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Saccharomyces cerevisiae as probiotics in aquaculture

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Abstract
Probiotics (originated from the Greek words *pro* and *bios*, which means for life) are beneficial microorganisms and their products, having the beneficial effects on the host. It is being recently used in aquaculture to control diseases and also treated as supplements for improving growth and in some cases as a means of replacing antimicrobial compounds. Besides, enhancing growth performance and improving haematological parameters of fishes, it also improves water quality which is considered as most important for freshwater fish habitat as fishes are extremely sensitive to changes in environmental factors *viz.*, temperature, water salinity, oxygen level *etc*. Thus, this review summarizes current studies regarding the effects of probiotics on growth performance, haematological parameters of various fishes and water quality.

Keywords: probiotics, *Saccharomyces cerevisiae*, growth performance, haematological, water quality parameters

Introduction
World aquaculture has grown tremendously and it is transforming itself into an economically important industry during the past few decades. In todayToday, it is the fastest-growing food-producing sector with the potential to meet the growing demand for aquatic food [21]. In India, about 85% of total aquaculture production is contributed by carps i.e., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* which are simultaneously becoming the dominant fish species in the aquaculture system in Southern Asia [26]. The total fish production has reached to 12.60 million metric tons during 2017-2018, of which inland and marine sectors contributed 65% and 45% respectively and; culture and capture fisheries contributed equally. Presently, India is at 2nd spot in the world in terms of total fish production with the contribution of 6.3% [27]. In south India, a major contribution to freshwater fish production is by *C. catla* [20].

Probiotics
Probiotics originally termed as *probiotika* (originated from Greek words, *pro* and *bios*, which means for life) are beneficial microorganisms and their products, having the beneficial effects on the host. It is being recently used in aquaculture to control diseases. It is also treated as supplements for improving growth and in some cases as a mean of replacing antimicrobial compounds [23]. Besides enhancing growth performance and improving haematological parameters of fishes, it also improves water quality which is considered as most important for freshwater fish habitats as fishes are extremely sensitive to changes in environmental factors *viz*., temperature, water salinity, oxygen level *etc*. The use of probiotics becomes important to maintain water quality for achieving better fish growth and survival. Simultaneously, to improve the growth performance and feed efficiency of cultured fish, feed quality and feeding methods are required to be thoroughly considered. Several studies have suggested that probiotic supplementation can reduce disease outbreaks by enhancing the immune system i.e., haematological parameters of fishes and hence, it decreases the culture cost by improving the growth and feed efficiency [3]. Probiotic bacteria prevent the colonization of pathogenic bacteria in the fish intestine [6] by competing for adhesion sites on the intestine folds and inner lining and other tissue surfaces. These also produce small amounts of certain B-vitamins including foliates, vitamin K and C, hence has nutritional significance to the fishes [5].

Mode of action of probiotic

The reported mode of action of probiotics [11] which is as follows:

1. stimulation of the humoral or cellular immune system;
2. alteration of microbial metabolism caused by an increase or decrease in the level of a relevant enzyme;
3. Competitive exclusion occurs when a probiotic antagonizes a potential pathogen by producing inhibitory compounds or competing for nutrients, space (adhesion sites in the digestive tract), or oxygen.

***Saccharomyces cerevisiae* as probiotic**

The research on the effects of *Saccharomyces cerevisiae* on survival rate and growth performance of convict chichlid (*Amatitlania nigrofasciata*), that it increased growth rate at 2% concentration of probiotic *S. cerevisiae* and also reported the best SGR, FCR and BWG at this concentration [17]. It had studied and evaluated the effect of three kind of probiotics, two bacteria and one yeast (*S. cerevisiae*) on the growth performance of Nile Tilapia and assessed in his research that among all treatments, the 40% protein diet supplemented with *S. cerevisiae* showed best growth performance and feed efficiency; and accordingly it was recommended that yeast (*S. cerevisiae*) is a beneficial growth promoting supplement in tilapia rearing [10].

Effect on growth parameters

The effects of probiotics on growth, survival and body composition of Nile tilapia observed and revealed that fish growth was improved in comparison of control diet and the survival was higher in probiotic supplemented feed than that of control diet and it was also observed that *S. cerevisiae* had more positive effect on growth as compared to *Bacillus subitilis* [19]. Further, effect of dietary probiotic mixture on haemato-immunology and cell apoptosis assessed wherein it was found that probiotic fed fish showed better growth performance than non-probiotic fed fish [16]. It was also observed that in probiotic fed fish, blood glucose level was lower in comparison to non-probiotic fed fish [17] and the observed similar results were observed by using different level of *S. cerevisiae* (1.0, 1.5 and 2%) in diet [9] and found best results for growth parameters of catfish at 2% concentration of yeast (*S. cerevisiae*) as it contains various immunostimulating compounds such as β-glucan, nucleic acids, mannan oligosaccharides and chitin; hence recommended for fish growth [8].

Recently, it was investigated on Nile Tilapia reared under different salinities fed with different diets; supplemented diet with 0.5% *S. cerevisiae* and basal diet, where it was observed that fish fed with yeast supplement diet and reared at 5 ppt water salinity had significantly better (p=0.05) growth performances in terms of weight gain (WG), specific growth rate (SGR), and average daily growth gain (ADG) than fish fed with basal diet. Thus, under salinity treatments, Nile Tilapia fed a 0.5 percent yeast supplement diet which showed improved growth performance, body composition, and blood chemistry [24]. A research was conducted to assess the effects of commercially available baker's yeast as a feed additive on freshwater catfish, *Mystus cavasius* growth performance, feed utilisation and disease resistance. It was found that the growth parameters (survival rate, weight gain, specific growth rate, and protein efficiency ratio) observed were remarkably (P <0.05) higher in fish fed experimental diets T2 (0.5g yeast/kg), T3 (1.0g yeast/kg) and T4 (1.5g yeast/kg) than in control T1, and T3 fed fish achieved significantly higher growth as compared to T2 and T4, henceforth the results showed that yeast supplementation is a promising growth promoter and could be an alternative to antibiotics for *M. cavasius* disease prevention [4].

The effect of *S. cerevisiae* was investigated at different concentrations (0.5%, 1%, 2%) and observed that growth rate significantly increased in fishes fed with probiotic, *S. cerevisiae* notably at 2% probiotic level of concentration and also the best FCR, SGR, BWG values were observed at 2% level. Thus, results suggested that this yeast could improve feed utilization in fish [17]. While use of live baker's yeast (*S. cerevisiae*) in diet to promote growth performance of Galilee Tilapia, *Sarotherodon galilaeus* (L.) and its resistance to environmental copper toxicity in three treatments T1, T2 and T3 where fish were fed with basal diet and in treatment T4, T5 and T6 where fishes were fed with yeast supplemented diet. Results obtained for growth performance was high in yeast supplemented treatment diet, which indicated *S. cerevisiae* as a growth promoter [2]. Similar positive results were observed on *Huso huso* with dietary commercial inactive brewer's yeast supplemented feed at 1% or 2% concentration, indicated 2% yeast supplementation remarkably enhanced final weight, weight gain, FCR, SGR compared to control treatment. So, they assessed that low level brewer's yeast could be used as growth enhancer for *H. huso* [15].

In the same way the role of dietary commercial brewer's yeast, *S. cerevisiae* on growth parameters at different concentration level of 0.5, 1.0, 2.0, 3.0 and 5.0 g/kg diet observed and founded that fishes which were fed with probiotic attained high body weight gain and specific growth rate than control fed fishes. They also found that 2g/kg conc. of yeast is optimum for growth of fishes in their study [13].

Effect on haematology

The effect of probiotic (*Lactobacillus acidophilus*) on haematological parameters of *C. catla* (Hamilton) was studied and observed a positive effect represented by significant increase in RBC count, Hb%, HCT% and red cell indices like MCV, MCH and MCHC [20]. A similar positive effects were also observed on influence of probiotics on growth performance and digestive enzyme activities among common carp (*C. carpio*) in which she compared probiotic supplemented and normal feed and suggested that the addition of probiotics in feed reduces the culture cost of common carp by making it free from disease outbreaks [22]. A study conducted on *Clarius batrachus* L. also supported these results, in which effect of three probiotics on four haematological parameters *viz.*, level of haemoglobin, total erythrocyte count, total leucocytes count hematocrit/packed cell volume of Indian magur (*C. batrachus* L.) was studied over a period of eight weeks and observed that level counts of hematological parameters showed significant increase in the blood of fish treated with probiotics alone versus control [6, 7].

The effect on haematological parameters of *L. rohita* by using *S. cerevisiae* at different concentrations of 5%, 7.5% and 10% and found highest TEC, Hb and HCT in 5% supplemented diet fed fishes and lowest TEC, Hb and HCT recorded in control group [25]. A similar positive effect was recorded in a research work on *Oreochromis niloticus* fed with different biotic forms of *S. cerevisiae*, wherein it had examined haematological parameters and reported increased erythrocyte

count, PCV, Hb and TLC in experiment group than control group [8]. Another similar kind of results were found in study on fry Nile Tilapia fed with commercial live baker's yeast supplemented at different level of concentration, 0.25, 0.50, 1.0, 2.0 and 5.0g yeast/kg. They observed higher Hb, RBC's and Ht values in fishes fed with diet containing 1.0-5.0g yeast/kg than control group fishes [1].

A study conducted to evaluate the effect of dietary probiotic, *L. acidophilus* and *S. cerevisiae* at a concentration of 10^8 cfu/ml. Three isocaloric (3500 Kcal metabolizable energy kg^{-1}dry matter) and isonitrogenous (300 g CP kg^{-1}dry matter) diets were formulated and probiotics were mixed in the experimental diets. The highest haemoglobin (Hb), red blood cells count (RBCs), hematocrite (Hct), and also the lowest mortality rate were recorded for fish which were fed the diet supplemented with *S. cerevisiae* compared to the other two groups [14]. In a study examined on *Channa striata* with feed containing two commercial probiotics (*S. cerevisiae*, *L. acidophilus*), three prebiotics (β-glucan, GOS or galacto-oligosaccharide, MOS or mannan-oligosaccharide) and a control, over 8 weeks of the feeding trial, order of the hematological parameters observed was LBA > L yeast > ß-glucan > MOS > GOS > control [18].

Effect on water quality

The effects of dry yeast levels on some water quality parameters were studied and observed that probiotic supplemented feed enhanced good water quality at highest level concentration [3]; while [12] had assessed yeast as a dietary additive in recirculating aquaculture system wherein the positive effects on hematological parameters and water quality in common carp culture within prescribed levels were observed by him. The positive effects of different probiotic bacteria on growth, body composition, immune response and haematological parameters of rainbow trout (*Oncorhynchus mykiss*) under sub-lethal water temperature [28].

The water physiochemical parameters were observed with in admissible range for fish growth. In all treatments, ammonia was in range of 0.04 to 0.14 mg/L, DO (dissolved oxygen) concentration measured was in range from 4.3 to 6.7 mg/L and pH was 7.2-8.0 in their experiment on fry Nile Tilapia fed with commercial live baker's yeast, *S. cerevisiae* supplemented feed [1]. The similar positive results were observed by [4] in his study on cat fish, *Mystus cavasius* fed with probiotic yeast, *S. cerevisiae* and also observed throughout culture period, the admissible range of water parameters that were good for growth rate and production of *M. cavasius* and also the efficacy of three commercially available probiotics P1, P2 and P3 consisting of mainly *Bacillus* spp. and nitrifying bacteria against *Vibrio* spp. loads in mass culture tanks of the rotifer *Brachionus plicatilis* was observed. In triplicates, all the tanks were inoculated with 50 rotifers ml^{-1} and were fed with *Nannochloropsis oculata* at a density of 1×10^7 cells ml^{-1}. On each alternate day, all the experimental tanks were treated with probiotics at a concentration of 1×10^4 cfu ml^{-1} and the experiment was carried out for one week. The result showed a significant increase in rotifer density and also in the elimination of *Vibrio* spp. in rotifer mass culture tanks.

Conclusion

As it is clear from our review that various studies were conducted with various types of probiotics and probiotic yeast, *S. cerevisiae* on different fishes had positive effects on fish growth performance, haematology, body composition which also boosted immunity of fishes. *S. cerevisiae* used as probiotics on various fishes showed a positive effect on growth and haematology. Therefore, in the near future, it is necessary to conduct more research relating to effect of *S. cerevisiae* on some other commercially important fish like *C. catla* to observe its effect on growth and blood parameters.

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