Background
The poultry industry has been accompanied by the emergence of a large variety of pathogens and bacterial resistance due to the increase in production scales and the use of Antibiotic Growth Promoters (AGP). As a result, poultry become more sensitive to harmful bacteria such as Escherichia Coli, Salmonella spp., Clostridium perfringens and Campylobacter jejunum. There are considerable numbers of producers that depend on AGP in feed to overcome these diseases. With consumers pressure about the use of antibiotics in animal feed and its link to the increase of antibiotic resistant bacteria, the European Union has decided to ban the antibiotics as feed additives in January, 1st 2006. In the US the poultry industry is facing a possible ban of antibiotic feed additives, and there is a growing interest in finding valuable alternatives to prevent diseases. Therefore, many activities were initiated to establish other substances with beneficial effects on animals via modification of the intestinal microflora. Among these alternatives to antibiotics are probiotics or direct-fed microbes (DFM). The effects of probiotic or DFM on gut health and performance in poultry is well documented. Several studies demonstrated an improvement in birds fed diets with probiotics in a challenge disease model. In addition several researches and data presented in this presentation suggest that probiotics have the potential to improve bird gut health and to overcome growing challenge in poultry production.

Introduction
Lately, consumers have been gaining an interest in animal practices with more attention on animal health, nutrition and production systems. The poultry industry depends on sub-therapeutic level of AGP to improve weight gain, feed efficiency and production, whereas avoiding enteric health problems through animal feeding operations (Trafalska and Grzybowska, 2004; Griggs and Jacob, 2005).

The main function of the digestive system is the absorption of broken down nutrients from the diet to support health and growth. With this complicated process in the gastro-intestinal tract (GIT), the digestibility of the nutrients and the health of the animal are greatly influenced by the microflora in the digestive tract. Nutritionists focus on modifying various processes to improve digestion and animal health to yield better food quality for human consumption. The microorganisms inside the digestive system vastly exceed the numbers of cells in the body, so the main goal is to maintain a balance in the microflora to limit the pathogen proliferation inside the intestine (Ewing, 2008).
Increase the production scales in the poultry industry has developed more potential risk to clinical and subclinical enteric diseases. With excessive use of AGP in animal feed, a resistance has been shown in few strains of E.Coli to antibiotic treatments (Smith and Halls, 1967; Walton, 1971). The beneficial effects of using antibiotics in farm animals are linked to the modification of the intestinal bacteria and their interaction with the host animal. Therefore, the intestinal microflora is not only improving the nutrient utilization along the gastrointestinal tract, but also supports animal health and production. The obligatory elimination of AGP by the European Union and the voluntary removal of these drugs in the US have resulted in a worldwide search for suitable alternatives to AGP in poultry diets. Some potential alternatives that have been tested include probiotics, prebiotics, organic acids, and plant extracts. Probiotic are being considered to fill the gap AGP affected on poultry industry (Denev, 1996; Kabir, 2009; and Tellez et al., 2012)

The objective of this presentation is to get an overview of probiotics usage in poultry diets with more emphasis on mode of action and gut health of the chicken.

**Probiotics Overview**

The concept of probiotics goes back almost 100 years ago to Elie Machinikoff who proposed that bacteria in fermented milk product may be capable to control bacterial fermentation in intestinal tract of men and thus are health promoting. Crawford (1979) defined probiotics as “a culture of specific living microorganisms (primarily Lactobacillus spp.) which implants in the animal to ensure the effective establishment of intestinal populations of both beneficial and pathogenic organisms”. In addition Fuller (1989) reported a unique definition for probiotics as “live microbial feed supplements, which beneficially affect the host animal by improving its intestinal microbial balance”. Also Salminen et al. (1998) defined probiotics as “a live microbial feed that is beneficial to health”. Recently, the Food and Drug Administration (FAO/WHO, 2002) defined Probiotics as live naturally occurring microorganisms, when administered in adequate quantities, can provide a health benefit to the host through balancing the normal population of the intestinal microorganisms.

The mode of action of different probiotics may differ (Davis and Anderson, 2002; Mai, 2004). Furthermore, different subtypes of species may have different effects; have different areas of adherence, different specific immunological effects, and different biological actions (Isolauri et al., 2004). Hence, probiotics can have similar effects as antibiotics, and can fill the gap of AGP as potential alternatives in farm animals to control specific enteric diseases (Boyle et al., 2007; Cartman, et al., 2008; Vila et al., 2009; Williams et al., 2009). In addition, Woo et al. (2006) reported the use of probiotic yeast (Saccharomyces cerevisiae) to control pathogenic bacteria infection in chickens. Similarly, Lee et al. (2007a, b) used the probiotic yeast (Saccharomyces boulardii) and probiotic bacteria (Pediococcus acidilactici) for treatment of Eimeria infected chickens.

The feed additives used in poultry that aim to enhance production performance and health of animals can be beneficial or effective through improving animal health, feed efficiency and growth. In the case of probiotics, the prevalence of science literature recommends that the production parameters improved are beneficially impacted by the ability of the probiotics to alter the immunity or the metabolic status of the animal. Yang et al (2009) reported that probiotics can inhibit pathogenic microorganisms in the GIT by competing for the metabolic substrate and
the attachment site to the epithelia as well as the production of the antimicrobial substances. Currently, the most universal types of bacteria that have been effectively involved are lactic acid producing bacteria. These bacteria are found naturally in the gastrointestinal tract of animals (Shahani and Ayebo, 1980). Some examples of lactic acid producing bacteria are Lactobacillus and Pediococcus, both have been associated with health benefits and used in food fermentation processes. These organisms are regularly safe and not associated with disease in healthy animals (Tellez et al., 2006). Other types of probiotics are those microorganisms that are not normally found in the GIT. For example, Saccharomyces boulardii has been shown to be effective in preventing the recurrence of Clostridium infections (Czerucka et al, 2007) and some colibacillosis in humans (Czerucka and Rampal, 2002).

Probiotic bacteria (such as Bacillus, Lactobacillus, Bifidobacterium, Enterococcus, Streptococcus, Lactococcus and Pediococcus) and yeast (Saccharomyces cerevisiae) are live cultures that intend to improve intestinal microbial balance and reduce the levels of enteric pathogens in the GIT. Probiotic strains have been shown to inhibit pathogenic bacteria through several different mechanisms. A summary of probiotics mode of action in poultry were reported in several literatures, which included; improving the immune system (Cebra, 1999; McCracken and Gaskins, 1999; Perdigon et al., 2001; Kabir et al., 2004; Huang et al., 2004; Dalloul et al., 2005; Lan et al., 2005; Nayebpor et al., 2007; and Apata, 2008), maintaining normal microflora in the gut through microbial antagonism and competitive exclusion (Nurmi and Rantala, 1973; Conway, 1996; Jin et al., 1998; Line et al., 1998; Nisbet et al., 1998; Jin et al., 2000a; Fritts et al., 2000; Roberto et al., 2003; Alexopoulos et al., 2004; Walsh et al., 2004; Kabir et al., 2005; and Schneitz, 2005; Berchieri et al., 2006; Mountzouris et al., 2007), improving nutrient metabolism through increasing digestive enzyme and decreasing ammonia production and pathogenic bacteria enzyme activity (Chiang and Hsieh, 1995; Han et al., 1999; Jin et al., 2000b; and Yoon et al., 2004), and improving digestion and feed intake (Tortuero and Fernandez, 1995; Horniakova, 2005; and Awad et al., 2006).

Competitive exclusion approaches of probiotic have been indirectly applied through naturally occurring intestinal microorganisms in chicks and poults. An attempt to control severe outbreaks of Salmonella infantis in later stage of broiler production using this concept was applied by Nurmi and Rantala (1973) and Rantala and Nurmi (1973). In their studies, they found that chicks were most susceptible to Salmonella infections in the first week post-hatch. And the use of a Lactobacillus strain did not produce protection to Salmonella. Then they evaluated a population of intestinal bacteria from adult chickens that were resistant to Salmonella. With oral administration of the extracted intestinal bacteria population, protection to Salmonella was achieved. When harmful microbes are established they could cause localized or systemic infections, intestinal breakdown and toxic production (Yegani and Korver, 2008). The competitive exclusion approach of inoculating day-old chicks with an adult microflora successfully demonstrates the impact of the intestinal microbiota on intestinal function and disease resistance (Nisbet et al., 1998; and Stern et al., 2001). Schneitz (2005) reported that competitive exclusion is a very effective measure to protect newly hatched chicks, turkey poults, and pheasants against Salmonella and other pathogens. The newly hatched chicks basically have sterile intestinal tracts (no microorganism population). Researchers have shown that it takes two to four weeks for a steady microbial consortium to form in the GIT of chickens (Lee et al., 2010; Amit-Romach et al., 2004). Beneficial or pathogenic microorganisms are established in the GIT at maturity through natural selection (Elijah and Ruth, 2012). Currently, the poultry industry has
been using these concepts to supply probiotics after hatching to provide the beneficial intestinal microbes and to improve immunity and performance of chickens.

Another benefit of probiotics is improving digestion. When probiotics are consumed, they can deliver many lactic acid bacteria to the GIT. Marteau and Rambaud (1993) reported that probiotics can help modify the intestinal environment and deliver enzymes and other beneficial substances into the intestines. For example, Supplementation of a mixture of Lactobacillus cultures to chickens significantly increased (P < 0.05) the levels of amylase after 40 d of feeding (Jin et al., 2000b). A similar finding by Collington et al. (1990) was reported; they found that inclusion of a mixture of multiple strains of Lactobacillus and Streptococcus faecium, significantly increased enzyme activities in the small intestine of piglets. The colonizing of lactobacilli in the intestine can secrete the enzyme, therefore increasing the intestinal amylase activity (Sissons, 1989). In addition, it is well recognized that probiotics modify gastrointestinal pH and microflora to help increase intestinal enzymes activity and nutrients digestibility (Dierck, 1989). Similarly, Han et al., (1999) reported that an increase in the digestibility of dry matter was closely related to the enzymes released by yeast supplementation. In addition, probiotics may stimulate microorganisms capable of modifying the gastrointestinal environment to improve feed efficiency (Dierck, 1989). Mechanisms by which probiotics improve feed conversion efficiency include; alteration in intestinal flora, enhancement of growth of non-pathogenic bacteria and lactic acid forming bacteria, suppression of growth of intestinal pathogens, and enhancement of digestion and utilization of nutrients (Yeo and Kim, 1997). Therefore, the major outcomes from using probiotics include improvement in growth (Yeo and Kim, 1997), reduction in mortality (Kumprecht and Zobac, 1998), and improvement in feed conversion efficiency (Yeo and Kim, 1997). These results are consistent with previous research conducted by Tortuero and Fernandez (1995), who observed improved feed conversion efficiency with the supplementation of probiotics to the diet.

An important function of probiotic microorganisms is the stimulation of immunity against pathogenic microbes via manipulation of gut microflora and development of the immune response (McCracken and Gaskins, 1999). Recently Higgins et al. (2007) and Mountzouris et al. (2007) described that probiotic species have a potential effect on modulation of intestinal microflora and pathogen inhibition. Probiotics including the normal microflora of the GIT have been shown to stimulate immunity in the host animal. The exact mechanisms of probiotics that mediate the immunity are not clear. However, it has been shown that probiotics stimulate the production of cytokines, which play a major role in the regulation of the immune response (Christensen et al., 2002; and Lammers et al., 2003). Several researchers have reported a close connection between the GIT microflora and intestinal immune system in chickens and other animals (Gabriel et al., 2006; Lee et al., 2010; Huang et al., 2004). Guo et al. (2004 a, b) reported that poultry feed containing plant extracts resulted in the enhancement of immunity against Eimeria tenella infected chickens. Chickens fed with probiotics exhibited increased heterphils, macrophages and lymphocytes when compared to the controls (Willis et al., 2010). Heterophils, macrophages and lymphocytes are known to play major roles in the defense against pathogenic microorganisms including Salmonella and Eimeria (Kogut 2009; and Kogut et al., 2005). The preventative effect of probiotics against Salmonella has been also reported by Pascual et al. (2001). In addition Kabir et al. (2004) reported a higher antibody production (P < 0.01) in treated broiler birds as compared to controls when they evaluated the probiotics effect on immune response. Furthermore, a study by Haghighi et al. (2005) reported enhancement in serum and intestinal natural antibodies to foreign antigens in chickens by probiotic
supplementation. On the other hand, Dalloul et al. (2005) reported that feeding a Lactobacillus probiotic for broiler chickens infected with Eimeria showed some measure of protection through the immune inflection to probiotic supplementation despite a fairly overwhelming dose of Eimeria. Francis et al. (1978) reported the use of Lactobacillus product at 75 mg/kg in feed significantly decreased the coliform counts in the ceca and small intestine of turkeys.

The beneficial impacts of probiotic supplementation on poultry performance have been reported in several research studies. The effects include: increase in body weight gain (Lan et al., 2003; Islam et al., 2004; Kabir et al., 2004; Teo and Tan, 2006; Torres-Rodriguez et al., 2007; Lee et al., 2007a; Ashayerizadeh et al., 2009; Vila et al., 2009; and Alkhalf et al., 2010); improve feed conversion (Kabir et al., 2004; Teo and Tan, 2006; and Vila et al., 2009); increase in egg production (Guerrero and Hoyos, 1991; Gerendia et al., 1992; and Mohan et al., 1995); increase hatchability (McDaniel, 1991); reduction of Salmonella in the GIT (Higgins et al., 2008; Grimes et al., 2008; and Revolledo et al., 2009); and decrease mortality rates (Teo and Tan, 2006; and Vila et al., 2009). In the US poultry industry, the use of probiotics has been widely accepted. Organic and antibiotic free production is one of the major concepts to adapt to protect the animal against enteric diseases. Also, there are more interest in combining probiotic and half levels of AGP to allow future transition to antibiotic free production and to improve performance.

Summary

In conclusion, the demand for poultry meat as one of the most important sources of animal protein is rapidly increasing as the world populations continue to increase. Infections caused by pathogenic microorganisms can cause a big threat to the poultry industry. Infections by Eimeria, Salmonella, and Clostridium are responsible for reduced growth rates and the resulting higher costs of production. Traditionally, AGP are used to treat infected chickens. Unfortunately, the long term and extensive use of antibiotics result in selection for the survival of resistant microbial species, therefore, posing a threat to the health of both animals and humans. Consequently, some countries have restricted the use of AGP in poultry. Since probiotics do not result in the development and spread of microbial resistance, they offer immense potential to become an alternative to antibiotics. This review reveals that probiotics could be successfully used as nutritional tools in poultry feeds for promotion of growth, modulation of intestinal microflora and pathogen inhibition, immunomodulation and promoting meat quality of poultry.

References


