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Length-weight relationship and condition factor in *Litopenaeus vannamei* supplemented with *Spirulina Spp*

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Abstract
The global demand for seafood is increasing due to population growth, necessitating sustainable aquaculture practices. This study investigated the length-weight relationships of *Litopenaeus vannamei* supplemented with *Spirulina spp*. from a pond at Dantrai, Bharuch, Gujarat. Standardized methods were applied to measure length and weight. Spirulina supplementation is known for enhancing growth, immune function, and disease resistance in shrimp through its rich nutritional and bioactive profile. The length-weight relationship and condition factor provide insights into the physiological status of shrimp and their adaptation to environmental conditions. Results showed favorable growth metrics and a credible length-weight relationship with a strong correlation coefficient, indicating that Spirulina supplementation effectively promotes shrimp growth and metabolic health. This research supports the integration of Spirulina as a functional feed additive to improve shrimp aquaculture productivity and sustainability

Keywords: *Litopenaeus vannamei*, *Spirulina spp*, growth, length-weight relationship, condition factor

Introduction

The global population is projected to approach approximately 9.6 billion by 2050, the demand for seafood is anticipated to rise significantly. Traditional fishing methods alone are insufficient to meet this growing need. Consequently, aquaculture has become an essential solution to address the increasing pressure on marine resources and contribute to global food security, helping to alleviate the challenges caused by the overharvesting of wild fisheries. (FAO, 2022; Tidwell & Allan,2001) [24]. Aquaculture is the farming of freshwater, saltwater and brackish water organisms as aquatic flora and fauna. Aquaculture produces the majority of the world's farmed shrimp. Shrimp represent one of the highest-value commodities with high-quality proteins, Nutrition and essential minerals. (FAO, 2022; New,2013) [18].

In India, the shrimp aquaculture industry primarily revolves around the cultivation of *Penaeus monodon* and *Litopenaeus vannamei.* Gujarat, endowed with an extensive coastline stretching over 2340 km and significant tracts of saline-affected wastelands, presents considerable potential for the development of brackish water aquaculture, particularly in the domain of shrimp culture. However, the switch from farming *Penaeus monodon* (tiger shrimp) in India was primarily driven by outbreaks of diseases such as White Spot Syndrome Virus (WSSV), which caused significant losses. *Litopenaeus vannamei* gained popularity due to its faster growth rate, better tolerance to high stocking densities, and availability as Specific Pathogen Free (SPF) stock. This shift brought transformative changes to the Indian shrimp farming sector, boosting overall production, enhancing export earnings, and leading the majority of shrimp farms to adopt *Litopenaeus vannamei* as the preferred species. (Devi *et al*., 2021 [3]; Karunasagar *et al*., 2020 [8]; Mohanty *et al*, 2013) [17].

Shrimp farming has faced challenges from outbreaks of various viral, fungal, and bacterial diseases. Several disease outbreaks have also been associated with vibriosis caused by bacteria such as Vibrio species.

Shrimp are influenced by a complex interplay of factors, notably diet, environmental conditions and pathogen presence. The nutritional composition and inclusion of functional feed additives directly affect the growth. Diets enriched with probiotics, prebiotics, or microalgae such as Spirulina have been shown to enhance beneficial bacterial populations while suppressing opportunistic pathogens, thereby improving shrimp growth and immune function (Devaraj *et al*., 2019 [2]; Wan *et al*., 2017) [25] Spirulina a filamentous blue-green alga, is renowned not only for its rich nutritional profile but also for its multifaceted bioactive properties that contribute to enhanced immune function and disease resistance. Spirulina as a compelling natural feed additive in aquaculture. Its capacity for antioxidant defences offers a sustainable alternative to antibiotics and chemical therapeutics in shrimp farming, potentially mitigating the risks associated with disease outbreaks and chemical residues while supporting animal welfare and productivity. The success of shrimp farming relies heavily on monitoring key physical, chemical, and biological factors. Metrics such as the length-weight relationship and condition factor provide valuable insights into the biological condition and health of aquatic species, aiding effective management and optimising production (Shah *et al*, 2013) [22]. The length-weight relationship is a key concept in fisheries science used to identify differences among populations (stocks) of the same species (King,2007) [12]. By comparing length-weight data across these stocks, researchers can evaluate variations in growth patterns, health, and overall condition. The condition factor (K) serves as an important indicator reflecting the interplay between living organisms and their environment, capturing biological health based on the relationship between weight and length. This index helps to evaluate how both biotic and abiotic factors affect the overall condition of aquatic life. It is also utilized as a quantitative measure to assess changes

in the nutritional health of aquatic organisms, providing insight into their energy reserves and overall physiological status. (Lizama *et al*,2000; [15] Prajapati and Ujjania, 2022). Investigating the length-weight relationship and condition factor (K) serves as a valuable approach to assess the environmental conditions, growth patterns, and overall health of shrimp populations. Hence, the current research was undertaken to provide insights into these parameters in shrimp fed with Spirulina as a supplement.

Methodology

Morphometric observations comprising length and weight measurements were recorded for 250 randomly selected specimens of *Litopenaeus vannamei* (fed with *Spirulina spp*. enclusion level 0.5-1 %/kg (Li *et al*., 2022)) collected from the pond at Dantrai village, Bharuch, Gujarat. A vernier calliper was used to measure the specimen's length from the rostrum to the end tip of the uropod and an electronic balance was used for weigh (Lester, 1983). According to Pauly (1983) [19], the length-weight relationship was computed from converted data using the linear equation Log (W) = log (a) + b log (L) and from the nonlinear power function Y= aX b (Ricker, 1973) [21]. The equation K = (W/L3) × 100 (Htun-Han, 1978) [7] gave the condition factor (K), where W is the weight (gm) and L is the total length (cm).

Result and Discussion

The data presented in Table 1 summarize the morphometric characteristics of 250 shrimp sampled from the study pond, detailing their total length, weight, and condition factor. The observed total length of the sampled shrimp ranged from a minimum of 14.900 cm to a maximum of 19.700 cm, with a mean value of 17.245±0.059 cm. The minimum and maximum weights measured were 25.120 g and 59.290 g, respectively, with a mean weight of 40.783 g (±0.393 SE). Li *et al*., (2022) reported that dietary Spirulina meal addition significantly improved final body weight, specific growth rate, and protein efficiency ratio while decreasing feed conversion ratio in aquaculture animals.

The condition factor values observed in this study (minimum 0.706, maximum 0.870, mean 0.791±0.003) demonstrate that Spirulina supplementation promoted metabolic efficiency and tissue accumulation relative to body length. Khademzadeh and Haghi, (2017) evaluated the length-weight relationship and condition factor in cultured *Litopenaeus vannamei* and established that condition factor serves as a reliable indicator of shrimp health and physiological status during culture operations. The maintenance of relatively elevated condition factor values in the present study, suggested that Spirulina supplementation supported optimal nutritional status and physiological robustness.

The regression coefficient (b) value of 2.705 observed in the cultured white leg shrimp. According to Mazumder *et al*, (2016) [16], when the regression coefficient (b) deviates from the theoretical isometric value of 3.0, allometric growth occurs, with b values less than 3.0 indicating negative allometry. The b value of 2.705 falls within the normal biological range (2.5–3.5) established by Froese *et al* (2006) [6] for aquatic organisms, validating the reliability of the length-weight relationship derived in this study. The negative allometric growth pattern observed suggests that the shrimp in the studied pond gained weight at a slower rate relative to their increase in body length. Khademzadeh and Hagh (2017) [9] similarly reported negative allometric growth in cultured *Litopenaeus vannamei* from Iran with a b value of 2.6935 (r^2 = 0.8895), findings that closely align with the present results. The coefficient of determination (r^2) value of 0.8868 indicates that approximately 88.68% of the variance in body weight is explained by variations in total length in this population. Faruque *et al*., (2024) [5] noted that r^2 values exceeding 0.86–0.96 demonstrate strong positive correlation and validate robust linear relationships between morphometric variables in aquatic organisms.

Table 1: Observation of Length and weight of the shrimp sample

0	Total length (cm)	Weight (gm)	Condition factor (K)
Minimum	14.900	25.120	0.706
Maximum	19.700	59.290	0.870
Mean±SE	17.245±0.059	40.783±0.393	0.791±0.003

Table 2: Statistical values of intercept, slope and coefficient of correlation and regression

N	A	b	r^2
250	-1.7381	2.705	0.8868

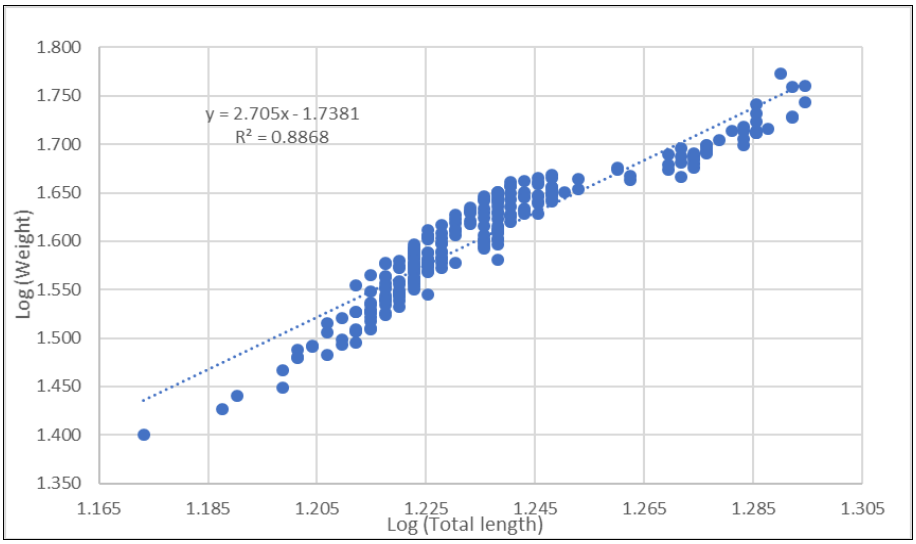

Fig 1: Length - weight relationship of *Litopenaeus vannamei* cultured fed with Spirulina

Supplementing shrimp feed with *Spirulina spp.* significantly enhances growth performance, antioxidant activity, and immune function in Pacific white shrimp by providing digestible proteins, essential nutrients, and beneficial bioactive compounds (Ahmed *et al*, 2025) [1]. These properties help optimize feed conversion and physiological health, making Spirulina a promising, sustainable alternative to conventional ingredients in aquaculture diets for improved shrimp production (Siddik *et al*, 2025) [23]. These findings indicate that the shrimp fed with Spirulina, exhibited moderate variation in growth parameters, reflecting uniform pond management and nutrition. The condition factor values suggest the shrimp maintained good physiological status during the culture period. The relatively low standard error associated with mean length, weight, and condition factor reflects consistency in individual growth among the population. This analysis provides a foundation for further assessment of growth performance, nutritional status, and overall health in pond-cultured *Litopenaeus vannamei*.

Conclusion

The study demonstrated that supplementing shrimp feed with Spirulina resulted in marked improvements in growth, condition factor, and overall health of *Litopenaeus vannamei* cultured. These results highlighted Spirulina's value as a functional feed additive, supporting metabolic efficiency and immune resilience, while enabling consistent growth and physiological stability in farmed shrimp. Findings reinforce the potential of Spirulina supplementation for sustainable aquaculture and optimized shrimp production systems.

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