

Review

## A review of the role of five kinds of alternatives to in-feed antibiotics in broiler production

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In view of severe restriction of total ban on the use of antibiotics as growth promoters and therapeutic agents in poultry industry, the search for alternatives to replace antibiotics has gained increasing interest in animal nutrition. Gut micro flora appears to be the target for IFAs and alternatives to exert health benefits and some growth-promoting effects. Subsequent to banning of use of antibiotics as growth promoter in poultry nutrition, numerous studies turned to finding of alternative solutions, that is, other natural substances, which would have positive effect on chicken growth and feed conversion. Today, several groups of these additives are in use and most often probiotics, prebiotics, synbiotic, acidifiers and phytobiotics additives. Considering that each of the stated groups has its own specificities, the objective of this work was to present main mechanism of their action and to present their effect on production results in fattening of broiler chickens through review of research published in this field.

**Key words:** Broilers, probiotics, prebiotics, phytobiotics, synbiotic, acidifiers

### INTRODUCTION

Growth promoters are chemical and biological substances which are added to livestock food with the aim to improve the growth of chickens in fattening, improve the utilization of food and in this way realize better production and financial results. Their mechanism of action varies. Positive effect can be expressed through better appetite, improved feed conversion, stimulation of the immune system and increased vitality, regulation of the intestinal micro-flora, etc. A probiotic is a live microbial feed supplement, which beneficially affects the host animal by improving its intestinal balance. It has been used as a substitute of antibiotics that is being used in considerable amounts as growth promoters in broilers production and is, associated with incalculable risks for human health resulting from the use of particular feed additives. Probiotics are one of the approaches that have a potential to reduce chances of infections in poultry and

subsequent contamination of poultry products (Bellisle et al., 1998). Prebiotics are selectively fermented, dietary ingredients that result in specific changes in the composition and/or activity of the gastrointestinal microbiota, thus conferring benefit(s) upon host health (Zhan et al., 2003). Aromatic plants (phytobiotics) have been used since ancient times for their preservative and medicinal properties and to impart aroma and flavor to food. Hippocrates, the 'father of medicine', used plant extracts and prescribed perfume fumigations. For centuries, aromatic plants, also known as herbs and spices, their essential oils and herbal extracts have been used as natural pharmaceuticals in traditional medicine and veterinary medicine. However, their use has not been based on rigorous scientific investigation, but has stemmed from ethno veterinary or even folkloric sources (Chang, 2000). The ban on the use of antimicrobial growth promoters

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within the EU (Barton, 1999) and the demand by consumers for safe products has renewed the interest in aromatic plants and their extracts mainly as a source of alternative therapeutics or natural antioxidants. Synbiotics is defined as a mixture of probiotics and prebiotics that beneficially affects the host by activating the metabolism of one or a limited number of health promoting bacteria and by selectively stimulating their growth, hence improving the hosts welfare (Collins and Gibson, 1999). Recent research showed that synbiotic products improved immune status in broiler chicks (Zhang et al., 2006). Organic acids are mixed with the feed to create an acidified pH which provides a favorable environment in the digestive tract of broilers for the effective digestion of dietary nutrients such as proteins. They act as growth promoters and feed preservatives in poultry where they can also maintain feed hygiene. Also organic acids improve protein and energy digestibility by reducing the microbial competition nutrients of the host, endogenous nitrogen losses and ammonia production are other beneficial effects for broilers (Dibner and Buttin, 2002). In any case, expected results of the use of these additives are increased financial effects of production. Because of 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 (Nahashon et al., 1996; Jin et al., 1998; Fuller, 1997).

## PROBIOTICS

Probiotics are organisms and substances which help to improve the environment of the intestinal tract (Green and Sainbury, 2001). Certain species of bacteria, fungi and yeasts belong to group of probiotics. Existing probiotics can be classified into colonizing species (*Lactobacillus* sp., *Enterococcus* sp. and *Streptococcus* sp.) and free, non colonizing species (*Bacillus* and *Saccharomyces cerevisiae*) (Zikic et al., 2006). Lilley and Stillwell (1965) first introduced the term "Probiotic" to describe, "growth promoting factors" produced by microorganisms. The word "probiotic" is derived from the Greek word 'probios' meaning 'for life' and has had several different meanings over the years. Parker (1974) used the term probiotics for microorganisms or substances that contribute to intestinal microbial balance. Fuller (1989) redefined the probiotic as "A live microbial feed supplement, which beneficially affects the host animal by improving the intestinal microbial balance". As mentioned by Fuller (1992) and Anonymous (2002), several microorganisms have been used as probiotics, containing bacteria belonging to genus *Bifidobacterium*; bacteria belonging to genus *Lactobacillus*; bacteria belonging to genus *Streptococcus*; yeast belonging to genus *Saccharomyces*; yeast belonging to genus *Candida*; Moulds; *Bacillus subtilis* etc.

Probiotics display several ways of action: Antagonistic

action towards pathogen bacteria by secretion of products which inhibit their development, such as bacteriocins, organic acids and hydrogen peroxide; the other way is competitive exclusion which represents competition for locations to adhere to the intestinal mucous membranes and in this way pathogen microorganisms are prevented from inhabiting the digestive tract, and the third way is competition for nutritious substances (Patterson and Brukholder, 2003). Vranesic (1992) reviewed the use of probiotics, live bacterial and or fungal cultures, as feed supplements and concluded that the probiotics stimulated numerous metabolic processes relating to feed digestion and absorption. It was also opined that few authors also include enzymes, yeasts and even organic acids in the group of probiotics. Hennig et al. (1993) evaluated the use of probiotics as growth promoters and opined that the experiments when supplemented with probiotics must end at a given weight. Palod and Singh (2004) indicated that the 'Probiotics' in broiler feeding was becoming a new area in biotechnology and offer a possible replacement for the use of sub-therapeutic level of antibiotics in broiler feeds. The probiotics include more than 200 species of bacteria and yeast. The various probiotics available in the market are either single or combination of bacteria, yeast and fungi. The use of probiotics in broiler feed causes better growth, higher feed conversion, better digestibility and improved product quality. The other results showed that adding primalc probiotics caused a decrease in the blood cholesterol, blood uric Acid and blood urea (Rezaei et al., 2013). Georgieva et al. (2000) observed a significant weight gain by less feed consumption at 49 days of age in broiler chicken when supplemented with a commercial probiotics, Lacto-Sacc compared to controls and antibiotic treated groups. Bhat et al. (2003) reported that the probiotic mixture containing *Lactobacillus sporogenes* 30,000 million cfu., *Lactobacillus acidophilus* 30,000 million cfu., *Sac. cerevisiae* SC – 47 1,25,000 million cfu., Alpha amylase 5 gm and sea weed extract 50 gm/kg when fed to broiler chicken at the rate of 0.1% in feed improved the body weight gain, feed consumption and feed conversion ratio. Panda et al. (2000) reported probiotic had no influence on dressing percentage or weight of internal organs such as liver, heart and gizzard. According to Mandal et al. (1994) there was no significant increase in body weight gain in Bioboost®, a commercial probiotic containing *Sac. cerevisiae* and *Bacillus coagulans* (*L. sporogenes*), supplemented group. They also reported serum biochemical components such as serum protein (5.70 ± 0.50 g/100 mL), serum calcium (9.00 ± 0.42 mg per 100 ml) and serum phosphorus (7.20 ± 0.42 mg/100 mL) which did not differ significantly between control and probiotics supplemented groups.

## PREBIOTICS

Gibson and Roberfroid (1995) defined a prebiotic as a

non-digestible food ingredient which beneficially affects the host by selectively stimulating the growth of and/or activating the metabolism of one or a limited number of health-promoting bacteria in the intestinal tract, thus improving the host's microbial balance. The growth of endogenous microbial population groups such as bifidobacteria and lactobacilli is specifically stimulated and these bacteria species are perceived as beneficial to animal health. Fructo-oligosaccharides were shown to support the growth of beneficial bacteria, such as lactobacilli (Xu et al., 2003; Yusrizal and Chen, 2003; Zhan et al., 2003), but failed to stimulate the growth of bifidobacteria (Vidanarachchi et al., 2006). It is reported that rapid fermentation of prebiotics, leading to high concentrations of organic acids, impaired the barrier function, which reduced the ability of rats to resist salmonella infection (Ten Bruggencate et al., 2003). It may also be worthwhile to examine the interaction between prebiotics(s) and bird sex. In the report by Yusrizal and Chen (2003), body weight and feed conversion ratio (FCR) of female birds were improved by 10 and 9% respectively, on oligofructose treatment but no such effects were observed in males. Similar results were stated also by Mateo et al. (2000). This proves that effect of application of prebiotics depends on the condition of animals, environment conditions, composition of food and level and type of prebiotic included in the mixtures. Maiorka et al. (2001) conducted an experiment with the treatments such as T1-no additives, T2-antibiotics (Olaquinox and Nitrovin), T3- prebiotic (0.2% *Sac. cerevisiae* cell wall), T4-probiotic (300 ppm *Bacillus subtilis*) and T5-symbiotic (T3+T4) and observed better live weight gain in broilers up to 45 days of age, fed with symbiotics followed by antibiotics, prebiotics and probiotics. The total absence of additives in the diets worsened broiler chicken performance. Prebiotics have been shown to alter gastro-intestinal micro flora, alter the immune system, prevent colonic cancer, reduce pathogen invasion including pathogens such as *Salmonella enteritidis* and *Escherichia coli* and reduce cholesterol (Cummins and Macfarlane, 2002). The other results indicated that addition of prebiotic supplementations to broiler diets, improved growth performance, carcass characteristics and decreased serum cholesterol level of the broiler chickens at 42 day of age (Fallah and Rezaei, 2013).

## SYNBIOTICS

A synbiotic is, in its simplest definition, a combination of probiotics and prebiotics (Collins and Gibson, 1999). This combination could improve the survival of the probiotic organism, because its specific substrate is available for fermentation. This could result as an advantage to the host through the availability of the live microorganism and the prebiotic. Recent research showed that symbiotic products improved immune status in broiler chicks

(Zhang et al., 2006). According to (Awad et al., 2008) an investigation, synbiotics can lead to better absorption of glucose in poultry. Synbiotic product had a comparable potential to improve broiler performance as avilamycin (an antibiotic growth promoter) (Mohnl et al., 2007). Liang and Shah (2006) concluded that the use of synbiotics consumption in broilers regulates the concentration of the organic acids and reduce cholesterol levels. Bailey et al. (1991) used a combination of Fructooligosaccharides and competitive exclusion flora to reduce *Salmonella* colonization in chickens. The combination was more effective in reducing *Salmonella* colonization Fructooligosaccharides than or in competitive probiotic alone.

## PHYTOBIOTICS

Plant products have been used for centuries by humans as food and to treat ailments. Natural medicinal products originating from herbs and spices have also been used as feed additives for farm animals in ancient cultures for the same length of time. To differentiate from the plant products used for veterinary purposes (prophylaxis and therapy of diagnosed health problems), phytobiotics were redefined by Windisch and Kroismayr (2006) as plant-derived products added to the feed in order to improve performance of agricultural livestock. Mechanism of the action of these additives is not completely clear. Some plant extracts influence digestion and secretion of digestive enzymes and besides, they exhibit antibacterial, antiviral and antioxidant (Cross et al., 2007). Antimicrobial activity and immune enhancement probably are the two major mechanisms by which phytobiotics exert positive effects on the growth performance and health of animals. Phytochemicals in phytobiotics are well known to have antimicrobial ability (Cowan, 1999). Polysaccharide components are considered to be the most important immune active components (Xue and Meng, 1996). A common feature of phytobiotics is that they are a very complex mixture of bioactive components. For example, hawthorn fruit, a common growth-enhancing and digestion modifier, has been shown to contain more than 70 kinds of organic chemicals along with some unidentified factors and active bio-active compounds (Wang et al., 1998). Therefore they may exert multiple functions in the animal body. Increased feed intake and digestive secretions are also observed in animals offered phytobiotic-supplemented feed (Windisch and Kroismayr, 2006). Growth enhancement through the use of phytobiotics is probably the result of the synergistic effects among complex active molecules existing in phytobiotics (Gauthier, 2002). However, the exact growth promoting mechanisms of phytobiotics in broiler chickens are poorly understood. Four factors may affect the effectiveness of phytobiotic additives: plant parts and their physical properties; source; harvest time and compatibility with the other ingredients in the feed (Wang et al., 1998), which may also explain why 50%

difference in BWG and 63% difference in FCR could happen when different kinds of phytobiotics are used in chicken diet (Xing, 2004). Although phytobiotics are a group of natural additives, research into their mechanisms of action, compatibility with diet, toxicity and safety assessment (based on the fact that some phytobiotic might have harmful substances) needs to be done before they can be applied more extensively in poultry feed. The results of the investigation by Fallah et al. (2013) showed that adding phytobiotic compounds as artichoke leaves meal and menthe extract in broiler diets caused a decrease in HDL and LDL concentration. Essential oils function mainly as antimicrobials and antioxidants; their antimicrobial ability may modulate the gut ecosystem to affect fat digestibility (Lee et al., 2004), starch or/and protein digestibility of feeds (Hernandez et al., 2004). A commercial preparation of essential oil components reduced faecal *Clostridium perfringens* counts of broilers in a field study (Mitsch et al., 2002).

## ACIDIFIERS

Acidifiers have been used in poultry nutrition for long time, in different forms and combinations which are constantly changing. Organic acids reduce pH value of food and in this way act as conserving agents and prevent microbiological/microbial contamination of food, and this effect is exhibited also in digestive tract of poultry (Eidelsburger and Kirchgessner, 1994). Several mechanisms through which dietary acids may produce desired effects have been proposed (Partanen, 2001); reduced gastric pH, reduced survival of pathogens through the stomach, increased digestion of nutrients and direct killing of bacteria appear to be the most prominent organic acids in undissociated form are lipophilic and can diffuse across bacterial cell membranes to reach the interior of the cell. In a relatively high intracellular pH, they dissociate and disrupt the bacterial cell function. The effect may be stronger in some bacteria than in others (Partanen, 2001). In brief, acids dissimilarly affect the microbial populations along the digestive tract. In the stomach, the numbers of coliforms and *E. coli* increase regardless of type and form of organic acid, but there is no clear-cut evidence about the effect of acidifiers on *Lactobacillus* population. Acids generally reduce the populations of *Lactobacillus* in the intestines and *E. coli* in the colon. It appears that addition of acidifiers to the diet may not result in an environment that is favorable for beneficial bacteria like *Lactobacillus* but adverse to coliforms and *E. coli* (Chapman, 1988). Favourable effect of supplementation of individual organic acids to mixtures was established relatively long time ago for formic acid (Kirchgessner et al., 1992) and fumaric acid (Vogt et al., 1981). In research published by Ao et al. (2009) it was established that citric acid in combination with  $\alpha$ -galactosidase increased the effect of enzyme action, but also had negative effect of feed consumption and gain.

Acidifiers, particularly the short chain fatty acids, acetate, propionate and butyrate have contributed greatly to the profitability in poultry and also provide people with health and nutritious poultry products (Patten and Waldroup, 1998). Moreover, acidifier improved growth performance through establishment of low gastrointestinal pH condition by supporting endogenous digestive enzymes and reducing undesired gut microorganism. Acidification of diet with weak organic acids such as formic, fumaric, propionic, lactic and sorbic acids have been reported to decrease colonization of pathogen and production of toxic metabolites, improved digestibility of protein, Ca, P, Mg, Zn and served as substrate in the intermediary metabolism (Richards et al., 2005).

## CONCLUSION

Withdrawal of antibiotics from poultry foods created need for alternative solutions which would influence improvement of health and production traits of broiler chickens. Alternative growth promoters are probiotics, prebiotics, synbiotic, acidifiers and phytogetic additives. By increasing the growth of beneficial microbes or by reduction and removal of potential pathogens, the alternatives to IFAs possibly can improve the health and performance of birds. However, their effects on gut micro flora interact with digestive physiology and thus growth in many complex ways, which can be further influenced or even determined by many other factors such as the compatibility between the diet and the alternative, hygiene standards and animal husbandry practices. There possibly remain many questions to be answered or barriers to be overcome so that the alternatives can be applied (more) successfully in the industry in future.

## REFERENCES

- Anonymous (2002). Guidelines for the Evaluation of Probiotics in Food. Report of a Joint FAO/WHO Working Group on Drafting Guidelines for the Evaluation of Probiotics in Food. London Ontario, Canada, 30 April and 1 May 2002.
- Ao T, Cantor AH, Pescatore AJ, Ford MJ, Pierce JL, Dawson KA (2009). Effect of enzyme supplementation and acidification of diets on nutrient digestibility and growth performance of broiler chicks. *Poult. Sci.* 88:111-117.
- Awad WA, Ghareeb K, Bohm J (2008). Intestinal structure and function of broiler chickens on diets *faecium* and oligosaccharides. *Int. J. Mol. Sci.* pp. 2205-2216.
- Bailey JS, Blankenship LC, Cox NA (1991). Effect of fructo-oligosaccharide on Salmonella colonization of the chicken intestine. *Poult. Sci.* 70:2433-2438.
- Barton MD (1999) The down-side of antibiotic use in pig production: The effect of antibiotic resistance of enteric bacteria. In manipulating Pig Production VII (ed PD Carnwell). Aust. Pig Sci. Association.
- Bellisle F, Diplock AT, Hornstra AT (1998). Functional food science in Europe. *Br. J. Nutr.* 80:3-4.
- Bhat GA, Khan AA, Mattoo FA (2003). Use of probiotic feed supplement in high fiber broiler ration. *Poultry Guide*, 18-20.
- Chang J (2000) Medicinal herbs: drugs or dietary supplements? *Biochem. Pharmacol.* 59:211-219.
- Chapman JD (1988). Probiotics, acidifiers and yeast culture a place for natural additives in pig and poultry production. Proceedings of Alltech's Fourth Annual Symposium. pp. 219-233.

- Collins MD, Gibson GR (1999). Probiotics, prebiotics, and symbiotics: approaches for modulating the microbial ecology of the gut. *Am. J. Clin. Nutr.* 69:1052S-1057S.
- Cowan MM (1999). Plant products as antimicrobial agents. *Clin. Microbiol. Rev.* 12:564-582.
- Cross DE, Mcdevitt RM, Hillman K, Acamovic T (2007). The effect of herbs and their associated essential oils on performance, dietary digestibility and gut microflora in chickens from 7 to 28 days of age. *Br. Poult. Sci.* 48:496-506.
- Cummings JH, Macfarlane GT (2002). Gastrointestinal effects of prebiotics. *Br. J. Nutr.* 87(2):145-151.
- Dibner JJ, Buttin P (2002). Use of organic acids as a model to study the impact of gut microflora on nutrition and metabolism. *J. Applied Poult. Res.* 11:453-463.
- Eidelsburger U, Kirchgessner M (1994). Zum Einfluß organischer Säuren und Salze im Futter auf die Mastleistung von Broilern. *Archiv für Geflügelkunde.* 58:268-277.
- Fallah R, Kiani A, Azarfar A (2013). Effect of Artichoke leaves meal and menthe extract (*Mentha piperita*) on immune cells and blood biochemical parameters of broilers. *Global Veterinarian.* 10(1):99-102.
- Fallah R, Rezaei H (2013). Effect of dietary prebiotic and acidifier Supplementation on the growth performance, carcass characteristics and serum biochemical parameters of broilers. *J. Cell Anim. Biol.* 7(2):21-24.
- Fuller R (1989). Probiotics in man and animals. *J. Appl. Bacteriol.* 66:365-378.
- Fuller R (1992). Probiotics. The Scientific Basis. Chapman and Hall, London.
- Fuller R (1997). The importance of Lactobacilli in maintaining kormal microbial balance in the crop. *Br. Poult. Sci.* 18:85-94.
- Gauthier R (2002). (XVIII Congreso Lantioamericano de Avicultura) (2002) Poultry Therapeutics: New alternatives. Accessed in 2006. [http://www.jefo.ca/pdf/ALA2003\\_en.pdf](http://www.jefo.ca/pdf/ALA2003_en.pdf).
- Georgieva V, Denev ST, Marinov B (2000). Effect of some probiotic and nutritive means on chicken broiler productivity. *Zhivotnov"dni Nauki.* 37:19-23.
- Gibson GR, Roberford MB (1995). Dietary modulation of the human colonic microbiota: introducing the concept of prebiotics. *J. Nutr.* 125:1401-1412.
- Green AA, Sainsbury DWB (2001). The effects of enzyme and probiotic supplementation to diets on broiler performance. *Turk. J. Vet. Anim. Sci.* 11:895-903.
- Hennig A, Ludke H, Schone F, Meixner B (1993). Some aspects of the use and evaluation of substances stabilizing intestinal microorganisms. *Poult. Abstr.* 19:1312.
- Hernandez F, Madrid J, Garcia V, Orengo J, Megias MD (2004). Influence of two plant extracts on broiler performance, digestibility and digestive organ size. *Poult. Sci.* 83:169-174.
- Jin LZ, Ho YW, Abdullah N, Jalaludin S (1998). Growth performance, intestinal microbial population and serum cholesterol of broiler fed diets containing Lactobacillus cultures. *J. Poult. Sci.* pp. 1259-1265.
- Kirchgessner M, Gedek B, Wiehler S, Bott A, Eidelsburger U, Roth FX (1992). Influence of formic acid, calcium formate and sodium hydrogen carbonate on the micro flora in different segments of the gastrointestinal tract. *J. Anim. Physiol. Anim. Nutr.* 68:73-81.
- Lee KW, Ecerts H, Beynen AC (2004). Essential oils in broiler nutrition. *Int. J. Poult. Sci.* 3:738-752.
- Lilley DM, Stillwell RH (1965). Probiotics: Growth promoting factors produced by microorganisms. *Poult. Sci.* 147:747-748.
- Liong MT, Shah NP (2006). Effects of a Lactobacillus Casei symbiotic on serum Lipoprotein, intestinal microflora and organic acid in rats. *J. Dairy. Sci.* 89:1390-1399.
- Maiorka A, Santin E, Sugeta SM, Almeida JG, Macari M (2001). Utilization of prebiotics, probiotics or symbiotics in broiler chicken diets. *Revista Brasileira de ciencia avicola.* 3:75-82.
- Mandal SK, Biswas TK, Mandal L (1994). Efficiency of different growth promoters on the performance of broilers. *Indian J. Poult. Sci.* 29:13-17.
- Mateo CD, Jacques KA, Harvez J (2000). Organic chromium, mannan oligosaccharides and zinc bacitracin: Effect on broiler performance and carcass characteristics. *Poult. Sci.* 79:116.
- Mitsch P, Kohler B, Gabler C, Losa R, Zitterl-Eglseer K (2002). CRINA poultry reduces colonisation and proliferation of Clostridium perfringens in the intestine and faeces of broiler chickens. Abstracts from the Eleventh European Poultry Conference, Bremen, Germany.
- Mohnl M, AcostaAragon Y, Acostaojedu A, Rodriguessanches B, Pasteiner S (2007). Effect of symbiotic feed additive in comparison to antibiotic growth promoter on performance and health status of broilers. *Poult. Sci.* 86(1):217.
- Nahashon SN, Nakave HS, Mirosh LW (1996). Performance of single comb white leghorn lagers fed with a live microbial during the growth and egg lagging phases. *Anim. Feed. Sci. Technol.* 57:25-38.
- Palod J, Singh VS (2004). Role of probiotics in Broiler feeding. Sadana's All India poultry Business Directory (Year Book 2003-2004) Special Millennium issue, 2nd ed. Sadana publishers and Distributors, Ghaziabad. pp. 147-148.
- Panda AK, Reddy MR, Rao SVR, Raju, MVL, Praharaj NK (2000). Growth, carcass characteristics, immune competence and response to *Escherichia coli* of broilers fed diets with various levels of probiotic. *Archiv fur Geflugelkunde.* 64:152-156.
- Parker R (1974). Probiotics, the other half of the antibiotic story. *Anim. Nutr. Health.* 28:240-255.
- Partanen K (2001). Organic acids their efficacy and modes of action in pigs. *Gut Enviroment of Pigs.* Nottingham University Press. pp. 201-218.
- Patten ID, Waldroup P (1998). Use of organic acid in broiler diets. *Poult. Sci.* 67:1178-1182.
- Patterson JA, Burkholder KM (2003). Application of prebiotics and probiotics in poultry production. *Poult. Sci.* 82:627-631.
- Rezaei, H, Jafari Khorshidi K, Fallah R (2013). The Effect of Feeding primalac probiotics on growth performance and blood parameters of ostriches. *Mal. J. Anim. Sci.* 16(1):79-86.
- Richards JD, Gong J, Delange CEM (2005). The gastrointestinal microbial and its role in monogastric nutrition and health with an emphasis on pigs; current understanding possible modulations and New technologies studies. *Can. J. Anim. Sci.* 85:421-435.
- Ten Bruggencate SJM, Bovee-Oudenhoven IMJ, Lettink-Wissink MLG, Van Der meer R (2003). Dietary fructo-oligosaccharides dose-dependently increase translocation of salmonella in rats. *J. Nutr.* 133:2313-2318.
- Vidanarachchi JK, Mikkelsen LL, Sims IM, Iji, PA, Choct M (2006). Selected plant extracts modulate the gut microflora in broilers. *Proceedings of Australian Poultry Science Symposium, Sydney, Australia.* 18:145-148.
- Vogt H, Matthes S, Harnisch S (1981). Der Einfluß organischer Säuren auf die Leistungen von Broilern und Legehennen. *Archiv für Geflügelkunde.* 45:221-232.
- Vranesic N (1992). Probiotics- useful bacteria as feed additives. *Poult. Abstr.* 18:1-5
- Wang R, Li D, Bourne S (1998). Can 2000 years of herbal medicine history help us solve problems in the year 2000? Biotechnology in the feed industry: Proceedings of Alltech's 14th Annual Symposium, Kentucky, USA. pp. 273-291.
- Windisch W, Kroismayr A (2006). The effects of phytobiotics on performance and gut function in monogastrics. Accessed in 2006. [www.feedinfo.com](http://www.feedinfo.com).
- Xing XL (2004). A comparative study on the effects of different Chinese herbal medicinal feed additives in broiler chickens. Accessed in 2006.
- Xue M, Meng XS (1996). Review on research progress and prosperous of immune activities of bioactive polysaccharides. *J. Tradition. Vet. Med.* 3:15-18.
- Yusrizal C, Chen TC (2003). Effect of adding chicory fructans in feed on broiler growth performance, serum cholesterol, and intestinal length. *Int. J. Poult. Sci.* 3:214-219.
- Zhan XA, Hu CH, Xu ZR (2003). Effects of fructo-oligosaccharide on growth performance and intestinal microflora and morphology of broiler chicks. *Zhong Guo Shou Yi Xue Bao* 32:196-198.
- Zhang G, Ma L, Doyle MP (2006). Efficiency of probiotics, prebiotics and synbiotics on weight increase of chickens. (*Gallus Domesticus*). <http://www.ugacfs.org/research/pdfs/Poultry2006.pdf>.
- Zikic D, Peric L, Uscebrka G, Milosevic N, Jotanovic S (2006). Probiotici i prebiotici u ishrani brojlera: 1. Efekat na proizvodne rezultate. 11. Savetovanje biotehnologiji, Čačak, 11(2):471.