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PROBIOTICS AS LIVE BOON TO SHRIMP AQUACULTURE: A MINI-REVIEW

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ABSTRACT
Shrimp aquaculture is dominated by the marine penaeids, with the tiger shrimp (*Penaeus monodon*) being the most widely cultivated shrimp worldwide. During large-scale production, shrimps are exposed to stressful conditions; problems related to diseases and deterioration of environmental condition often happen and result in serious economic losses. Many studies have demonstrated positive effects of probiotics in disease prevention, raising juvenile shrimps and improving water quality. The benefits include better larval growth, higher survival rate, increased tolerance/ resistance to stress and diseases, modulation of digestive enzymes and immunity, reduced pathogen load and improvement of water quality. Probiotic supplements work better when taken at the beginning of a shrimp culture than when disease first manifests itself. The most highly researched probiotic bacteria as alternative to antibiotics are *Lactobacillus acidophilus, L. bulgarium, Bifidobacterium longum, B. infantis and Bacillus spp*. In this review, probiotics as alternative to antibiotic treatment, types, selection criteria and benefit of probiotics in shrimp aquaculture are being focused. Further studies are still necessary to increase the knowledge about use of probiotics to control viral infections in shrimp aquaculture production.
Keywords*:* Crustacean, Fisheries, Marine ecosystem, Mollusc, Ocean resources, Nigeria.

INTRODUCTION
The term "probiotics" comes from the Greek words "pro" and "bios" meaning "for life". It is opposed to the term "antibiotic" meaning "against life" (Hamilton-Miller, 2003). A bacterial supplement of a single or mixed culture of selected non-pathogenic bacterial strains is termed probiotics. Fuller (1989) defined probiotics as a live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance. This definition has emphasized the importance of live cells as the essential component of a potential probiotics. Probiotics, according to the currently adopted definition of the Food and Agricultural Organization and World Health Organization, are live microorganisms that when administered in adequate amounts confer a health benefit on the host (WHO, 2001).
Aquaculture is emerging as one of the most viable and promising enterprises for keeping pace with the surging need for animal protein, providing nutritional and food security to humans, particularly those residing in regions where livestock is relatively scarce. Meanwhile, shrimp aquaculture is the fastest growing animal food producing sectors in the world due to its high demand in developed countries; however, they are affected by diseases mainly caused by opportunistic pathogens and result in huge economic losses (Kumar *et al*., 2016). Conventionally, the disease control in aquaculture has relied on the use of chemical compounds and antibiotics. The development of non-antibiotic and environmentally friendly agents is one of the key factors for health management in aquaculture. Consequently, with the emerging need for environmentally friendly aquaculture, the use of alternatives to antibiotic growth promoters in fish nutrition is now widely accepted. In recent years, probiotics have taken center stage and are being used as an unconventional approach, where its application against pathogen in shrimp farming had been a novel and safe approach, promoting the innate immune response, which has been well-documented (Bidhan *et al*., 2014; Knipe *et al*., 2021). The present review reveals the types and selection of probiotics and their benefits in shrimp aquaculture.

PROBIOTICS AS ALTERNATIVE TO ANTIBIOTIC TREATMENT
During large-scale production, shrimps are exposed to stressful conditions; problems related to diseases and deterioration of environmental condition often happen and result in serious economic

losses. Prevention and control of diseases through the use of antibiotics and vaccines have been in practice throughout the world. However, the utility of antimicrobial agents as a preventive measure is doubtful, giving extensive documentation of the evaluation of antimicrobial resistance among pathogenic bacteria (Kumar *et al*., 2016). The problems from the use of antibiotics have attracted a global concern in terms of development of resistance among the pathogenic bacteria, hence the use of probiotic bacteria. The repercussion of using antibiotics in shrimp aquaculture is that it adversely affects aquatic micro-flora, leading to accumulation of harmful residues in the aquatic organism, and also develops drug-resistant bacteria and pathogens. Such *antimicrobial* resistant bacteria/ pathogens are usually transferred from shrimp to humans via the food chain. The most highly researched probiotic bacteria as alternative to antibiotics are *Lactobacillus acidophilus, L. bulgarium, Bifidobacterium longum, B. infantis and Bacillus spp*. To our knowledge, Maeda and Liao (1992) conducted the first investigations on the use of probiotics in shrimp farming, employing bacterial strain PM-4 that was initially isolated from a crustacean culture pond. However, several studies have since been conducted (Table 1).

TYPES OF PROBIOTICS

(1) Gut probiotics are being mixed with feed and administrated orally to sustain and enhance the useful microbiome of the gut. Gut probiotics are not suitable for postlarvae and juvenile shrimp culture.

(2) Water probiotics are being proliferated in water and excluded the pathogenic strains by consuming all available nutrients. Thus, the pathogenic strains can be eliminated through starvation. This type is currently used in shrimp aquaculture.

SELECTION CRITERIA

The ultimate and major need of engaging probiotics are to establish an amicable relationship between beneficial microbiome and pathogenic strains in order to persist the constituents of intestinal load of the shrimp. Probiotics must be nonpathogenic and non-toxic in order to neglect unwanted consequences while administering to shrimp. Screening of probiotics for antagonism, adhesion and challenge tests in vitro etc., are essential things (Fig. 1).

BENEFITS OF PROBIOTICS

(1) Growth Promoters: Probiotics have growth promoting effect on shrimp either by direct involvement in nutrient uptake or by providing nutrients. Among the large number of probiotic products in use today are bacteria spore formers, mostly of the genus *Bacillus*. *Bacillus fusiformis* improved the survival and accelerated the metamorphosis of *P. monodon* and *L. vannamei* (Guo *et al.*, 2009).

(2) Disease Prevention: The effect of these beneficial organisms is achieved through optimising the immune system of culture shrimps, increasing their resistance to disease or producing inhibitory substance that prevents the pathogenic organisms from establishing disease in the host. Among 80 bacterial strains isolated from healthy wild shrimp *L. vannamei*, *Vibrio* P62, *V.* P63, and *Bacillus* P64 show inhibitory effects against *V. harveyi* (S2) at 54%, 19%, and 34%, respectively (Hai *et al.*, 2009). Moreover, *Bacillus* P64 shows both probiotic and immunostimulatory features, while *Vibrio* P62 only shows good probiotic properties (Gullian *et al.*, 2004). *Bacillus* spores have been used as biocontrol agents to reduce vibrios in shrimp culture facilities where *Bacillus* spp. are often antagonistic against other microorganisms, including fish and shrimp pathogen bacteria (Rengpipat *et al*., 2000).

(3) Water Qualities: Probiotics have been reported to regulate microflora; enhance the decomposition of the undesirable organic substance; improve ecological environment by minimizing the toxic gases like NH_3, N_2O, H_2O_2, methane, etc.; and increase population of food organism in culture water. The introduction of *Bacillus spp.* in close proximity to pond aerators reduces chemical oxygen demand and increases shrimp harvest (Porubcan, 1991).

Table 1: Effect of probiotic on shrimp aquaculture

Species (Probiotics)	Isolated from	Doses/duration	Shrimp species	Parameters investigated	References
Enterococcus Faecium	Shrimp gut	2–4 × 10^8 CFU g^{-1} feed/ 42 days	*Litopenaeus vanname*	↑ Survival, adhesive activity, expression of immune and digestion related genes in the mid gut	Sha *et al*. (2016)
Lactobacillus lactis	shrimp intestine	2–4 × 10^8 cells g^{-1}/16 days	*L. vanname*	↑ Haemolymph PO activity, relative mRNA expression of LvproPO1, LvproPO2 and resistance against *V. parahaemolyticus*	Chomwong *et al*. (2018) Adel *et al*. (2017)
E. Faecium	Shrimp intestine	Not available	*Penaeus monodon*	↑ Growth and resistance against *Vibrio*	Shefat (2018)
Lb. acidophilus	Homemade curd	10^5 CFU g^{-1}/30 days	*L. vanname*	↑ Resistance against *V. alginolyticus*	Sivakumar *et al*. (2012)
Lb. acidophilus	Homemade curd	10^6 cells·g^{-1}/ one month	*Macrobrachium rosenbergii*	↑ Growth and resistance against *Vibrio spp*.	Khan and Mahmud (2015)
Lb. Lactis	shrimp intestine	105 CFU g^{-1}/7 days	*Marsupenaeus japonicus*	↑ Up regulation of lysozyme gene expression in intestine and hepatopancreas, and resistance against *V. penaeicida*	Maeda *et al*. (2014)
Lb. plantarum	Intestine of rainbow trout	0, 107 (LB7), 108 (LB8), and 109 (LB9)	*Astacus leptodactylus*	↑ Total haemocyte count, semi granular cells, hyaline cells count	Valipour *et al*. (2019)
Lb. rhamnosus	Gut of female P. pelagicus	106, 5 × 106 and 107 CFU mL-1/14 days	*P. pelagicus*	↑ Growth and digestive enzyme (protease and amylase) activities by multiple probiotics	Talpur *et al*. (2012)
Streptococcus cremoris	Shrimp intestine	5 × 106 cells g-1/4 weeks	*P. indicus*	↑Resistance against *V. parahaemolyticus*	Ajitha *et al*. (2004)
Pediococcus acidilactici	Commercial probiotic	107 CFU g-1 feed/1 month	*Litopenaeus stylirostris*	↑ Antioxidant status, resistance against V. nigripulchritudo	Castex *et al*. (2010)

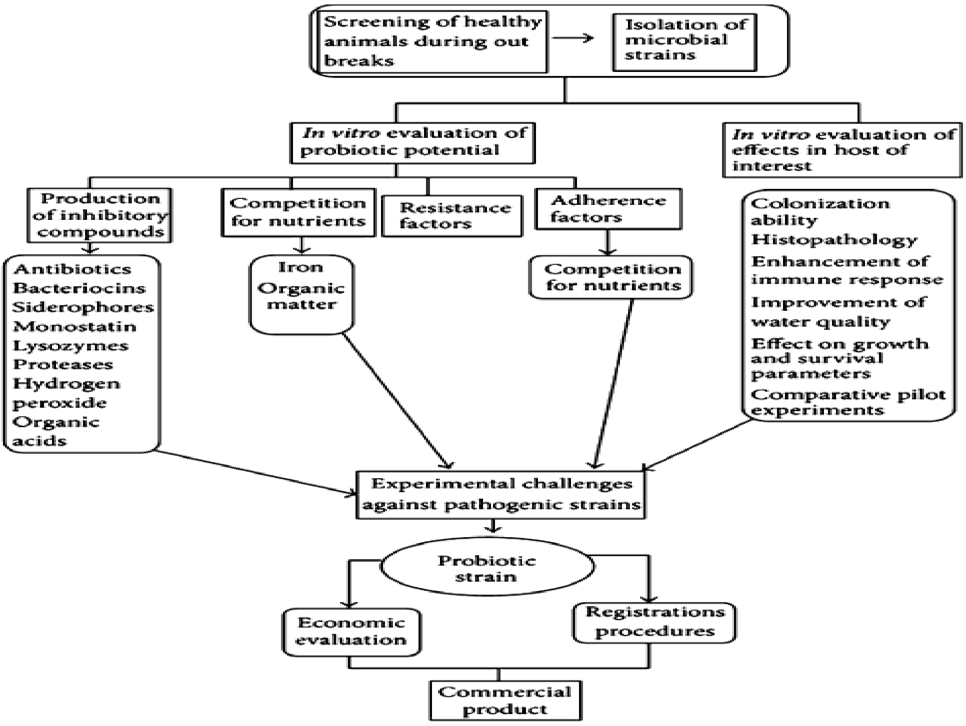

Figure 1: Procedure for evaluation of probiotic potential of microbial strain for shrimp aquaculture (Lakshmi *et al*., 2013)

CONCLUSION AND FUTURE PROSPECTIVE

Due to the abuse or improper use of antibiotics as well as the genes that cause antibiotic resistance in opportunistic pathogens like *Vibrio* species, the incidence of infectious illnesses in shrimp aquaculture is a severe issue. It is an innovative and secure strategy to employ probiotics in shrimp farming to combat disease. Probiotics, live microorganisms that, when administered in adequate amounts, confer a health benefit on the host, offer an alternative to antibiotics and have become popular among shrimp farmers for use in the regulation of pond water quality, promotion of shrimp growth and the prevention of disease. The most highly researched probiotic bacteria are *Lactobacillus acidophilus, L. bulgarium, Bifidobacterium longum, B. infantis* and *Bacillus spp*. According to the literature and findings that are now accessible, probiotic supplements work better when taken at the beginning of a culture than when disease first manifests itself. Therefore, the best recommendation is to add probiotics in the shrimp normal diet to help protect it from various infections and maintain its health, which raises its market value. The use of probiotics for bacterial illnesses like vibriosis is well known, but research on the real strains of bacteria for viral illnesses is still needed.

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