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Research Article

Immune Stimulatory Effects of Saccharomyces Cerevisiae in shrimp (*Penaeus vannamei*) Diets

Govindharaj Sathish Kumar[1,2]*, Nathan Felix[2], Elangovan Prabu[2] and Kalidoss Manikandan[2]

[1]*Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Institute of Fisheries Post Graduate Studies (IFPGS), Chennai, India*

[2]*Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Directorate of Incubation and Vocational Training in Aquaculture (DIVA), Chennai, India*

***Corresponding Author:** Govindharaj Sathish Kumar, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Institute of Fisheries Post Graduate Studies (IFPGS), Chennai, India.

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Abstract

Pacific white shrimp (*Penaeus vannamei*) culture is the dominant shrimp aquaculture practice worldwide owing to the advantages of having high growth performance, good flesh taste, and high consumer preference. However, shrimp diseases caused by bacteria and viruses frequently lead to serious economic losses for shrimp aquaculture industries. As a consequence, the application of antibiotics and chemotherapeutants has been increased to prevent disease outbreaks, and as a result, the aquaculture industries have been polluted. Therefore, various alternative methods have been developed to prevent shrimp production from disease outbreaks. Yeast is a microbial ingredient and it has been widely used for a very long time as an application of probiotics to prevent diseases and improve the health status of shrimp through feed or water. In recent years, due to their good nutrient profile and bioactive contents, various yeast and yeast products have been used as either ingredient or additive in aqua diets to protect against diseases through increasing the immune responses of various commercial farmed shrimp and fishes. Therefore, this article is designed to discuss the importance of Saccharomyces cerevisiae in the Pacific white shrimp diet as well as the effects of growth performance, immune stimulants, and antioxidant status on the Pacific white shrimp.

Keywords: Alternative to Antibiotics; Feed Additive; Immune Stimulant; Pacific White Shrimp; *Saccharomyces Cerevisiae*

Introduction

Among the crustacean species, the intensive culture of *Penaeus vannamei* is practiced widely around the world, and it accounts for the largest percentage of the world's annual yield of penaeid shrimp, due to its rapid growth, tremendous economic value, tender flesh, and high nutritive value [14]. However, due to the occurrences of disease outbreaks like bacterial, viral and fungal diseases, the cultivation of *P. vannamei* has led to substantial economic loss in the shrimp industry in recent years [22]. In particular, due to the outbreaks of *vibriosis*, the *P. vannamei* aquaculture industry has faced significant economic losses [19]. Generally, the application of chemotherapeutic agents and antibiotics are the two critical ways to prevent the outbreak of diseases in shrimp aquaculture. On the other hand, widespread use of those drugs over time may result in the development of resistant pathogenic bacteria, the eradication of beneficial bacteria, drug residues, and the accumulation of toxic chemicals within the aquaculture environment, posing a threat not only to cultured animals but also to humans [9]. For that reason, alternative methods like the application of probiotics and prebiotics have emerged to replace currently employed methods and improve the health status of aquatic animals. Recently, improvement of the health status of cultured animals through dietary supplementation of yeast (*Saccharomyces cerevisiae*) products has drawn more attention, due to better stability and richer and more

direct functionality [15]. Therefore, this article has designed to review the applications of yeast (*S. cerevisiae*) products in shrimp (*P. vannamei*) diet.

Yeast (*Saccharomyces cerevisiae*)

Yeast (*S. cerevisiae*) is a single cell-protein, which has been used as a probiotic over the years in shrimp aquaculture industries to enhance immunity, growth, and protection against pathogen infections. Previous studies have reported that dietary supplementation of yeast culture as either ingredients or additives has enhanced the growth performance of aquatic animals such as *P. vannamei* [6; 14; 5 and 27], Gibel carp [26] and Nile tilapia [7] through improving the internal microbiota, immune function, and inhibiting the pathogens of the digestive tract. Yeast culture is a micro-ecological product formed by the anaerobic fermentation of yeast with a specific medium, which consists of yeast extracellular metabolites, fermented medium, and inactive yeast cells [26]. Besides, it contains nutrient such as protein, lipid, B-Vitamins, β-glucan, chitin, nucleic acid, mannan oligosaccharides (MOS) and some unknown growth factors [12].

References	Ingredient	Substrates used	Production conditions		
			Inoculation level	Time	Temperature
Zhang., *et al*. 2022 [27]	Yeast culture (*S. cerevisiae*)	Soybean meal, glucose and gluten	5 x 10^8 CFU/g	48hr	60-70°C
Burgents., *et al*. 2004 [6]	Yeast culture (*S. cerevisiae*)	molasses, ground yellow corn, hominy feed, corn gluten feed, wheat middlings and rye middlings	-	-	-

Table 1: Substrates and production conditions of yeast culture.

Proximate composition	Yeast culture	Hydrolysed yeast (Rhodotorula mucilaginosa)	Yeast hydrolysate (*S. cerevisiae*)	Brewer's yeast (*S. cerevisiae*)	Hilyses (commercial *S. cerevisiae* fermented product)
Crude protein	67.72	17	56.50	53.83	-
Crude lipid	3.18	-	0.50	0.50	-
Nucleotides	-	-	-	-	6.3
β-glucan	0.42	24.3	-	-	23.5
Mannose oligosaccharide	0.47	14.2	-	-	14.2
Inosine monophosphate	0.006	-	-	-	-
Uridine monophosphate	0.002	-	-	-	-
Cytidine monophosphate	0.004	-	-	-	-

Table 2: Nutritional composition of yeast culture (%of dry matter).

Source: [14; 26; 1 and 7].

Amino acid composition	Yeast culture (*S. cerevisiae*)	Yeast hydrolysate (*S. cerevisiae*)	Brewer's yeast (*S. cerevisiae*)	Hydrolysed yeast (*Rhodotorula mucilaginosa*)
Essential amino acid				
Threonine	2.61	2.16	2.14	0.71
Valine	3.75	2.44	2.39	0.86
Methionine	1.68	0.66	0.64	0.26
Isoleucine	2.79	2.14	2.07	0.71
Leucine	4.62	3.26	3.13	1.10
Phenylalanine	2.65	1.90	1.83	0.70
Lysine	5.52	3.45	3.22	0.87
Histidine	1.47	1.25	1.09	0.81
Arginine	3.64	2.04	2.20	0.67
Cystine	0.88	0.50	0.46	-

Non-essential amino acid				
Aspartic acid	4.64	4.25	4.16	1.29
Serine	3.64	2.33	2.14	0.79
Glutamic acid	7.83	9.80	9.65	1.83
Glycine	3.91	4.39	4.28	1.06
Alanine	2.78	3.01	2.95	1.09
Tyrosine	1.28	1.21	1.20	0.36
Proline	4.62	1.63	1.54	0.79

Table 3: Amino acid composition of various yeast-based ingredients (% of dry matter).

Source: [26 and 7].

Effects of growth performance of *P. vannamei*

Dietary supplementation of yeast culture significantly improved the specific growth rate and survival and significantly reduced the feed conversion ratio in *P. vannamei* diets [4]. Similarly, dietary supplementation of yeast culture and yeast hydrolysate or brewer's yeast has increased the weight gain rate, specific growth rate, and decreased the feed conversion ratio of juvenile shrimp [14; 22; 4 and 5]. Besides, dietary supplementation of yeast and yeast extract significantly does not alter the growth parameters like weight gain rate, specific growth rate, and survival in juvenile *P. vannamei* diets. [27] Has reported that, dietary level of 4% of fish meal can be replaced by yeast culture in *P. vannamei* diets.

Effects of intestine morphology

Shrimp intestine is an important organ for nutrient breakdown and absorption as well as protection against pathogenic infections, and thus plays an important role in growth as well as improving the host animals immunity. According to previous studies, increased villus height, width, and villus height: crypt depth ratio are usually correlated with nutrient absorption efficiency and healthier digestive tracts. The intestinal villus height and crypt depth ratio were increased while increasing the dietary supplementation level of yeast culture in *P. vannamei* diets [12]. Furthermore, supplementation of yeast culture products significantly increased villus height and width in *P. vannamei* diets compared to the control diet [5]. Some intestinal microbiota are helpful to digestion, absorption, and utilization of nutrients, as well as regulating the immune system, whose microbiota composition has an important impact on intestinal health. Dietary supplementation of yeast culture does not alter the following predominant bacteria phyla such as *Firmicutes, Proteobacteria*, and *Bacteriodetes* in juvenile Pacific white shrimp diets [12].

Effects of serum immune parameters

Serum analysis provides information on the health status of aquatic animals as it has an essential role to play in the physiological, nutritional, and pathological status of aquatic organisms. In *P. vannamei* diets, dietary yeast culture supplement at 0.3-0.5% improved serum phenol oxidase, lysozyme, acid phosphatase, and alkaline phosphatase, which indicates that it improved the innate immune response [12; 4, 5]. Similarly, serum total protein and glucose levels were increased and decreased, respectively, when supplemented with yeast culture in *P. vannamei* diets, which indicates that increasing the immune response as well as the host may not lead to stress [5].

Effects of immune gene expressions

The supplementation of dietary yeast culture, mRNA levels of *tlr, myd88, nf-κbp65* and *caspase-1* were significantly down regulated compared to the control group, which indicates that dietary supplementation of yeast culture showed a protective effect on the digestive tract of juvenile shrimp through reducing inflammation and improving its health status [12]. The mammalian target rapamycin (*mTOR*) signalling pathway, which senses and responds to nutrient availability, energy sufficiency, stress, hormones, and mitogens to modulate protein synthesis, The shrimp fed 1% yeast hydrolysate had up regulated the relative gene expression of genes in the *mTOR* signal pathway, including *eif4ebp, eif4ela, eif4e2 and*

p70s6k, which indicates that dietary supplementation of yeast hydrolysate increased protein synthesis. Moreover, supplementation with yeast hydrolysate and brewer's yeast extract increased the expression of immune-related genes such as *proPo, dorasal*, and *relish* in shrimp intestine and *proPo* and *IMD* in hepatopancreas, respectively [14]. Intestinal microbes are considered indispensable accessories in the life cycle of animals because of their essential functions in promoting host health by regulating nutrient absorption, metabolic processes, and immune responses. As mentioned earlier, *Vibrio species* are the major causative agents of *P. vannamei* diseases in intensive farming. However, previous studies have reported that dietary supplementation of yeast related products can improve the immune response against the following bacterial strain infections, such as *Vibrio parahaemolyticus* and *Vibrio harveyi* in *P. vannamei* [6; 4 and 5].

Conclusion

Pacific white shrimp is an intensively culture shrimp species among the crustaceans worldwide. In recent years, *P.vannamei* production has been affected mainly as a result of various disease outbreaks. Therefore, different investigations have been raised to improve the immune response of *P. vannamei*. Yeast (*S. cerevisiae*) contains various bioactive components, including immune regulators (β-glucan), prebiotics (Mannose oligosaccharide) and nucleotides (Inosine monophosphate, Uridine monophosphate, and Cytidine monophosphate). As a consequence, several studies have indicated that supplementation of dietary yeast or yeast products has increased the production of *P. vannamei* through enhancing the immune response and antioxidant status of the host. Therefore, rather than using antibiotics, supplementing yeast or yeast products as a feed additive or ingredient can increase *P. vannamei* production against a variety of disease outbreaks.

Bibliography

1. Abu-Elala NM., *et al*. "Influence of dietary fermented *Saccharomyces cerevisiae* on growth performance, oxidative stress parameters, and immune response of cultured *Oreochromis niloticus"*. *Fish Physiology and Biochemistry* 46.2 (2020): 533-545.

2. Acar U., *et al*. "Evaluation of the effects of essential oil extracted from sweet orange peel (*Citrus sinensis*) on growth rate of tilapia (*Oreochromis mossambicus*) and possible disease resistance against *Streptococcus iniae". Aquaculture* 437 (2015): 282-286.

3. Adeniyi OV., *et al*. "Growth performance and nutrient digestibility of Clarias gariepinus (Burchell 1822) fed diets fortified with Tamarindus indica pulp and leaf meal". *Asian Fisheries Science* 31.1 (2018): 17-31.

4. Ayiku S., *et al*. "Effects of reducing dietary fishmeal with yeast supplementations on *Litopenaeus vannamei* growth, immune response and disease resistance against *Vibrio harveyi"*. *Microbiological Research* 239 (2020): 126554.

5. Ayiku S., *et al*. "Effects of dietary yeast culture on shrimp growth, immune response, intestinal health and disease resistance against *Vibrio Harveyi"*. *Fish and Shellfish Immunology* 102 (2020): 286-295.

6. Burgents JE., *et al*. "Disease resistance of Pacific white shrimp, *Litopenaeus vannamei*, following the dietary administration of a yeast culture food supplement". *Aquaculture* 231.1-4 (2004): 1-8.

7. Chen XQ., *et al*. "Effects of dietary hydrolyzed yeast (*Rhodotorula mucilaginosa*) on growth performance, immune response, antioxidant capacity and histomorphology of juvenile Nile tilapia (*Oreochromis niloticus*)". *Fish and Shellfish Immunology* 90 (2019): 30-39.

8. Chowdhury DK., *et al*. "Feeding turmeric in combination with ginger or garlic enhances the digestive enzyme activities, growth and immunity in *Labeo rohita* fingerlings". *Animal Feed Science and Technology* 277 (2021): 114964.

9. Dash G., *et al*. "Evaluation of paraprobiotic applicability of *Lactobacillus plantarum* in improving the immune response and disease protection in giant freshwater prawn, *Macrobrachium rosenbergii* (de Man, 1879)". *Fish and Shellfish Immunology* 43.1 (2015): 167-174.

10. Gul P and Bakht J. "Antimicrobial activity of turmeric extract and its potential use in food industry". *Journal of Food Science and Technology* 52.4 (2015): 2272-2279.

11. Guo J., *et al*. "Effects of nucleotides on growth performance, immune response, disease resistance and intestinal morphology in shrimp *Litopenaeus vannamei* fed with a low fish meal diet". *Aquaculture International* 24.4 (2016): 1007-1023.

12. Guo Y., *et al*. "Effects of dietary yeast culture on health status in digestive tract of juvenile Pacific white shrimp *Litopenaeus Vannamei"*. *Fish and Shellfish Immunology Reports* (2022): 100065.

13. Ishida Y., *et al*. "New detection and separation method for amino acids by high-performance liquid chromatography". *Journal of Chromatography A* 204 (1981): 143-148.

14. Jin M., *et al*. "Dietary yeast hydrolysate and brewer's yeast supplementation could enhance growth performance, innate immunity capacity and ammonia nitrogen stress resistance ability of Pacific white shrimp (*Litopenaeus vannamei*)". *Fish and Shellfish Immunology* 82 (2018): 121-129.

15. Kumar P., *et al*. "Effects of dietary synbiotic on innate immunity, antioxidant activity and disease resistance of *Cirrhinus mrigala* juveniles". *Fish and Shellfish Immunology* 80 (2018): 124-132.

16. Labrador JRP., *et al*. "Effect of garlic powder-supplemented diets on the growth and survival of Pacific white leg shrimp (*Litopenaeus vannamei*)". *Cogent Food and Agriculture* 2.1 (2016): 1210066.

17. Lawhavinit OA., *et al*. "Study on effects of ethanol tumeric (*Curcuma longa Linn*.) extract on Vibrio spp., growth and immunity of white shrimp (*Litopenaeus vannamei*)". In Proceedings of the 48th Kasetsart University Annual Conference, Kasetsart, 3-5 March, 2010. Subject: Fisheries. Kasetsart University (2010).

18. Livak KJ and Schmittgen TD. "Analysis of relative gene expression data using real-time quantitative PCR and the 2- ΔΔCT method". *Methods* 25.4 (2001): 402-408.

19. Phiwsaiya K., *et al*. "A natural *Vibrio parahaemolyticus* Δ pirA Vp pirB Vp+ mutant kills shrimp but produces neither Pir Vp toxins nor acute hepatopancreatic necrosis disease lesions". *Applied and Environmental Microbiology* 83.16 (2017): e00680-00717.

20. Pongpet J., *et al*. "Partial replacement of fishmeal by brewer's yeast (*Saccharomyces cerevisiae*) in the diets of Thai Panga (*Pangasianodon hypophthalmus* × Pangasius *bocourti*)". *Aquaculture Nutrition* 22.3 (2016): 575-585.

21. R Miles and S Bootwalla. "Direct-fed microbials in animal production, Direct-fed microbials in animal production A review" (1991): 117-132.

22. Tassanakajon A., *et al*. "Discovery of immune molecules and their crucial functions in shrimp immunity". *Fish and Shellfish Immunology* 34.4 (2013): 954-967.

23. Vanichkul K., *et al*. "Immunological and bactericidal effects of turmeric (*Curcuma longa Linn*.) extract in pacific white shrimps (*Litopenaeus vannamei* Boone)". *Agriculture and Natural Resources* 44.5 (2010): 850-858.

24. Yang C., *et al*. "Phytogenic compounds as alternatives to in-feed antibiotics: potentials and challenges in application". *Pathogens* 4.1 (2015): 137-156.

25. Zahran E., *et al*. "Effects of dietary *Astragalus polysaccharides* (APS) on growth performance, immunological parameters, digestive enzymes, and intestinal morphology of Nile tilapia (*Oreochromis niloticus*)". *Fish and Shellfish Immunology* 38.1 (2014): 149-157.

26. Zhang P., *et al*. "Effects of dietary yeast culture on growth performance, immune response and disease resistance of gibel carp (*Carassius auratus gibelio* CAS III)". *Fish and Shellfish Immunology* 82 (2018): 400-407.

27. Zhang X., *et al*. "Effects of yeast culture substituting fishmeal on growth, nonspecific immunity, intestinal, and hepatopancreatic histology of *Litopenaeus vannamei"*. *Journal of the World Aquaculture Society* (2022).