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Article in Journal of Animal and Veterinary Advances · January 2009
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The Potential Benefits of Probiotics in Animal Production and Health

1College of Veterinary Medicine, University of Yangzhou, Yangzhou, 225009, China
2Faculty of Veterinary Science, University of Nyala, Nyala, 155, Sudan

Abstract: Probiotics are defined as microbial food supplements which beneficially affect the host animal by improving its intestinal microbial balance. The probiotics were improved feed conversion for the target species, reduced morbidity or mortality and benefits for the consumer through improved product quality. In this study, we found that a combination of probiotics with different mechanisms of action could amplify the protective range of bio-therapeutic preparations and the potentiated probiotics are more effective than their components separately. Bacterial probiotics were effective in chickens, pigs and pre-ruminant calves, whereas yeasts and fungal probiotics were given better results in adult ruminants. Probiotics were enhanced the growth of many domestic animals improved the efficacy of forage digestion and quantity and quality of milk, meat and egg. Probiotics protected animals against pathogens, enhanced immune response, reduced antibiotic use and shows high index of safety. The trend for future could be focus on basic research to identify and characterize existing probiotics strains, determine optimal doses needed for certain strain and asses their stability through processing and digestion.

Key words: Probiotics, growth, meat, milk, health, animal

INTRODUCTION

Understanding how probiotics exert their beneficial effects is the issue of debate nowadays. Foods containing probiotic microbes for human consumption have been marketed in Japan since the 1920s (Svensson, 1999). The first bacteria used were Lactobacillus acidophilus and L. casei which were components of fermented milk products. The definition of probiotic was formulated simultaneously with the use of living cultures in feed for various animals in order to substitute the application of nutritive antibiotics or chemotherapeutics. In the meantime probiotics are applied as feed supplements, pharmaceuticals, dairy products, fruit juices, chocolates and even meat products. A prebiotic is defined as non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or more of the gut-beneficial microbe groups (Gibson and Roberfroid, 1995). The most commonly used prebiotics are carbohydrate substrates with the ability to promote the components of the normal intestinal microflora which may evince a health benefit to the host. However, the symbiotics is the combined administration of specific prebiotics with probiotics to provide definite health benefits by synergistic action (Harish and Varghese, 2006). The selection of a suitable strain of a microorganism can be regarded as the primary requirement for the use as a probiotic. The composition of the probiotic preparations varies from those containing one strain of microorganism or those containing many strains. The multi-strain probiotic can act in broad spectrum and expected to be active in different species of host animals and against microbial infections (Timmerman et al., 2004).

The conventional use of probiotics to modulate gastrointestinal health, such as improving lactose intolerance, increasing natural resistance to infectious diseases in the gastrointestinal tract, suppressing traveler's diarrhea and reducing bloating, has been well investigated and documented (Liong, 2007). The probiotic research was applied in pets, horses and farm animals, 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 (Kyriakis et al., 1999) and broilers (Tellez et al., 2001). Studies on efficacy of probiotics strains must be performed in target species/animal categories. The claims for microbial products are: improved performance and feed conversion for the target species; reduced morbidity or mortality; benefits for the consumer through improved product quality. Recombinant probiotics and the principle of alternative gene therapy represent the latest approach of using...
Genetically Modified Organisms (GMO) for biomedical applications. Probiotic treatment has no clinical side effects (Furrie et al., 2006). In this study, we investigated the potential benefit of probiotic strains both in animal health and production.

MICROORGANISM USED IN PROBIOTICS

The crucial event in the development of the probiotic approach to animal health was the finding that the newly hatched chicken could be protected against salmonella colonization of the gut by dosing it with a suspension of gut contents prepared from healthy adult chickens (Nurmi and Kantala, 1973). Microorganisms used in probiotics include those derived from the Lactobacillus, Streptococcus, Enterococcus, Bacillus, Clostridium, Bifidobacterium species and E. coli Nissle 1917 (Kruis et al., 2004). Bacterial probiotics have been effective in chickens, pigs and pre-ruminant calves; whereas yeasts and fungal probiotics such as (Saccharomyces cerevisiae) and Amaferm (Aspergillus oryzae) have given better results in adult ruminants (Fuller, 1999). The combinations of probiotics strains could increase the beneficial health effects compared with individual strains, because of their synergistic adhesion effects (Collado et al., 2007).

PROBIOTICS CRITERIA

The potential probiotic strains were characterized as a normal inhabitant of the target species, have ability to adhere and colonize the epithelial cells of the gut and to survive and grow in the respective ecological units. The strains were genetically stable, able to produce antimicrobial substances, antagonistic toward pathogenic or cariogenic bacteria (Kullen and Klaenhammer, 1999). The strains were able to compete with normal microflora and resistance to bile and acids can exert one or more clinically documented health benefits (Parvez et al., 2006). Cell immobilizations, selections of acid and bile-resistant strains, oxygen-impermeable containers have been proposed to improve the viability of probiotic bacteria (Shah, 2000; Champagne et al., 2005). In addition, molecular tools based on 16S ribosomal DNA sequences and PCR techniques have been developed for identifying probiotics strains (Ben Amor et al., 2007).

PROBIOTICS MECHANISM OF ACTION

Four mechanisms have been summarized to explain the protective effects of probiotic: Antagonism through the production of antimicrobial substances (Vandenbergh, 1993); competition with the pathogen for adhesion sites or nutritional sources (Guillot, 2003) immunomodulation of the host (Isolauri et al., 2001) and inhibition of the production of bacterial toxins (Brandao et al., 1998). The first three mechanisms are ordinarily attributed to lactic acid bacteria while the last two are more specifically attributed to yeast. Probiotic bacteria exhibit host-specific and strain-specific differences in their actions, a combination of probiotics with different mechanisms of action could perhaps amplify the protective range of bio-therapeutic preparations (Lima-Filho et al., 2000).

POTENTIATED PROBIOTICS

Potentiated probiotics are a bio-preparations containing production strains of microorganisms and synergistically acting components of natural origin that potentiate probiotic effect on both small intestine and colon. Potentiated probiotics more effective than their components separately and their potentiated protective and simulative effects were expressed in all parts of the digestive tract (Bomba et al., 2002). PUFA-potentiated probiotics positively affected the adhesion of lactobacilli, pH and the level of organic acids in the digestive tract of germ-free piglets (Kastel et al., 2007) and fish (Ringo and Gatesoupe, 1998). Organic acids together with probiotics and specific carbohydrates are often suggested as alternatives to the use of antibiotic growth promoters (Jensen, 1998). The application of probiotics in conjunction with antibiotics prevented both the increase in the number of ampicillin-resistant bacteria and their translocation into the liver (Bomba et al., 2002). Some microbes have the ability to bind metal ions present in the external environment at the cell surface or to accumulate them in the cell. The addition of magnesium to the growth medium increases the viable count of L. casei and L. plantarum (Calomme et al., 1995). The inhibiting effect of zinc has been used successfully in the treatment of E. coli diarrhea in post weaning piglets (Owusu-Asiedu et al., 2003).

PROBIOTICS APPLICATIONS IN ANIMAL PRODUCTION

Improved growth rate: In animal nutrition microorganisms used as probiotics was linked with a proven efficacy on the gut microflora. Administration of probiotic strains separately and in combination was significantly improved feed intake, feed conversion rate, daily weight gain and total body weight in chicken, pig, sheep, goat, cattle and equine (Chiofalo et al., 2004; Li et al., 2006;
The use of antibiotics in poultry feeds has become undesirable because of the residuals in meat products and included a ten-fold increase in survival rate, significantly reduced morbidity and mortality of growing rabbits during with the invasive food borne pathogen Listeria monocyctogenes and Salmonella typhimurium and protect pigs against diarrhea (Corr et al., 2007). The protection included a ten-fold increase in survival rate, significantly increased their productivity and improve quality of the carcass output and conditions may be attributable to the probiotic properties. The number of viable microbial cells that should be present in a probiotic product has been estimated to be between $10^6$ and $10^8$ CFU mL$^{-1}$ (Kailasapathy and Rybka, 1997). Cheese was optimized by no effect on chick quality or production efficiency in the addition of 2004).

Milk production: The supplementing animals feed with probiotics have a beneficial effect on subsequent yield, fat and protein content (Sara et al., 2002; Kritas et al., 2006). Blood and milk parameters were significantly improved using probiotic, as shown by higher serum cholesterol and total lipids concentrations and higher milk fat and protein content at mid-suckling period in sow (Alexopoulos et al., 2004). Aspergillus oryzae and Saccharomyces cerevisiae have increased milk production, milk Solids-Not-Fat (SNF) and tended to increase milk protein percentages in dairy cows (Yu et al., 1997). This is due to the numbers of cellulolytic bacteria, fiber degradation and changes in Volatile Fat Acid (VFA) in the rumen (Martin and Nisbet, 1990).

In the traditional milk products, microbes are selected and decrease egg contaminations (Van Immerseel et al., 2005). Probiotic reduced leg weaknesses in broilers (Plavnik and Scott, 1980), prevented starvation sterility of young sows (Bohmer et al., 2006). Probiotics has a positive effect on various digestive processes, especially cellulolysis and synthesis of microbial protein (Yoon and Stern, 1995). Probiotics were stabilizers of ruminal pH and lactate, increased the absorption of some nutrients and displayed a growth-promoting effect that was comparable to avilamycin treatment (Mountzouris et al., 2007).

Egg production: Probiotics increased egg production and egg quality (Haddadin et al., 1996; Kurtoglu et al., 2004) and decrease egg contaminations (Van Immerseel et al., 2006). Probiotic was also increased egg shell weight, shell thickness and serum calcium (Panda et al., 2003, 2007). In addition, probiotic was significantly reduced the plasma cholesterol and triglyceride (Haddadin et al., 1996), confirming the important roles of Gastrointestinal Tract (GIT) microorganisms in recycling of lipids. Probiotics had no effect on chick quality or production efficiency in broilers produced by the breeder flock (O'Dea et al., 2006).

PROBIOTICS APPLICATIONS IN ANIMAL HEALTH

Protection against pathogens: The indigenous intestinal bacteria inhibit pathogens by competition to colonization sites and nutritional source and production of toxic or stimulation of the immune system (Paravez et al., 2006). These mechanisms are not mutually exclusive and inhibition may comprise one, or all of these mechanisms. The variation in efficacy of probiotics under different conditions may be attributable to the probiotic preparation itself or may be caused by external conditions. Probiotics can significantly protect mice against infection with the invasive food borne pathogen Listeria monocytogenes and Salmonella typhimurium and protect pigs against diarrhea (Corr et al., 2007). The protection included a ten-fold increase in survival rate, significantly.
higher post-challenge food intake and weight gain and reduced pathogen translocation to visceral tissues (Shu et al., 2000). Probiotics have been shown to be involved in protection against a variety of pathogens in chicken including Escherichia coli (Chateau et al., 1993), Salmonella (Stern et al., 2001), Campylobacter (Stern et al., 2001), Clostridium and Eimeria (Dalloul and Lillehoj, 2005). Probiotic activity was largely inhibitory since the probiotics bacteria can reduce the level of E. coli O157 carriage and faecal shedding in cattle and calves (Brashears et al., 2003) and decreased the severity and duration of diarrhea in Escherichia coli O157:H7-infected infant rabbits (Ogawa et al., 2001; Casey et al., 2007). The growth of Enterohemorrhagic Escherichia coli EHEC O157:H7 and the production of Shiga-like toxins were inhibited by co-incubation with Clostridium butyricum (Takahashi et al., 2004). Probiotic was reduced gastric inflammation and bacterial colonization in Helicobacter pylori-infected animals (Johnson-Henry et al., 2005) and induced an inflammatory response in feedlot steers fed high-grain diets (Emmanuel et al., 2007). Probiotics tended to improve the health status and fertility of sows (Alexopoulos et al., 2004), reduce the adhesion of porcine enteropathogenic E. coli and invasion of Salmonella typhimurium with epithelial cells in vitro (Kleta et al., 2006). The Pediococcus acidilactici based probiotic effectively enhances the resistance of birds and partially protects against the negative growth effects associated with coccidiosis (Lee et al., 2007). Probiotic can exhibit antibacterial activity against fish pathogenic bacteria (Sugita et al., 2002) and could reduce mortality of fish challenged with a virulent strain of Aeromonas salmonicida (Nikoskelainen et al., 2001). Probiotic can alter the balance of gastrointestinal microflora in healthy cats (Marshall-Jones et al., 2006) and were shown to be effective in preventing antibiotic associated diarrhea (Hawrelak et al., 2005).

Enhance the immune response: The intake of probiotics has been associated with beneficial effects on the immune system, such as improved disease resistance and reduced risk of allergies. Probiotic in the organism of a healthy animal stimulate non-specific immune response and enhance the system of the immune protection (Ceslovas et al., 2005). Probiotic increased intestinal IgA secretion both in sows and piglets and elevated IgG and IgM levels in turkey (Cetin et al., 2005). The effect of intestinal IgA secretion could be related to a more successful mucosal defense which in turn led to a lower level in systemic IgG production in piglets after weaning (Scharek et al., 2007). Furthermore, administration of probiotic results in beneficial systemic and immunomodulatory effects in cats (Marshall-Jones et al., 2006). A probiotic influence transport properties of small intestine epithelium and increased absorption of glucose could be interpreted as a positive effect for the animal (Lodemann et al., 2006). The probiotic that enhance immunoglobulin levels have more positive effect on growth performance, production and ability to disease resistance (Cetin et al., 2005). The protective effects of feeding the immunoenhancing probiotic to mice can reduce the severity of E. coli O157:H7 infection and this reduction may be associated with enhanced humoral and cellular immune responses (Shu and Gill, 2002). Probiotic shows an immunoregulatory on cell-mediated immunity and humoral immune response in poultry and this provides a rationale for further study to investigate the beneficial effects of probiotics in animals’ food (Panda et al., 2007). Clostridium butyricum can mediate the humoral immune responses and improve the growth performance in Miichthys miuy (Song et al., 2006). The addition of probiotic in the diet significantly increased the cutaneous basophilic hypersensitivity response (Panda et al., 2003).

SAFETY ASPECTS OF PROBIOTICS

The concentration of probiotics in food production varies tremendously and there are currently no national standards of identity for levels of bacteria required in yogurt and other fermented product. Theoretically probiotics may responsible for four types of side-effects systemic infections, deleterious metabolic activities, excessive immune stimulation in susceptible individuals and Gene transfer (Marteau and Boutron-Ruault, 2002). Most of the micro-organisms used as a probiotics in animal are safe, although some have problems particularly the enterococci, which may harbour transmissible antibiotic resistance determinants and Bacillus cereus group that are known to produce enterotoxins and an emetic toxin (Arturo et al., 2006). Particular attention for safety assessment is focused on the presence of transmissible antibiotic resistance markers and the potential for production of harmful metabolites. Thus the appealing properties of probiotics include the ability to reduce antibiotic use, the apparently high index of safety and the public’s positive perception about natural or alternative therapies (Strompfoa et al., 2006). In vitro tests are critical to assess the safety of probiotic microbes, although it is useful to gain knowledge of strains and the mechanism of the probiotic effect. The main currently used in vitro tests for the study of probiotic strains are resistance to gastric acidity and bile acid, adhesion to gut epithelial tissue, antimicrobial activity against potentially pathogenic bacteria and ability to modulate immune responses (Collins et al., 1998).
FUTURE TREND IN PROBIOTICS RESEARCH

Strain identity is important to link a strain to a specific health effect as well as to enable accurate surveillance and epidemiological studies. The trend for future could be focus on basic research to identify and characterize existing probiotics strains, determine optimal doses needed for certain strain and asses their stability through processing and digestion. For the probiotics to represent a real and effective alternative to antibiotics and chemotherapeutics it is absolutely necessary to ensure their consistently high efficacy. It is important to search for ways to potentiate the efficacy of probiotic microorganisms in all parts of the digestive tract. The efficacy of probiotics may be enhanced by selection of more efficient strains of microorganism, gene manipulations, combination of a number of strains of microorganism and combination of probiotics and synergistically acting components. Genetic engineering techniques can be use to insert one or more antigen from a pathogen into probiotic strains with good colonizing capacity for use in immunotherapeutic applications, such as vaccination and delivery of immunoregulatory substances.

CONCLUSION

Although, the highly complex relationship of food and health is still poorly understood, recent research advances in different disciplines provide promising new approaches to improve our understanding. The demand of safe and qualitative animal product on the market has considerably increased. In this study, we conclude that probiotics have a positive effect on animal production by improving growth rate and increasing milk, meat and eggs production.

In addition, probiotics can inhibit pathogens by competition for a colonization sites or nutritional sources and production of toxic compounds, or stimulation of the immune system. In order to enhance the efficacy of probiotics, it is necessary to obtain additional knowledge on their mode of action. The efficacy of probiotics may be potentiated by several methods: The selection of more efficient strains; gene manipulation; the combination of several strains and the combination of probiotics and synergistically acting components. The adoption of logical criteria for the in vitro selection of probiotic bacteria can result in the isolation of strains capable of performing effectively in the gastrointestinal tract.

ACKNOWLEDGEMENT

This study was supported by grants from the Chinese National Science Foundation Grant (No.30571374 and No. 30771603) and China Postdoctoral Science Foundation Grant (No. 20070420201).

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