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Dietary supplementation of *Bacillus licheniformis* HGA8B improves growth parameters, enzymatic profile and gene expression of *Oreochromis niloticus*

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ABSTRACT

The current study was designed to investigate the probiotic potential of a *Bacillus licheniformis* strain HGA8B in the fish tilapia (*Oreochromis niloticus*). Fish were fed with the feed containing two levels such as 1×10^6 and 1×10^8 CFU g^{-1} of the probiotic bacterium for sixty days. The investigation revealed that the probiotic bacterium could significantly ($P < .05$) increase growth parameters such as weight gain, specific growth rate, feed conversion ratio and hepato-somatic index. The probiotic preparation modulated digestive and antioxidant enzyme activity. Growth-related genes such as growth hormone receptor genes (GHR-1 and GHR-2) and insulin-like growth factor genes (IGF-1 and IGF-2) were significantly modulated in the liver tissue. The expression of IGF-1 gene was significantly increased in the muscle tissue. Significant up-regulation of immune-related genes marked by an increase in TLR-2 and anti-inflammatory cytokine such as IL-10 was recorded. All these results show that the probiotic preparation can benefit pisciculture.

1. Introduction

Probiotics are live beneficial microorganisms which confer health benefits when administered in required amount (Guardiola et al., 2016; Carbone and Faggio, 2016; Faggio et al., 2015; Nath et al., 2018; Aragona et al., 2018; Rashidian et al., 2018). Probiotics are integral parts of aquaculture practices recently for getting a high yield of aquaculture produces (Hossein et al., 2018; Capillo et al., 2018). The application of probiotics in nutrition, growth, immune modulation, disease resistance and other advantageous in fish have been proven beyond any distrust (Elumalai et al., 2019; Anjugam et al., 2018; Van Doan et al., 2018). Fish is one of the species which is most studied in the field of probiotics and nutrition because fish is the richest sources of protein and considered the fastest developing food processing industry around the globe. Since we obtain 25% of our protein requirement, from fish and shellfish their demand is ever increasing (Nayak, 2010). A lot of microorganisms have been recognized as potent probiotics for aquaculture practices. The dominant group of probiotics used in aquaculture belongs to the group of gram-positive bacteria especially *Bacillus*, *Lactobacillus* and *Bifidobacterium* groups (Cruz et al., 2012). They are also reported to produce digestive enzymes such as amylase, lipase, protease (Kar and Roy, 2008), antibiotics, bacteriocins, lysozymes and also modulate antioxidant and immunological responses in fish (Cutting, 2011; Burgos-aceves et al., 2016; Trischitta and Faggio, 2008; Lauriano et al., 2016; Burgos-aceves et al., 2018; Savoca et al., 2019; Faggio et al., 2011; Neethu et al., 2018a, 2018b).

There are several genes responsible for the growth of the fish. Among them, growth hormone receptor genes such as GHR-1 and GHR-2, growth factor genes such as insulin-like growth factor-1 (IGF-1) and IGF-2 are important (Le Roith et al., 2001). The growth factors are produced either by endocrine stimulation by growth hormone (GH) or paracrine/autocrine stimulation by the tissue. The GH-IGF axis is the major growth and tissue proliferation channel in most of the vertebrate species. Studies have shown that the growth promoting effect of any kind of feed additives have a direct or indirect effect on growth factors as well as growth hormone (Reinecke et al., 2005). The gut is the preliminary targets for the functioning of probiotic strains especially in the case of immune modulation because it is the place where probiotics establish and interact with the host body. Fish gut lack Peyer's patches, the major immune functioning modules in the vertebrate gut immune system. The major immune functioning module present in the fish gut is the gut-associated lymphoid tissue (GALT). Secretory Ig A, antigen transporting M cells, diffusely arranged lymphoid cells, macrophages, and granulocytes are the major immune functioning system in the fish

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