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A Review on Probiotics Application in Aquaculture

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Abstract

The growth of aquaculture as an industry has accelerated over the years; this has resulted in food production and positive economic impact. But the emergence of disease outbreak has been the constraint. The need for increased disease resistance, growth of aquatic organisms and feed efficiency has brought about the use of probiotics as non-antibiotic agent in aquaculture productions. There are documented evidences that probiotics can improve the water quality, growth promoters, disease resistance and enhancement of immune response. The field of probiotics as well as the selection steps to acquire probiotic strain for the management of disease in aquaculture is discussed. This report provides a summary of probiotic application and significance in aquaculture.

Keywords: Probiotics; Aquaculture; Disease outbreak; Non-antibiotic agent

Introduction

Aquaculture has grown tremendously during the last years becoming an economically important industry [1]. Today it is the fastest growing food-producing sector in the world with the greatest potential to meet the growing demand for aquatic food [2]. Although aquaculture activity in Nigeria started about 50 years ago [3], aquaculture production in Nigeria is currently about 40,000 metric tonnes contributing only 6% of domestic fish production [4]. Nigerians are high fish consumers and offer the largest market for fisheries production in Africa. Thus, Nigeria has become one of the largest fish importers in the developing world, importing about 600,000 metric tonnes annually [3].

With the increasing intensification and commercialization of aquaculture production, disease is a major problem in the fish farming industry [5]. However the utility of antimicrobial agents as a preventive measure has been questioned, given extensive documentation of the evaluation of antimicrobial resistance among pathogenic bacteria. On the other hand antibiotics inhibit or kill beneficial microbiota in the gastrointestinal (GI) ecosystem but it also made antibiotic residue accumulated in fish products to be harmful for human consumption [6]. Because of the health risks associated with the use of antibiotics in animal production, there is a growing awareness that antibiotics should be used with more care [7]. In view of the risk associated with the use of antibiotics, the development of non-antibiotic agents is one of the key factors for health management in aquaculture. According to Browdy [8], one of the most significant technologies that evolved in response to disease control problems is the use of probiotics. The term probiotic means life; it was derived from two Greek words 'pro' and 'bios' [9]. Probiotics are live microbes that can be used to improve the host intestinal microbial balance and growth performance. Development of probiotics in aquaculture management will reduce the use of antimicrobial drugs which were prophylactive alone and whose over dependence in recent times poses potential hazards to man who consume them [10]. This report summarizes the probiotics selection procedures, application and its significance in aquaculture.

Selection of probiotics

The initial major purpose of using probiotics is to maintain or re-establish a favourable relationship between friendly and pathogenic microorganism that constitute the flora of intestinal or skin mucus of fish. A successful probiotic is expected to have a few specific properties in order to certify, a beneficial effect. And in order to produce probiotics for commercialization, the following steps are to be put into consideration as in Figure 1:

A healthy source of microorganisms from a digestive tract of healthy aquatic animals must be selected.

The microorganisms with which the work is to be carried out are isolated and identified by means of selective culture.

A new culture with only the colonies of interest for conducting in vitro evaluations such as inhibition of pathogens; pathogenicity to target species; resistance conditions of host; among others are performed.

In case of the absence of restrictions on the use of the target species, experiments with in vivo supplementation, and small and large scale, are carried out to check if there are real benefits to the host.

Finally, the probiotic that presented significantly satisfactory result can be produced commercially and utilized.

Characteristics of good probiotics

Fuller [11] listed the following as features of good probiotic bacteria:

(i) It should be a strain, which is capable of exerting a beneficial effect on the host animal e.g. increased growth or resistance to disease.

(ii) It should be non-pathogenic and non-toxic.

(iii) It should be present as viable cells preferable in large numbers.

(iv) It should be capable of surviving and metabolizing in the gut environment e.g. resistance to low pH and organic acid.

(v) It should be stable and capable of remaining viable for periods under storage and field conditions.

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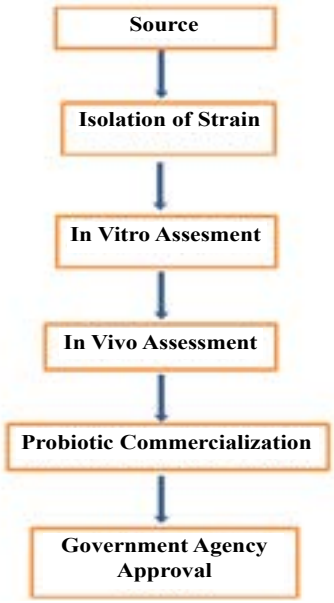

Source: Modified (Balcazar et al., 2006)

Figure 1: Flow chart for selection of probiotics

A probiotic agent with all these features has considerable advantage over antibacterial supplements such as antibiotics currently in use. They do not induce resistance to antibiotics which will compromise therapy. They are not toxic and therefore will not produce undesirable side effect when being fed and in the case of food animal will not produce toxic residues in the carcass. They may stimulate immunity whereas the immune status remains unaffected by antibiotics.

Constraints to probiotics in aquaculture

(i) Inability of strains to be produced in commercial quantities and consequent demonstration on a large scale.

(ii) Difficulty in proving performance at the farm level.

(iii) Inability of companies to conduct extensive research on how to make product specifically for aquaculture purposes.

Probiotics significance in aquaculture

There are some possible benefits linked to the administering of probiotics which have already been suggested as:

Improvement in water qualities

Nitrogenous compounds contamination such as ammonia, nitrite and nitrate in fish culture systems/ponds has been a serious concern. The susceptibility of cultured aquatic species to high concentration of these compounds is generally species-specific, but in high concentrations, these compounds may be extremely harmful and cause mass mortality in all cases. Ma et al. [12] reported the ability of *Lactobacillus spp.* JK-8 and JK-11 simultaneously removes nitrogen and pathogens from contaminated shrimp farms. In several other studies, water quality has been improved by the addition of probiotics especially Bacillus spp. [13,14]. The reason is that gram – positive Bacillus spp. according to Stanier et al. [15] are generally more efficient in converting organic matter back to CO_2 than gram – negative bacteria, which would convert a greater percentage of organic carbon to bacterial biomass or slime.

As growth promoters

It has been demonstrated experimentally that probiotics indeed may enhance the growth of fish. The ability of organisms to out-grow the pathogens in favour of host or to improve the growth of the host and yet no side effect on the host made it a probiotic bacteria.Yassir et al. [16] in attempt to use probiotic bacteria as growth promoter on tilapia (*Oreochromis niloticus*) identified that the highest growth performance was recorded with *Micrococcus luteus* a probiotic and the best feed conversion ratio was observed with the same organism. So *M. luteus* may be considered as a growth promoters in fish aquaculture. Lactic acid bacteria also had an effect as growth promoters on the growth rate in juvenile carp though not in Sea bass [17].

For disease prevention

Probiotics or their products for health benefits to the host have been found useful in aquaculture, terrestrial animals and in human disease control. These include microbial adjunct that prevent pathogens from proliferating in the intestinal tract, on the superficial surfaces and in culture environment of the culture species [13]. The effect of these beneficial organisms is achieved through optimizing the immune system of culture organism, increasing their resistance to disease, or producing inhibitory-substance that prevent the pathogenic organisms from establishing disease in the host.

Source of nutrients and enzymatic contribution to digestion

Some researchers have suggested that microorganisms have a beneficial effect in the digestive processes of aquatic animals. In fish, it has been reported that *Bacteroides* and *Clostridium sp.* have contributed to the host's nutrition, especially by supplying fatty acids and vitamins [18]. Some microorganisms such as *Agrobacterium sp.*, *Pseudomonas sp., Brevi-bacterium sp., Microbacterium sp., and Staphylococcus sp.* may contribute to nutritional processes in *Salvelinus alpinus L* [19].

Enhancement of the immune response

Among the numerous beneficial effects of probiotics, modulation of immune system is one of the most commonly purported benefits of probiotics. Fish larvae shrimps and other invertebrates have immune systems that are less well developed than adult stage and are dependent primarily on non-specific immune responses for their resistance to infection [13,20] evaluated the ability of *Lactobacillus fermentum* LbFF4 isolated from Nigerian fermented food ('fufu') and *L. plantarum* LbOGI from a beverage 'Ogi' to induce immunity in *Clarias gariepinus* (Burchell) against some selected fish bacterial pathogens.

Probiotics in aquaculture management

These organisms can be administered to the aquaculture management through feeding, injection or immersion of the probiotic bacteria [21].

Application in feed

Probiotics are applied with the feed and a binder (egg or cod liver oil) and most commercial preparation contain either *Lactobacillus sp* or *Saccharomyces cerevisiae* [22]. According to FAO and WHO guidelines, probiotic organisms used in food must be capable of surviving passages through the gut i.e. they must have the ability to resist gastric juices and exposure to bile [23]. Furthermore they must be able to proliferate and colonize the digestive tract and they must be safe, effective and maintain their effectiveness and potency for the duration of the shelf life of the product [23].

Direct application to pond water

The water probioics contain multiple strains of bacteria like *Bacillus acidophilus, B. subtilis B. lecheniformis, Nitrobacter sp, Aerobacter* and *Sacharomyces cerevisiae.* Application of probiotic through water of tanks and ponds may also have an effect on fish health by improving several qualities of water, since they modify the bacteria composition of the water and sediments [24,25].

Application through injection

Application of probiotics by injection is a possibility. Austin et al., [26] suggested the possibility of freeze-drying the probiont like vaccine and applied either through bathing, or injection. Yassir et al. [16] has demonstrated the experimental administration of probiotic *Micrococcus luteus* to *Oreochromis niloticus* by injection through intra peritoneal route which had only 25% mortality as against 90% with *Pseudomonas* using the same route. According to Yassir et al. [16,27] the use of probiotics stimulate *Rainbow trout* immunity by stimulating phagocytes activity, complement mediated bacterial killing and immunoglobulin production [17].

Conclusion

Increased use of antibiotics has led to the high proportion of antibiotic-resistant bacteria which provide threat to fish and man through consumption of the infected fish. Inefficiencies in antibiotic treatment of fish illnesses lead to significant economic losses. But the use of probiotics in aquaculture has shown to have beneficial impact on fish health and thereby economic performance of fish farming. At the same time, the use of probiotics has also important environmental benefits. By reducing the risk of diseases, the necessity of medication and thereby the risk of residues left in the environment is reduced. Therefore the use of probiotics in fish feed should also be seen as an important step in aquaculture sustainability.

Recommendations

Fish farmers and other stakeholders in aquaculture management should make use of probiotics because of its colonization ability as preventive measures against over dependency on antibiotic therapy which is costly.

Fish farmers are also encouraged to incorporate probiotics in their feed formulations because of its importance in digestibility improvement.

Close network of aquaculture experts, fish nutritionists and microbiologists necessary to develop such aquatic foods.

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