ROLE OF PROBIOTICS IN ENHANCING AQUACULTURE: A MARCH TOWARDS FOOD SECURITY

Pavel Biswas[1], Goutam Sengupta[2], Sufia Zaman[3], and Abhijit Mitra[4]

[1]Research Scholar, Department of Oceanography, Techno India University, West Bengal, EM 4 Salt Lake, Sector V, Kolkata 700091, India.

[2]Rector, Techno India University, West Bengal, EM 4 Salt Lake, Sector V, Kolkata 700091, India.

[3]Associate Professor, Department of Oceanography, Techno India University, West Bengal, EM

[2]Director (Research), Techno India University, West Bengal, EM 4 Salt Lake, Sector V, Kolkata 700091, India.

Abstract

Aquaculture, the farming of aquatic organisms (especially fish), has become increasingly significant in the global economic and livelihood landscape. As the demand for fish for human consumption rises, the importance of the fishery sector continues to grow. To boost growth and production rates, various types of artificial feed are employed. Recently, probiotics (live microorganisms) have been introduced in aquaculture to enhance disease resistance and improve water quality. This review article provides an overview of the different types of probiotics used in the aquaculture industry.

Keywords: Aquaculture, artificial feed, probiotics

Introduction

Fish is one of the most nutritious components of the human diet, serving as an excellent source of animal proteins. To enhance their growth within a limited timeframe, fish are often provided with artificial feed. This feed, made from fish meal, meets the protein requirements of the fish (Alam et al., 1996). The amount and quality of feed needed depend on the fish's feeding habits, size, digestive anatomy, temperature, and the types of natural food available in their habitat (Glencross et al., 2007).

Artificial feed is produced by combining various ingredients to achieve optimal production outcomes. Soybean meal is the primary ingredient used, along with other components such as milk powder and corn flour. This complete artificial feed includes all essential nutrients, such as protein, carbohydrates, fat, ash, phosphorus, water, and trace amounts of vitamins and minerals (Table 1).

Table 1: Nutrient level in ideal fish feed

Nutrients	Required percentages in the feed
Proteins	32–45 %
Fat	4–28 %
Carbohydrates	10–30 %
Minerals (inorganic mineral elements, including calcium, phosphorous, magnesium, iron, copper, manganese, zinc, iodine, and selenium.	1.0–2.5 %
Vitamins	1.0–2.5 %

Types of Fish feed

Fish feed may be of natural origin or they may be prepared artificially considering the nutritional requirement of the species.

A. Natural Feed

This type of feed grows naturally in the aquatic ecosystem and sometimes from the terrestrial habitats.

- Plankton
- *W*olffia, *Eichhornia*, *Pistia*, *Lemna*
- Tiny aquatic insects
- Rotted part of animal and plants
- Basal organic elements
- Different types of grasses (napier, para etc.)

B. Artificial Feed

Artificial feed are mainly used for fast growth and increase production. Besides these are available in all times and can be made into different pellet sizes according to different sizes of the fishes.

Mainly three types of feed are available in the market namely (i) Crumbles, (ii) Floating pellets and (iii) Sinking pellets.

The pellet size should be approximately 20-30% of the size of the fish species mouth gap (Fig. 1).

Artificial Fish Feed preparation process

A. Ingredients

1) Fish meal
2) Soyabean meal
3) Rice bran

4) Rice polish
5) Mustard oil cake
6) Ground nut oil cake
7) Maize bran
8) Yeast and baking powder
9) Vitamin premix
10) Cotton seed meal

B. Process

The process of preparing floating / sinking fish feed consists of 5 steps.

a) Grinding
b) Mixing
c) Extrusion
d) Drying
e) Cooling and packing

Schematic diagram of fish feed preparation

All the ingredients are grinded by hammer mill machine. In that machine, materials are smashed under high-speed rotation of hammers

⇩

Then grounded materials are mixed thoroughly in the mixer to make high quality nutritional feed with the addition of premixes and other micro ingredients

⇩

In case of the preparation of sinking feed pellet, fat contain should be high (8 %) and starch contain should be low (15 %)

⇩

The mixture is passed through floating fish feed extruder machine to make pellets in different sizes depending upon disc size under high temperature

⇩

The pellets are dried by dryer machine to make low moisture feed

⇩

Oil spraying machine can be used to spray oil to the surface of the dried pellets

⇩

The pellets are cooled for hardening and packaged in bags

Fig. 1. Different sizes of Fish Feed

Uses of Probiotics

Now a days aquaculture has become an economically important industry as it is the fastest growing food producing sector in the world with the greatest potential to meet the growing demand for aquatic food (FAO, 2006; Subasinghe *et al*., 2009). Disease is the major threat in the fishery sector due to increasing trend of intensification and commercialization of the production (Bondad-Reantaso *et al*., 2005). Prevention and control of these diseases has focused on the use of chemical additives and medicines especially antibiotics which inhibit or kill beneficial microbiota in the gastrointestinal (GI) ecosystem and this antibiotic significantly poses adverse impact on public health by promoting selection, propagation and persistence of bacterial resistance strains (Nomoto, 2005; FAO/OIE/WHO, 2006; WHO, 2012). Therefore a non-antibiotic agent has developed that controls the disease without any harmful effect on fishes as well as human beings and that is known as probiotics (Browdy, 1998). Probiotics are live microbes that can be used to improve the host intestinal microbial balance and growth performance. It can also be considered as bio-friendly agent to enhance the immunity of fish under stressful environmental conditions, by modulating the gut colonization of the probiotic bacterial strains and production of antibodies, acid phosphatase, lysozyme and anti-microbial peptides (Mohapathra *et al.,* 2012; Panigrahi, 2007; Taoka *et al.,* 2006; Salminen *et al.,* 1999). They do not have any undesirable side effects on treated organisms.

According to Fuller (1989), a probiotic has five important characters which indicate the potential or efficiency of the probiotic in context to its use in the aquatic environment.

- Effectiveness in application
- Non-pathogenic and non-toxic
- Existing as viable cells preferably in large numbers

- Capable of surviving and metabolizing in the gut environment e.g. resistance to low pH and organic acid
- Stable and capable of remaining viable for periods under storage and field conditions

Types of probiotics

Probiotics are of two types,

(i) **Gut probiotics** – It can be blended with feed and orally administrated to increase the useful microbial flora of the gut.

(ii) **Water probiotics** – It can proliferate in aquatic medium and exclude the pathogenic bacteria by consuming all available nutrients and therefore pathogenic bacteria are eliminated through starvation (Sahu *et al*., 2008).

Microorganisms used as probiotics

Lactic acid bacteria (LAB) such as some *Lactobacillus* species are frequently used as probiotics in fish nutrition (Nayak, 2010) because they have the most promising effects on disease resistance, survival, and growth parameters for a wide variety of fish species (Nayak, 2010; Esteban *et al*., 2014; Muñoz-Atienza *et al*., 2014; Hai, 2015; Sahoo *et al*., 2015; Dawood *et al*., 2016; Gobi *et al*., 2016;). *Bifidobacterium* and some yeast may have probiotic properties (Table 2).

Table 2: Microorganisms commonly used as probiotics

Lactobacilli	Bifidobacteria	Others
L. casei Shirota	*B. longum*	*Escherichia coli* Nissle
L. rhamnosus GG	*B. bifidum*	*Saccharomyces boulardii*
L. johnsonii	*B. infantis*	*Enterococcus faecalis*
L. acidophilus	*B. lactis*	*Lactococcus lactis*
L. gasseri	*B. breve*	Propionibacteria
L. reuteri	*B. animalis*	
L. casei	*B, adolescentis*	
L. fermentum		
L. crispatus		

[Source: Kaur et al., 2002; Senok et al., 2005; de Vrese and Schrezenmeir, 2008]

Gram-positive, non-spore-forming and non-flagellated rods shaped, aero-tolerant, fastidious, acid-tolerant lactobacilli ferment the glucose into lactic acid, CO_2 and ethanol. On the other hand, gram-positive, rod-shaped, non-gas-producing, non-spore forming, catalase negative and anaerobic bifidobacteria produces acetic acid and lactic without CO_2 generation.

Beneficial effects of probiotics in aquaculture

Some beneficial effects of probiotics are described here.

1. Competition for binding sites

Probiotic bacteria bind with the binding sites in the intestinal mucosa and form a physical barrier which prevents the connection of pathogenic bacteria.

2. **Production of inhibitory substances**

   Probiotic bacteria produce a variety of chemicals like hydrogen peroxide, bacteriocins, lysozymes, proteases that are inhibitory to both gram positive and gram negative bacteria through antibacterial properties. Besides, organic acid is also produced which lower the pH of the GI track and prevents the growth of pathogenic bacteria.

3. **Competition for nutrients**

   Probiotic bacteria utilize the nutrients and competition for nutrients can play an important role in the composition of the microbiota of the intestinal tract or ambient environment of the cultured aquatic organisms. Therefore successful application of the principle of competition to natural situation is not easy and this remains as a major task for microbial ecologists.

4. **Stimulation of immune system**

   Some probiotic bacteria stimulate the immune system by increasing the production of antibodies, and also activation of macrophages, T cell proliferation and interferon production.

5. **Source of nutrients and enzymatic contribution to digestion**

   Probiotic microbes have a beneficial effect in the digestive processes of aquatic animals. Sakata (1990) reported that Bacteroides and *Clostridium* sp. have contributed to the host's nutrition, especially by supplying fatty acids and vitamins. Besides, some probiotics may participate in the digestion processes of bivalves by producing extracellular enzymes, such as proteases, lipases, as well as providing necessary growth factors (Prieur *et al*., 1990).

6. **Influence on water quality**

   Probiotics have a role to improve the water quality of the aquaculture ponds by turnover of organic nutrients in the ponds.

Application of probiotics in aquaculture

Probiotics can be administered through feeding, injection and directly to water.

a) **Application in feed**

   Probiotics are generally used in the fish feed by directly mixed with the feed ingredients or by spraying the prepared feed (Fuller, 1989). They have the capability of surviving while passing through the gut and should have the ability to flourish and settle in the gut which should be safe and effective for the host species. The commonly used probiotics in

aquaculture are *Lactobacillus* sp., *Bacillus* sp. and *Saccharomyces cerevisiae* (Akter *et al*., 2016).

b) Application through injection

Probiotics are applied by injecting to fish species through intra peritoneal route to decrease the mortality rate (experiment had done by Yassir *et al*., 2002).

c) Application to culture water

According to Venkateswara (2007), direct application of probiotics in the water exhibits beneficial effect on fish health by changing the microbial composition of the water and sediment. Among the probiotic bacteria, *Bacillus* spp., *Aerobacter* sp., *Nitrobacter* sp. and *Saccharomyces cerevisiae* (yeast) have an important role in the water quality improvement (Akter *et al*., 2016).

Case Study

1) Researchers (Swapna *et al*., 2015) had worked with two probiotics (*Bacillus licheniformis* and *Lactobacillus rhamnosus*) on Pacific white shrimp *Litopenaeus vannamei* to observe the growth performance. Probiotic fed shrimp showed significantly higher growth than the control.

2) The experiment of the Rajikkannu *et al*. (2015) suggested that *Bacillus pumilus* could be used effectively as a probiotics for the use in aquaculture.

3) Munirasu *et al*. (2017) reported that probiotic mixed diet have a role to increase the growth performance of freshwater fish *Labeo rohita* fingerlings as well as changes their proximate composition in compared with control diet of the fish.

4) A recent study (Zulfikar *et al*., 2018) have revealed that inclusion of Bactocell (*Pediococcus acidilactici*) as probiotic in feed at 0.05% level can improve growth performance, nutrient utilization and feed efficiency in *Mystus cavasius* fry.

Conclusion

Probiotics (live microorganisms) are important ingredients in aquaculture that have a role in feed conversion, growth performance, immune response, and disease resistance. They bring important health benefits such as antimicrobial effects inhibiting intestinal and food poisoning pathogens, improvement of gut functions by normalizing microflora balance, reducing constipation and improving intestinal mobility. They also improve nutrition through enhanced breakdown of vitamins, minerals and amino acids and their absorption through the intestinal walls and also have role in the management of diarrhoea. Probiotics have demonstrated the ability to prevent and treat some infections, particularly GI tract. Therefore,

the use of probiotics in fish feed should also be seen as an important step in aquaculture sustainability.

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