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REVIEW ARTICLE

Probiotics in Broiler Poultry Feeds: A Review

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Abstract

Poultry is one of the fastest growing segments of agriculture and animal husbandry sector. Feed is one of the largest items of expenditure in poultry production and it alone accounts to 70% of total poultry production. The constant increase in the cost of poultry feed ingredients and compounded feed is making less profit to poultry farmers. To minimize the cost of feeding, several feed additives (as growth promoter) like synthetic hormone and antibiotics have been extensively used for enhancing poultry production in recent years. To avoid the health hazards of antimicrobials to human as well as poultry, in recent years, a probiotics as feed additives for better and safe production in poultry was employed. Probiotic are “mono or defined mixed culture of live microorganisms which when applied to animals, beneficially affect the host by improving the properties of the indigenous micro biota”. Various species are used in probiotic preparations i.e. *Lactobacillus bulgaricus, L. acidophillus, L. casei, L. helveticus, L. salvarius, L. plantarum, L. faecalis, Streptococcus thermophilus, Enterococcus faecium, Enterobactris faecalis, Bifidobacteria species, Saccharomyces cerevisiae* and *Toulopsis sphaerica*. However, *Lactobacilli* and *Streptococci* are most commonly used treatments of bacteria in the production of probiotics. In this review, the effect of probiotics on growth rate, body weight gain, feed intake, feed conversion efficiency, survivability of probiotics in GIT, mineral metabolism, cholesterol metabolism, dose rate of probiotics, carcass characteristics and sensory quality of chicken meat was discussed.

Keywords: Chicken broiler, Feed additives, Probiotics, *Lactobacilli*, *Streptococci*, Carcass and meat quality.

1. Introduction

Poultry is one of the fastest growing segments of agriculture and veterinary sector. Like other sector of agricultural industry, major aim of this industry is also to produce maximum with minimum input. Feed is one of the largest items of expenditure in poultry production and it alone accounts to 70% of total poultry production. The constant increase in the cost of poultry feed ingredients and compounded feed is making the profit less for poultry farmers. Therefore, balanced and effective feeding is most important requisite to superior germplasm for economic poultry production. Several feed additives (as growth promoter) like synthetic hormone and antibiotics have been extensively used for enhancing poultry production but due to development of antibiotic resistant bacterial strains and residual effects of these feed additives in eggs and meat, they lead to various health hazards to consumers. Thus the best of all above to the use of probiotics as feed additives for better and safe production in livestock in general (Bidarkar *et al.*, 2014) and specific in poultry.

Probiotic are “mono or defined mixed culture of live microorganisms which when applied to animals, beneficially affect the host by improving the properties of the indigenous micro biota”. They are also known as DFM (direct fed microbial). Parker (1974) was the first to coin the term ‘probiotic’ and described it as “microorganism or substance, which contributes to the intestinal microbial balance”. In 1989, Fuller defined probiotic as “a live microbial feed supplement, which beneficially affects the host animal by improving its intestinal balance”. The term ‘probiotic’ is derived from a Greek word ‘probios’ means’ ‘for life’. Probiotic have been described as opposite of antibiotics. While antibiotics destroy life, probiotics build up or promote life.

The species that are used in probiotic preparations are *Lactobacillus bulgaricus, L.acidophillus, L.casei, L. helveticus, L. salvarius, L. plantarum, L. faecalis, Streptococcus thermophilus, Enterococcus faecium, Enterobactris faecalis, Bifidobacteria species*, *Saccharomyces cerevisiae* and *Toulopsis sphaerica*. *Lactobacilli* and *Streptococci* are most commonly used treatments of bacteria in the production of probiotics. Besides yeast and unicellular fungi are also known for their fermentative ability. Yeasts reduce enzymes such as amylase, protease, lipase, cellulose as well as B complex vitamins in the medium in which they grow. The benefits of feeding probiotics to poultry are that they stimulate immune system (Sanders, 1984), improve utilization of proteins, intestinal tract health, feed conversion ratio, strengthen beneficial microbial populations and suppress harmful bacterial growth in the digestive system, counteract adverse effect of antibiotic treatment by sustaining the population of beneficial bacteria, and also in nutrient synthesis.

2. Use of Probiotics in Broilers

In vertebrates, there are more microbial cells within the gastrointestinal (GI) tract than total cells within the body-proper (Hove *et al*., 1999). The microorganisms most commonly observed are bacteria and yeast. The populations of microorganism which are found within the gastrointestinal tract of poultry are of two types. Firstly the bacteria which colonize the gut from the environment as a result of feeding behavior or other activities. These are called *autochthonous* bacteria (Gusils *et al*., 1999). The second type of bacteria are those which are exogenous in nature and are introduced as a dietary supplement into the GI tract through the feed or drinking water as direct fed microbial (DFM) or probiotics. These types of bacteria are called, *allocthonous* bacteria (Patterson and Burkholder, 2003; Chichlowski *et al.,* 2007).

2.1 Concept of Probiotics

Probiotics are "mono or defined mixed culture of live microorganisms which when applied to animals, beneficially affect the host by improving the properties of the indigenous micro biota". They are also known as DFM (direct fed microorganism). Probiotics act as growth promoters when used as feed additives and consist of live culture of one or a number of microorganisms (Hertrampf, 1979). Jernigan *et al.* (1985) defined probiotics as culture of specific living microorganisms which implant in animal to which they are given ensures effective establishment of intestinal microbial population. Probiotics are viable bacterial cell preparation or food containing viable bacterial cultures or components of bacterial cells that have beneficial effect on health of host (Delly *et al*., 1990; Hertel *et al*., 1991; Ehrmann *et al*., 1992; Charteris *et al*., 1997).

Probiotics, which are live microbial feed supplements and beneficially affect the host animal by improving its intestinal microbial balance, have been used as the alternative tools for helping newly hatched chicks to colonize normal micro flora as conventionally hatched chicks do (Fuller, 1989). Generally two types of micro flora (viz. beneficial and harmful) colonize the gastrointestinal tract in animals. Beneficial microbes' colonize gut surfaces in a symbiotic relationship with the host and harmful microbes are potentially pathogenic. Under normal physiological conditions, the beneficial organisms predominate, which are essential to normal physiological functions such as nutrient supply to host, help in digestion of dietary nutrients and compete with potential pathogens. Probiotics also prevent contamination of carcasses by intestinal pathogens during processing and improve growth rate and feed conversion efficiency in growing chickens (Hose and Sozzi, 1991; Juven *et al*., 1991). When adverse internal conditions prevail in the internal environment, the resistance of animal lowered due to stress thus normal micro flora of GIT gets affected and pathogenic microbes proliferate which leads to various problems like reduced feed intake, lowered production , reduced performance, diarrhea and gastroenteritis (Patil *et al.,* 2015)**.**

Parker (1974) was first to use the word 'probiotic' to describe microorganisms and substances that contribute to intestinal microbial balance. The intensive production system of poultry industry produces a great stress on the birds. Beneficial effects with the use of probiotics have been obtained on productive parameters in broilers (Katoch *et al*., 1994; Samantha and Biswas, 1997; Rincon *et al*., 2000). Ghadban, (2002) discussed the use of probiotics and methods of administration. Most of the probiotics now available in the market contains *Lactobacilli, Lactococci*, yeast cultures alone or in combination.

2.2 Bacterial Probiotics

The survival of beneficial bacteria in gut depends on their colonization characteristics and their ability of resisting the antibacterial factors present in gut. Stable flora of intestine resists the infection of gut. This phenomenon has been described by various workers under different names as bacterial antagonism (Freter, 1965), barrier effect (Ducluzean *et al.,* 1970), colonization resistance (Van Der Waaij *et al.,* 1970). Among all these terms competitive exclusion is most commonly used. The competitive exclusion concept was first applied by Nurmi in Finland in 1973 and known as "Nurmi concept". This can be defined as "early establishment of complete intestinal micro flora to prevent colonization by enteropathogens".

Lactic acid bacteria are commonly used in most probiotics preparation due to historical belief that they are desirable members of the intestinal micro flora and thus generally regarded as safe. The specific role of lactic acid bacteria as probiotics has been extensively discussed by Juven *et al.* (1991). Lactic acid bacteria produce much kind of metabolites, which might affect the other microbes in gut. The lactic acid produced by homolactic and hetrolactic strains reduces the pH of the luminal content, which is detrimental to some pathogenic bacteria. Moreover, acetic acid and hydrogen peroxide produced by lactic acid bacteria are inhibitory against coli forms, *Salmonella* and *Clostridia*. *Lactobacilli* treatment in general is claimed to improve the performance of layers and broilers by suppressing the harmful effect of *E.coli* in the digestive tract (Mudalgi *et al*., 1993; Kumprecht *et al.*, 1994).

2.3 Characteristics of an Ideal Probiotics

An ideal probiotic should have the following characteristics

- Capability of exerting beneficial effects on the host animal viz. increased growth or resistance to disease
- Non-pathogenic and non-toxic to animals and human
- Should be present as viable cells, preferably in large numbers although the minimum effective dose is not fully defined
- Ability to withstand processing and storage
- High tolerance to bile and gastric acid (low pH)
- Ability to adhere to epithelium or mucus
- Persistency in intestinal tract
- Ability to modulate immune response
- Ability to produce inhibitory compounds
- Capability of altering microbial activity

2.4 Mode of Action of Probiotics

The beneficial effects of probiotics may be mediated by direct antagonistic effects against specific treatment of organisms, resulting in decrease in number or by an effect on their metabolism or by synthesis of some essential nutrients or by stimulation of immunity. The mode of action of probiotics was proposed and discussed by many workers (Jin *et al*., 1997; Ghadban, 2002).

Suppression of viable count

- ➢ By production of antibacterial compounds
  - ✓ *The antibacterial substances like lactocidin, acidophillin, organic acids and bacteriocins*
  - ✓ *Production of hydrogen peroxide*
- ➢ By competitive exclusion
  - ✓ *Competition for adhesion sites*
  - ✓ *Competition for nutrients. Pathogenic and non-pathogenic bacteria usually compete for nutrients. Nonpathogenic bacteria usually have high competitive power and thus colonize the intestine better*

Alteration of microbial metabolism

- ➢ By increased activity of the digestive enzymes viz. β galactosidase, α amylase, etc. which aid in digestion of various carbohydrates, fat and protein and absorption of nutrients
- ➢ By decreased bacterial enzyme activity e.g. glucoronidase, nitroreductase and azoreductase which are produced by some pathogenic bacteria
- ➢ By decreasing ammonia production

Stimulation of immune system, making birds less vulnerable to disease

- ➢ By increasing antibody level
- ➢ By increasing microphage activity
- ➢ By improving production of immunoglobulin-IgA, IgM and IgG and also cytokine

Further, other mode of action are creation of micro ecology hostile to pathogenic microbes by decreasing gut pH with production of lactic acid; offering digestive protein, vitamins, enzymes and other cofactors; and some growth factors (malic acid, some short chain FAs) for proliferation of beneficial bacteria; neutralization of enterotoxins; increasing the area of absorption of small intestine by improving intestinal morphology (increase the villus height, increase goblet cell number, and decrease the crypt depth).

3. Effect on Growth Rate and Body Weight Gain

It can be inferred from various studies that supplementation of probiotics to broiler diet improve body weight gain in broilers. Probiotics also improve general health of chicks (Chapman and Lyons, 1989; Buche *et al*., 1992; Holoubek, 1993; Sharma and Katoch, 1996; Ghabdan, 1998). When broilers were fed LBA (*streptococcus faecium*) at 200g/400kg feed by Krecov and Puijic (1975), they observed that total body weight gain in birds fed with and without LBA were 1570 and 1545 g, respectively. Melluzi *et al*. (1986) studied the effect of lactic acid bacteria and *Bifidobacteria* in broiler chicks and observed that birds fed with 2% of lactic acid bacteria culture gave significantly ($P \leq 0.05$) higher body weight than that of control given reconstituted sterile milk. Kim *et al.* (1990) observed increased weight gain of chicken offered maize diet supplemented with probiotics.

Mohan (1991) reported improve in growth rate in broilers after feeding probiotics. Cho *et al.* (1992) reported growth promoting ability of *Lactobacillus casei* with antibiotics and observed 3.4 to 6.0% increase in body weight gain in broilers. Moses (1992) reported that when probiotics and antibiotics were used in combination, the body weight at seventh week was 1.6 kg against 1.2 kg in control. Khan *et al*. (1992) observed no increase in body weight gain in broilers after supplementing probiotics to broiler diet. Baidya *et al*. (1993) reported that Biospir 50 containing *Lactobacillus sporogenes* grew faster than control up to six week of age. Mudalgi *et al*. (1993) observed that birds offered probiotic cultures (*L. acidophilus and L.bulgaricus*) appeared to gain numerically higher weights than those fed control diets. Chicks fed *L.bulgaricus* with low and high protein diet gained 5.7 and 6.5% more weight respectively over the control birds. Bhatt (1993) reported significantly ($P \leq 0.05$) higher live weight gains in broiler stock supplemented with *Streptococcus lactis and Saccharomyces cerevisiae.* Manickam *et al*. (1994) recorded a highly significant ($P \leq 0.01$) difference in weight gain between control and experimental group of broiler when *Lactobacillus sporogenes* based probiotic was given at 1 g per liter of drinking water for a period of 0-6 weeks.

Bhatt *et al.* (1995a) tested the effect of dietary supplementation of four different strain (L_1, L_2, L_3 and L_4) of *Lactobacillus bulgaricus* on commercial broilers and concluded that only L_4 (HPKV, Palampur) was promising due to significant ($P \leq 0.05$) gain in weight during the finisher phase. Bhatt *et al*. (1995b) studied the effect of dietary supplementation of *Saccharomyces cerevisiae* (Y_3) on 'Starbo' broiler chickens and observed significant ($P \leq 0.05$) higher live weight gain during starter phase. Chiang and Hsiegh (1995) observed better weight gain ($P \leq 0.01$) in birds fed with probiotics-supplemented diet (mixture of *Lactobacillus, Bacillus* and *Streptococcus*) as compared to the probiotics-unsupplemented diets. Samanta and Biswas (1995) reported that supplementation probiotics (*Lactobacillus* sp.) in drinking water of broiler housed in battery cage observed increase in body weight at starter and finisher phase.

Kumprecht and Zobac (1996) studied the effect of *Saccharomycs cerevisiae* var. elipsoideus and *Bacillus* CIP-5832 as probiotic on broiler and reported significant ($P \leq 0.05$) increase in body weight gain. Jin *et al.* (1996) reported significant ($P \leq 0.05$) higher weight gain in broilers given diets supplemented with *Bacillus subtilis* and *Lactobacillus* culture. Hamid *et al.* (1996) reported that feeding of broiler chicks with diets supplemented with *L. acidophilus* culture showed higher gain in weight (945.5g) against control (773.5g). Wohlke *et al.* (1996) studied the effect of *Bacillus natto* in different dosages (0, 50, 75 and 100 $x10^9$ spores/ton ration) on broiler performance and conclude that in male chicken there was improvement in weight gain and feed conversion. Katoch *et al*. (1996) supplemented different probiotics in broiler diet and observed improvement in body weight gain in the range of 1063.47g to 1213.28g against 961.85g in control. Kaistha *et al.* (1996) reported that dietary supplementation of three isolates of microbes i.e. *Lactobacillus acidophilus* (Bottle gourd), *Streptococcus uberis* (Bitter gourd) and *Saccharomyces cerevisiae* (Bitter gourd) vis-à-vis their respective standard strains *L.bulgaricus* (L_4), *S. lactis* (S_1) and *Saccharomyces cerevisiae* (Y_3) did not have any effect on the biological performance of the broilers during starter phase, however during finisher phase, all the treatment showed significant ($P \leq 0.05$) improvement in weight gain. Whereas Katoch *et al*. (1996) reported significantly ($P \leq 0.05$) better growth performance of broilers while fed Y_3 strain of *Saccharomyces cerevisiae* during 1-6 weeks age. Mohan *et al.* (1996) reported increased body weight in broilers fed probiotics at 75 mg/kg feed.

Jin *et al.* (1997) reported improved growth performance in broiler after addition of probiotics in feed. Joy and Samuel (1997) administered *Lactobacillus sporogenes* at 0, 50 and 100 million organisms orally per chick daily from day 1 to 42 and reported that probiotics treatment at 100 million organisms increased ($P \leq 0.01$) body weight gain in broilers. Sarkar *et al.* (1997) observed that when different cultures of yeast and antibiotics were used in broiler ration, the weight gain in six weeks of age was between 1677.27 g to 1733.35g against 1644.91g in control. Samanta and Biswas (1997) reported that dietary supplementation of *Lactobacillus spp.* slightly improved body weight of broilers along with the reduction in mortality without affecting the feed intake and feed conversion ratio. Bhatt *et al*. (1997) reported the effect of dietary supplementation of different strains of *Streptococcus lactis* on the biological performance of commercial broilers (Starbro strain). S_1 strain from CFTRI, Mysore, was most effective because it showed significantly ($P \leq 0.05$) higher broiler live weight gain coupled with efficient feed efficiency ratio and minimum chick mortality during both the starter and finisher phases.

Jin *et al*. (1998) reported that addition of *Lactobacillus* or mixture of 12 *Lactobacillus* strains to broiler diet increased body weight. Gohain and Sapcota

(1998) reported that addition of probiotics in broiler ration significantly ($P \leq 0.05$) increased growth of broilers. Katoch *et al.* (1998) reported that dietary supplementation of selected strains of *Lactobacillus bulgaris* (L_4), *Streptococcus lactis* (S_1) and *Saccharomyces cerevisiae* (Y_3) alone and in different combinations on 'IBL-80' broilers gave significantly ($P \leq 0.05$) higher growth rates and efficiency ratio coupled with no mortality as compared to control treatment during the starter phase.

Singh and Sharma (1999) studied the effect of different levels (0.02, 0.03 and 0.04%) of probiotics (*Lactobacillus sporogenes*) on commercial broilers and observed highest weight gain in broilers offered diet supplemented with 0.02 % probiotics. Mahajan *et al.* (1999) studied the effect of probiotics (Lacto-sacc) feeding during summer and winter season on the growth performance and carcass quality of broilers and observed significantly ($P \leq 0.05$) higher body weight for Lacto-sacc fed broilers as compared to control during summer season. Zaho (1999) reported that when *Lactobacillus* was fed to 60 chickens, their daily weight gain was increased by 24.4% as compared to control. Naik *et al.* (2000) evaluated the effect of different probiotics (*Lactobacillus acidophilus, Saccharomycs cerevisiae* and their combination) on the performance of broilers and reported that supplementation of both *Lactobacillus* and *Saccharomyces* invidually to the basal diet at 0.05% improved body weight gain in broilers. Katoch *et al.* (2000) reported that the 'Vencobb' broilers out of three strains of commercial broilers gave significantly ($P \leq 0.05$) higher gain in body weight when they were fed diet supplemented with combination of *Lactobacillus acidophilus, Streptococcus faecalis and Saccharomyces carlsbergensis* isolated from leopard excreta and combination of their respective standard counterpart i.e. *L.bulgaricus* (L_4), *S. lactis* (S_1) and *Saccharomycs cerevisiae* (Y_3) up to six weeks of age. Shome *et al.* (2000) reported that when mixture of *Lactobacillus acidophilus* and *L. salivarius* was fed to broilers, the live weight of chicken was higher during starter phase in experimental groups compared to control.

Safalaoh *et al.* (2001) shown that effective microorganisms (probiotics) had growth promoting and hypocholesteraemic effects as potential alternative to antibiotics in broiler diets. Sharma *et al.* (2001) observed that only the microbial combination of *L. lactis* (tomato)+ *S. faecium* (banana)+ *T. sphaerica* (banana) presented a good mutual compatibility in the 'Kegbro' strain of broilers due to better effective colonization in the GI tract along with decrease in cost of per kg gain in live weight. Bandy and Risam (2001) conducted an experiment to determine the efficiency of probiotic (Biospur) at three different levels- 25, 50 and 75 g/100kg feed respectively and observed that chicks fed with probiotics grew faster than control and highest live weight was obtained in the treatment fed probiotics at 75/100kg feed. Kumar *et al.* (2002) observed that the supplementation of EY Micromix at 30 g and 40 g per quintal of feed showed significantly ($P \leq 0.01$ and $P \leq 0.05$, respectively) higher gain in body weight at marketable age. Upendra and Yathiraj (2002) observed that supplementation of Lacto-sacc (a combination of, *Saccharomycs cerevisiae*, *Lactobacillus acidophilus* and *Streptococcus faecium*) at 250g/ton of feed resulted in numerical increase in body weight gain by 1.7 % as compared to control. Gupta (2003) supplemented different strains of *Lactococcus* isolated from excreta of Sambhar, Himalayan Black bear and Monal and their standard counterpart- *L.lactis* (CFTRI, Mysore) and Bacitracin. He observed that differences in body weight gain were significant ($P \leq 0.05$) in all treatment treatments as compared to unsupplemented control and also concluded that treatment s fed with Bacitracin and *Lactococcus* species isolated from Monal showed highest % increase in body weight gain i.e.6.80 and 5.44 %over control.

Arslan *et al.* (2004) reported that probiotics had no significant ($P \leq 0.05$) effect on growth in broilers. Chitra *et al.* (2004) conducted an experiment to study the effect of probiotics and ascorbic acid supplementation independently either in feed or in drinking water on production performance of broilers in summer season and observed that inclusion of probiotic and ascorbic acid both independently and simultaneously either in feed or in drinking water to broilers had made significant ($P \leq 0.01$) improvement in body weight of commercial broilers. Gupta (2004) also reported higher body weight gain in broilers after supplementation of probiotics at the field level.

Anjum *et al.* (2005) reported that multi-strain probiotics (protexin) supplementation in the diet significantly ($P \leq 0.05$) improved body weight gain in broilers. Das *et al.* (2005) reported no significant ($P \leq 0.05$) difference in dressed weight and blood parameters in broilers after supplementation of commercial probiotics preparation. Sabiha *et al.* (2005) studied the effects of different levels(0.025% and 0.05%) of probiotics *(Lactobacillus acidophilus*, *Streptococcus faecium* and Yeasacc 1026) supplementation on the performance of broiler chicken and observed statistically ($P \leq 0.05$) higher body weight gain up to 6 weeks of age in 0.025 % probiotics supplemented birds. Some researchers have reported non-significant ($P \leq 0.05$) difference in live weight gain among the treatments fed high quality rations or with probiotics (Adler and DaMassa, 1980; Watkins and Kratzer, 1984). Yadav *et al.* (1994) reported that the supplementation of 'live bakers' yeast culture culture (as probiotics) to rations had no influence on weekly body weight gain in broilers. Wambeke and Peters (1995) observed that body weight was not affected at three and six weeks of age of broilers by peciflor supplementation. Kahraman *et al.* (1996) reported that the addition of probiotics Fastrack R alone or with sodium bicarbonate to broiler diet did not influence the growth performance of broiler chickens. Choudhury *et al.* (1998) reported that probiotics (G-pro, Vetcare B.No.50813) did not have any growth promoting influence as compared to antibiotic (Teteracycline hydrochloride) and control. Saha *et al.* (1999) observed non-significant ($P \leq 0.05$) effect of Baker's yeast supplementation on growth, nutrient utilization and carcass quality of broilers. Ladukar *et al.* (2001) conducted an experiment to study the effect of five commercial probiotics on the growth performance of broiler chicks and observed no significant ($P \leq 0.05$) difference in live weight gain. Panda *et al.* (2001) studied the effect of dietary supplementation of probiotics on growth and gut microflora of broilers and no significant ($P \leq 0.05$) effect on body weight gain was reported, however a significant ($P \leq 0.05$) decrease in *E.coli* count was reported.

4. Effect on Feed Intake and Feed Conversion Efficiency

Hertrampf (1979) reported that probiotics had been successful in improving feed conversion efficiency in broilers. Cho *et al.* (1992) reported that the supplementation of *Lactobacillus casei* improved feed conversion ratio by 0.3 to 3.1% as compared to control and treatments supplemented with antibiotics or other probiotics. Moses (1992) reported that supplementation of probiotics product Biospur in the diet of broiler resulted in improved feed conversion efficiency (2.18 vs 2.9) at 17th week of age. Khan *et al.* (1992) observed no increase in feed intake and feed conversion efficiency in broilers after supplementing probiotics to the broiler diet. Cavazzoni *et al.* (1993) reported 6 % improvement in feed conversion efficiency in broilers fed diet supplemented with probiotics (*Bacillus coagulans*) as compared to control. Baidya *et al.* (1993) observed that probiotics were less effective than antibiotics in improving feed gain ratio in broilers. Kumprecht *et al.* (1994) studied the effects of *Saccharomycs cerevisiae* var. *elipsoideus* and *Streptococcus faecium* C-68 (SF-68) as probiotics on broilers and reported improved feed intake and FCR. Manickam *et al.* (1994) reported significantly($P \leq 0.05$) lower feed conversion efficiency for probiotics supplemented treatment (2.36±0.01) as compared to control (2.55 $\pm$ 0.01). Yadav *et al.* (1994) observed that 'Bakers yeast' had no influence on feed intake and feed conversion efficiency in broilers. Wambeke *et al.* (1995) reported that paciflor R (*Bacillus* CTP strain 5832) supplements to broiler diets improved FCR. Samanta and Biswas (1995) reported that supplementation of probiotics (*Lactobacillus* sp.) in drinking water of broilers housed in battery cage increased feed intake during both starter and finisher phases. Bhatt *et al.* (1995b) used different strains of *Saccharomycs cerevisiae* in broilers and recorded feed intake in the range of 2522.1 to 2717.5 vs. 2555.2g in control. Chiang and Hsiegh (1995) observed that in hen broiler chickens fed diets supplemented with six probiotics levels up to 6 weeks of age, weight gain: feed ratio was improved with reduction in ammonia production in litter.

Jin *et al.* (1996) reported improved feed: gain ratio in broilers given *Lactobacillus* in drinking water. Hamid *et al.* (1996) observed improvement in feed: gain ratio in broilers fed basal diet plus biomass of *Lactobacillus acidophilus* culture on whey and zinc bacitracin from 2.32 to 2.01. Singh and Sharma (1996) investigated the effect of feeding *Lactobacillus sporogenes* at 0, 0.02, 0.03 and 0.04 % level in broilers and reported that probiotics combination did not affect feed intake, however, at 0.02 % level, *Lactobacillus* improved feed conversion efficiency significantly ($P \leq 0.05$). Kaistha *et al.* (1996) reported that dietary supplementation of isolates of microbes i.e. *Lactobacillus acidophilus*(bottle gourd), *Streptococcus uberis* (bitter gourd), *Saccharomycs cerevisiae* (bitter gourd) vis-a-vis their respective standard strains *L .bulgaricus* (L_4), *S. lactis* (S_1) and *Saccharomycs cerevisiae* (Y_3) showed better FCR in broilers only during finisher phase. Jin *et al.* (1997) reported improved feed conversion efficiency in broilers after addition of probiotics in feed. Takahashi *et al.* (1997) observed improvement in feed conversion efficiency in broilers fed with *Bacillus cereus* even when chicken were raised in unhygienic conditions but, no improvement in live weight gain or feed intake was noticed. Joy and Samual (1997) administered *Lactobacillus sporogenes* to broilers at 0, 50 and 100 million organisms orally per chick daily from day 1 to 42 and reported that probiotic treatment at 100 million organisms increased feed intake and improved feed efficiency. Bhatt *et al.* (1997) reported the effect of dietary supplementation of different strains of *Streptococcus lactis* on biological performance of commercial broilers ('Starbro' strain) and observed S_1 strain from CFTRI, Mysore, the most effective in improving feed conversion efficiency.

Jin *et al.* (1998) reported that addition of *Lactobacillus* or mixture of 12 *Lactobacillus* strains to broiler diet improved feed: gain ratio. Georgieva *et al.* (1998) observed that when broilers were fed with probiotics Lacto-sacc (1g/kg feed), the feed: gain ratio (FCR) was improved by 8.2%. Gohain and Sapcota (1998) reported improvement in FCR of broiler chicks fed *Lactobacillus acidophilus* and *Streptococcus faecium* microbial cultures supplemented diets. Rajmane and Sonawane (1998) reported that when broilers were treated with probiotics through water at 20g/1000 chicks for first five days and from sixth day onwards at 50g/ton of feed till the end of 42^{nd} day of age, the better performance in term of FCR as compared to control was noticed. Katoch *et al.* (1998) reported that dietary supplementation of the selected strain of *Lactobacillus bulgaris* (L_4), *Streptococcus lactis* (S_1) and *Saccharomycs cerevisiae* (Y_3) alone and in different combinations on 'IBL-80' broilers improved FCR as compared to control treatment during the starter phase. Singh and Sharma (1999) studied the effect of different levels (0.02, 0.03 and 0.04%) of probiotics (*Lactobacillus sporogenes*) on commercial broilers and observed highest feed efficiency in broilers offered 0.02 % probiotics. Mahajan *et al.* (1999) studied the effect of probiotics (Lacto-sacc) feeding during summer and winter on growth performance and carcass quality of broilers. Feed intake and feed conversion ratio on cumulative basis were significantly ($P \leq 0.05$) higher in probiotics fed broilers.

Naik *et al.* (2000) valuated the effect of different probiotics *Lactobacillus acidophilus*, *Saccharomycs cerevisiae* and their combination) on the performance of broilers and reported that supplementation of *Lactobacillus* to the basal diet at 0.05% improved feed efficiency in broilers as compared to unsupplemented controls. Safalaoh *et al.* (2001) showed that effective microorganisms (probiotics) improved feed efficiency in broilers alone or with antibiotics, which is more pronounced at the higher dosage (30g/kg feed). Upendra and Yathiraj (2002) observed that supplementation of Lacto-sacc at 250g/ton of feed resulted in an improvement of FCR, which was 10.8% better over that of control. Gupta (2003) supplemented broiler diets with different strains of *Lactococci* and Bacitracin. He observed that all the diets showed lower ($P \leq 0.05$) FCR than control. Chitra *et al.* (2004) reported that inclusion of probiotics and ascorbic acid both independently and simultaneously either in feed or in drinking water to broilers had made significant ($P \leq 0.01$) improvement in total feed consumption and feed efficiency during summer season. Gupta (2004) also observed that supplementation of probiotics improved FCR in broilers at the field level. Anjum *et al.* (2005) observed that there was significant ($P \leq 0.05$) improvement in feed conversion ratio after supplementation of multi-strain probiotics (protexin) in broilers, however, no improvement in feed intake was observed. Sabiha *et al.* (2005) studied the effects of different levels (0.025% and 0.05%) of probiotics viz. *Lactobacillus acidophilus Streptococcus faecium* and Yeasacc 1026 supplementation on the performance of broiler chicken and observed no significant ($P \leq 0.05$) difference in feed intake and feed efficiency at 6 and 8 weeks of age.

5. Survivability in GIT

Hussein and El-Asry (1991) found that administration of a *Lactobacillus* concentrates at 0.5g/kg starter mixture to broiler chickens decreased the incidence of diarrhea and mortality. Talukdar (1992) reported non-significant ($P \leq 0.05$) difference between probiotics treatments; however, marginally lower mortality was observed in the treatments fed pure *Lactobacilli* culture. Adsul (1993) recorded total cumulative mortality of 3.05, 4.14, 3.04 and 4.19% in the birds fed pure *Lactobacilli* culture, enzyme feed supplement, *Lactobacilli* culture with enzyme supplement and control, respectively. He concluded that the treatment received pure *Lactobacilli* culture showed lesser mortality. Lee *et al.* (1994) noticed that the viability of the broiler treatments given antibiotics and probiotics was higher than that of the control treatment, which was statistically non-significant ($P \leq 0.05$).

Bhatt *et al.* (1995) observed favorable effect on the livability of broilers after addition of probiotics in the diet of broilers. Kaistha *et al.* (1996) recorded lesser mortality in broilers fed diets supplemented with *Lactobacillus acidophilus*, *Streptococcus uberis and Saccharomycs cerevisiae*. Samantha and Biswas (1997) observed that mortality was reduced in broilers fed diet supplemented with probiotics. Bhatt *et al.* (1997) reported the effect of dietary supplementation of different strains of *Streptococcus lactis* on the biological performance of commercial broilers ('starbo' broilers) and found that S_1 strain from CFTRI, mysore, showed minimum chick mortality during both starter and finisher phases. Katoch *et al.* (1998) reported that dietary supplementation of the selected strains of *Lactobacillus* bulgaricus (L_4), Streptococcus *lactis* (S_1) and *Saccharomycs cerevisiae* (Y_3) alone and in different combinations to diet of 'IBL-80' broilers showed no mortality as compared to control treatment during the starter phase. Rajmane and Sonawane (1998) reported reduction in chick mortality from 7 to 2 per cent oral administered probiotics through drinking water at 20g/ 1000 chicks. Singh *et al.* (1999) investigated the influence of *Lactobacillus sporogenes* on mortality of broiler chicks in summer and found that addition of probiotics decreased the mortality. Mahajan *et al.* (1999) reported lower cumulative mortality in Lacto-sacc fed broiler chicks in summer and winter when compared with control treatment. Shome *et al.*

(2000) reported zero mortality in broilers fed *Lactobacillus acidophilus* and *L. salvarius* and 12.7% mortality in unsupplemented control treatment, mostly due to bacterial enteropathogens. Upendra and Yatiraj (2002) recorded significant ($P \leq 0.05$) reduction (54.25%) in chick mortality when chicks were fed diets supplemented with Lacto-Sacc. Gupta (2004) concluded that probiotics supplementation decreased mortality percentage in broilers. Sabiha *et al.* (2005) reported that mortality was not affected by the supplementation of probiotics in broilers.

6. Effect on Mineral Metabolism

An important factor affecting the bio availability of Ca i.e. Oxalic acid takes important role, which is chemical compound and forms insoluble precipitates with oxalate, specially calcium oxalate, which lowers the bio availability of Ca. Oxalic acid and oxalates are abundantly present in many plants used as source of feed for poultry birds. Tang *et al.* (2007) reported that fermentation with strains of *Lactobacillus* leads to increase in calcium solubility which was related to lowered pH associated with production of lactic and acetic acids which in turn enhance the calcium bioavailability due to increased calcium solubility.

7. Effect on the Cholesterol Metabolism

Several direct fed microbial have shown to be capable of hydrolyzing bile acids. This prevents its reabsorption from intestine. Bile acids are formed from cholesterol in the liver and, therefore, any increase in illumination of bile acids from body would increase the rate of conversion of cholesterol to bile acids. This eventually is supposed to decrease the level of cholesterol in blood. Many research findings have shown that probiotics decrease the cholesterol content in meat as well as serum. Joy and Samual (1997) reported that Probiotics treatment with 100 million organisms gives lower serum cholesterol in treated birds. Jin *et al.* (1998) also reported that *Lactobacillus* fed group bird show significantly lower ($P \leq 0.05$) serum cholesterol at 30 day of age. Kim *et al.* (2000) reported that there was significant lowered ($P \leq 0.05$) blood cholesterol levels in the broiler birds supplemented with probiotics. Pietras (2001) reported that protein content of chicken given probiotics is higher, while their crude fat and serum cholesterol is lower than control treatment. Chitra *et al.* (2004) also reported that supplementation of probiotics showed highly significant ($P \leq 0.01$) reduction of serum cholesterol level. Cenesz *et al.* (2008) also reported that supplementation of probiotic in broiler birds significantly ($P \leq 0.05$) reduced total cholesterol serum level.

8. Effect of Probiotics with Dose Rate

Past research shows that probiotics works at different stress level with varied dose rate. As probiotics are used for therapeutic and/or growth promotion, the dose and frequency of administration is variable. The dose is key factor for effect of probiotics in broilers. The action of probiotics varies with the dose. Much of the studies have been conducted to standardize the dose of various probiotics in poultry. But still this area needs much more investigation. Krecov and Puijic (1975) fed LBA, *Streptococcus* at 200g/400kg feed to broiler birds. They observed that total body weight gain in birds fed with and without LBA were 1570 and 1545 g, respectively. A study conducted by Watkins and Kretzer (1983) revealed that when *Lactobacilli* were fed to day old broiler chicken at dose rate of 5^{10}, 7^{10} or 9^{10} CFU, a slightly depressed growth was found at dose rate of 7^{10} CFU and above. Studies focused that commercial probiotic consumption often increases specific intestinal microflora. Melluzi *et al*. (1986) studied the effect of lactic acid bacteria and Bifidobacteria in broiler chicks and observed that birds fed with 2% of lactic acid bacteria culture gave significantly ($P \leq 0.05$)higher body weight than that of control given reconstituted sterile milk.

Cho *et al*. (1992) studied growth promoting activity of *Lactobacillus casei* (TSC-66) at the dose rate of 2.0×10^5 Cfu/g diet for broiler chickens and concluded that *L. casei* TSC-66 can improve growth of broiler chickens and can reduce or replace antibiotics used for growth. Similarly Cavazzoni *et al*. (1993) reported that probiotics given at dose of 4×10^{10} Cfu/kg from day 1 to day 7 and 1×10^{10} Cfu/kg from day 8 to day 59 to 144 male improved feed conversion ratio. Samantha and Biswas (1995) fed *Lactobacillus acidophilus* 2 ml (5×10^{12} Cfu/ml), *L. bulgaricus* 2.5 ml (4.0×10^{12} cfu/ml) to of broilers and found that mortality was low in fowls given probiotics in varied doses.

Probiotics works on dose wise at particular stagewise. It is also evident in past research the majority of reported research cases that specific bacteria do not increase unless subjects consume very high dosages of probiotics, which needs to be determined. Maruta *et al*. (1996) reported experiment with probiotics at dose of (3×10^5 Cfu/g) and elaborated that there was decrease in number and detection rate of pathogenic organism. Singh and Sharma (1996) investigated the effect of feeding *Lactobacillus sporogenes* added at 0, 0.02, 0.03 and 0.04% level in broilers and reported that probiotics combination did not affect feed intake, however, at 0.02% level, *Lactobacillus* improved the feed conversion efficiency significantly ($P \leq 0.05$). Kumprecht and Zobac (1996) reported that probiotics having 1.5 x 10^6 *Streptococcus faecium* C-68 in 1 g feed- 4 g/100 kg decreased the count of *Escherichia coli* in caecal contents by about 50%.

Satbir *et al.* (1999) reported commercial broiler fed with diet containing probiotic *Lactobacillus sporogenes* and found that weight gain and feed efficiency were highest for diets containing 0.02% probiotic and lowest for diets with 0.04% probiotics. Further, Satbir *et al.* (1999) fed probiotics in feed at 0, 0.02, 0.03 and 0.04% and reported that the microbial counts tended to decrease with increasing levels of probiotics. Results have not always been beneficial when animals have been fed Direct Fed Microbial owing to lack of organism specificity, proper dose and survival as there needs to adjust delicate microbial balance in GIT. Naik *et al.* (2000) reported the effect of different probiotics in combination and singly of *Lactobacillus acidophilus, Saccharomyces cerevisiae* on the performance of broilers and reported that supplementation of both *Lactobacillus* and *Saccharomyces* individually to the basal diet at 0.05% improved the body weight gain in broilers. Ramesh *et al.* (2000) reported that birds fed *L. acidophilus* at dose rate 10^8 cfu/bird for 2 weeks showed a lowered surface pH in the duodenum, jejunum, ileum and caecum due which better environment for absorption of minerals. Banday and Risam (2001) conducted an experiment to determine the efficiency of probiotic at three different dose levels-25g, 50g and 75g/100kg feed and observed that chicks fed with probiotics grew faster than control and highest live weight was obtained in the treatment fed probiotics at 75/100kg feed. Upendra and Yathiraj (2002) reported that supplementation of Lacto-sacc i.e. a combination of, *Saccharomycs cerevisiae, Lactobacillus acidophilus* and *Streptococcus faecium*) at 250g/ton of feed resulted in numerical increase in body weight gain by 1.7% as compared to control.

Yu *et al*. (2004) fed probiotics in commercial broilers and reported that chickens fed diet containing 0.2% probiotics had higher weights and feed conversion than those fed other level where as chicken fed diet containing 0.4% probiotics had better carcass rate. Kramarova and Chmelnicna (2004) conducted study to investigate the influence of a probiotic preparation on the lipid metabolism in poultry and found that probiotic premix containing 2.5x10^9 Cfu/ml of *Enterococcus faecium* M-74 in one kg mixture decreased content of plasma cholesterol and total lipids. Sabiha *et al*. (2005) stated that probiotics supplementation *Lactobacillus acidophilus, Streptococcus faecium* and *Yea sacc*a1026 at 0.025% led to higher body weight and weight gain upto 6 weeks of age as compared to supplementation at dose of 0.05%. Kavitha *et al.* (2006) supplemented broiler chicks with calculated amount of probiotics and found that group fed higher dose rate of probiotic i.e 8 g /litre of water led to poor feed conversion efficiency and the pathogenic *E.Coli* counts were more by 35 days of age and concluded that as the dose of probiotic supplementation increased, not only was there an increase in beneficial bacteria , but also the *E.Coli* bacteria too. Panda *et al.* (2006) conducted experiment with dietary supplementation of *L. sporogenes* at dose of 6x10^8 spore/ g at 100 mg/kg diet significantly ($P \leq 0.05$) enhanced the live weight gain, feed conversion ratio, bone ash (calcium) and bone breaking strength and lowered total cholesterol, cholesterol and triglyceride concentrations in the serum of broiler chickens as compared to dietary supplementation at 200 mg/kg of *L. sporogenes* at dose of 6x10^8 spore/g.

9. Effect of Probiotics on Carcass Characteristics and Sensory Quality of Meat

Probiotics on sensory characteristics of meat are varies. Some studies indicate a positive effect of probiotics on sensory characteristics whereas other studies indicate no role of probiotics in this regard. Nurmi 1973 stated that probiotics may have an impact on flavour of meat (Selgas *et al.,* 1988). Jensen and Jensen (1992) studied a positive effect of probiotics containing *Bacillus licheniformis* and *Bacillus subtilis* spores on the flavor of broiler meat after cooling for 5 days however Loddi *et al*. (2000) found out in his studies that probiotics fed with water and feed did not had any effect on sensory characteristics of meat. Mahajan *et al.* (2000) stated in their study that the scores for the sensory attributes of the meat balls i.e. appearance, texture, juiciness and overall acceptability were significantly ($P \leq 0.05$) higher and those for flavor were lower in the probiotic-Lacto-Sacc fed treatment. Pelicano *et al.* (2003) reported that significant($P \leq 0.05$) improvement in meat flavor feeded with probiotics apart from this studies conducted on effect of probiotics on meat characteristics of other species of animals also reveal contradicting results on sensory characteristics of meat. In a study by Ceslovas *et al*. (2005) stated that probiotic supplementation significantly ($P \leq 0.05$) increased the meat tenderness and meat quality. Most of the carcass characteristics are directly proportional to the increased body weight at the time of slaughter. Anna *et al*. (2005) observed no significant ($P \leq 0.05$) difference in carcass % between probiotic treated and untreated treatments on the sensory parameter basis.

10. Conclusion

It can be concluded that feeding probiotics to poultry are that it improve the utilization of proteins, intestinal tract health, feed conversion ratio, strengthen beneficial microbial populations and suppress harmful bacterial growth in the digestive system, counteract adverse effect of antibiotics, nutrient synthesis, stimulate immune system, decreased diarrhoea and mortality. Further, it improve the feed intake, feed conversion ratio, body weight, lower cholesterol in blood, serum and meat, increase the tenderness and meat quality along with carcass yield. So that feeding probiotcs in broiler chicken is highly beneficial for economic production of poultry.

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