

Feature Review

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Evaluation of Probiotic Applications in Healthy Farming of Grass Carp (*Ctenopharyngodon idella*)

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Abstract Probiotics have emerged as an important strategy for promoting sustainable and healthy aquaculture by improving growth performance, enhancing immunity, and maintaining ecological balance. Grass carp (*Ctenopharyngodon idella*) is one of the most widely cultured freshwater fish species; however, intensive farming practices often lead to microbial imbalance, disease outbreaks, and reduced production efficiency. This review summarizes the application effects of probiotics in grass carp aquaculture, focusing on their regulatory mechanisms and practical benefits. Probiotics can improve feed utilization, stimulate digestive enzyme activities, maintain intestinal microbial homeostasis, and enhance nutrient absorption. Moreover, they contribute to improved antioxidant capacity, immune responses, and resistance against bacterial pathogens. The application of probiotics also plays an important role in regulating water quality by reducing harmful microorganisms and promoting environmentally friendly aquaculture systems. A case study of compound probiotic preparations demonstrates their potential in improving growth performance, intestinal microbiota composition, disease resistance, and economic benefits. Despite these advantages, challenges remain regarding strain selection, functional stability, and precise application strategies. Future research integrating omics technologies and targeted microbial regulation will further promote the development of probiotic-based green aquaculture technologies for grass carp production.

Keywords Probiotics; Grass carp (*Ctenopharyngodon idella*); Intestinal microbiota; Immune regulation; Healthy aquaculture

1 Introduction

Grass carp (*Ctenopharyngodon idella*) is one of the most important freshwater aquaculture species, with very large global production and particular importance in China as an affordable source of aquatic animal protein (Gharti et al., 2023). It is also described as an important economic fish whose germplasm resources are strategically important for the stable supply of high-quality aquatic protein and for the sustainable development of the industry. Projections indicate that grass carp production in China alone may exceed 6.4 million tons by 2030, underscoring the continuing expansion and economic weight of this farming sector. At the same time, aquaculture more broadly remains the fastest-growing animal food production sector and is under increasing pressure to provide food security while improving environmental performance (Fachri et al., 2024). This tension is especially relevant to grass carp culture, because production growth has been accompanied by rising concern over pollution, eutrophication, and resource use, with life-cycle assessment showing that feed processing and water pollution are major contributors to the environmental burden of commercial grass carp production. Farm-level studies also show that culture environment strongly shapes production outcomes: poor pond water quality reduces output, product quality, and profit, whereas improved systems and management can enhance fish quality. Because grass carp is an herbivorous species with distinctive nutritional physiology and high forage intake capacity, healthy farming must integrate suitable feeding, water-quality maintenance, welfare, and disease prevention rather than focus on yield alone (Pedrazzani et al., 2022). This broader healthy-aquaculture perspective is reinforced by welfare-based work showing that nutritional and environmental conditions are directly linked to stress resistance and gut health in cultured grass carp. Even relatively simple production studies in ponds indicate that grass carp can achieve strong growth under different plant-based feeding regimes, but survival, feed conversion, and water-quality stability depend on how culture conditions are managed. Together, these findings show that the