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A review of antibiotic growth promoters as alternatives on intestinal health and growth performance of broiler

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Abstract

The purpose of this study was to investigate the effect of alternatives to Antibiotic Growth Promoters (AGP) on intestinal health and growth performance of broiler chickens. One potential challenge on broiler chickens is an increased resistance of pathogenic bacteria to the approved antibiotics used for growth promotion in feeds. The occurrence of AGP-associated resistant bacteria has led to concerns of human health risks. Due to the growing concern of bacterial resistance passing from animals to humans, the research for alternatives to replace antibiotics in broiler feeds has gathered great importance in animal nutrition. The removal of antibiotics from animal diets has put tremendous pressure broiler producers to look for alternative solutions. These solutions should be natural substances, which would have a positive effect on chicken health, growth, feed conversion and should not impair with human health. Today, several groups of these additives are in use and most often probiotics, prebiotics, synbiotics, enzymes, acidifiers, antioxidants and phytogene additives.

Keywords: antibiotic growth promoters; probiotics; prebiotics; enzymes; additives

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Introduction

The use of antibiotics as additives in poultry feeds has been widely practiced in the poultry industry since early 1950's (Dibner and Richards, 2005; Mroz, 2005; Markovic et al., 2009; Eseceli et al., 2010). Antibiotic growth promoters (AGP) are chemical substances which are added to livestock food primarily to control diseases and more recently to promote growth and improve feed conversion (Peric et al., 2009; Eseceli et al., 2010). The main site of AGP activity is within the gastro-intestinal tract (Botlhoko, 2009). According to Miles et al. (2006), the establishment of microbial population in the gastro-intestinal tract (GIT) of all warm-blooded animals soon after birth cannot be avoided. A bacterial population is present in the small intestine in the avian species within 24 hours following hatch (Miles et al., 2006). A large number of these microorganisms originate from the surrounding environment (Steiner and Wegleitner, 2007). The micro-flora capable of intense metabolic activity has detrimental and beneficial effects

on the host animal. The gut micro-flora decrease nutrient absorption of the host animal by increasing the GIT thickness and by increasing the rate of digest passage within the GIT (Bray, 2008). Lastly, it decreases nutrient absorption by competing with the host animal for a portion of the dietary energy and protein, while it causes diseases to the host (Miles et al., 2006). However, the inclusion of AGP's in broiler feeds reduces microbial use of nutrients and enhances the uptake and use of nutrients, due to thinning of the intestinal wall of the host animal (Bray, 2008).

The AGP also inhibit endemic subclinical infection by controlling growth and proliferation of microorganisms to the host animal, thus preventing diseases (Oguttu et al., 2007). The beneficial effects of gut micro-flora to the host include vitamin production, stimulation of the immune system through nonpathogenic mechanisms, and inhibition of the growth and establishment of harmful microbial groups. Over the years less was known that the microorganisms could easily accept and transfer genes for coding for antibiotic resistance (Oguttu et al., 2007). According to Botlhoko (2009), antibiotic resistance refers to an antibiotic that previously was effective in killing or inhabiting the growth of a particular microorganism but has lost its usefulness so that bacterial infection is more difficult or expensive to treat. Resistance develops when a bacterium survives exposure to an antibiotic that normally kills or inhabit bacterial population, this usually occurs after mutation has occurred (Oguttu et al., 2007).

Alternative growth promoters

The alternative growth promoters, all in majority of cases demonstrate a positive effect on intestinal health and growth performance of broiler chickens (Peric et al., 2009). However, mechanism of these alternatives varies and their positive effect can be expressed through better appetite, improved feed conversion, stimulation of the immune system and increased vitality and regulation of the intestinal microflora (Peric et al., 2009). The fact that growth promoters have different mechanisms of action, it is necessary to present every group individually and present the effect which can be expected with their utilization.

Characteristics of good AGP alternatives

Ideally, the main characteristic of a good alternative from a practical point of view is that it must have the same beneficial effect as AGPs (Huyghebaert et al., 2011). The most well known mechanism is that AGPs have an antibacterial action that favours performance of broilers in different ways (Bray, 2008; Botlhoko, 2009). A good AGP alternative should be capable of reducing the incidence and severity of subclinical intestinal infections of broilers (Huyghebaert et al., 2011) by reducing the microbial use of nutrients (Bray, 2008;) and by improving absorption of nutrients because of thinning of the intestinal wall (Mroz, 2005).

Probiotics

Probiotics are defined as direct-fed mono or mixed cultures of live microorganism, which when administered in adequate amounts confer a healthy benefit on the host by improving the properties of the indigenous microflora (Botlhoko, 2009; Alkhaf, 2010). The individual microorganisms or groups of microorganisms have favorable effect on host by improving intestinal microbial balance (Peric et al., 2009; Taheri et al., 2010). The maintenance of intestinal micro-flora balance is stated by several researchers as important in the prevention of disease by controlling the

overgrowth of enter pathogens (Dhawale, 2005; Botlhoko, 2009; Raja et al., 2009). Probiotics are given to poultry orally to help birds fight illnesses and diseases (Botlhoko, 2009). The probiotics which are in use or currently under research are mostly selected from native gut microflora (Botlhoko, 2009), with the selection of optimal strains often largely empirical. The microorganisms used in animal food are mainly strains of gram-positive bacteria (Angelakis and Raoult, 2010). Commercially available probiotic species include *Lactobacillus, Streptococcus, Bacillus, Bifidobacterium, Enterococcus, Asperilugus, Candida* and *Saccharomyces* (Raja et al., 2009). Peric et al. (2009) classifies these probiotic species into colonizing species (*Lactobacillus* sp., *Enterococcus* sp. and *Streptococcus* sp.) and free, non-colonizing species (*Bacillus* and *Saccharomyces* sp). Botlhoko (2009) explains that these microorganisms inhibit the growth of potentially pathogenic microorganisms such as *Salmonella* sp, *Shingella* sp, *campylobacter* and *E. coli* by lowering the pH through production lactate, lactic acid and volatile fatty acids. Microorganisms to be considered for probiotic use must be able to pass the stomach in a viable condition so that they multiply at the site of destination in the intestine (Mátéová et al., 2008).

Lactobacillus species

Lactobacillus species are one of the most important probiotic strains (Botlhoko, 2009). These bacteria are known to produce large amounts of lactic acid which lowers pH of GIT and lower pH is fatal to many bacteria (Raja et al., 2009). Most published papers on probioitics in broilers show that the supplementation of the different strains of *Lactobacillus* has good results in both intestinal health and broiler performance from the first week up to the whole fattening period of broilers. Probiotic supplementation of the intestinal microflora of broilers with *Lactobacillus* species has beneficial effects on resistance to infectious agents such as *Escherichia coli, Salmonella gallinarum, Campylobacter* sp and more recently, *Eimeria acervulina* (Raja et al., 2009). Among *Lactobacillus* species considered *L. fermentum* strains showed antagonistic effect against the enteropathogens, such as *Escherichia coli, Salmonella* sp., *Shigella sonnei* and some enterotoxigenic *Staphylococcus aureus* (Raja et al., 2009). Feeding diets containing *Lactobacillus reuteri* enhanced the production of anti-salmonella in newly hatched chicks (Khaksefidi and Ghoorchi, 2006). According to Ashraf et al. (2005), broiler chicks fed with probiotics containing *Lactobacillus casei* and *L. acidophilus* reported a positive effect on body weight of the broilers and thus increased growth performance.

***Bacillus* species**

Bacillus substilis increases the anaerobic condition of the digesta leading to increased numbers of bacterial lactic acid forming bacteria (Botlhoko, 2009). When *Bacillus substilis* demonstrated by yellow dots in the figure below is added to a diet it will consume oxygen and produce an amount of enzymes (Orffa info, 2011). This will create a favorable environment for beneficial bacteria such as *Lactobacilli* and *Bifidobacterium,* demonstrated by blue dots in the figure (Botlhoko, 2009). These beneficial bacteria will colonize the gut wall and block adhesion receptors (Orffa info, 2011). Besides, these bacteria produce lactic acid which will decrease pH in the gut (Raja et al., 2009). Khaksefidi and Ghoorchi (2006) discovered that the supplementation of broilers with 50 mg of *Bacillus substilis* per kg feed increases body weight gain of broilers from 1-42 day period.

However, they also discovered that a supplementation 25 mg per kg feed of *Bacillus substilis* was the same as the control. This therefore suggests that the amount *Bacillus substilis* supplemented per kg feed has a significant impact in the performance of broilers.

***Bifidobacterium* species**

Bifidobacterium are anaerobic, rod-shaped, gram-positive bacteria that are normally present in the intestinal flora of animals (Jung et al., 2008). Some strains show a tendency to inhibit the growth of such harmful bacteria as *Salmonella* (Ashraf et al., 2005). Increasing the numbers of *Bifidobacterium* in the intestine of broilers is believed to induce immunostimulation, compete with pathogenic bacteria for adhesion sites, and produce essential volatile fatty acids for energy (Willis et al., 2009). As probiotics, they stimulate the immune system, aid in digestion, and assist in the absorption of food ingredients and nutrients. They are also capable of synthesizing some vitamins. *B. adolescentis* for example have strong effects against gram negative bacteria and prevent the colonization of invading pathogens by competing for nutrients and attachment sites (Ashraf et al., 2005). *Bifidobacterium* species act in caecum where they colonize pathogenic bacteria by producing substances such as lactic acid and acetate, thus they inhibit growth of the gram- negative bacteria which usually result in intestinal diseases (Botlhoko, 2009).

***Enterococcus* species**

Enterococci are among the wide variety of microbial species that have been used extensively as probiotics (Awad et al., 2008). Following feeding of these probiotics, improvements in growth performance and feed efficiency have been reported in broiler chickens (Taheri et al., 2010). Recently, it was shown that adding of probiotic containing *Enterococcus faecium* microorganism to broiler diets increased the jejuna villus height and ileal villus height (Botlhoko, 2009). Moreover, increased intestinal villi height was reported after addition of *Bacillus substilis* in association with probiotics (Awad et al., 2008).

***Saccharomyces* species**

Non-pathogenic yeast, *Saccharomyces cerevisiae*, has been widely used in human medicine in combination with therapeutic antibiotic administration to avoid diarrhea (Santin, et al., 2001). However, there are limited reports on the improvement of broiler performance and reduction of the proliferation of enteropathogenic bacteria resulting from the addition of yeast or yeast products to poultry feed (Santin, et al., 2001; Botlhoko, 2009). Brummer et al. (2010) reported that when supplementing poultry diets with 0.02% *Saccharomyces cerevisiae* there are changes in body weight and ileal morphology with decreased goblet cells and crypt depth.

Prebiotics

Another way of manipulating the gut microflora is by supplementation of the diet with small fragments of a special group of carbohydrates (Botlhoko, 2009). Prebiotics are defined as non-digestible food components/ingredients which have positive effect on host in their selective growth and/or activation of certain number of bacterial strains present in intestines (Botlhoko, 2009; Peric et al., 2009). These are indigestible carbohydrates which pass through the small intestines and are broken down in the colon (Peric et al., 2009). They are not digested in the intestines, but are selectively fermented in the colon by *Bifidobacterium* to short-chain fatty acids, which in turn reduce pH in the

colon. This creates unfavourable conditions for development of pathogenic bacteria and facilitates reabsorption of minerals (Peric et al., 2009). The most often used prebiotics are fructo-oligosaccharides, inulin and oligosaccharides. These are considered as the standard prebiotics (Peric et al., 2009) and have been reported to enhance the communities of intestinal microflora within the GIT (Botlhoko, 2009). Normal intestinal microflora such as *Lactobacillus* or *Bifidobacterium* utilize inulin for fermentation more efficiently that other groups of bacteria and produce short chain fatty acids (SCFA) and lactate, thus inhibit the growth of harmful bacteria (Botlhoko, 2009). Mannan- oligosaccharirides are also used as prebiotics, but they do not selectively enrich the beneficial bacterial population but they improve feed conversion efficiency (Janardhana et al., 2009). Avian species cannot digest lactose because they lack the endogenous enzyme lactase; hence lactose present in the feed is being digested by intestine bacteria. In the course of these microbial processes more volatile fatty acids and lactic acid are released which lowers the pH of the intestinal environment.

Synbiotics

According to Peric et al. (2009), synbiotics are combination, primarily of probiotics and prebiotics, as well as other promoting substances which together exhibit joint effect in regard to health of digestive tract, digestibility and performances of broilers. A combination of probiotic and prebiotic, which is termed synbiotic, have a synergistic effect in promoting growth of existing strains of beneficial bacteria in the colon as well as improving the survival and growth of newly added probiotic strains (Peric et al., 2009). The functional benefits of synbiotic, such as resistance to gastrointestinal bacterial infection, antimicrobial activity, and improvement of immune system are envisaged in the development of synbiotic products (Saminathan et al., 2011). In recent years, studies have shown that synbiotic has the potential to be an alternative to antibiotic as a growth promoter for broilers. According to Botlhoko (2009) a mixture of 11 *Lactobacillus* strains and inulin has been used as a multi-strain probiotic for chickens and results showed that it could significantly improve the growth performance of broiler chickens.

Enzymes

Increasing the growth performance of broiler chickens by supplementing their diets with exogenous enzymes can also contribute to positive changes in gut health (Peric et al., 2009). Enzyme supplementation reduced *E. coli* levels in the caecum of broilers fed wheat- or corn-based diets (Rosin et al., 2007; Botlhoko, 2009). Similarly, Peric et al. (2009) observed that a further reduction in *E. coli* numbers in broilers fed the same diets supplemented with a combination of enzymes and probiotics. Supplementation of mixtures for broiler with enzymes is usually applied in order to increase the efficiency of production of poultry meat (Raja et al., 2009). Enzyme supplements used in poultry diets have a direct, positive effect on animal performance by aiding in the absorption of fat and other nutrients and by reducing the viscosity of digesta caused by non-starch polysaccharide (NSP) fractions present in various cereals. The combination of xylanase, amylase and protease enzymes has been shown to improve protein, amino acid and energy utilization, improve

performance/uniformity and impact microbial population in a beneficial manner in the upper and lower intestine of broilers.

Acidifiers

Organic acids have been studied as a tool to reduce undesirable bacteria during poultry production. Organic acids could control and limit the growth and colonization of numerous pathogenic and non-pathogenic species of bacteria in the gut. Organic acids reduce pH value of feed and in this way act as conserving agents and prevent microbiological/microbial contamination of feed, a similar effect that is exhibited in the digestive tract of poultry (Gaggia et al., 2010). Moreover, acidifiers may improve growth performance through establishment of low gastrointestinal pH conditions, which support endogenous digestive enzymes and reduce undesired gut microorganisms. Many dietary acidifiers are based on propionic acid, formic acid, lactic acid and others, either as single components or in combination. Some acidifiers also contain inorganic acids such as phosphoric acid (Peric et al., 2009).

Furthermore, water and feed acidification play an important role in gut flora management (Botlhoko, 2009). Formic acid is an effective acidulant that acts by inhibiting microbial enzymes. Tollba (2010) reported that the antimicrobial activity of formic acid primarily controls yeasts and some bacteria such as *E. coli,* coliforms, *enterococcus, Staphylococcus, Salmonella* and *Clostridium perfiringens*. Commercially available organic acids such as acetic, butryic, fumaric, lactic, propionic and sorbic acids in the calcium, potassium or sodium salt forms are reported to have both growth promoting and feed conversion effects, by decreasing intestinal pH, creating a healthier microbial population and increasing nutrient absorption (Botlhoko, 2009).

Antioxidants

To this group belong substances which act as antioxidants, such as vitamin E, selenium, and carotinoids (Peric et al., 2009). Selenium is an essential element that regulates a major component of antioxidant defense mechanism, it plays an important role in immune functioning and health and performance of broiler chickens (Zeinali et al., 2011). Selenium and other antioxidants have favorable effect on quality of broiler meat (Peric et al., 2009). Beside positive effect on quality of meat, selenium establishes better feathering and increased body mass of chickens fed organic forms of selenium (Botlhoko, 2009; Peric et al., 2009)

Phytogene additives

Phytogenic additives influence improvement of consumption and conversion of food, digestibility and gain of broiler chickens (Peric et al., 2009). This group consists of substances deriving from medicinal plants or spices which have positive effect on production and health of animals. The basic ingridients of plant extract preparations are secondary plant metabolites like allylisothiocyanates, thymol, carvacrol, cinnaldehyde, capsaicin, piperin and numerous other active agents (Botlhoko, 2009; Huyghebaert et al., 2011). The addition of herbs, oils, botanicals and spices in feed additives increases the secretion of digestive fluids and improves the immune system of broilers (Tollba, 2010). Despite the improved health, a better nutrient digestibility, reduced frequency of digestive disorders and also increased performance of broilers is ensured (Botlhoko, 2009). Huyghebaert et al. (2011) reported that plant of the *Juglandacea* family has a significant effect on body

weight gain and feed efficiency by decreasing the intestinal pH.

Conclusion

Alternatives for AGPs are only of practical significance when they improve animal performance at levels comparable to AGPs. Due to growing concerns about antibiotic resistance and the potential for a ban for antibiotic growth promoters, there is an increasing interest in finding alternatives to antibiotics in poultry production. The effects of probiotics, prebiotics, enzymes, acidifiers, antioxidants and phytogene additives on gut health and performance in poultry is currently researched and in use. The exploitation of gastrointestinal micro-flora as probiotics to replace antibiotic growth promoters for animals has received increasing interest due to the growing concern on the development of antibiotic resistant bacteria. Alternatives of AGPs all in majority of the cases have demonstrated to positively affect intestinal health and growth performance of broilers.

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