



## Probiotics in Aquaculture : Potential for Sustainable Development

### KEYWORDS

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**ABSTRACT** Aquaculture industry is an important source for animal protein food producing sector utilizing the natural resources and has become a fast developing industry creating several employment opportunities. Sustainable production is affected by multiple factors including poor water quality management, nutritionally imbalanced supplementary feeds and the disease incidence. The occurrence of pathogenic and non-pathogenic diseases resulted in a consistent damage to the industry. To control these diseases indiscriminate use of chemicals and drugs which are reported not to be environment friendly and hence use of antibiotics and certain drugs has been banned in aquaculture industry. The presence of antibiotic residues in culture organisms i.e., fish / prawn / shrimps are rejected by the European countries in the recent years. When they are faced disease problems, the common response from the aqua farmer has been to use to antimicrobial drugs.

### Introduction

The livestock and aquaculture industries have experienced widespread use of antimicrobial drugs in their farming practices. Certain antimicrobial drugs has been shown to positively influence growth of livestock and used widely (Acar et al., 2000; Witte, 2000; Wierup, 2001 and Phillips et al., 2004).

The indiscriminate use of antimicrobial drugs in agriculture and aquaculture has led to the emergence of antibiotic resistant bacteria (Schwarz et al., 2001; Akinbowale et al., 2006). FAO (2001) formulated a set of practices for responsible management of aquaculture systems to provide safe food for the consumers. In aquaculture this was felt most dramatically in shrimp industry where massive increase in production, over crowding of organisms and unchecked antibiotic usages led to the emergence of numerous antibiotic resistant bacteria resulting in production crashes in many countries (Karunasagar et al., 1994; Moriarty, 1999). With in aquaculture, there are numerous reports of antibiotic resistant bacteria of farm origin (Chelossi et al., 2003; Sahul Hameed et al., 2003; Alcaide et al., 2005). The antimicrobial effect of bacteria results from factors such as the production of antibiotics, bacteriocins, siderophores, lysozymes, protease, hydrogen peroxide, the alteration of pH values and the production of organic acids, ammonia and H<sub>2</sub>S. However, risk is not just potential loss to the farmers, but also the emergence of antibiotic resistant bacteria on aquaculture farms posing a risk to human health. There are many reports illustrating the transferral of resistant genes between bacteria (Witter, 2000; Schwarz et al., 2001). This process means antibiotic resistant bacteria originating from a shrimp farm could potentially transfer plasmids to bacteria involved in human health problems (Kesarcodi Watson et al., 2008).

### Definition and Principles

The new biotechnical product called 'Probiotics' which means "for life" originating from the Greek Words 'pro' and 'bios' (Gismondo et al., 1999). Earlier, Fuller (1989) defined probiotics as "a live microbial feed supplement which beneficially affects the host animal by improving its intestinal balance." The use of live microorganisms to enhance human health is not new. For thousand of years long before the discovery of antibiotics, people have been consuming live microbial food supplement such as fermented milk. A scientific explanation of the beneficial effect of lactic acid bacteria

present in fermented milk was first provided in 1907 by the Nobel Prize winning Russian physiologist Eli Metchnikoff. In this fascinating treatise, "The Prolongation of Life". Metchnikoff states that "The dependence of the intestinal microbes on the food makes it possible to adopt measures to modify the flora in our bodies and to replace the harmful microbes by useful microbes (Talwalkar, 2003). Lily and Stillwell (1965) had originally proposed the use of the term to describe compounds produced by a protozoan that stimulated the growth of another. The scope of this definition was further expanded in the early 1970's to include tissue extracts that stimulated microbial growth (Gomes and Malcata, 1999).

Aquatic animals shares much closer relationship with their external environment. Potential pathogens are able to maintain themselves in the external environment of animal (aquatic medium) and proliferate independently of the host animal (Hasen and Olafsen, 1999; Verschaere et al., 2001).

Based on the intricate relationship aquatic organisms have with external environment when compared with that of terrestrial animal, the definition of probiotic for aquatic environments needs to be modified. Verschuere et al., (2000) suggested definition "a live microbial adjunct which has a beneficial effect on the host by modifying the host associated or ambient microbial community, by ensuring improved use of the feed or enhancing its nutritional value, by enhancing the host response towards disease or by improving the quality of its ambient environment". Apart from requirement of the probiotic to be a live culture, this definition in a lengthy way of describing a probiotic as defined by Irianto and Austin (2002) thus a probiotic is an entire or components of a microorganisms that is beneficial to the health of the host. An alternative prophylactic treatment would be to support the natural non-specific host microbial and therapeutic defence mechanism by administration of live bacteria with demonstrable inhibitory effect upon pathogens as probiotics. This concept has already been proved to be successful in terrestrial animals and humans (Conway, 1989). Studies have shown that Streptococcus, Leuconostoc, Lactobacillus and Cyanobacterium belong to normal biota of the gastrointestinal tract in healthy fish. The principal bacterial groups used as probiotics in culture of shrimp, crab, oyster and fish have been Vibrio, Pseudomonas, Bacillus and several Lactobacilli.

### Mode of action

The advantages of the use of probiotics might be obtained by some specific action particularly stimulating the immunity of the host. The antimicrobial activity of probiotics is to be accounted for large part by their ability to colonize the colon and reinforce the barrier function of the intestinal mucosa. It is an ecofriendly approach and probiotics can be stabilize gut microflora, improve microbial balance leading to improved feed quality and enhanced disease resistance. Several studies have been demonstrated certain modes of probiotic action in effect on the aquatic environment. The mode of action of a feed in aquatic organisms is different ways. Bairagi et al., (2002) assessed aerobic bacteria associated with G17 of nine fresh water fish. They determined that selected strains produced digestive enzymes, thus facilitating feed utilization and digestion. Ramirez and Dixon (2003) reported on the enzymatic properties of anaerobic intestinal bacteria isolated from three fishes, showing the potential role played by the probiotics. According to Fuller (1992) immunity may be improved by the probiotic in three ways. (1) Increasing macrophage activity, shown by the enhanced ability to phagocytose microorganisms or carbon particles. (2) Increasing the production of systematic antibiotics, usually of immunoglobulin and interferon (a non-specific antiviral agent); (3) Increasing local antibodies at mucus surfaces such as the gut wall. Rama Rao et al., (2006) reported that the therapeutic application of probiotics, the 'friendly' bacteria which maintain a healthy intestinal tract and help to fight illness and disease. Further, they clearly explained the mode of action of probiotic in the intestine and colon. Today probiotics are quite common place in health promoting "functional foods" for humans as well as therapeutic, prophylactic and growth supplements in animal production and human health (Sullivan and Nord, 2002; Senok et al., 2005). When looking at probiotics intended for the aquatic usage, it is most important to consider certain influencing factors that are fundamentally different from terrestrial based probiotics.

### Advantages of the use of probiotics in Aquaculture

Probiotics in recent years are used in aquaculture to modify and manipulate microbial population in the pond environment and to reduce or eliminate selected pathogenic of microorganisms leading to better growth and survival of the culture species (Irianto and Austain, 2002). Recently farmers are using different types of feed probiotics, water probiotics and soil probiotics are used in different culture operations. The use of single or mixed culture of selected bacteria to modify or manipulate the microbial communities in water or sediment, in order to reduce or eliminate the pathogenic microorganisms and to improve the growth and survival of the targeted species have been studied (Everschuere et al., 2000 and Irianto and Austin, 2002). Infact, adding of probiotics in culture systems, the pond ecology and other parameters are very much affected due to high bacterial load even though they are non-pathogenic. There will be stiff competition for D.O. and increased eutrophication etc., leading to fall in D.O. more so from the midnight and worsen the situation at dawn. Since the shrimp/fish ponds are almost always alkaline, the organic acids produced by the probiotics such as lactic, malic, formic and acetic will try to reduce pH of pond water and by both phyto and zooplankton blooms has dominates the pond water causing severe problems and also heavy phytoplankton formation leading to crash. There will be increased BOD and COD and drop in D.O. in the pond water particularly from midnight to dawn. This is due to the utilization of lactic acid by some phyto and zooplankton. Since probiotics or if carries are not gas absorbing agents of unionised ammonia, hydrogen sulphide and Methane etc., because increased release in pond water depriving the shrimp from little available dissolved oxygen. Probiotics can not stop putrefication and decaying at the pond bottom as expected acclaimed. The enzymes added or released from these probiotics cannot degrade the pond bottom debris as there are not anaerobic in nature. The modes of action such as competition for nutrients and production of inhibitory substances could occur

in the culture. Additional effect of probiotic action should also be considered, given the modified definition including change of the water quality and interaction of phytoplankton (Verschuere et al., 2000). Phytoplankton are capable of producing substances toxic to other bacteria and could potentially act in a beneficial manner. For example, *Skeletonema costatum*, a common microalgae used in molluscan and crustacean larviculture, has been shown to produce an organic extract capable of inhibiting the growth of *Lintonella anguillarum* and three other vibrios (Naviner et al., 1999).

The future application for probiotics in aquaculture industry looks encouraging. There is an over-increasing demand for aquaculture products and a similar increase in the search for alternative to antibiotics. The field of probiotics intended for aquaculture organisms is now attracting considerable attention and a number of commercial products are available i.e., feed; soil and water probiotics, in aquaculture operations. Shani John and Jamila Patterson (2007) concluded that disease problems in shrimp ponds can be overcome by applying probiotics and right combination of bacteria and other combinations. The transfer of antibiotic resistance to human pathogenic bacteria, which is exacerbated by the abuse of antibiotics in aquaculture, will decrease. The bacterial resistance problems already recognized in human and veterinary medicine need to be studied, further among bacterial pathogens occurring in aquaculture operations. Many failures in the probiotic research could be attributed to selection of inappropriate microorganisms (Gomez Gill et al., 2000). General selection criteria are mainly determined by bio-safely consideration, methods of production and processing, methods of administration of probiotic and location in the body where microorganisms are expected to be active and should not be harmful to the host. Further investigations on these lines would throw more light into the actual mechanism of probiotic action in Aquaculture sector.

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