterium, Entero coccus, Aspergillus, Candida and Saccharomyces have a beneficial effect on broiler performance, modulation of intestinal micro flora and pathogen inhibition , intestinal histological changes, immunomodulation, certain haemato biochemical parameters , improving sensory characteristics of dressed broiler meat and promoting microbiological meat quality of chickens (Hosseindoust *et al.,2016).*

The objectives of this paper is to review probiotics as alternatives for antibiotics use in poultry summarize their applications in the poultry industry.

2. Overview of Probiotics : Alternatives for antibiotic use in poultry

2.1. Classes of alternatives to antibiotics in poultry

An ideal alternative should have the same beneficial effects, ensure optimum animal performance, and increase nutrient availability (Hosseindoust *et al., 2016).* Considering the proposed mechanism of action of microbiome and immune modulating activities, a practical alternative should possess both of these properties in addition to having a positive impact on feed conversion and/or growth . Several classes of alternatives have been proposed and tested in poultry production, including probiotics, prebiotics, synbiotics, organic acids, enzymes, phytogenics and metals. Novel alternatives such as hyper immune egg yolk IgY, antimicrobial peptides (AMP), bacteriophages, and clay have come into existence in recent years (Kabir, 2009).

2.1.1. Definition of probiotics

Probiotics, sometimes used interchangeably with the term direct fed microbials (DFMs), are gaining acceptance as potential alternatives to antibiotics to improve production efficiency (Lee et al., 2010c). They are defined as “live microbial feed supplements which beneficially affect the host animal by improving its intestinal microbial balance” (Majidi-Mosleh, *et al.,* 2017).

A recent definition adopted by FAO/WHO (2001) states that "Probiotics are mono or mixed cultures of live organisms which when administered in adequate amounts confer a health benefit to the host." Novel application strategies such as spraying on chicks or embryonated eggs are also practiced and potential methods such as in ovo application are being explored (Wolfenden *et al.,* 2007; Cox and Dalloul, 2015).

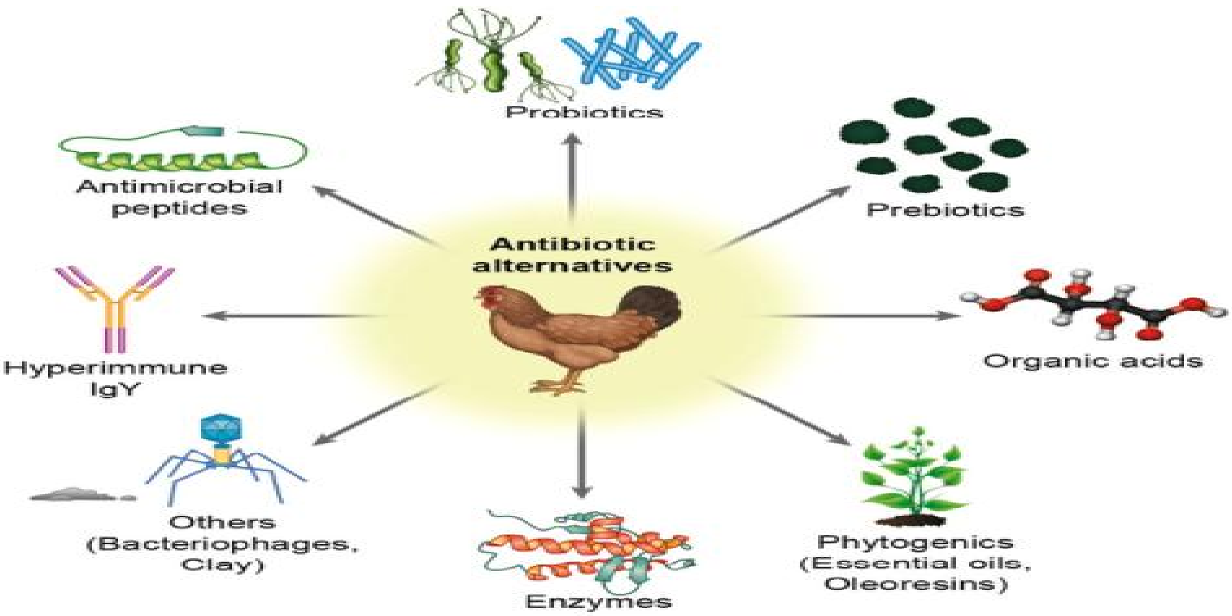

Figure 1: Alternatives to antibiotics (Cox and Dalloul, 2015).

Over the years the word probiotic has been used in several different ways. It was originally used to describe substances produced by one protozoan which stimulated by another, but it was later used to describe animal feed supplements which had a beneficial effect on the host animal by affecting its gut flora. According to the currently adopted definition by FAO, probiotics are: "live microorganisms which when administered in adequate amounts confer a health benefit on the host". More precisely, probiotics are live microorganisms of nonpathogenic and nontoxic in nature, which when administered through the digestive route, are favorable to the host's health (Wolfenden *et al.,* 2007; Cox and Dalloul, 2015).

It is believed by most investigators that there is an unsteady balance of beneficial and non-beneficial bacteria in the tract of normal, healthy, non-stressed poultry. When a balance exists, the bird performs to its maximum efficiency, but if stress is imposed, the beneficial flora, especially lactobacilli, have a tendency to decrease in numbers and an overgrowth of the non-beneficial ones seems to occur. This occurrence may predispose frank disease, i.e., diarrhea, or be subclinical and reduce production parameters of growth, feed efficiency, etc. The protective flora which establishes itself in the gut is very stable, but it can be influenced by some dietary and environmental factors. The three most important are excessive hygiene, antibiotic therapy and stress. In the wild, the chicken would receive a complete gut flora from its mother's faeces and would consequently be protected against infection (Figure 1). However, commercially reared chickens are hatched in incubators which are clean and do not usually contain organisms commonly found in the chicken gut. There is an effect of shell microbiological contamination which may influence gut micro flora characteristics. Moreover HCl gastric secretion, which starts at 18 days of incubation, has a deep impact on micro flora selection. An immediate use of probiotics supplementation at birth is more important and useful in avian species than in other animals. The chicken is an extreme example of a young animal which is deprived of contact with its mother or other adults and which is, likely to benefit from supplementation with microbial preparations designed to restore the protective gut micro flora (Wolfenden *et al.*,2007; Cox and Dalloul, 2015).

In probiotic preparations the mostly used are: *Lactobacillus bulgaricus*, *Lactobacillus acidophilus*, *Lactobacillus casei*, *Lactobacillus helveticus*, *Lactobacillus lactis*, *Lactobacillus salivarius*, *Lactobacillus plantarum*, *Streptococcus thermophilus*, *Enterococcus faecium*, *Enterococcus faecalis*, *Bifid bacterium spp*. and *Escherichia coli.* With two exceptions, these are all intestinal strains. The two exceptions, lactobacillus bulgaricus and Streptococcus thermophilus, are yoghurt starter organisms. Some other probiotics are microscopic fungi such as strains of yeasts belonging to *Saccharomyces cerevisiae* species (Hosseindoust *et al.*,2016).

Two genera of bacteria are frequently used; lactic acid bacteria of the genus lacto bacillus and bifid bacterium. Besides, different medicinal fungi including mushroom and yeast have been used as a potential probiotic in farm animals including poultry. The mode of action of probiotic includes; competitive exclusion, microbial antagonism and immune modulation (Dalloul *et al.,* 2005).

2.2. Mechanisms of action of probiotics

The mode of action of probiotics in poultry includes: (i) maintaining normal intestinal micro flora by competitive exclusion and antagonism; (ii) altering metabolism by increasing digestive enzyme activity and decreasing bacterial enzyme activity and ammonia production ;(iii) improving feed intake and digestion; and (iv) stimulating the immune system (Dalloul *et al.*,2005).

Upon consumption, probiotics deliver many lactic acid bacteria into the gastrointestinal tract. These microorganisms have been reputed to modify the intestinal milieu and to deliver enzymes and other beneficial substances into the intestines (Majidi and Mosleh *et al.*,2017).

Probiotic is a generic term, and products can contain yeast cells, bacterial cultures, or both that stimulate microorganisms capable of modifying the gastrointestinal environment to favor health status and improve feed efficiency (Latorre *et al.,* 2017).

Mechanisms by which probiotics improve feed conversion efficiency include alteration in intestinal flora, enhancement of growth of nonpathogenic facultative anaerobic and gram positive bacteria forming lactic acid and hydrogen peroxide, suppression of growth of intestinal pathogens, and enhancement of digestion and utilization of nutrients. Therefore, the major outcomes from using probiotics include improvement in growth, reduction in mortality, and improvement in feed conversion efficiency. These results are consistent with previous experiment of Tortuero and Fernandez , who observed improved feed conversion efficiency with the supplementation of probiotic to the diet (Majidi and Mosleh *et al.*,2017).

2.3. Criteria for selection of probiotics in the poultry industry

The perceived desirable traits for selection of functional probiotics are many. The probiotic bacteria must fulfill the following conditions: it must be a normal inhabitant of the gut, and it must be able to adhere to the intestinal epithelium to overcome potential hurdles, such as the low pH of the stomach, the presence of bile acids in the intestines, and the competition against other micro organisms in the gastro-intestinal tract. Many in vitro assays have been developed for the pre selection of probiotic strains. The competitiveness of the most promising strains selected by in vitro assays was evaluated in vivo for monitoring of their persistence in chickens (Hosseindoust *et al.,* 2016).

2.4. Effects of Probiotics on growth performance and feed consumption efficiency

Inclusion of a *bacillus* base direct fed microbial could improve body weight, body weight gain and feed consumption in broiler when compared to the control group. *Bacillus amyloliquefaciens* based direct fed microbials (DFM) showed better body weight gain, feed consumption and improved apparent digestibility of dry matter (DM), crude protein (CP) and gross energy (GE) efficiency than that of control and could be an alternative to the antibiotic growth promoter in broilers diets (Latorre *et al.*,2017). This study further showed that *bacillus amyloliquefaciens* based DFM improved gut structure and resulted in a greater absorption surface, as indicated by improved villus height and villus height to crypt depth ratio in the different small intestinal segments compared to the antibiotic growth promoter-free control diet. Dietary supplementation with probiotic containing *enterococcus faecium* was reported as increased nutrient retention and reduction in nutrient excretion, leading to improved nutrient digestibility and reduced excreta ammonia emission in laying hen (Kabir, 2009).

Chickens fed with *bacillus subtilis*, had greater body weight gain (BWG) than those fed with the control diet was reported by Hosseindoust *et al*, (2010). Dietary probiotic significantly enhanced the feed intake and weight gain in starter phase only was reported by Cengiz *et al*, (2012). Increased in feed intake and water consumption is recorded in laying hens fed with liquid probiotic mixed culture (LPMC) containing two type microorganisms, *Lactobacillus* and *Bacillus* species (Pambuka *et al.,2008).*

Abdel Raheem *et al*, (2012), reported that significantly higher body weight is recorded on broiler flocks that received probiotic. Probiotic *Saccharomyces cervisiae*) supplementation of broilers, at level of 1, 1.5 and 2% had significantly increased the body weight gain, feed consumption and feed conversion efficiency (Kabir, 2009). In some studies, dietary *bacillus* based direct fed microbials are reported to have beneficial effects on animal and poultry growth and feed conversion efficiency (Mansoub, 2010).

Effects of probiotics on egg production and quality: Park *et al*, (2015) reported that probiotic (*Enterococcus faecium* DSM 7134) supplementation resulted in a significant increase in egg production, egg shell thickness and nutrient digestibility in laying hens. Highest hen day production and egg weight in layers supplemented with probiotics mixed culture containing two type of microorganisms, *Lactobacillus* and *Bacillus* species was reported by Pambuka *et al*, (2014).

Tang *et al*. (2016), reported that laying hens fed with probiotics significantly improved egg yolk total unsaturated fatty acids, total omega 6 and polyunsaturated fatty acids (PUFA), including linolenic and alpha linolenic acid as well as significantly decreased egg yolk cholesterol, total saturated fatty acids when compared with control. The improvements in the levels of essential fatty acids (EFA) (linolenic acid and alpha linolenic acid) can be increased via supplementation with probiotics Yi *et al*, (2014).

In addition, Park *et al*. (2015), indicated that significant higher egg production was recorded in hyline layers supplemented with probiotic *Saccharomyces cerevisiae*. Besides, in some studies, laying hens fed with the probiotic found greater egg production, egg weight and higher eggshell thickness than hens fed the diets without the probiotic (Pambuka *et al., 2008).*

2.5. Effect of probiotic on chicken gut micro flora

Chen *et al*, (2017) reported that probiotic which contain *Lactobacillus* culture can control the pathogens population and alter gastrointestinal flora. In another recent study by Majidi and Hosseindoust *et al*, (2010);stated that injection of probiotic bacteria especially *B. subtilis* into the amniotic fluid has a beneficial effect on ileal gene expression and bacteria population during the 1st week post-hatch in broiler chicken. The result showed that probiotic strains decreased significantly the *Escherichia coli* population and increased the lactic acid bacteria population during the 1st week of post hatch.

Latorre *et al*, (2019), reported that chickens fed on the *bacillus* DFM diet showed a significant reduction in the number of Gram-negative and anaerobic bacteria in the duodenal content compared to control. The population of l*actobacillus* spp. in gizzard was significantly higher in the probiotic diet contain *bacillius subtilis* compared with control (Kabir, 2009; Salim *et al*, (2014); stated that the dietary supplementation of DFM decreases the number of *E. coli* and improves the ileal morphology of broiler chickens. Dietary supplementation of the probiotic increased excreta *Lactobacillus* counts and decreased *Escherichia coli* counts compared with hens fed the diets without the probiotic (Ramasamy *et al.*, 2009).

Probiotic significantly increased *Lactobacillus* counts in the cecum, ileal and excreta, as well as reduced *Escherichia coli* counts in the cecum and excreta, compared with control. In addition, supplementation of probiotic also tended to reduce *Clostridium perfringens* counts in the large intestine and excreta, while linearly reducing *Salmonella* counts in the cecum, ileal, large intestine and excreta, compared with control (Higgins *et al.*, 2008).

Lourenco *et al*, (2008), indicated that feeding *bacillus subtilis* decreased significantly the *Salmonella* population in the broiler gut. Digestive tract of chickens is free of microorganism before hatch; early placement of beneficial bacteria in the gut can prepare suitable conditions for establishing a normal micro flora and improve quality and health of the gut.

It was shown that addition of probiotic to diet of broiler chickens enhanced nutrient digestibility and improved caecal micro flora composition. The bacteria gut digest and through molecular studies identified 640 species belonging to 140 genera and the diversity of the microbial flora of chicken GIT depends on several factors including diet composition, age of the chicken, breed, geographic location and the specific section of the GIT such as small intestine, ileum, cecum. At maturity, the chicken GIT is quite diverse consisting mostly of bacteria and to a lesser extent protozoa and fungi (Pambuka *et al., 2008).*

2.6. Effect of probiotic on immune response in chicken

One of the most important roles of probiotic microorganism is to stimulate the immunity against invading pathogenic microbes. Different probiotic microorganisms including the normal micro flora of the GIT have known to stimulate immunity in the host species. Dietary probiotic supplementation had a positive effect on serum immunoglobulin M (IgM) and cell-mediated immunity when compared to the control, whereas serum immunoglobulin A (IgA) and immunoglobulin Y (IgY) were improved but not significantly in broiler study. In another recent study in broilers treated with probiotic cultures showed a satisfactory immune response compared with control (Pambuka *et al.*, 2008).

In a previous study, probiotic supplementation resulted in increases of antibody titres to sheep red blood cells, as well as Newcastle diseases virus (NDV) and infectious Bursal disease virus (IB) (Pambuka *et al.*, 2008).

The polysaccharides extracted from different mushroom are also known to exhibit immuno modulatory properties (Pambuka *et al.,* 2008). The polysaccharide containing extracellular fractions from oyster mushroom, *Pleurotus ostreatus* was found to stimulate immune system response against microbial infections in vaccinated chickens. Significantly higher antibody production on immune response of broilers was observed by several previous studies (Higgins *et al.,* 2008).

3. Conclusion and Recommendations

The present review reveals that probiotics could be successfully used as an alternative to conventional antibiotic growth promoter as well as nutritional tools in poultry feeds for promotion of growth, modulation of intestinal micro flora and immunomodulation in poultry. In this study we propose to add probiotic in poultry ration as substitute for antibiotics so that it would be a potential strategy for economic poultry production which would be saves for human consumption.

Since probiotics do not result in the development and spread of microbial resistance, they offer immense potential to become an alternative to antibiotics. The present review reveals that Probiotics could be successfully used as nutritional tools in poultry feeds for promotion of growth, modulation of intestinal micro flora and pathogen inhibition, immuno modulation and promoting meat quality of poultry.
In line with the above conclusion the following recommendations are forwarded:

❖ Probiotics should be used as alternatives to antibiotics in poultry.

❖ In addition, future study was recommended by many researchers regarding the role of probiotic as a poultry supplement as an alternative to antibiotics.

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