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Review

Probiotics in animal production: A review

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Probiotics have been recently defined by the Food and Agriculture Organization/ World Health Organization (FAO/WHO) as live microorganisms which when administered in adequate amounts confer a health benefit on the host. A good probiotic should be non-pathogenic, non-toxic and capable of exerting beneficial effect on the host animal. It should be present as viable cells and capable of surviving and metabolizing in the gut environment. It should also be stable and capable of remaining viable for periods under storage and field conditions. Probiotics have been shown to promote growth, improve efficiency of feed utilization, protect host from intestinal infection and stimulate immune responses in farm animals. In laying chicken, probiotics increased hen-gay egg production. Weight gain performance was significantly increased in broilers and turkeys. In ruminants, probiotics also improved growth rate. Increased weight gain and higher efficiency of feed utilization were the results of the trials in pigs. Mortalities especially due to diarrhoea were reduced in pigs. The beneficial effects of probiotics in animal production have been related to different modes of action. The improvements in productive performance of all animal species fed with probiotics were mostly due to the fact that probiotics promoted the metabolic processes of digestion and nutrient utilization.

Key words: Probiotics, nutrient utilization, immune, animal production.

INTRODUCTION

Probiotics: Definitions

The term probiotic etymologically appears to be a composite of the Latin preposition *pro* ("for" or "in support") and the Greek adjective (biotic) from the noun *bios* ("life") meaning 'for life' or 'in support of life' and has had several different meanings over the years. It was first used by Lilley and Stillwell (1965) to describe substances secreted by one microorganism which stimulated the growth of another. It thus meant the exact opposite of antibiotic (Fuller, 1992). However, its use in this form did not persist and it was subsequently used by Sperti (1971) to describe tissue extracts which stimulated microbial growth. It was not until 1974 that Parker used it in the context in which we shall use it in this thesis. Parker defined probiotics as 'organisms and substances which contribute to intestinal microbial balance (Parker, 1974). This definition related probiotic use to the intestinal microflora but the inclusion of substance gave it a wide connotation which would include antibiotics. In an attempt to improve the definition, Fuller (1989) redefined probiotics as 'a live microbial feed supplement which benefits the host animal by improving its intestinal microbial balance'. This revised definition stressed the need for a probiotic to be viable. Below is a chronicle of the evolution of definitions of probiotics:

1. Substances secreted by one microorganism that stimulate another microorganism (Lilly and Stillwell, 1965).
2. Tissue extracts that stimulate microbial growth (Sperti, 1971).

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3. Organisms and substances that have a beneficial effect on the host animal by contributing to its intestinal microbial balance (Parker, 1974).
4. A live microbial feed supplement that beneficially affects the host animal by improving its intestinal microbial balance (Fuller, 1989).
5. A viable mono- or mixed culture of microorganisms that, applied to animals or humans, beneficially affects the host by improving the properties of the indigenous microflora (Havenaar, 1992).
5. A live microbial culture of cultured dairy product that beneficially influences the health and nutrition of the host (Salminen, 1996).
6. Viable bacteria, in a single or mixed culture, that has a beneficial effect on the health of the host (Donohue and Salminen, 1996).
7. Living microorganisms that on ingestion in certain numbers exert health benefits beyond inherent basic nutrition (Guarner and Schaafsma, 1998).
8. A microbial dietary adjuvant that beneficially affects the host physiology by modulating mucosal and systemic immunity, as well as improving nutritional and microbial balance in the intestinal tract (Naidu et al., 1999).
9. A preparation of or a product containing viable, defined microorganisms in sufficient numbers that alter the microflora (by implantation or colonization) in a compartment of the host and by that exert beneficial health effects in this host (Schrezenmeir and De Vrese, 2001).
10. Specific live or inactivated microbial cultures that have documented targets in reducing the risk of human disease or in their nutritional management (Isolauri et al., 2002).
11. Preparation of viable microorganisms that is consumed by humans or other animals with the aim of inducing beneficial effects by qualitatively or quantitatively influencing their gut microflora and/or modifying their immune status (Fuller, 2004).
12. Live microorganisms, which when administered in adequate amounts, confer a health benefit on the host (FAO/WHO, 2009).

HISTORICAL PERSPECTIVES OF PROBIOTICS

Although the use of the word probiotic in relation to feed supplements only dates from 1974, the history of live microbial feed supplements goes back thousands of years. Probably, the first foods that contained living microorganisms were the fermented milks that are recorded in the Old Testament (Genesis 18:8). There is also evidence from wall paintings dating back to 2500 B.C. that Sumarians were in the habit of inoculating milk to induce fermentation (Kroger et al., 1989).

Metchnikoff is regarded as the godfather of probiotic. From his studies on probiotic and findings of his other coworkers, he wrote a book which in the original French edition published in 1907 was entitled "Essais optimistes". In the book, he discussed the philosophy, literature, religion, folklore and science of ageing. Only a small part of this discourse contained his views on the lower gut flora and the beneficial effects that fermented milk might have on it in humans. At the end of this section of the book, in the English edition, he concludes:

"If it be true that our precocious and unhappy old age is due to poisoning of the tissues (the greater part of the poisoning coming from the large intestine inhabited by numberless microbes), it is clear that agents which arrest intestinal putrefaction must at the same time postpone and ameliorate old age. This theoretical view is confirmed by the collection of facts regarding races which live chiefly on soured milk and amongst which great ages are common. However, in a question so important, the theory must be tested by direct observations. For this purpose, the numerous infirmaries for old people should be taken advantage of and systematic investigation should be made on the relation of intestinal microbes to precocious old age and on the influence of diets which prevent intestinal putrefaction in prolonging life and maintaining the forces of the body. It can only be in the future, near or remote, that we shall obtain exact information upon what is one of the chief problems of humanity".

In spite of these guarded statements, he is always quoted as having established a relationship between consumption of fermented milk and long life. This reputation was seemingly endorsed by the English translation of his book which was given the little "The Prolongation of Life". The consumption of fermented milk was given an added support by the publication in 1911 of a book by Londen Douglas called "The Bacillus of Long life". In the book, the author reiterated the connection between fermented milks and longevity. He also summarized what was known at that time of the Bacteriology of fermented milks (Douglas, 1911).

One of the most convincing demonstrations of the role of the gut microflora in resistance to diseases was provided by Collins and Carter (1978). They showed that the germ-free guinea-pig was killed by 10 cells of *Salmonella enteritidis* but it required 10^9 cells to kill a conventional grade animal with a complete gut microflora. There is thus, no doubt that animals have in their intestine a population of microorganisms that protects them against diseases. If that is the case, why do we need probiotics? Under normal conditions there would be no need for probiotics. In the wild, the young animal rapidly acquires a protective flora from its mother and the environment. However, modern methods of pre-natal care tend to limit the contact with the mother and provide unnatural foods and unnatural environmental condition especially in poultry where after the egg is laid, the chick is permanently separated from their mother. The result is that the gut microflora is deficient in some of the normal components that are responsible for resistance to diseases.

Tannock (1983) reported that even the gut microflora of an adult can be affected by diet, antibacterial drugs and stress. The use of probiotic supplements seeks to repair these deficiencies. The development of probiotics has been in part stimulated by the public misgivings about the side effects that often follow the use of antibiotics as therapeutic agents and growth promoters. There is therefore a growing demand for an effective alternative to the antibiotic growth promoters, and probiotics could fill the gap. Recently, interest in the use of probiotics to improve the productive performance and general health status of livestock animals has been rekindled by legislations to curtail the use of sub – therapeutic doses of antibiotics in animal diets (Cook, 2000; Langhout, 2000; Mellor, 2000; Gill, 2001; Plail, 2006).

Characteristics of good probiotics

Fuller (1989) listed the following as features of a good probiotic:

1. It should be a strain, which is capable of exerting a beneficial effect on the host animal, for example increased growth or resistance to disease.
2. It should be non-pathogenic and non-toxic.
3. It should be present as viable cells, preferably in large numbers.
4. It should be capable of surviving and metabolizing in the gut environment for example, it should be resistant to low pH and organic acids.
5. It should be stable and capable of remaining viable for periods under storage and field conditions.

Benefits/advantages of probiotics

Intestinal probiotics, particularly bacteria play an important role in determining the digestive mechanisms and general health in all animals and humans (Fuller, 1992). The beneficial effects of probiotic will depend on a number of factors, including the strain chosen, level of consumption, duration and frequency of exposure, and the physiological condition of the individual (Koop-Hoolihan, 2001).

Some of the beneficial effects of the practical uses of probiotics are:

1. Growth promotion in farm animals (Mordenti, 1986; Chang *et al*., 2001): Hydrocarbons are broken down by probiotic bacteria which means the food is being split into its most basic elements. This allows almost total absorption through the digestive system. In this way, probiotics dramatically increase overall nutrition and enhance rapid cellular growth and development. For instance, *Lactobacillus* and *Bifidobacteria* increased weight gain and reduced mortality in young piglets (Abe et al., 1995). Also, piglets fed *Bacillus coagulans* had lower mortality and improved weight gain and feed conversion than un-supplemented piglets and did as well as or better than piglets fed sub-therapeutic antibiotics (Adami and Cavazzoni, 1999).
2. Protection of host from intestinal infections (Nurmi and Rantala, 1973; Pascual et al., 1999; Oyetayo et al., 2003): The intestinal tract is cleansed by probiotics. They go under the layer of crud on the intestinal walls, attach themselves and dislodge the accumulated decay. This waste is then flushed out naturally. Yeast and fungal infections are prevented and sometimes eliminated with supplements of probiotics. Probiotic bacteria added to feed may protect piglets from intestinal pathogens by several possible mechanism, including competitive exclusion which entails adherence to intestinal mucosal thereby preventing attachment of pathogens, production of antimicrobial compounds (bacteriocins and organic acids), competition with pathogens for nutrients and stimulation of intestinal immune responses (Ellin, 2001).
3. Alleviation of lactose intolerance (Garvie et al., 1984; Jiang, 1996): In humans, majority become lactase deficient during the 10 to 20 years of life and the inability to digest lactose causes a decrease in milk product consumption, eliminating a high quality source of protein and calcium. *Lactoba acidophilus* and *Lactoba bifidus* participate in the hydrolytic digestion of ingested lactose. Therefore, ingestion of milk product with live *Lactobacillus* is better tolerated and may actually alleviate malabsorption in lactose intolerant people (Fuller, 1992).
4. Relief of constipation (Graf, 1983): Constipation is quickly relieved by probiotics and the bowel movements become normalized. *Lactobacillus* can be taken both during and after antibiotic treatment. This helps in alleviating antibiotic-induced diarrhea caused by the indiscriminate killing off of both ‘good’ and ‘bad’ bacteria in the gastrointestinal tract (Fuller, 1992).
5. Anti-carcinogenic effect (Walker and Duffy, 1998; Zabala et al., 2001). *Lactobacillus* inactivates carcinogenic intestinal beta-glucouronidase and nitroreductase. Studies at the Sloan Kettering Institute for Cancer Research and the University of Nebraska showed *Lactobacillus* to possess a definite anti-tumor activity and to inhibit tumor proliferation (Fuller, 1992). Animal studies have suggested that some lactic-acid bacteria might help protect against colon cancer, but more research is still needed.
6. Anticholesterolaemic effects (Tahri et al., 1995):

Lactobacillus species possess anticholesterolemic and antilipidemic factors, which aid in cholesterol reduction. People that consume probiotics have experienced lowered cholesterol (Fuller, 1992).

7. Nutrient synthesis and bioavailability (Koop-Hoolihan, 2001): Probiotic bacteria synthesize certain amino acids, which are directly assimilated for example, lysine from specific strains of *L. plantarum*. They produce B vitamins, such as folic acid, niacin, riboflavin, B_{12}, B_6 and pantothenic acid, which are biocatalysts in food metabolism and help to fight stress (Fuller, 1992).

8. Probiotics has a protein-sparing effect: The lacto-bacillus primarily use carbohydrates as a growth medium, while the pathogens use primarily protein. By decreasing the pathogenic population, more protein is made available for assimilation (Fuller, 1992).

9. Prevention of genital and urinary tract infections (Redondo-Lopez et al., 1990; Martin et al., 1989): *Candida albicans* which is the primary yeast responsible for candidiasis has been shown to be inhibited by some probiotics (Fuller, 1992).

10. Immunostimulatory effects (Aattour et al., 2002): It has been discovered that conventional animals with a complete gut flora have increased phagocytic activity and immunoglobulin levels compared with germ-free animals. *Lactobacilli casei* in particular was found to be active in the stimulation of phagocytic activity when administered to mice (Perdigon et al., 1986).

Applications of probiosis to poultry

Probiotics for chicken are designed for two main reasons namely:

(a) To replace beneficial organisms that is not present in the alimentary tract.
(b) To provide the chicken with the effects of beneficial organisms.

Such beneficial organisms may be absent possibly because present methods of husbandry prevent contact between the newly hatched chicks and its parents preventing rapid vertical transfer of beneficial microorganisms or by management practices which may disturb intestinal microecology (Barrow, 1992). According to Barrow (1992), there are two major groups of probiotic preparations based on their site of action: those which are primarily intended to be effective in the crop and the anterior regions of the alimentary tract and those whose effects are directed at the caeca. However, it is likely that both types of preparation are to some extent, effective throughout the gut.

Among the first group are the lactobacillus cultures and preparations which are thought to colonize the crop and small intestine in ways described by Fuller (1978). They are thought to exert antibacterial effects against potential pathogens (Fuller, 1974, 1978) and are also considered to increase performance by an unknown mechanism. There is less rationale for the later effect than the former. The assumption is that once pathogen burden is reduced, the animal will naturally perform better. Intestinal colonization is essential for the efficacy of probiotics. Whether many of these organisms actually become established in the gut is questionable since a number of criteria must be fulfilled to ensure colonization ability (Morishita et al., 1971; Fuller, 1978, 1986). These criteria may include adhesion to the crop epithelium, ability to grow in the nutritional environment of the gut and ability to resist innate or microbially produced inhibitory mechanisms.

From work with monocontaminated and dicontaminated gnotobiotic chicken, Morishita et al. (1971) found that whereas avian strains *of L. acidophilus, L. plantarum* and *L. fermentum* in addition to the non-intestinal *L. plantarum* and *L.casei* colonized well, a human *L. acidophilus* strain *L. melveticus* and *L. brevis* were rapidly eliminated from the alimentary tract. This indicated the importance of choosing both the right species and strain. A number of technical and experimental points must be considered in assessing the value of probiotic preparations and assessing experimental work carried out by others to do this.

Statistical and biological significance must be calculated but lack of significance in one area does not necessarily imply insignificance of the other (Barrow, 1992). Barrow further stated that statistical significance must be aimed for, but even if it cannot be attained the result may nevertheless be of biological significance. For example, a small but consistent weight gain may be economically significant for a large number of birds even if it is not statistically significance.

A critical review of the available literature on the application of probiosis to poultry performance and health is essential in assessing its value.

PROBIOTICS FOR CHICKEN

As with other mammals, the use of probiotics for poultry has developed out of our increasing understanding of the microflora of the gastrointestinal tract although an earlier observation suggested that the host and its intestinal micro flora were interdependent. This description of the intestinal microflora in adversarial terms was perpetuated by Dubos et al. (1965) who divided the indigenous microflora into the autochthonous organisms (such as *Lactobacilli* and *Bacteroides*, which had developed an evolutionary symbiotic relationship with the host) and allochthonous organisms (such as *Eschericha* and

Clostridium which were potential pathogens). These, together with non-enteric organisms acquired from the environment, comprised the normal intestinal flora. These descriptions are far too simplistic and must be seen as early models attempting to describe several highly complex ecosystems. For instance, microbial opportunism and true commensalisms were largely ignored. Regarding the flora as a climax community in which every niche is occupied is also patently inaccurate. Their inadequate understanding of microbial taxa at that time presumably led to regarding *Escherichia coli* as potential pathogen although many strains may be beneficial to the host and can be used in that way (Linton et al., 1978; Duval-Iflah et al., 1983). However, these hypotheses provided an important stimulus to studying the microecology of the alimentary tract. The early models had profound effect on the development of probiotics. Many preparations currently used for poultry and other animals are based on the assumption that the early hypotheses are correct with the result that the approach to probiosis is often too simplistic.

Probiotic effect on laying hens

A number of different cultures and products have been tested in laying hens producing equally variable results. Krueger et al. (1977) reported the results of feeding a so called Lactobacillus complex to young Leghorn hens at a concentration of 2.27 kg/ton. Three groups each of treated and control pens housing 26 young females and 2 males were monitored for 140 days. The treatment produced an improvement in egg production and feed efficiency of 3.03 and 7.41%, respectively. Crawford (1979) tested a mixed lactobacillus preparation at 340 g/ton in 101,615 commercial hens. The results showed an increase in egg production from 69.5% in control hens to 72.17% in treated birds. The amount of feed required to produce a dozen of eggs was reduced from 1.75 to 1.69 kg. Miles et al. (1981a) carried out a study at three sites: Florida, South Dakota and Arizona. A mixed lactobacillus was again tested in the feed at varied levels of 0.0125, 0.0375 and 0.0625%. The viable counts of different batches of probiotic were estimated at a minimum of 4×10^6 organisms per gram. The treated and untreated feed was given to seven groups of ten layers from 24 weeks of age for 280 days. The results revealed an increase in egg production in Florida with concentrations of 72.77, 72.57 and 70.88% in treated birds compared with 70.89% for the control. Similar results were obtained at Arizona but not at South Dakota. The absence of an increase at the higher level was attributed to excessive numbers of organism, but this again suggest that probiotic is not dose dependent rather it is threshold dependent (Numan, 2001).

Yoruk et al. (2004) reported that supplementation of layers' diet humate and probiotic resulted in increase in egg production and a decrease in mortality. They also observed that the treatment did not have any effect on egg quality. Similarly, Ezema (2012) observed that supplementation of layers' diets with varied levels of probiotic (*Saccharomyces cerevisiae*) significantly increased ($p < 0.05$) hen-day egg performance but did not have any significant effect ($p > 0.05$) on egg quality.

Effects on broiler performance

Couch (1978) reported several studies in broilers. In the first study, a lactobacillus strain was incorporated in the feed at 0.025, 0.0375, 0.05. 0.0625 and 0.075%. The birds were stressed due to abnormal cold weather. The results showed an increase in growth rate in males of 7 to 10% and in the females of 5 to 6% among all the treated groups. In a second study, chicken in battery cages were given feed containing 0.05, 0.1 and 0.2% cultures for a period of 3 weeks. The diet had suboptimal levels of amino acid. But there was an accelerated growth when lactobacillus was administered. Couch suggested, in line with many other claims that probiotics are of particular use when poultry are reared under stressful conditions. It is important to add here that the poultry production system in the tropics is under serious stress due to high ambient temperature and other management inadequacies.

Avends (1981) administered a bile acid-resistant Lactobacillus strain via the drinking water to broilers held under field conditions. In the first trial, four houses of birds containing 116,000 broilers were given 10^6 lactobacilli per day for 30 days. The controls consisted of two houses of 58,242 birds. A 6% weight increase and 3% feed conversion increase were observed. In a second trail comprising 31,000 birds in treated and control groups, a 3% weight increase and 1% feed conversion increase was obtained.

In another study, Ezema (2007) used a total of 140 day-old broiler chicks (Anak, 2000) which were randomly divided into seven groups of 20 birds each. Each group was subdivided into four replicates of five birds each. Groups 1 to 5 were placed on experimental diet made of 70% basal diet and 30% PKC. Groups 1 to 4 had probiotic supplement at varied levels of 0.4, 0.8, 1.2 and 1.6 gm yeast/kg of feed, respectively. Group 5 had no yeast (control 1). Groups 6 and 7 had no PKC (normal broiler diet) but group 6 had 1.2 gm yeast/kg of feed. Group 7 had no yeast (control 2). Group 2 weighed significantly heavier ($p < 0.05$) than the rest. Groups 2 and 3 had the highest apparent crude fibre digestibility of 30.86 and 30.87%, respectively. The cost of feed to produce 1 kg live weight gain of group 2 was ₦129.85 ±

2.17/kg, group 5 was ₦154.00 ± 2.08/kg and group 7 was ₦192.28 ± 6.84/kg. Group 2 performed significantly better than others in weight gain, carcass weight and economic gain. Based on the results of this study, 0.8 gm yeast/kg of feed was recommended for optimum broiler production in the tropics.

In a recent study in breeding layer and broiler hens using different probiotic preparations, Bozkurt et al. (2011) observed that egg production rate, egg weight and egg mass benefited from some of the probiotics while overall, the probiotics led to significant improvement in the feed conversion ratio of layer hens. These research workers further reported that no study has yet shown that probiotic feeding has any detrimental effects on health status and productivity.

Probiotic effects on turkeys

Probiotic cultures have also been administered to turkeys and other poultry. In several separate studies, the mixed lactobacillus preparation described in broilers has been assessed in turkeys (Dilworth and Day, 1978). Francis et al. (1978) tested the commercial preparation in groups of 48 broad-breasted large white turkey poults administering 750 mg per kg in the feed for 3 weeks. An increase in body weight from 4.11.8 to 424.6 g was observed but feed efficiency fell slightly from 1.40 to 1.39.

This probiotic was also tested by Crawford (1979) who found a 6.1% weight increase at 12 weeks of age after continuous administration of 0.2 kg per ton. In a study using 72 (15 days old) white hybrid converter turkey poults, Cetin et al. (2005) investigated the effects of manna oligosaccharide (MOS) and probiotic supplementation on haematological and immunological parameters of turkeys. The experiment showed that probiotic supplementation caused significant increase ($p < 0.05$) in the erythrocyte count, haemoglobin concentration and haematocrit values, but MOS supplementation did not have any significant effect ($p > 0.05$) on these parameters. This study also revealed that both the probiotic and MOS supplementation resulted in significant increases ($p < 0.05$) in the serum IgG and IgM levels. This trial suggests that MOS and probiotic that enhanced immunoglobulin levels will have more positive effects on growth performance and turkeys' ability to resist diseases.

It has been demonstrated that direct fed microbial (DFM) may offer an effective alternative to antibiotic growth promoter in turkeys. Wolfenden et al. (2011) identified 4 *Bacillus* isolates and evaluated their potential as DFM candidates. These isolates were shown to significantly increase body weight gain as well as reduce recovery of *Salmonella* after experimental infection.

Higgins et al. (2005) investigated the effects of selected probiotic bacteria on performance of poults in 3 separate commercial turkey brooder houses. In all the experiments, treatment of probiotic cultures or antibiotics were administered in water. Poults were tagged and placed into individual pens (20 per pen, 4 replicates per treatment). Performance was evaluated by body weight or body weight gain. In the first experiment poults received 1 of 2 probiotic cultures and weighed significantly more than non-treated or antibiotic treated poults. In the second experiment, there was no significant difference among any of the groups. In the third experiment which was performed during clinically significant *Salmonella seftenburg* infection, poults that received antibiotic followed by a probiotic culture had significantly higher weight gain than non-treated poults.

In another study, Torres-Rodriguez et al. (2007) evaluated the effects of probiotic culture in combination with dietary lactose as a prebiotic in two experiments. Treated poults (*Lactobacillus* spp. based probiotic culture) received dietary lactose (0.1%) continuously in the feed and probiotic culture (~ 10 cfu/ml) in the drinking water. Three hundred and twenty selected female poults were tagged and randomly divided into 2 treatments with 4 replicates each (n = 40). The poults in experiment 1 were challenged with ~10^4 cfu of *Salmonella enteritidis* but experiment 2 was not challenged. Body weights were determined on days 1, 7 and 14 (experiment 1 trial 1 and 2, expteriment 2 trial 3) and on day 1, 8 and 18 (experiment 2 trial 4). Body weight and Feed Conversion Ratio (FCR) were significantly ($p < 0.05$) improved by treatment in *Salmonella* challenged poults (trials 1 and 2). In contrast, unchallenged turkey poults (trials 3 and 4) showed no significant difference ($p > 0.05$) in either body weight or FCR. These results suggest that dietary lactose with appropriate probiotic organisms may enhance performance of poults following a mild pathogenic challenge.

Vicente et al. (2007) studied the ability of 2 probiotic cultures (P1 and P2) to reduce conventional *Salmonella* in commercial turkey flocks 2 weeks prior to processing with or without the use of a commercial organic acid. Two weeks after treatment, the recovery of *Salmonella* was significantly reduced ($p < 0.05$) in houses in which P1 and P2 cultures were administered in combination with organic acid. The results indicate that administration of selected probiotic candidate bacteria in combination with organic acid, may reduce environmental *Salmonella* in turkey houses prior to live haul and that this practise could help to reduce the risk of *Salmonella* in the processing plant.

Probiotic effects on ruminants

Yeast and yeast- containing products has been used in ruminants' diets for many years as a source of protein and energy (Eckles and Williams, 1925; Carter and Philips, 1944). However, since the late 1980s there has been an enormous increase in interest in products based on yeast and/or filamentous fungi that are analogous to probiotics and which enhance gut functions (Wallace and Newbold, 1992). These researchers stated that products based on yeast or fungi were fed to adult ruminants to achieve a production response that is unrelated to the prevention of diarrhea. They further observed that these products nevertheless improved the nutrition of growing or adult ruminants much more than would be expected from their gross nutrient content. The products in current use contain either the yeast (*Sac. Cerevisiae)* or the aerobic fungus (*A. oryzae)* or sometimes both together, hence they are described loosely as fungal feed additives or fungal probiotics. The effectiveness of fungal probiotics stem from their influence on rumen fermentation, so they fall into the category of rumenal modifiers among the so called growth promoters (Wallace and Newbold, 1992).

The effects of a commercial preparation called "yeasture" which composed of live yeast cultures from three strains of *Saccharomyces cerevisiae* in combination with probiotic bacteria and enzymes were investigated on 80 Holstein – Friesian cows divided into two groups (Sretenovic et al., 2008). The diets for the two groups were identical and the trial group received 10 g of "yeasture" daily. The application of "yeasture" started 15 days prior to calving and lasted until 60th day of lactation. The study showed that the commercial preparation (yeasture) influenced quantity and composition of the milk. The difference between the trial and control groups was 2.57 kg 4% FCM or 8.70% ($p < 0.01$) and 7.16% milk fat ($p < 0.05$). Supplemented group had lower somatic cells count by 7.3% which indicated better health of the cows' udder.

Probiotic effects on pigs

In pigs, several organisms are used as probiotics while others are under investigation as potential probiotics (Tuschy, 1986; Tournut, 1989). The major aim of using probiotics in pigs is to improve the performance and health of the animals. Growth rate, efficiency of feed utilization, mortality and number of days with diarrhea, sometimes irrespective of the cause, are most commonly measured (Jonsson and Conway, 1992).

Wilcock (2011) reported that supplementing live yeast in pigs' diet during lactation increased the quantity and quality of the milk produced and improve the growth rate (+ 12%) of piglets. The researcher further observed that weaning weight was increased by 0.73 kg while increasing number of pigs weaned by 0.42 pigs per litter.

CONCLUSION

The beneficial effects of probiotics in animal production have been related to different modes of action. The improvement in productive performance of all poultry species fed with probiotics were mostly due to the fact that probiotics promoted the metabolic processes of digestion and nutrient utilization. Experimental studies have shown that probiotic dietary supplementation might influence these mechanisms by exerting enzymatic activities, increasing the passage rate of digestion and deconjugating bile salts and acids. It is believed that the improvement in metabolic processes that were observed as a result of probiotic supplementation were due to improved development of the gut and increased microvilli height which led to the enlargement of the microvillis' absorptive surface and enabled the optimal utilization of nutrients.

REFERENCES

Aattour N, Bouras M, Tome D, Marcos A, Lemonnier D (2002). Oral ingestion of Lactic acid bacteria by rats increases lymphocyte proliferation and interferon production. Br. J. 87:367-373.

Abe F, Ishibashi N, Shimamura S (1995). Effect of administration of *Bifidobacteria* and lactic acid bacteria to newborn calves and piglets. J. Diary Sci. 78 (912):2838-2846.

Adami A, Cavazzoni V (1999). Occurrence of selected bacterial groups in the faeces of piglet feed with *Bacillus coagulans* as probiotic. J. Basic Microbial. 39 (1):3-9.

Avends` LG (1981). Influence of L. acidophilus administer via the drinking water on performance of broilers. Poult. Sci. 60:1617 (Abstract).

Barrow P A (1992). Probiotics for chicken (in Probiotics: The scientific basis, ed.. by R. Fuller). Chapman and Hall, London. pp 225-257.

Carter HE, Philips GE (19944) The nutritive value of yeast proteins. Fed. Proc. 3, 123-8.

Cetin N, Guclu BK, Cetin E (2005). The effects of probiotic and mannanoligosaccharide on some haematological parameters in turkeys. J. Vet. Med. Physio. Pathol. Clin. Med. 52(6):263-7.

Chang Y, Kim J, Kim W, Kim Y, Park Y (2001). Selection of a potential probiotic *Lactobacillus* strain and subsequent *in-vivo* studies. Antonne Van Leeuwenhoek. pp. 193-199.

Collins FM, Carte PB (1978). Growth of salmonellae in orally infected germfree mice. Infect. Immunol. 21**,** 41-7.

Cook M (2000). Alternatives to antibiotics found for growing chickens. World Poult. 16: 45.

Couch JR (1978). Poultry researchers outline benefits of bacteria, fungistatic compounds, other feed additives. Feedstuffs, 50, 6.

Crawford JS (1979). 'Probiotics in animal nutrition. *Proc. 1979 Arkansas* Nutr. Conf. 45-55.

Dilworth BC, Day EJ (1978). Lactobacillus cultures in broiler diets. Poult. Sci. 57, 1101 (Abstract).

Donohue DC, Salminen S (1996). Safety of probiotic bacteria. Asia Pac. J. Clin. Nutr. 5:25–8.

Duval-Iflah Y, Chappuis JP, Ducluzea R, Raibaud P (1983). Intra-specific interactions between Escherichia coli in human newborns and in gnotobiotic mice and piglets. Progress in Food and Nutrition Science.7;107-16.

Eckles CH, Williams VM (1925). Yeast as a supplementary feed for lactating cows. J. Dairy Sci. 8, 89-93.

Ellin DM (2001). Alternatives to Antibiotic use of growth promotion in animal husbandry. Food Research Institute Briefings.

Ezema C (2007*).* The performance of broilers fed palm kernel cake-based diet supplemented with bioactive yeast. M.Sc Dissertation. Dept. of Animal Health and Production, University of Nigeria, Nsukka. p.47*.*

Ezema C (2012). Probiotic Effects of *Saccharomyces cerevisiae* on Laying Chicken Fed Palm Kernel Cake-Based Diets. PhD Thesis, Department of Animal Health and Production, Faculty of Veterinary Medicine, University of Nigeria, Nsukka. p 84.

FAO (2009) Food and Agriculture Organization of the United Nations.Guidelines for the evaluation of probiotics in food. Available at: ftp://ftp.fao.org/es/esn/food/ wgreport2.pdf (accessed January 27, 2009).

Francis C, Janky DM, Arafaharms RH (1978) Interelationship of lactobacillus and zinc bacteria in the diets of turkey poults. Poult. Sci. 57, 1687-9.

Fuller R (1974). Ecological studies on the lactobacillus flora associated with the crop epithelium of the fowl. J. Appl. Bacterio. 36, 131-9.

Fuller R (1986). Probiotics. Journal of Applied Bacteriology Symposium. No. 15, Pp. 1-7.

Fuller R (1989). Probiotics in man and animals. J. Appl. Bacteriol. 66, 365-378.

Fuller R (1992). Probiotics: the Sdientific basis. Ed. Fuller R London; Chapman and Hall.

Fuller R (2004). What is a probiotic? Biologist , 51:232.

Fuller R. (1978). Epithelial attachment and other factors controlling the colonization of the intestine of the gnotobiotic chicken by *lactobacilli*. J. Appl. Bacteriol*.* 4B:335-342.

Garvie EI, Cole CB, Fuller R, Hewitt D (1984). The effect of yoghurt on some components of the gut micro flora and the metabolism of lactose in the rat. J. Appl. Microbiol*.* 56:237-245.

Gill C (2001). Safe and sustainable feed ingredients. Feed International. 22:40-45.

Graf W (1983). Studies on the therapeutic properties of acidophilus milk. Symposia of Swedish Nutrition Foundation XV, 119-121.

Guarner F, Schaafsma GJ (1998). Probiotics. Int. J. Food Microbiol. 39:237–8.

Havenaar R (1992). *Huis In't Veld JMJ. Probiotics:* a general view. In: Wood BJB, ed. Lactic acid bacteria in health and disease. Vol 1. London: ElsevierApplied Science Publishers; p. 151-70.

Higgins SE, Torres-Rodriguez A, Vicente JL, Sartor CD, Pixley CM, Nava GM, Tellez G, Barton JT, Hargis BM (2005). Evaluation of Intervention Strategies for Idiopathic Diarrhea in Commercial Turkey Brooding Houses. J. Appl. Poult. Res. 14:345-348.

Isolauri E, Rautava S, Kalliomaki M (2002). Role of pro-biotics in food hypersensitivity. Current Opinion in Immunological Clinical Allergy*,* 2:263-271.

Jiang T, Mustapha A, Savaiano DA (1996). Improvement of lactose digestion in humans by ingestion of unfermented milk containing *Bifidobacterium longum*. J. Diary Sci. 79 (5):750-757.

Jonsson E, Conway P (1992). Probiotics for pigs (in Probiotics: The scientific basis. Ed. by R. Fuller) Chapman and Hall, London. pp 259 -316.

Koop-Hoolihan L (2001). Prophylactic and therapeutic uses of Probiotics: *A Review of Journal of the American Dietetic Association.* 147:747-748.

Kroger M, Kurmann JA, Raic JL (1989). Fermented milks – past and present. *Food Technology.* 43, 92-9.

Krueger WF, Bradley JW, Patterson RH (1977). The interaction of gentian violet and lactobacillus organisms in the diet of Leghorn hens. Poult. Sci. 56**,** 1729 (Abstract).

Langhout P (2000). New additives for broiler chickens. World Poultry. 7: 18-19.

Lilly DM, Stillwell RH (1965). Probiotics: Growth promoting factors produced by microorganisms. *Science*. 147:747-748.

Linton AH, Howe K, Richmond MH (1978). Attempts to displace the indigenous antibiotic resistant gut flora of chickens by feeding sensitive strains of Escherichia coli prior to slaughter. J. Appl. Bacteriol. 45**,** 221-227.

Martin SA, Nisbel BJ, Dean RF (1989). Influence of a commercial yeast supplement on the in-vitro ruminal fermentation. Nutr Reprod. Int*.*

Mellor S (2000). Nutraceuticals – alternatives to antibiotics. World Poultry. 16:30-33.

Metchnikoff E (1907). The prolongation of life. Optimistic studies. G.P. Putman,s sons. Mitswka T (1992). The human gastrointestinal tract. In the lactic acid bacteria in health and disease Vol.I. ed Wood B.J. D. Elsevier Appl. Sci*.* London. 69-114.

Miles RD, Arafa AS, Harms RH (1981a). Effects of a living non-freeze dried lactobacillus culture on performance, egg quality and gut micro flora in commercial layers. Poult. Sci*.* 60**,** 993-1004.

Morishita Y, Mitsuoka T, Kaneuchi C (1971). Specific establishment of lactobacilli in the digestive tract of germfree chickens. Japan J. Microbiol*.* 15**,** 531-8.

Naidu AS, Bidlack WR, Clemens RA (1999). Probiotic spectra of lactic acid bacteria (LAB). Crit. Rev. Food Sci. Nutr. 39:13-126.

Numan O (2001). Heterologous expression of genes in the yeast *Saccharomyces cerecisiae* Turk, J. Agric. 25: 45-49.

Nurmi E, Rantala M (1973). New aspects of *Salmonella* infection in broiler production. Nature. P. 241, 210-211.

Oyetayo VO, Adetuyi FC, Akinyosoye FA (2003). Safety and protective effect of *Lactobacillus acidophilus* and *Lactobacillus casei* used as a probiotic agent *in vivo*. Afr. J. Biotechnol. 2 (11):448-452.

Pascual M, Hugas M, Badiola JI, Monfort JM, Garriga M (1999). *Lactobacillus salivaricus* CTC 2197 prevents *Salmonella enteritidis* colonization in chicken. Appl. Environ. Micorbiol. 65: 4981-4986.

Perdigon G, Macais MEN, Alvarez S, Oliver G, De Ruiz-Holgado AAP (1986). Effect of perorally administered *Lactobacilli* on macrophage activation in mice. Infect. Immun. 53: 404-410.

Plail R (2006). The innovative power of probiotics. Poult. Int. 45: 34- 36.

Redondo-Lopez V, Cook RL, Sobel JD (1990). Emerging role of *Lactobacilli* in the control and maintenance of the vaginal bacterial microflora Rev. Infect. Dis. 12:856-872.

Salminen S (1996). Uniqueness of probiotic strains. International Dairy Feeding Sand Nutrition Newsletter*.* 5:16-18.

Sperti GS (1971). Probiotics. West Point (CT): AVI Publishing Co.; 1971.

Tahri K, Crociani J, Ballongue J, Schneider F (1995). Effects of three strains of *Bifidobacteria* on cholesterol. Lett. Appl. Microbiol. 21(3):149-151.

Tannock GW (1983). Effects of dietary and environmental stress on the gastrointestinal microbiota, in Human Intestinal Microflora in Health and in Disease, (ed. Hentges DJ) Academic Press, New York. pp. 517-39.

Torres-Rodriguez A, Higgins, S., J. Vicente, Wolfenden, A., Gaona-Ramirez, G., Barton, J., A. M. Donoghue, G. Tellez, B. M. Hargis (2007) Effect of Lactose as a Prebiotic on Turkey Body Weight Under Commercial Conditions. J. Appl. Poult. Res. 16:635-641.

Tournut J (1989). Applications of probiotics to animal husbandry. Review of Science and Technology Office of International Epizootics*.*, 8**,** 553 - 566.

Tuschy D (1986). Verwendung von Probiotika als Leistungsförderer in der Tierernährung, Übers. Tierenährg*,* 14**,** 157-178.

Vicente J S, Higgins LB, Tellez G., Donoghue A, Hargis BM (2007). Effect of Probiotic Culture Candidates on Salmonella Prevalence in Commercial Turkey Houses. J. Appl. Poult. Res.:16:471-476.

Walker AW, Duffy LC (1998). Diet and bacterial colonization: Role of probiotics and prebiotics: Rev J. Nutr. Biochem. 9:668-675.

Wallace RJ, Newbold CJ (1992). Probiotics for ruminants (in Probiotics: The scientific basis. Ed. by Fuller R) Chapman and Hall, London. pp 317-353.

Wilcock P (2011). Piglets performing better with yeast during lactation. Pig Progress*,* Vol. 27, No. 3. pp 22-23.

Wolfenden RE, Pumford MJ, Morgan S, Shivaramaiah AD, Wolfenden CM, Pixley J, Green G, Tellez G, Hargis BM (2011). Evaluation of selected direct-fed microbial candidates on live performance and Salmonella reduction in commercial turkey brooding houses. Poult. Sci. 90:2627-2631.

Zabala A, Martin MR, Haza AI, Fernandez L, Rodriguez JM, Morales P (2001). Anti-proliferative effect of two lactic acid bacteria strains of human origin on the growth of a myeloma cell line. Lett. Appl. Microbiol. 32:287-292.