



# Combined effects of dietary bovine lactoferrin, *Lactobacillus plantarum*, and xylooligosaccharide on hemato-immunological and digestive enzymes of silvery-black porgy (*Sparidentex hasta*) fingerlings

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## Abstract

A 6-week study was conducted to evaluate the effects of the following eight experimental diets, which varied in bovine lactoferrin (LF), xylooligosaccharide (XOS), and *Lactobacillus plantarum* (LP) as probiotic silvery-black porgy (*Sparidentex hasta*) juveniles including control (diet 1), 400 mg kg<sup>-1</sup> LF + 5 g kg<sup>-1</sup> XOS (diet 2), 400 mg kg<sup>-1</sup> LF + 10 g kg<sup>-1</sup> XOS (diet 3), 400 mg kg<sup>-1</sup> LF + 1 × 10<sup>6</sup> CFU g<sup>-1</sup> LP (diet 4), 800 mg kg<sup>-1</sup> LF + 5 g kg<sup>-1</sup> XOS (diet 5), 800 mg kg<sup>-1</sup> LF + 10 g kg<sup>-1</sup> XOS (diet 6), and 400 mg kg<sup>-1</sup> LF + 1 × 10<sup>6</sup> CFU g<sup>-1</sup> LP (diet 7). Growth performance and humoral immune responses were not affected by different experimental groups ( $P > 0.05$ ). Hematological parameters including red blood cell count, hemoglobin content, and hematocrit increased by supplementing diets with different combinations of immunostimulants ( $P < 0.05$ ). Fish fed diet supplemented with 800 mg kg<sup>-1</sup> LF + 5 g kg<sup>-1</sup> XOS had highest total protease (1.0 ± 0.1 U mg protein<sup>-1</sup>) and α-amylase (34.9 ± 2.3 mg protein<sup>-1</sup>) activities ( $P < 0.05$ ). Our results suggest that diets supplemented with selected levels of LF, XOS, and *L. plantarum* could not improve growth performance and humoral immunity, however improved hematological and digestive enzyme activities in *S. hasta* fingerlings.

**Keywords** Hematology · Intestine flora · Immunostimulants · Prebiotic · Probiotic · Sparidae

## Introduction

Immunostimulants can be used as a sustainable way for reducing antibiotic usage in aquaculture (Dawood et al. 2017; Wang et al. 2017). Various immunostimulants [e.g., lactoferrin (LF) as

a multifunctional immune protein, xylooligosaccharides (XOS) as a prebiotic, and probiotics such as *Lactobacillus plantarum* (LP) as functional feed ingredients] have been proven to induce specific and non-specific cellular and humoral immune responses through increasing and the maintenance of lactic acid-producing bacteria (LAB) and producing antimicrobial substances in the host intestine (Mussatto and Mancilha 2007; Achary and Prapulla 2011; Akhter et al. 2015; Giansanti et al. 2016; Liu et al. 2016; Vallejos-Vidal et al. 2016; Wang et al. 2017). Several studies conducted on the effects of above mentioned immunostimulants on growth performance (Son et al. 2009; Mohammadian et al. 2017; Pagheh et al. 2017) and immunological responses (Kumari et al. 2003; Son et al. 2009; Welker et al. 2010; Van Doan et al. 2016; Pagheh et al. 2017). Moreover, the positive effects of the abovementioned stimulants on digestive enzyme activities and intestine microflora of fish were reported in different fish species (Xu et al. 2009; Geraylou et al. 2012; Hosseinfar et al. 2014; Dawood et al. 2015a, b; Mohammadian et al. 2017; Pagheh et al. 2017).

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