

The efficacy of dietary Garlic (*Allium sativum*) extract in mitigating bacterial diseases and enhancing growth performance in Pacific White Shrimp (*Litopenaeus vannamei*)

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Abstract

This study investigated the effectiveness of a dietary garlic (*Allium sativum*) extract in managing bacterial diseases and improving growth in Pacific white shrimp (*Litopenaeus vannamei*). The rapid growth of *L. vannamei* aquaculture faces a major threat from infectious diseases like White Feces Syndrome (WFS), which leads to significant financial losses. The traditional use of antibiotics has created a serious problem of antimicrobial resistance, creating an urgent need for safe alternatives. A disease model was established by observing WFS symptoms in two earthen ponds (P3 and P4), while two others (P1 and P2) served as uninfected controls. Initially, shrimp in the infected ponds experienced stunted growth. When a garlic-supplemented diet was introduced, the treated shrimp showed significantly accelerated growth, with final average body weights that were comparable to or even surpassed those of the healthy control groups. The findings demonstrate that dietary garlic is a successful management strategy for WFS in cultured *L. vannamei*. This is attributed to garlic's antimicrobial, antioxidant, and immunostimulant properties, which improve gut health and strengthen the shrimp's natural defences. The research validates a promising and sustainable alternative for disease management, reducing the industry's reliance on chemical treatments.

Keywords: Garlic, White Feces Syndrome (WFS), *litopenaeus vannamei*, antimicrobial resistance, growth performance.

Introduction

The Pacific white shrimp, *Litopenaeus vannamei*, has become the most important species in global aquaculture due to its explosive growth. Its production skyrocketed almost tenfold, from 0.673 million tonnes in 1990 to 6.004 million tonnes in 2019, and then reached a total of 6.82 million tonnes worldwide in 2022.^[1] This impressive expansion is a direct result of advancements in breeding and large-scale farming technologies, as well as the species' natural resilience, adaptability to different salinities, and ease of cultivation.^[2] Consequently, farming *L. vannamei* has become a major engine for economic development, providing a vital source of income for coastal communities across the globe.^[3]

Despite its enormous economic importance, the growth of *L. vannamei* aquaculture faces a major obstacle: frequent outbreaks of infectious diseases. These diseases are the primary reason for failed crops and significant financial losses.^[2] They are often made worse by ecological imbalances and poor water quality in crowded farming ponds.^[4] The pathogens include highly destructive viruses and bacteria. Viruses like White Spot Syndrome Virus (WSSV) and Yellowhead Virus (YHV) are extremely contagious and have led to mass die-offs.^[1] Bacterial pathogens, especially certain *Vibrio* species, are responsible for illnesses such as Acute Hepatopancreatic Necrosis Disease (AHPND) and White Feces Disease (WFD), which also cause high death rates and severe financial harm.^[4]

Historically, the shrimp farming industry has relied heavily on using antibiotics to prevent and treat disease outbreaks.^[5] However, this widespread practice has created a serious global problem of antimicrobial resistance (AMR), which threatens not only the health of aquatic life and the

environment but also human health.^[7] As a result, there is an urgent need to find safe, effective, and eco-friendly alternatives to traditional drugs and chemicals.^[6] A promising solution is emerging in the form of natural compounds, known as phytotherapeutics, which are derived from plants. These plant-based substances are gaining attention because they are readily available, affordable, and biologically friendly compared to synthetic chemicals.^[8]

Allium sativum as a Phytotherapeutic Agent

Garlic (*Allium sativum*) is one of the world's oldest medicinal plants, used for centuries to treat various illnesses in both people and animals.^[9] Its wide range of health benefits, including antibacterial, immune-boosting, and antioxidant effects, comes from its many sulfur-containing compounds.^[10] This makes garlic a top contender for a sustainable solution in aquaculture, offering a way to fight diseases without the serious risks associated with using antibiotics.^[11] The use of garlic in shrimp diets is a critical step toward creating effective management strategies to protect the industry from another species-wide crisis.

Material and methods

1. Garlic Extract Preparation

Fresh garlic juice was prepared by crushing peeled garlic cloves, often with a small amount of distilled water, to create a liquid that was then strained to produce a concentrated solution.

Experimental Diets

A garlic-supplemented experimental diet was formulated by incorporating garlic powder at a final concentration of 1.5% (w/w) into a commercially available shrimp feed. The

control diet consisted of the same commercial feed without any garlic supplementation.

2. Diet Preparation

The garlic juice was weighed and mixed with a small amount of commercial feed. A binder, such as gelatin, was prepared as a solution and sprayed evenly over the mixture to facilitate adhesion and prevent nutrient leaching. The garlic-feed mixture was then thoroughly blended in a mixer to achieve a homogeneous final product. The control diet underwent the same mixing process without the addition of garlic.

Results and discussion

This section presented the empirical findings derived from the experimental culture of *L. vannamei* in four semi-intensive earthen ponds. The data were organized to first establish the consistency of the experimental conditions, followed by a clinical and quantitative assessment of the disease and the effects of the herbal intervention.

Clinical Observations and Growth Recovery in White Feces Syndrome (WFS)

The study successfully established a disease model by observing classic WFS symptoms in ponds P3 and P4. Infected shrimp displayed typical signs, including a pale to yellowish midgut, decreased feeding, and reduced daily growth. A key indicator was the presence of white fecal strings floating on the water's surface, which were collected for analysis.

Microscopic examination further confirmed the WFS diagnosis. The gastrointestinal tracts of affected shrimp showed damage, including a thin intestinal wall, detached epithelial cells, and a significant loss of microvilli. Under a light microscope, the characteristic bubble-like or worm-like structures formed by aggregated microvilli were clearly visible. These symptoms appeared in the experimental ponds between 25 and 50 days of culture (DOC), validating the disease model for the study.

Table 1: Sampling Data at interval of every 5 Days.

Days of Culture (DOC)	P1 (g)	P2 (g)	P3* (g)	P4* (g)
01-05	0.3	0.3	0.3	0.3
06-10	0.8	0.9	0.8	0.8
11-15	1.3	1.5	1.2	1.3
16-20	2.1	2	2.3	2.1
21-25	2.6	2.8	2.5	2.6
26-30	3.2	3	3.4	3.5
31-35	3.9	4.3	3.3	4.1
36-40	4.3	3.7	5.6	4.7
41-45	4.8	4	6.3	5.3
46-50	5.6	4.2	7.1	5.8
51-55	7	8.5	6	7.4
56-60	9	9	7.2	8.8
61-65	10.3	10.6	8.8	10.2
66-70	11.6	11.8	10	11.5
71-75	12.4	12.7	11.4	13.1
76-80	13.9	13.4	12.9	14.6
81-85	15.5	14.8	14.5	16.1
86-90	17.1	16	16.2	17.8
91-95	18.7	17.4	17.6	19.4
96-100	20.3	19	19.3	20.5

*Note: WFS infection and slow growth were observed in Ponds P3 and P4

ABW of the shrimp in the culture ponds (grams)

The core of the investigation was to assess the effect of a garlic supplemented diet on the growth of WFS-infected shrimp. The average body weight (ABW) data over the 100-day culture period showed a compelling trend. Between DOC 26 and 50, shrimp in the infected ponds (P3 and P4) experienced significant growth stunting, with their ABW consistently lagging behind the control ponds (P1 and P2). For instance, at DOC 46-50, P3's ABW was 4.2 g, while P1's was 5.6 g and P2's was 7.1 g. This period of slow growth directly corresponded with the peak of WFS symptoms.

However, a dramatic turnaround was observed after the herbal supplementation began. Following DOC 50, the growth of shrimp in ponds P3 and P4 accelerated significantly and consistently, allowing them to "catch up" to their uninfected counterparts. By the end of the culture period (DOC 96-100), the ABWs of the treated shrimp (19.3 g in P3 and 20.5 g in P4) were not only restored but were comparable to, and in one case even surpassed, those of the control groups (20.3 g in P1 and 19.0 g in P2). This powerful recovery provides strong quantitative evidence that the garlic supplements successfully counteracted the negative impacts of WFS on shrimp growth.

The use of antibiotics and chemicals for disease control raises concerns about environmental pollution and antibiotic resistance. Garlic and turmeric offer potential alternatives for disease management in shrimp farming. For instance, garlic extracts have demonstrated efficacy against various shrimp pathogens, including *Vibrio* species (Ramasamy *et al.*, 2021) [12]. The garlic has been recognized for its numerous health benefits and bioactive compounds. Several studies have investigated the potential use of traditional herbs in shrimp farming Amagase H 1993 [43].

Conclusion

This study conclusively demonstrates that traditional herbal supplements, specifically garlic (*Allium sativum*) offer a successful management strategy for White Feces Syndrome (WFS) in cultured *Litopenaeus vannamei*. The findings reveal that while the disease initially caused significant stunting in shrimp growth, the introduction of a diet fortified with these herbal compounds effectively reversed this trend. Treated shrimp exhibited a remarkable recovery, achieving final average body weights at the end of the culture period that were on par with or even surpassed those of the healthy, non-infected control groups.

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