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Review Article

# Probiotics in aquaculture

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ABSTRACT

Aquaculture is the world's fastest growing food production sector. However, fish culture is currently suffering from serious losses due to infectious diseases. The use of antimicrobial drugs, pesticides and disinfectant in aquaculture disease prevention and growth promotion has led to the evolution of resistant strains of bacteria. Thus, the research into the use of probiotics for aquaculture is increasing with the demand for environment – friendly sustainable aquaculture. The benefits of such supplements include improved feed value, enzymatic contribution to digestion, inhibition of pathogenic microorganisms, antimutagenic and anti-carcinogenic activity, and increased immune response. These probiotics are harmless bacteria that help the well being of the host animal and contribute, directly or indirectly to protect the host animal against harmful bacterial pathogens. The use of probiotics in aquaculture has just begun, due to the fact that gastrointestinal microbiota of aquatic organisms has been poorly characterized, and their effects are not studied extensively. This review summarizes and evaluates brief knowledge about the probiotic organism, the action of probiotic in fish culture and the safety evaluation of probiotics in aquaculture.



## 1. Introduction

Today, aquaculture is the fastest growing food-producing sector in the world, with an average annual growth rate of 8.9% since 1970, compared to only 1.2% for capture fisheries and 2.8% for terrestrial farmed meat production systems over the same period.[1] World aquaculture has grown tremendously during the last fifty years from a production of less than a million tonne in the early 1950s to 59.4 million tonnes by 2004. This level of production had a value of US$70.3 billion. The diseases and deterioration of environmental conditions often occur and result in serious economic losses.[2]

During the last decades, antibiotics used as traditional strategy for fish diseases management and also for the improvement of growth and efficiency of feed conversion. However, the development and spread of antimicrobial resistant pathogens were well documented.[3,4] There is a risk associated with the transmission of resistant bacteria from aquaculture environments to humans, and risk associated with the introduction in the human environment of non-pathogenic bacteria, containing antimicrobial resistance genes, and the subsequent transfer of such genes to human pathogens.[5] Considering these factors, there has been heightened research in developing new dietary supplementation

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strategies in which various health and growth promoting compounds as probiotics, prebiotics, synbiotics, phytobiotics and other functional dietary supplements have been evaluated.[6] In this context, microbial intervention can play a vital role in aquaculture production, and effective probiotic treatments may provide broad spectrum and greater nonspecific disease protection.[7,8] This review summarizes and evaluates the broader knowledge about the probiotics, selection of probionts, commonly used probiotic organism, their mode of action and safety regulation of probiotics in aquaculture.

## 2. Definition of probiotics

The word "probiotic" was introduced by Parker, 1974.[9] According to his original definition, probiotics are "organisms and substances which contribute to intestinal microbial balance". Fuller, 1989[10] revised the definition as "live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance". Therefore, several terms such as "friendly", "beneficial", or "healthy" bacteria are also commonly used to describe probiotics. Although application of probiotics in aquaculture seems to be relatively recent,[11] the interest in such environment friendly treatments is increasing rapidly. Moriarty, 1998[12] proposed to extend the definition of probiotics in aquaculture to microbial ''water additives''. A growing number of studies have dealt explicitly with probiotics, and it is now possible to survey its state of the art, from the empirical use to the scientific approach.[13,14]

## 3. Selection of probiotics

Selection of probiotic bacteria has usually been an empirical process based on limited scientific evidence. Many of the failures in probiotic research can be attributed to the selection of inappropriate microorganisms. Selection steps have been defined, but they need to be adapted for different host species and environments. It is essential to understand the mechanisms of probiotic action and to define selection criteria for potential probiotics.[15] General selection criteria are mainly determined by bio safety considerations,

a. Methods of production and processing.
b. Method of administration of the probiotic and
c. The location in the body where the microorganisms are expected to be active.[15]

Three general modes of probiotics actions have been classified and presented by Oelschlaeger, 2010[16] as follow: (1) Probiotics might be able to modulate the host's gut defenses including the innate as well as the acquired immune system and this mode of action is most likely important for the prevention and therapy of infectious diseases but also for the treatment of inflammation of the digestive tract or parts thereof. (2) Probiotics can also have a direct effect on other organisms, commensal and or pathogenic ones and this principle is in many cases is of great importance in the prevention, treatment and restoration of the microbial equilibrium in the gut. (3) Finally, probiotic effects may be based on actions affecting microbial products, host products and food ingredients and such actions may result in inactivation of toxins and detoxification of host and food components in the gut. According to above summary, all three modes of probiotics actions are all likelihood associated with gut and/or gut microbiota. Therefore, it has become apparent that we are in fact dealing with another "organ", the so called "microbiotic canal" with the increased knowledge of the specific activity of the gut microbiota.[17]

## 4. Probiotic organism

Today probiotics are quite commonplace in health promoting "functional foods" for humans, as well as therapeutic, prophylactic and growth supplements in animal production and human health.[18–20] Typically, the lactic acid bacteria (LAB) have been widely used and researched for human and terrestrial animal purposes, and LAB are also known to be present in the intestine of healthy fish.[21,22] Interest in LAB stems from the fact that they are natural residents of the human GIT with the ability to tolerate the acidic and bile environment of the intestinal tract. LAB also function to convert lactose into lactic acid, thereby reducing the pH in the GIT and naturally preventing the colonization by many bacteria,[23] The most widely researched and used lactic acid bacteria are the *Lactobacilli* and *Bifidobacteria*.[20,24,25]

Other commonly studied probiotics include the spore forming *Bacillus* sp. and yeasts. *Bacillus* sp. have been shown to possess adhesion abilities, produce bacteriocins (antimicrobial peptides) and provide immunostimulation.[26–29] Gram-positive obligate or facultative anaerobes are dominant in the gastrointestinal microbiota of man and terrestrial farm animals.[30] Most probionts belong to dominant or sub-dominant genera among these microbiota, e.g., *Bifidobacterium*, *Lactobacillus*, *Streptococcus*.[30] Gram-negative facultative anaerobes prevail in the digestive tract of fish and shellfish, though symbiotic anaerobes may be dominant in the posterior intestine of some herbivorous tropical fish.[31] *Vibrio* and *Pseudomonas* are the most common genera in crustaceans,[32] marine fish and bivalves.[33,34] *Aeromonas*, *Plesiomonas* and *Enterobacteriaceae* are dominant in freshwater fish.[33] *Bacillus* spp. hold added interest in probiotics as they can be kept in the spore form and therefore stored indefinitely on the shelf.[35] The list of microorganism authorized as probiotics in feeding stuffs under Council Directive 70/524/EEC are given in Table 1. In addition, other probiotics are commercialized on the market that has been notified, but that do not appear in the last authorized list of feed additives published by the Commission.

## 5. Mechanisms of action

Different modes of action or properties are desire on the potential probiotic like antagonism to pathogens[36,37] ability of cells to produce metabolites (like vitamins) and enzymes,[38] colonization or adhesion properties[39] enhance the immune system.[40]

### 5.1. *Competitive exclusion of pathogenic bacteria*

Competitive exclusion is a phenomenon whereby an established microflora prevents or reduces the colonization of a