POTENTIAL OF PROBIOTICS IN LIVESTOCK PRODUCTION

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Livestock sector plays a significant role in the rural economy of India. It contributes about 5 per cent of the total gross domestic product (GDP) and one-fourth of the agricultural GDP. The sector is unique in terms of employment opportunities as two-thirds of female workforce in rural India is engaged in livestock rearing (Kumar and Singh, 2008). Keeping in view the above fact, major thrust should be towards profitable livestock production. One of the suitable methods of achieving the above target is application of directly fed microbes (DFM) or probiotics as feed additives boosting animal production. Bacteria either through protecting the body against pathogenic bacteria or assisting in recovery from an illness are termed as probiotics. In contrast to antibiotics, probiotics are defined as microbially derived factors that stimulate the growth of other microorganisms. According to World Health Organization, probiotics denotes to live microorganisms that are administered in optimum quantity to confer a health benefit on the host and consumed as part of fermented foods with specially added active live cultures or as dietary supplements. Microbial food supplements can also be used as probiotics, which benefits the host animals by improving their intestinal microbial balance. The quality animal production in the target species can be achieved through reduced morbidity or mortality, stimulating forage digestion, and augmenting the quality and quantity of milk, meat and egg production. In addition, probiotics protects animals against several pathogens, enhances immune response, reduces antibiotic use and shows high index of safety (Hamilton-Miller et al., 2003).

Apart from improving the intestinal microbial balance, beginning of 20th century showed the beneficial effect of probiotics for inhibiting pathogens and toxin producing bacteria. However, serious health problems are at present investigated and documented including alleviation of chronic intestinal inflammatory diseases (Mach, 2006), prevention and treatment of pathogen-induced diarrhea (Yan and Polk, 2006). The probiotic research was applied in pets, horses and farm animals' research while the majority of research was done in chickens and pigs. In clinical trials, probiotics have been reported to enhance the growth of many domestic animals including cows (Doreau and Jouany, 1998), neonatal calves and piglets, broilers, and humans (Penna, 2000).

Development of probiotics

A Russian scientist and Nobel laureate Eli Metchnikoff (1907), in the beginning of the 20th century, first noticed the beneficial role of certain bacteria and suggested that it would be possible to modify the gut flora and to replace harmful microbes with useful microbes. Milk fermented with lactic-acid bacteria inhibits the growth of proteolytic bacteria because of the low pH produced by the fermentation of lactose. Metchnikoff had also observed that certain rural populations in Europe, for example in Bulgaria and the Russian steppes that lived largely on milk fermented by lactic-acid bacteria were exceptionally long lived. Based on these facts, Metchnikoff proposed that consumption of fermented milk would "seed" the intestine with harmless lactic-acid bacteria and decrease the intestinal pH and that this would suppress the growth of proteolytic bacteria. Metchnikoff himself

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introduced in his diet sour milk fermented with the bacteria he called "Bulgarian Bacillus" and found his health benefited. (Vaughan, 1965).

After Metchnikoff's death in 1916, the centre of activity moved to the United States. It was reasoned that bacteria originating from the gut were more likely to produce the desired effect in the gut, and in 1935 certain strains of Lactobacillus acidophilus were found to be very active when implanted in the human digestive tract (Rettger, 1935).

Ideal characteristics of probiotics

An ideal probiotic should have several potential characteristics viz. non-pathogenic and non-toxic in nature, beneficial to the host animal, high viability, stable on storage and in the field, able to survive in or colonize the gut, and amenable to cultivation on an industrial scale

Mechanism of action of probiotics

It has been hypothesized that probiotics might have the following modes of action: (1) Production of anti-pathogenic substances (2) Competition of available nutrients (3) Enhancement of the immune system (4) Competition of colonization sites.

Effect on inflammatory bowel disease:

Probiotics act through the induction of regulatory T cells that suppress inflammation-inducing effector cells. Probiotics have the potential characteristics to interact with the mucosal immune system that does not arouse an inflammation inducing innate response, and the consequent induction of master inflammatory cytokines such as IL-12 or IL-23. These organisms also stimulate cells that lead to the elaboration of regulatory or suppressor cytokines. Hence, probiotics are responsible for correcting the imbalance between effector and regulatory mechanisms that are the hallmark of inflammatory bowel disease. (Boirivanta Stroberb, 2007).

Effect on immune system

Effect on Molecular Signaling Inside the Cell

The protective effects of probiotics may be mediated by their own DNA rather than by their metabolites or ability to colonize the colon. Toll-like receptor 9 (LR9) signaling is essential in mediating the anti-inflammatory effect of probiotics, and DNA derived from probiotic bacteria can be sufficient to attenuate experimental colitis (Rachmilewitz et al 2004). In a human and murine inflammatory model, VSL#3 DNA inhibited IL-8 secretion, reduced p38 mitogen-activated protein kinase activation, delayed nuclear factor kappa B activation, stabilized levels of Ikappa B, and inhibited proteasome function (Jijon et al., 2004). Similarly, S. boulardii prevented enterohemorrhagic Escherichia coli infection by interfering with the transduction pathways that control tight-junction structure as well as inhibiting NF-kappaB and MAPK signaling pathways leading to the production of IL-8. Petrof, et al (2004) demonstrated that probiotics inhibited the pro-inflammatory nuclear factor kappa B pathway and triggered the expression of cell protective heat shock proteins in the intestinal cells. Furthermore, the probiotic produced factors that inhibited the breakdown of the heat shock proteins, which would normally occur through intracellular protein destroyers known as proteasomes. Proteasome inhibition was an early event that began almost immediately after exposure of the colonic cells to the probiotic. The resulting inhibition of nuclear factor-kappaB and increased expression of heat shock proteins may account for the anti-inflammatory and cytoprotective effects reported for probiotics and may be a novel mechanism of microbial-epithelial interaction (Petrof, 2004).

Immune enhancement

Probiotics have an immunomodulating effect on host. There is extensive information on the immune system (Mayer, 1998; Muir, 1998; Hershberg and Mayer, 2000; Shanahan, 2000; Erickson and Hubbard, 2000; Jeurissen et al., 2000; Spellberg and Edwards, 2001; Toms and Prowrie, 2001), the intestinal epithelium (Dai et al., 2000; Freitas and Cayuela, 2000; Deplancke and Gaskins, 2001; McCracken and Lorenz, 2001) and their interaction. Stress detrimentally affects the immune system and intestinal epithelium (Blecha, 2000; Matteri at al., 2000; Maunder, 2000; Tache et al., 2001). The neuro-endocrine system is intimately involved in the response of immune and epithelial systems to stress (Kohm and Sanders, 2000; Levite, 2001; Petrovsky, 2001). Havenaar and Spanhaak (1994) has reported that probiotics stimulate the immunity of the chickens in two ways (a) flora from probiotic migrate throughout the gut wall and multiply to a limited extent or (b) antigen released by the dead organisms are absorbed and thus stimulate the immune system. At present it is believed that there is some relationship between the ability of strain to translocate and the ability to be immunogenic. The improvement in the immune system may be by three different ways: (a) enhanced macrophage activity disturbance and enhanced ability to phagocytose microorganism or carbon particles; (b) increased production of antibodies usually of IgG and IgM classes and interferon (a nonspecific antiviral agent) and; (c) increased local antibodies at mucosal surfaces such as the gut wall (usually IgA).

Growth stimulation

There is a controversy that whether probiotics has any role in increasing growth of the animal. Some study revealed that supplementation of probiotics has no effect on the performance of broiler chicks (Ergun et al., 2000; Kumprechtova et al., 2000). But Baidya et al., (1993) stated that probiotics were the most effective growth promoter. Probiotics fed chickens had more weight than other groups (Zulkifli et al., 2000; Lan et al., 2003). Recently, it has been reported that poultry growth is promoted with the increasing doses of probiotic (Protexin, Hilton Pharma, Karachi Pakistan) from 0.5 to 1.5 grams per 10 small kg feed. Ahmad (2004) reported that the growth pattern of treated birds showed an increase in weight gain relative to the control, up to 1.0 gram per 10 kg feed.

Effect on feed conversion ratio

Feed conversion ratio as affected by probiotics is the subject of controversy. Some studies show that probiotics supplementation in feed of chickens improve the feed conversion ratio (Hamid et al., 1994; Silva et al., 2000) while others suggest no such effect on feed conversion ratio (Samanta and Biswas, 1997; Gohain and Sapcota, , 1998; Panda et al., 1999; Ergun et al., 2000; Panda et al 2000).

Characterists of probiotic:

Competing for adhesion receptors: Lactobacilli are among the indigenous open flora colonizing the chicken's crop, stomach of mice and rats, and the lower ileum in man. Bacteria colonizing such high-transit-rate sites must adhere firmly to the mucosal epithelium. Most of the bacterial colonies adhere to the intestinal wall and so does the probiotic. This is the reason that the colonies are not swept away due to the peristalsis along the intestinal wall. This effect prevents the pathogenic bacterial colonization along the intestinal wall and therefore, prevents disease development (Fuller, 2000). Numerous studies have shown that probiotics inhibit pathogens and of the intestinal microbiota with the antibiotics can competition for nutrient, production of toxic conditions probiotics increase resistance to infection (Rolfe, 2000). Proposed mechanisms of pathogen inhibition by the intestinal microbiota include increase susceptibility to infection but addition of bacteroicins, competition for binding sites intestinal epithelium and stimulation of the immune system (Fuller, 1989; Gibson and Fuller, 2000).

Digestion and absorption is of special importance in the ruminants and to some extent in non-ruminants and provides substantial amount of energy to the host. In the chicken's crop, amount of starch is broken down by the fermentative process. However, this is less significant and is achieved with the help of enzymes present in the small intestine of chickens. The organic acids namely, acetic acid, butyric acid, propionic acid and others cause reduction in pH which in turn reduces the activity of enzymes in the small intestine which is not desired. Some of the bacteria are useful for the production of vitamins i.e. vitamin A and K of the deficient diet in physiological functions (Fuller, 1997). Probiotics have effect on the main of the gastrointestinal tract such as which are digestion, absorption and propulsion (Fioramonti et al., 2003).

Health management of diseased animals:

Vanderhoof (2001) reviewed the concept of probiotics as a viable therapeutic modality in the treatment of disease. The antibiotics used for the hope of growth stimulation affect the gut microflora, which results in the microflora assisting digestive process is damaged. The exact mechanism is not clear and is open for research (Areneo et al., 1996). Sub-therapeutic antibiotics not only influence intestinal microbial populations and activities but also affect animal metabolism and specifically alter intestinal function (Anderson et al., 2000). Following administration of low concentration of antibiotics, the intestinal pathogenic micro-flora develops resistance and affects the helpful baterial population responsible for synthesis of essential minerals and vitamins. But administration of probiotic helps and repairs the deficiencies in the gut flora and a balanced intestinal microbiota enhancing resistance to infection (Fuller, 1989; Blecha, 2000).

Beneficial effects of probiotics

Probiotic supplements are now widely used in quality animal production and accepted as agents that can bring significant health benefits such as

1.Enhancement of the immune system.

2.Antimicrobial effects inhibiting intestinal and food poisoning pathogens.

3.Improvement of gut functions by normalizing microflora balance, reducing constipation and improving intestinal mobility.

4.Nutraceutical effects including contributing to the reduction of serum cholesterol, management of diabetes and prevention of osteoporosis.

5.Improved nutrition through the enhanced breakdown of vitamins, minerals and amino acids and their absorption through the intestinal walls.

6.Cleansing of the bloodstream by making it freer of toxins.

7.Prevention of infection by harmful bacteria.

Recent research on the molecular biology and genomics of Lactobacillus has focused on the interaction with the immune system, anti-cancer potential, and potential as a biotherapeutic agent in cases of antibiotic-associated diarrhoea, travellers' diarrhoea, pediatric diarrhoea, inflammatory bowel disease and irritable bowel syndrome .

Therapeutic uses:

Increasing milk production in cattle

It is generally accepted that certain viable microbial cultures beneficially affect the productive potentials of ruminants, pig and poultry. The species employed in probiotic preparation are mainly lactic acid bacteria for non-ruminants and for ruminants, the yeast culture (YC), Saccharomyces cerevisiae was considered as the promising probiotic culture for efficient nutrient utilization. The viable YC preparations can stimulate specific groups of beneficial anaerobic bacteria in the rumen, and has provided mechanistic models that can explain their effects on animal performance. The effects of YC on animal productivity are strain-dependant. It is well known that volatile fatty acids (VFA) production, microbial counts and microbial protein synthesis are improved due to addition of yeast culture in ruminants. Yeast culture may alter the pattern of VFA production. Supplementation with 2 specific Enterococcus faecium strains produced 2.3kg more milk/cow per day than did non-supplemented cows and early lactation cows receiving supplemental DFM (two specific Enterococcus faecium strains) produced more milk and consumed more DM during the pre- and post-partum periods has been documented. The increased milk yield was due to enhanced nutrient supply to the mammary gland rather than mobilization of body reserves. The feeding systems for lactating animals followed by the Indian farmers are diversified; basically the farmers are dependent on grazing/ pasture land and crop residues; therefore, researchers should stress more on proper selection of probiotics and direct-fed-microbials which are effective on high fibrous diet. (Dutta et al. 2009).

Role in poultry industry

Singh et al. (2009) conducted a study to observe the effects of dietary supplementation of probiotics on broiler chicken. The probiotic supplement was used in the form of Lacto-Sacc (Alltech, Bangalore) that contained live yeast culture (Yea Sacc1026 4.49×109, Lactobacillus acidophilus 108 and Streptococcus faecium 108 per gram and the study revealed that supplementation of probiotics at varying levels to the broiler chicken yielded positive effects on growth performance (3.28-4.03 per cent higher body weight than control) in broilers such as increased body weight gain, feed efficiency, protein efficiency and performance index and the best effect was observed for the supplementation at 0.025% level. Though, there was no significant effect on haematobiochemical parameters assessed at six weeks of age except serum cholesterol level (mg/dl) which was significantly ($P<0.05$) lower in probiotic supplemented groups it was concluded that probiotic supplementation at different level in poultry diet has beneficial effect on growth performance. (Singh et al. 2009). Probiotics are used in industry to improve yields of pork and chicken production.

Rabbit production

The body-weight, ADG and FCR of probiotics supplemented rabbits were greatly improved. The improvement range of the parameters was also economically important, since 4.7% higher bodyweight or 6.7% higher ADG have been observed in probiotic treated rabbits, a range that is expected in other species only after the continuous use of growth promoters from weaning to slaughter (Buttery, 1993).

Abe et al. (1995) showed the effect of administration of bifidobacteria and lactic acid bacteria to newborn calves and piglets and reported that administration of the probiotic BioPlus 2B at 400 g /ton of feed to fattening rabbits starting 4 days post weaning up to 5 days prior the slaughter age reduces mortality and the presence of E. coli and C. perfringens in the faeces, and improves growth performance characteristics (ADG and FCR).

Swine production

Probiotic supplementation has been shown to improve body weight gain, feed conversion, piglet survival rate, and scouring. Nevertheless, the effect of probiotics on pigs is not always consistent. The variation between trials may come from losses of probiotic activities or inappropriate selection of animals. Therefore, use of probiotics in swine production needs further studies to verify its safety and efficiency. (Sissons, 1989).

Benefits of Probiotics on Human Health

Balanced intestinal flora are primarily composed of good bacteria that work relentlessly to ensure our body is protected against microbes and other infectious germs, maintaining a healthy digestive system. These good bacteria stimulate the immune system, promote digestion through the production of enzymes, produce antibacterial substances and compete against a variety of invading micro-organisms. Probiotics can help in maintaining and restoring balance to our intestinal flora, so that it can adequately assume its functions through stimulation and modulation of the immune system, improvement of intestinal function, resisting pathogenic invasion and growth and action on the immune system.

Immune system

The immune system is a complex system comprised of cells, tissues and organs distributed throughout the body, including the intestine. This system provides the body's protection by means of non-specific (innate immunity) and specific (acquired immunity) defense mechanisms. Skin, mucous membranes, mucous and hair are among the body's non-specific defenses which constitute physical barriers used to reject foreign bodies. The inflammatory reaction is another of the body's non-specific responses, and is characterized, among other things, by a surge of blood toward the infected region and by the recognition and destruction of the foreign body by phagocytic cells (ex. macrophages). The body's specific defenses initiate an acquired response targeted to the invader. This response involves the action of antibodies produced by B lymphocytes (humoral immunity) and T lymphocytes that coordinate the immune response to directly attack the infected cells (cellular immunity).

Intestinal Immune System

The intestine is very rich in lymphocytes, which can be found under the intestinal mucous membrane. Because of its direct contact with external invaders capable of inducing infections, the intestine must be able to adequately defend the body. It plays a major role in an individual's immunity. A person's normal bacterial flora also plays a part in the immune responses via the epithelial cells of the intestine that make up the mucous membrane (Perdigon et al., 1999).

Probiotics and the Immune System

Consumption of beneficial bacteria such as L. acidophilus and L. casei reinforces intestinal mucous membrane immunity (mucosal immunity) as well as the body's global immunity (systemic immunity). A more detailed explanation is that human consumption of Lactobacillus stimulates phagocytic activity and increases production of T and B lymphocytes and production of antibodies, particularly IgM, IgA and IgG. However, stimulation of these intestinal immune responses by commensal bacteria (specific to man) or probiotics does not readily provoke a significant inflammatory response, as it can be observed in the presence of an infectious agent. That being said, a person can safely consume probiotic bacteria on a regular basis (Mowat, 2003).

Digestive system

The food must be broken down into nutrients to be assimilated by the body. This process is called digestion. Nutrients like mineral salts (iron, calcium, etc.), vitamins, fatty acids and fibre are essential to meet the fundamental needs of an individual. During digestion, the cells produce enzymes which break up food into increasingly smaller particles (nutrients) until they can be absorbed by the body. Without these enzymes, the body would not have access to these nutrients and would suffer from severe deficiencies.

Various digestive disorders, ranging from mild to severe, occur due to the presence of non-digested materials in the intestine. The good bacteria that colonize our intestines actively participate in digestion. They also produce enzymes which break down food in such a way that it can be absorbed and have an effect on the entire body. Consequently, the intestinal flora plays a very important role in digestion and health.

Probiotics and the digestive system

L. acidophilus and L. casei are among the good bacteria that comprise the intestinal flora. These bacteria improve food digestion and the body's capacity for absorption. The consumption of probiotics helps to maintain the intestinal flora's balance. As a result, they provide the body with a large quantity of good bacteria and facilitate, among other things, the digestion of food and the assimilation of nutrients while improving digestive system health.

Action against Pathogenic Invasion

Pathogens are micro organisms capable of causing disease. Nowadays, the presence of pathogens in water, food and public buildings can become a threat to our health. Moreover, taking medications like antibiotics and anti-acids can destroy intestinal flora, cause diarrhea and increase the risk of infection. Antibiotic-associated diarrhea (AAD) and C. difficile-associated diarrhea (CDAD) are well known side effects of antibiotic treatments and can have severe consequences on our health (Putamen and Simor, 2004).

The good bacteria that comprise the intestinal flora are the first line of defense against intruders. They temporarily adhere to the intestinal wall and reinforce the physical barrier against pathogens. They compete with them for a spot to adhere to the intestinal wall and for the nutrients which are found there. They also produce natural antimicrobial substances called bacteriocins. These two methods of defense discourage implantation, growth and survival of pathogens. The production of organic acids, hydrogen peroxide and bacteriocins by lactic bacteria, particularly L. acidophilus and L. casei, inhibits the pathogens' actions. Production of lactic and organic acids is specific to lactic bacteria. The organic acids regulate the intestinal pH to maintain it at a level that reduces the growth of infectious agents (Sanders, 2000). Regular consumption of the BioK+ CL1285® formula of L. acidophilus and L. casei is a simple, effective and inexpensive solution to preventing infections, particularly in at-risk environments (hospitals, trips, daycares etc.) and while taking antibiotics.

Other Therapeutic Applications of Probiotics: Candida albicans and vaginal infections

An imbalance in the intestinal flora can have effects on the whole body, particularly the vaginal system, and involve an overgrowth of pathogens which translates into vaginal bacterial or yeast infections, such as Candida albicans. L. acidophilus is one of the most important bacteria found in the vaginal and intestinal flora. These friendly bacteria create an environment that is hostile to pathogens by maintaining low pH in the flora and by producing bacteriocins. In addition, L. acidophilus produces hydrogen peroxide and hypothiocyanate which inhibits the growth of Candida albicans.

Cholesterol

Certain studies have demonstrated that probiotics could help to reduce bad cholesterol (LDL). Their mechanism of action has not yet been well explained. However, probiotic bacteria could be involved in bile acid deconjugation which limits the reabsorption of cholesterol since cholesterol is a major component of bile.

Cancer

Many researchers are studying the question of a possible role of probiotics in the treatment or prevention of cancer. According to certain research, probiotics can have a protective role in the development of certain cancers, notably colon cancer, by inhibiting the body from producing mutagens and carcinogenic agents.

Future directions in probiotics use:

Studies with probiotics have been difficult to assess because many of the earlier studies were not statistically analyzed, experimental protocols were not clearly defined, microorganisms were not identified and viability of the organisms was not verified (Simon et al., 2001). The antibiotics used for the hope of growth stimulation affect the gut microflora, which results in the reduction of the resistance to infection caused by certain bacteria. (Areneo et al., 1996). The mechanism of action of probiotics is not yet known and is open for research, although there are several hypotheses. There is increasing evidence to suggest that probiotics act by stimulating the host's immune systems. The only accepted example of effective protection against infections provided by living micro-organism is the 'Nurmi concept', whereby one-day-old chicks acquire an enhanced protection against Salmonella infections when they are administered the complex intestinal flora of older chicks. The effects of probiotics on the growth, feed conversion or production of farm animals are, even in specific situations, not consistent enough to consider their use out of economic considerations (Veldman, 1992), In a very short period of time, many studies have been conducted to validate the concept of probiotics as a viable modality in the poultry production. Some known beneficial effects of probiotics include reduction in the severity and duration of rotavirus diarrhea (Oberhelman et al., 1999), reductioin in the risk of traveler's diarrhea (Ribeiro and Vanderhoof, 1998), reduction in the risk of relapsing after the occurrence of Clostridium difficile -associated diarrhea (Pochapin et al., 1998), reduction in the risk of antibiotic-associated diarrhea in children , immune enhancement (Prowrie, 2001), stimulating the growth (Kumprechtova et al., 2000; Zulkifli et al., 2000; Lan et al., 2003) feed conversion ratio (Ergun et al., 2000; Panda et al., 2000) digestion and absorption (Fuller, 1997), competing for adhesion receptors (Savage, 1972; Fuller, 1973). Although the number of organisms studied is small, the list is growing and it is likely that many more probiotic organisms with a variety of different benefits will be discovered. Additional organisms may eventually be developed through genetic engineering (Vanderhoof, 2001).

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