**Probiotics in broiler production – a review**

**Probiotika in der Broilerfütterung – eine Übersicht**

G. S. Ghadban


**Introduction**

In 1988–1989 as a result of a public food poisoning from infections with *S. interitidis* eggs in England, egg consumption decreased within a short time by 90 %. This caused a very serious economic loss for the government and the producers of about 70 mil. £ Sterling, and lead to a culling of a vast number of birds (and the producers of about 70 mil. £ Sterling, and lead to caused a very serious economic loss for the government consumption decreased within a short time by 90 %. This

Different analyses revealed that 67 % of the feed containing animal proteins and 69 % from the mixtures at the feed factories were contaminated with *Salmonella* (PUBLIC HEALTH SERVICES LABORATORY, 1991).

For the rapid colonization of the intestinal tract of newly hatched chicks with useful intestinal micro-flora different biological products are used. Due to the politics of banning growth promoters (feed antibiotics), the group of probiotics faced increasing interest in the past. Probiotics are biological products, which stimulate the immune system and increase its defensive activity against pathogenic bacteria. Probiotics competitively exclude the *Salmonella* bacteria from the intestinal tract of the treated chickens. The auspicious effect of probiotics over the organism is due to the better adhesion of the lactic acid bacteria to the intestinal epithelium in comparison to the pathogenic bacteria, and stopping the implementation of that bacteria over the mucosa of the intestine (FULLER, 1989).

Probiotics stimulate the natural resistance of the organism by increasing the number of antibodies and increasing the effectiveness of macrophages (GOLDEN and GORBACH, 1984b). Usually probiotics contain one or more types of bacteria depending on the media of their growth. The idea of using pure cultures of microorganisms for prophylaxis against gastrointestinal infections appeared during the past century. In 1889, BRUDZINSKI recommended the prophylactic use of *coli* bacteria cultures, PEREZ (1932) curatively used *coli* bacteria cultured in sterile milk for gastrointestinal infections and named this preparation “Colibacterin” (COLICIN; GRATIA and FREDERICA, 1925).

For the first time METCHINKOFF (1961) used lactic acid bacteria for suppressing the growth of putrefactive and pathogenic bacteria in the chicken's intestinal tract, the preparations were called “Lactobaciline”: fermented milk with *L. bulgaricus* and lactic acid streptococci.

Different substances containing defined bacteria have a protective effect in the organism of the bird. Filtrates without containing bacteria obtained from fermented cultures of material taken from intestinal or caecum suspension – have no protective effects (RANTALA, 1976; SNOEYENBOS et al., 1978; SOERIADI et al., 1978).

The principal effect and the greatest value of probiotics is derived from reducing colonization of chicks by *Salmonella*, thereby reducing the prevalence of *Salmonella* at slaughter and reducing the risk of *Salmonella* poisoning for consumers. The cost of *Salmonella* poisoning to the Canadian economy is in the region of $ 1,344,000,000 per annum. In the UK in 1993, it produces a staggering total cost of over 6 billion £ Sterling. The potential economic impact of probiotics may be demonstrated by the observation in Sweden, where 179 high risk, commercial broiler flocks were treated with CE and only one of those was subsequently found to be contaminated with *Salmonella*. In Finland from the broiler’s flocks received Broilact only in 0.4 % of the flocks were found *Salmonella* (WIERUP et al., 1992).

Furthermore, Broilact® treatment may significantly increase the performance of broilers, which means a clear profit to the producer. Considering prevailing poultry meat and feed prices this was worth approximately £ 22 per 1000 birds after subtracting the cost of Broilact® (BROIILACT NEWSLETTER, 1994). Growth-promoting antibiotics are much cheaper than probiotics, their use costs about one third of a Sterling penny per bird, but most of them favour colonization of the gut by *Salmonella* and they are unpopular by consumers. Probiotics cost one Sterling penny per bird, but provide the additional benefits stated above.

**Definition of probiotic**

The term “probiotic” is derived from Greek and means pro: for and bios: life (for life) in contradiction to antibiotic which means: against life. The term probiotic was first introduced by LILLY and STILLWEL (1965) to describe growth-promoting factors produced by microorganisms. PARKER (1974) first specified designation “probiotic”.

He defined probiotics as microorganisms or substances, which contribute to the balance of the intestinal microflora. CRAWFORD (1979) defined probiotics as a culture of specific living microorganisms, primarily *Lactobacillus spp.* that are implanted in the organism and ensure the rapid and effective establishment of a beneficial intestinal population.

FULLER (1989) discussed the definition given by PARKER (1974) and considered it too broad, as cultures, cells, and metabolites are also included in antibiotic preparations. He redefined “probiotic” as a live microbial feed additive, which beneficially affects the animal by improving its microbial balance.

HAVENAAR et al., (1992) pointed out that the definition of “probiotic” made by FULLER (1989) was restricted to...
feed supplements, animals, and their intestinal tract. Therefore, they generalized Fuller’s definition of “probiotic” as a mono or mixed culture of living microorganisms, which beneficially affect the host by improving the properties of the indigenous micro-flora.

Through 1989, United States Department of Agriculture (USDA) advised manufactures to use the term: “direct-fed microbial” (DFM) instead of “probiotic” (Miles and Bootwalla, 1991). The USFDA defined DFM as a source of live naturally occurring microorganisms, including bacteria, fungi, and yeast. Vanbelle et al. (1990) pointed out that most researchers considered “probiotic” for selected and concentrated viable counts of lactic acid bacteria.

Koht et al. (1992) pointed out that as a biological product for newly hatched chicks a bacterial culture producing acetic acid could be used. Such a culture might be supplied to the chicks either through their drinking water or by the feed. For controlling the biological balance in the chicken’s intestinal tract different probiotics may be used.

**Modes of action of probiotics in poultry**

Different modes of action of probiotics, which beneficially affect the treated chicks, were discussed. Some of the proposed modes of action of probiotics in poultry include: 1) maintaining a beneficial microbial population by “competitive exclusion” and “antagonism” (Fuller, 1989); 2) improving feed intake and digestion (Naanson et al., 1992 and 1993); 3) altering bacterial metabolism (Cole et al., 1984 and 1987; Jin et al., 1997 a,b).

**Maintaining normal micro-flora and beneficial microbial population in the alimentary tract through antagonism and competitive exclusion**

**Antagonistic activity**

The antagonistic activity of lactic acid bacteria against different pathogenic microorganisms can be related to the production of bacterial substances as bacteriocins, organic acids, and hydrogen peroxides. Bacteriocins are defined as compounds produced by bacteria, which have a biologically active protein moiety and a bactericidal action (Tagg et al., 1976). Lactobacilli have been extensively studied for the production of antagonistic substances, which are referred to as bacteriocins. These include well-characterized bacteriocins (DeKlerk and Smith, 1967; Barefoot and Klænhammer, 1983; Joergen and Klænhammer, 1986), bacteriocin-like substances (Vincent et al., 1959), and other antagonistic substances not necessarily related to bacteriocins (Shanahan et al., 1976). DeKlerk and Smith (1967) found that out of the studied 121 strains of *L. fermentum*, 25 produced bacteriocin-like substances, which were not affected by pH or catalase, were non-dialyzable, and were precipitated by ammonium acetate. Bacteriocins from *L. helveticus*, known as lactocin-27, have been identified and characterized by Uperti and Hindssill (1973, 1975) and by Joergen and Klænhammer (1986).

**Competitive exclusion (CE)**

Metcalfiokoff (1907) recognized the beneficial effects of probiotics, based on his observations on the longevity of Bulgarian pheasants who consumed large amounts of milk fermented with *Lactobacillus acidophilus*. He specified that detrimental microbials in the intestinal tract produce harmful substances to the host, which could be neutralized by beneficial organisms in yoghurt. Later, it was assumed that the beneficial effects were due to the colonization of the gut by *L. acidophilus* (Rettger and Chaplin, 1921).

Tortuero (1973) used for poultry preparations containing living bacteria and observed that using of lactobacilli resulted in performances similar to those obtained when using antibiotics. Competitive exclusion implies the prevention of entry of one entity into a given environment by occupying the available space. This may act by the way that the competing entity is better suited to establish and maintain itself in that environment or the competing entity is producing a product hostile (toxic) to its competitor (Voltera, 1928). The same author was the first to use different mathematical models and several mechanisms to suggest that the indefinite coexistence of two or more species limited by the same resource is impossible and that autochthonous or native micro-flora competitively exclude undesired bacterial contamination from the intestinal tract of poultry.

Millner and Shaffer, (1952) recognized that in chicken natural resistance to *Salmonella* infections developed with the establishment of a mature intestinal flora. The significance of normal indigenous intestinal micro-flora, especially the anaerobes, in protecting the host against pathogenic transient bacteria such as *Salmonella typhimurium* was demonstrated in mice (Bonhoff et al., 1954) and with Vibrio cholera in guinea pigs (Freter, 1955). Royal and Mutimer (1972) were the first to demonstrate that caecal cultures inhibited the growth of *Salmonella typhimurium* in vitro, and they forecasted the use of these cultures as a preventive in vivo treatment.

Nurmi and Rantala (1973) introduced the method of “competitive exclusion” (CE) to increase the resistance of young chicks to *Salmonella* infection by inoculating them orally with intestinal content from adult birds. They demonstrated that orally inoculation of 1–2 day old chicks with a 1:10 dilution of normal intestinal contents from healthy adult birds one day prior to oral challenge with *S. infantis* resulted in 77% of birds free from infection. This study was the basis for further development of the competitive exclusion methods. During the past two decades, many studies on the efficiency of CE against pathogenic bacteria (i.e. *Salmonella*, Escherichia coli, and Campylobacter) have been carried out. Undefined preparations of cultured fecal or caecal micro-flora generally reduce the prevalence of infected chicks following challenge with a standard dose of *Salmonella* under laboratory conditions (Goren et al., 1984; Blankenship et al., 1993). In contrast, results under field conditions have been more variable (Stavric and D’Aoust, 1993). Defined cultures are less effective than undefined cultures under laboratory conditions. The potency of defined cultures has been found to decrease gradually during cold storage and during repeated laboratory manipulation of the bacterial isolates (Stavric et al., 1991; Mead, 1989).

Lactic acid bacteria have been the component of the used defined cultures. The results on competitive exclusion by lactic acid bacteria are sometimes contradictory or confusing. Fuller (1977) reported that host-specific *Lactobacillus* strains 59 and 74/1 were able to decrease *E. coli* in crop and small intestine, but not in caeca of gnotobiotic chickens. Muralidhara et al. (1977) found that the homogenates of washed intestinal tissues dosed with *L. lactis* had higher numbers of attached *Lactobacilli* and lower *E. coli* counts than control birds.
Jin et al. (1996c) found that only 26% of the isolates of *Lactobacillus* spp. from chicken intestines were able to attach moderately or strongly to the ileal epithelial cells of chickens. The ability of *Lactobacillus* to adhere in *vitro* to intestinal epithelial cells varies considerably among species and among strains of the same species (Barrow et al., 1980; Kleeman and Klaenhammer, 1982; Jin et al., 1996c).

Sissons (1989) suggested that *Lactobacilli* compete with pathogens for sites of adherence on the intestinal surface. Attachment is necessary for proliferation and for reducing the rate of removal of organisms from specific sites in the gastrointestinal tract due to the movement of digesta caused by peristalsis. Light and electron microscopic studies confirmed that invading *Salmonella* penetrate through the laminar surface of the epithelial cells of the intestine (Turnbull and Richmond, 1978). Electron microscopic examination revealed that *Salmonellae* adhere firmly to the mucosa of the caeca and, in the absence of other micro-flora are able to colonize any point along the gastrointestinal tract (Soerjadi et al., 1982). The adherent bacteria of the intestinal flora are interconnected with fibers to the mucosal surface. Bacterial colonization on the epithelial wall of the caeca is more extensive in treated than in untreated chicks. Maximum colonization of chick’s intestinal flora occurs at 48–72 hours after treatment (Soerjadi et al., 1982). The early colonization of the intestinal wall by a dense mat of micro-flora plays an important role in the initial protection of chicks against *Salmonella* infection. This supports the theory that direct competition for attachment sites is probably the primary mechanism of competitive exclusion (Muralidhara et al., 1977; Cownway et al., 1987; Stavric, 1987).

Pivnick and Nurmi (1982) summarized the basis for the competitive exclusion concept as follows:

- Newly hatched chicks may be infected by a single cell of *Salmonella*.
- Older birds are resistant to infection due to the autochthonous micro-biota of the gut, particularly in the caeca and probably in colon.
- Chicks hatched by setting hens are probably populated rapidly by the autochthonous gut micro-flora of the adult.
- Hatcheries have replaced setting hens, however, and probably in colon.
- The rearing barns in which the newly hatched chicks are placed are usually sanitized and the floors covered with fresh litter between groups of chickens. Thus, autochthonous flora of adult birds is not readily available to populate the gut of the newly hatched chicks.
- The introduction of intestinal micro-flora of adult birds to newly hatched chicks makes them immediately resistant to infectious doses of 10^5–10^6 cells of *Salmonellae*.
- The intestinal flora of adult birds may be introduced as a suspension of fecal droppings, caecal material, or anaerobic cultures; these are designated as “treatments”. Treatments may be introduced directly into the crop or by addition to the drinking water and possibly by feed. Aerosols may also be useful vectors.
- The source of treatment in the homologous species, although treatment derived for chickens protect turkeys and vice versa.

**Alteration metabolism by increasing digestive enzyme activity and decreasing bacterial enzyme activity and ammonia production**

**Digestive enzyme activity**

*Lactobacillus* spp. have been shown to produce digestive enzymes in *vitro* and the enzymes may enrich the concentration of intestinal digestive enzymes. Szylt et al. (1980) reported that two of five strains of *Lactobacillus* isolated from male chicks showed *α*-amylase activity. *Lactobacillus* spp., which are used in cheese products were found to have amylolytic, lipolytic, and proteolytic activities (Moon and Kim, 1989; Lee, 1990). Jin et al. (1996b) reported that all 12 *Lactobacillus* spp. isolated from chicken’s intestine were found to secret amylase, protease, and lipase, either extracellularly or intracellularly, or both extracellularly and intracellularly. They also found that amylase activity in small intestine increased when *Lactobacillus* cultures were fed to the broilers, but there was no effect on lypolytic and proteolytic activities (Jin et al., 1996a). Collington et al. (1990) found that the inclusion of a probiotic (mixture of multiple strains of *L. plantarum*, *L. acidophilus*, *L. casei*, and *S. faecium*) in the diet resulted in significantly higher carbohydrase activities in the mucosal tissue of pigs.

**Bacterial enzyme activity**

Goldin and Gorbach (1977) reported that the activities of nitroreductase, azoreductase and β-glucuronidase in the gut of rates could be reduced by feeding supplements of *L. acidophilus*. The same results were observed in humans (Goldin and Gorbach, 1984a). A similar reduction in β-glucuronidase has been detected in chickens fed 40% yoghurt in the drinking water (Coelo et al., 1984) and in pigs (Cole et al., 1987).

**Ammonia production**

Suppressing ammonia production and urea’s activity can be beneficial for improving animal health and enhancing growth as ammonia can cause damage to the surface of cells. Chang and Hsiun (1995) reported that probiotics containing *L. acidophilus*, *S. faecium*, and *B. subtilis* reduced the concentration of ammonia in the excreta and litter of broilers.

**Increasing feed intake and digestion**

The intestinal bacterial flora of domestic animals has an important role in the digestion and absorption of feed. It participates in the metabolism of dietary nutrients such as carbohydrates, proteins, lipids, and minerals and in the synthesis of vitamins. Njanshon et al. (1992, 1993, 1994, and 1996) determined that addition of *Lactobacillus* cultures in maize/soybean or maize/harley/soybean diets stimulated appetite and increased fat, nitrogen, calcium, phosphorus, copper, and manganese retention in layers.

**Enterotoxin neutralization**

A substance produced by a probiotic may neutralize enterotoxins produced by pathogenic bacteria. Different studies...
with *L. bulgaricus* showed that this microorganism produces a metabolite that has a neutralizing effect on enterotoxins released from *coli*-forms (M itchell and K enworthy, 1976; Stuart et al., 1978; Schwab et al., 1980).

**Stimulation of immune system**

Immunity resulting from gut exposure to a variety of antigens, such as pathogenic bacteria and dietary protein, is important in the defense of young animals against enteric infections (P urdignon et al., 1990 and 1995). Dunham et al. (1993) reported that birds treated with *L. reuteri* exhibited longer ileal villi and deeper crypts, which are a response associated with enhanced T cell function and increased production of anti-Salmonella IgM antibodies. Nahanshion et al. (1994) found that *Lactobacillus* supplementation of layers diets increased cellularity of Peyer’s patches in the ileum indicating a stimulation of the mucosal immune system that responded to antigenic stimuli by secreting immunoglobulin (IgA).

**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:

a) Introducing the treatment material into the crop by tube and syringe.

b) Introducing the treatment material into the beak using a hypodermic syringe fitted with a beaded needle.

c) Allowing each chick to drink from the tip of a pipette.

d) Dipping the beak of the bird in the treatment material.

From investigation of Nurmi and Rantala (1973) it was concluded that intubation into the crop has been used in laboratory trials especially when precise control of the treatment dose is important.

Mead et al. (1989) recommended the method, which allows chicks to drink from the tip of pipette. Administration of competitive exclusion (CE) preparations via the beak is also commonly used in laboratory trials and beak dipping may be appropriate in some circumstances.

**Administration via drinking water**

This method was introduced by Rantala (1974). The method is effective as treatment of individual chicks by gavage even though the first field application of the method showed only 11% reduction in the incidence of *S. typhimurium var. copenhagen* (Seuna et al., 1978). Better results were reported from field trials in Sweden (Wierup et al., 1988).

Practical application of competitive exclusion preparations through the first drinking water of the hatched chicks while the feed is withheld is not always optimal. Sometimes some of the chicks refuse to drink and the CE preparation spreads unevenly among the flock. The viability of the anaerobic organisms shows a rapid decline especially in chlorinated water (Seuna et al., 1978). Ghadbhan et al. (1998) studied different methods of application of competitive exclusion preparations to newly hatched chicks through spray treatment and first drinking water administration for preventing the intestinal colonization of birds with pathogenic bacteria.

**Droplet and spray application**

Pynick and Nurmi (1982) applied first the method of administering competitive exclusion cultures by using aerosols.

Goren et al. (1984) developed a spray application method for treating of newly hatched chicks, either in the hatchers themselves or in the delivery boxes. Newly hatched chicks were treated with a homogenate of either crop or caecal material or a mixture of both cultures of aerobically and anaerobically cultured intestinal microorganisms from adult hens.

Spray application of competitive exclusion cultures in the hatchers followed by drinking water administration on the farm was described by Blankenship (1992). This method is highly effective for the control of Salmonellae (Schneitz et al., 1990). Schneitz (1992) studied the method of automated spray application of competitive exclusion (CE) preparations, an automated cabin for the vaccination against Infectious Bronchitis were used.

Ghadban et al. (1998) and Ghadbhan (1999) reported that spray application of competitive exclusion preparations when 50–60% of the chicks were hatched followed by treatment of the chicks through their first drinking water on the farm was a highly effective method in controlling Salmonellae and *E. coli* and in improving growth performance of treated chicks.

**Administering through the feed**

Classical probiotics like *Lactobacillus* or *Streptococcus* rarely produce optimum results in the pelleted feed usually fed to broilers. This seems to be due to the fact that the lactic acid bacteria are destroyed partly or totally by the current pelleting process. The optimum viability temperature of lactic acid bacteria is around 35–38°C (Crawford, 1979), while pelletization may increase the temperature of finished feed up to 80°C. Gould and Hurst (1969) reported that spores of Bacillus are well known for being able to survive high temperatures.

Two probiotics, Toyocerin (containing spores of *Bacillus toyo; Kozasa, 1986*) and Paciflor (formed from spores of *Bacillus CIP 5832; Nguyen et al., 1987; 1988a, b; Schuermann, 1993) are potential growth promoters and feed savers for chicks fed with crumbles and pellets.

**Effects of probiotics on growth performance**

Hygiene in broiler production is also important and usually different hygienic conditions have relative influence on the effectiveness of treating broilers with probiotics. The Hazard Analysis Critical Control Point (HACCP) concept can also be applied to live bird production (Simonse n et al., 1987; Mead, 1991). Live bird production involving breeding, hatching and rearing belong to the second category of Critical Control Points (CCP2) (Icmsf, 1988). For broiler flocks, the following requirements should be met (Oosterom, 1991): 1) *Salmonella* free breeders producing non-infected chicks; 2) measures to prevent any domestic or wild animals from gaining access to the premises;
3) provision of protective clothing, effective cleaning and disinfection, and appropriate resting periods; 4) use of Salmonella-free feed and litter, and avoidance of spreading slurry or manure too close to premises.

Despite the introduction of the most stringent quality control and hygiene measures, absolute biosecurity is impossible especially under commercial conditions. Competitive exclusion (CE) has proved very effective in controlling both vertical and horizontal infection of Salmonella. It is essential that the CE product (probiotic) is combined with a proper biosecurity programme to minimize pathogens entering the farm and ultimately the final product (ICMSF, 1988). Administration of probiotic is one of the most effective means of controlling Salmonella infection in poultry under correct hygienic conditions and requirements.

The supplementation of either mixture of Lactobacilli cultures or preparations of Lactobacilli and other bacteria in chickens’ feed has given variable results. Kim et al. (1988) reported that addition of commercial probiotic (L. sporogenes) increased weight gain of chicks fed a diet containing 10% mouldy maize at 2 or 6 weeks of age. Similar improvement in body weight gain of chickens fed containing 10% mouldy maize at 2 or 6 weeks of age. (1988) reported that addition of commercial probiotic (L. sporogenes) increased weight gain of chicks fed a diet containing 10% mouldy maize at 2 or 6 weeks of age. Similar improvement in body weight gain of chickens fed a diet containing L. sporogenes have also been reported by Kalbande et al. (1992) and Mohan Kumar and Christopher (1998).

Han et al. (1984) supplemented chicks’ diets with an aerobic spore-former (L. sporogenes) and Clostridium butyricum and found significant improvements in weight gains and feed conversion rates. Similar results were obtained by Meluzzi et al. (1986) with male chicks fed diets containing a mixture of L. lactis and Streptococcus thermophilus 2% (2 x 10^9 cells/kg feed) from day 1 to day 60 of age. Tortuero et al. (1989) demonstrated that weight gain and feed efficiency increased significantly (P < 0.05) when chickens were fed with a diet containing 30% beans supplemented with a mixture of L. acidophilus and S. faecium (2 x 10^9 CFU/kg) for 5–8 weeks.

Mohan et al. (1995) reported that body weight gain could vary by 5% to 9% when chickens were supplemented with probiotic containing a mixture of L. acidophilus, L. casei, Bifidobacterium bifidum, Aspergillus oryzae, and Torulopsis. Owings et al. (1990) observed that feed efficiency and body weight were significantly (P < 0.05) improved in broilers treated with S. faecium in the feed and in the water compared to birds supplemented antibacterial products.

Jin et al. (1996a) treating two hundred 10 days—old broiler chicks with commercial Lactobacilli added to their diets under a hot and humid environment found that weight gain was significantly higher and feed gain ratio was significantly lower than that of control birds (P < 0.05). Jin et al. (1997) reported that adding to the feed from 0 to 6 weeks of age of either a single strain of L. acidophilus I 26 or a mixture of Lactobacillus (adherent Lactobacillus cultures isolated from the intestine of the chickens) significantly improved body weight and feed gain ratios of broilers (P < 0.05). Yto and Kim (1997) reported that feeding a diet containing probiotic (L. casei) significantly increased average daily gain during the first 3 weeks (P < 0.05).

Addition of probiotic Streptococcus faecium M-74 to broiler diet (0.5 mill. CFU/g and 1.0 mill. CFU/g) from 14th to 21st day of age increased body weight, improved feed conversion ratio, and decreased mortality of the treated chickens (Gerendai and Gippert, 1988). Including the probiotic Lactosacc and S. faecium JMB 52 cultures (400 mill. CFU/g) to the feed of broilers leads to the improvement of their productivity, consistent improvement has also been reported by Koudela et al. (1992).

Nguyen et al. (1988a) fed broiler chicks with five diets supplemented with probiotics Toyocerin and Pagilfor, presented in crumbles and pellets, and reported that both probiotics acted as potential growth promoters and did not affect microbial quality of carcasses. Van Wambeke and Pieters (1995) studied the effect of probiotic Phaseol added to broiler’s diet and determined that it had no significant effect on the chickens’ body weight and did not improve feed conversion ratio. Grashorn (1998) studied the possibilities of using probiotics (Pagilfor and Toyocerin) and/or digestion enhancers (CRINA) instead of antibiotics (Virginaminycin) in the feed of heavy turkeys. He observed no negative effects on turkey performance. Ghadban (1999) observed the insufficiency of probiotic Toyocerin to overcome high temperatures during pelletization and reported that spray application and drinking water administration were more effective methods for probiotic treatment to broiler-chicks resulting in a significantly better growth performance.

Mohan-Kumar and Christopher (1988) observed that lactic acid bacteria exert an influence on the synthesis of vitamins of complexes B12 and K. Those bacteria also were effective against different strains of pathogenic microorganisms such as E. coli, Salmonella, Shigella, Pasteurella, and Staphylococcus. Baseing on the in vitro activity against some pathogenic strains several authors considered the possibilities of lactic acid bacteria to be used for controlling and inhibiting the growth of non-useful microflora at the gastrointestinal tract of animals and humans (Vicent et al., 1959; Gilliland et al., 1977; McCormick et al., 1983).

Application of probiotic to poultry resulted in 5–6% less mortality through the first week, fully suppressing the growth of E. coli, improving daily gain and feed conversion ratio (Karabchev et al., 1994). Bilgili and Moran (1990) used a probiotic bacterial culture from Bifidobacterium pseudolongum, Bifidobacterium thermophilium, and L. acidophilus in dose of 6.8 x 10^9 for obtaining safe and healthy poultry products.

Vladimirova and Souridyska (1996) reported that a combined supplementation of probiotics, Yeasacc, and Lactosac to diets in doses of 0.1% from 1st to 28th day of live and 0.05% from 29th to 42nd day of live increased live weight significantly by 11% in the groups and by 12% when probiotics were used combined. Ghadban (1998) studied the effect of spray application of probiotics when chicks were 50–70% hatched followed by drinking water administration and reported that treated chicks had significantly higher weight gain ratio at the end of the 6th week of age, less mortality by 55–70%, and better feed conversion ratio compared to chicks from the control group.

There are many other investigations lacking positive effects of probiotics. Watkinz and Kratzer (1984) using a strain from the specific host (KTM, 74/1 and 59), Lactobacilli, and commercial products containing Lactobacilli did not find any improvement in growth performance of treated chicks. Matolino et al. (1992) did not find any significant differences in live weights of chickens fed diets containing L. acidophilus and S. faecium from 8 to 60 days of age.

The effect of probiotic against Salmonella contamination

Spray application of probiotic to newly hatched chicks followed by administration via the chicks’ first drinking water has been a very efficient method for controlling of
the intestinal Salmonella colonization in poultry. GOREN et al. (1988) treated 284 flocks with resuspended freeze-dried intestinal homogenates from specific pathogen free (SPF) birds. The incidence of Salmonella infected flocks was reduced from 38.6% to 7.6% and the incidence of infected broilers within the positive flocks was reduced from 38.6% to 5.2%. BLANKENSHIP et al. (1993) reported that Salmonella prevalence in ceca and in processed carcasses was significantly reduced from 41% in control flocks to 10% in treated flocks. This shows that treating chickens with probiotics can serve as useful means to reduce Salmonella contaminations. The same authors, using mucosal competitive exclusion (MCE) for the treatment of newly hatched chicks through spraying followed by water administration reported that initial feed, water, and litter contamination was at a low frequency (<10%). Eggshell fragment and chicks paper pads were frequently contaminated (>50%). After 3 weeks growth, contamination of litter, skin with feathers, and ceca were significantly (P < 0.05) reduced in treated flocks as compared to control ones.

GHADBAN et al. (1998) reported that spray application of probiotic followed by water administration showed a clear tendency for elimination of Salmonella (38.8% in control group to 9.72% in treated groups) and E. coli (51.4% in control group to 22.2% in treated group) in the organism of treated chickens and it was concluded that the probiotic was highly effective in preventing intestinal colonization by pathogenic bacteria. The same authors found that the main challenged organism in birds of the control group grew heavily at the pure culture, while the same organism grew only in a single colony in the experimental groups.

BOLDER et al. (1995) studied the effect of spray application of Broilact® followed by its administration by drinking water in broilers in a field trial with 2.4 × 10⁶ day old chicks from 40 farms during six consecutive rearing periods. They determined that application of this probiotic led to a significantly lower Salmonella incidence in cloacal swabs at 4 weeks of age and to a significantly lower Campylobacter incidence in the caecal content at the moment of slaughtering. The Salmonella incidence of both swabs and ceca contents were significantly correlated with the Salmonella status of the one-day-old chicks. The same authors reported that the Broilact® treatment significantly reduced the incidence at 4 weeks of age of initially Salmonella positive one-day-old chickens from 58.3% to 38.1%.

STERN et al. (1998) tested a Mucosal Starter Culture™ (MSC) with over 100.000 broiler chicks. Salmonella incidence in treated chicks was significantly reduced both on the farm and after processing with 9% and 31%, respectively. Untreated control birds were 2% and 7.5% Salmonella positive, respectively, on the farm and after processing compared to 0% and 3.5% after the probiotic treatment (BAILEY et al., 1994). STERN et al. (1998) have tested the MSC in a field trial involving over 160.000 birds. Salmonella on final processed carcasses was reduced from 5% positive in untreated control birds to 0% in carcasses of treated birds.

Administration of probiotic to chickens protected them from S. enteritidis colonization and reduced the incidence of Salmonella in litter from 52% to 13% (HINTON et al., 1991).

**Influence of antibiotics on the effectiveness of probiotics**

The widespread use of antibiotics as therapeutic agents and growth promoters resulted in the development of resistant populations of bacteria, which made subsequent use of antibiotics for therapy difficult. The SWANN COMMITTEE curtailed their use as animal feed additives in 1969, whose recommendations resulted in the restriction of growth-promoting antibiotics to those, which were not used in the treatment of disease. Recently, antibiotics have come under renewed scrutiny from the “anti-additive” lobby and some supermarkets are already selling antibiotic-free meat (FULLER, 1989).

Over the past twenty years, there has been increasing concern on the possible contribution of antibiotics used routinely at sub-therapeutic levels to the reservoir of resistant Salmonellae and to the occurrence of resistant Coliforms to which susceptible human beings may be exposed and to the occurrence of antibiotics residues in the poultry products (DuPont and STEELE, 1987).

Antibiotic treatment of chicks at sub-therapeutic levels is effective in different situations, but it has negative effect on the lactic acid bacteria, which are the main bacteria of the anaerobic micro-flora of the gastrointestinal tract of the birds. Lactic acid bacteria are very sensitive to different antibiotics (TORTUERO, 1973; DILWORTH and DAY, 1978; SYLIT and CHARLET, 1981; WATKINS and KRATZER, 1984; ROTH and KIRCHGESSNER, 1986; BOUGON et al., 1987; GHADBAN, 1999).

The influence of a therapeutically antibiotic treatment of broilers with Furazolidone and Trimethoprim/Sulfamethoxasol on the stability and the efficacy of Broilact® were tested, as well (BOLDER and PALMU, 1995). Probiotic treatment of broilers resulted in an increased competitive potency against colonization with Salmonella. The IF (Infection Factor) in the probiotic treated groups or groups treated with a combination of probiotics and antibiotics was lower than in the other groups. Treatment of chicks with Furazolidone after Broilact® treatment initially damaged the intestinal micro-flora, but after two weeks, the broilers appeared to be able to “self repair” and re-establish the exclusion of Salmonella from the gut. When Trimethoprim/Sulfamethoxasol was given after Broilact®, IF of broilers increased although the differences were not significant. The probiotic treatment showed a protection against Salmonella colonization of broilers and led to lower Salmonella CFU counts in the Salmonella positive broilers (BOLDER et al., 1992 and GOREN et al., 1984). MOHAN et al., (1995) studied the effect of probiotic and combined probiotic and antibiotic supplementation on growth, nitrogen utilization, and serum cholesterol content of broiler chickens. In the first experiment chicks treated with probiotic had a better weight gain, retained significantly more nitrogen than the control birds, and serum cholesterol content was lower in the probiotic-supplemented birds. In the second experiment, the probiotic plus antibiotic supplemented group had the highest weight gain. Nitrogen utilization was greatest in the antibiotic treated group.

There is also a reaction against the use of antibiotics as therapeutic agents because of the intestinal upsets, which often follow oral treatment with these agents. Although they are effective in curing the disease for which they are prescribed, the effect on the indigenous gut flora may persist after cessation of the treatment. The possibility of antibiotics ceasing to be used as growth stimulants for farm animals and the concern about the side effect 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 role and farmers are using them in preference to antibiotics (FULLER, 1989).
Conclusion

The reviewed evidences represent main sources of information for identifying the possibilities of using “probiotics” in poultry production as real alternatives to antibiotics. Probiotics appear to be the feed additives of the future, especially under the politics of banning of growth promoters (feed antibiotics). The obtained responses from the different modes of action of probiotics always depend on a wide variety of factors:

- The need to insure that effective methods of administration are used. Obviously, the most effective method and the best way of administration of probiotics is through the early treatment of the birds: by using a combined method of spray application of newly hatched chicks, either in the hatchers themselves or in the delivery boxes, followed by treatment via the first drinking water on the farm.

- The possibility that there will be an increasing need of probiotics to include specificity to meet the challenge from different strains of pathogens. Therefore, it will be necessary to develop specific probiotics with high inhibitory activity.

- The probiotic preparations have to be of adequate concentration and sufficiently stable both in storage and during administration to the birds, especially for those administered through the feed to be able to support high temperature of feed pelletization.

In the case of most types of probiotics, the extent to which adequate levels of colonization in the digestive tract of the whole birds in the flock can be achieved has to be determined. The establishment of desirable microorganisms may depend on environmental factors such as the composition of the diet, the existing gut micro-flora at the time of administration, the general health status of the birds, and the different hygienic conditions.

The complex micro-flora present in the gastrointestinal tract of the birds is effective in providing resistance to disease, but this protective flora can be altered by dietary and environmental influences. The probiotic treatment is re-establishing the natural condition which exists in the wild animals but which has been disrupted by modern trends in condition used for rearing birds, and in modern approaches to nutrition and disease therapy.

Key words

Broiler, nutrition, feed additives, probiotics, competitive exclusion, performance

Summary

As a result of a public food poisoning from infection with S. enteritides eggs in England in 1988–1989, egg consumption decreased by 90% and caused serious economic losses for the government and the producers. That anxiously put the question on effective losses for the government and the producers. That an-

The complex microflora present in the gastrointestinal tract of the birds is effective in providing resistance to disease, but this protective flora can be altered by dietary and environmental influences. The probiotic treatment is re-establishing the natural condition which exists in the wild animals but which has been disrupted by modern trends in condition used for rearing birds, and in modern approaches to nutrition and disease therapy.

Key words

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Zusammenfassung

Probiozika in der Broilerfütterung – eine Übersicht

Bedingt durch ein gehäuftes Auftreten von Salmonellenlosen in England in den Jahren 1988/1989, die durch mit S. enteritidis infizier-

Stichworte

GHADBAN, Probiotics in broiler production 55

Die komplexe Mikroflora im Verdauungstrakt des Geflügels ist

Die vorliegende Literaturübersicht stellt den Wissensstand zu den Verwendungsmöglichkeiten von Probiotika als Alternativen zu den antibiotischen Leistungsförderern im Futter insbesondere in der Hühnermast dar. Behandelt werden unter anderem die Wir-

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Correspondence: Dr. G. S. Ghadbani, Technical Department, Al-Ghadbani Poultry Co. Ltd., P.O.Box 287, Tulkarm, Palestine; E-mail: ghadbani@pulnet.com

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