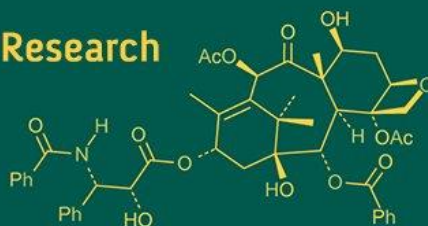


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(6): 117-126
www.biochemjournal.com
 Received: 03-03-2026
 Accepted: 08-04-2026

P Shanthanna
 Ph.D. Scholar, Department of
 Aquaculture, College of
 Fishery Science, Andhra
 Pradesh Fisheries University,
 Muthukur, SPSR Nellore,
 Andhra Pradesh, India

Dr. P Anand Prasad
 Assistant Professor & Head,
 Department of Aquaculture,
 College of Fishery Science,
 Andhra Pradesh Fisheries
 University, Muthukur, SPSR
 Nellore, Andhra Pradesh, India

Dr. A Chandrasekhara Rao
 Principal Scientist & Head,
 Fisheries Research Station,
 Andhra Pradesh Fisheries
 University, Undi, West
 Godavari, Andhra Pradesh,
 India

Dr. N Madhavan
 Director of Extension,
 Professor & University Head,
 Department of Fisheries
 Engineering, College of Fishery
 Science, Andhra Pradesh
 Fisheries University,
 Muthukur, SPSR Nellore,
 Andhra Pradesh, India

Dr. K Madhavi
 Associate Professor &
 Associate Dean, College of
 Fishery Science, Andhra
 Pradesh Fisheries University,
 Narasapuram, West Godavari,
 Andhra Pradesh, India

Corresponding Author:
P Shanthanna
 Ph.D. Scholar, Department of
 Aquaculture, College of
 Fishery Science, Andhra
 Pradesh Fisheries University,
 Muthukur, SPSR Nellore,
 Andhra Pradesh, India

Nutritional configuration, effect of dietary brown seaweed *Sargassum wightii* powder individually and in combination with red seaweed *Gracilaria edulis* meal on survival and growth performance of *Litopenaeus vannamei* (Boone, 1931)

P Shanthanna, P Anand Prasad, A Chandrasekhara Rao, N Madhavan and K Madhavi

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6b.8566>

Abstract

Experimental work was conducted in the uniform size glass aquarium tanks of 60 liters capacity for the period of 120 days to evaluate the influence of brown seaweed *Sargassum wightii* meal separately and with collaboration of red seaweed *Gracilaria edulis* meal on survival, growth and nutrient utilization parameters of pacific white leg shrimp *Litopenaeus vannamei* through addition of various levels in the experimental diets. A total of 252 shrimps were randomly allotted to 21 tanks with an average initial weight of 1.09 ± 0.04 g (12 shrimps per tank) with 7 different treatment groups and 3 replicates per treatment and fed twice per day. Seven practical iso-nitrogenous diets (~ 36% Protein) were manufactured with predetermined levels of brown seaweed *Sargassum wightii* powder solely and with mixing of red seaweed *Gracilaria edulis* meal. The control treatment diet (C) is without seaweed meals; 2% (T₁), 4% (T₂) and 6% (T₃) *Sargassum wightii* meal solely; in other hand, 2% (T₄), 4% (T₅) and 6% (T₆) *Sargassum wightii* and *Gracilaria edulis* mixture in equal proportions. Results reflected that a significant difference ($P < 0.05$) in connection with nutrient profile of brown seaweed *Sargassum wightii* meal, which comprised of preferred crude protein level $9.78 \pm 0.23\%$, but least in crude fat levels with $1.02 \pm 0.07\%$ and a significant difference ($P < 0.05$) was noticed in growth and nutrient utilization parameters such as final body weight, weight gain%, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) along with survival rate of the experimental animals. The highest weight gain, weight gain% and specific growth rate were discovered in the group fed with diet T₆, whereas the lowest values of those respective growth parameters were noticed in control and T₄ diets. Regarding to nutrient utilization parameters the less feed conversion ratio and more protein efficiency ratio were perceived in the experimental animal *Litopenaeus vannamei* fed diet T₆, in contrast the highest feed conversion ratio in control diet and least protein efficiency ratio in control and T₄ diets were observed. The maximum survival rate of experimental animal was determined in T₃ group fed diet compared to other treatment groups. The overall results demonstrated that the *Litopenaeus vannamei* fed with mixed diet of 3% *Sargassum wightii* meal and 3% *Gracilaria edulis* meal (T₆ group) revealed the best performance in terms of growth and nutrient utilization parameters in this study. Hence, it can be concluded that *Sargassum wightii* meal can be included up to 6% along with combination of *Gracilaria edulis* in the diet of *Litopenaeus vannamei* for optimum production without any deleterious effects.

Keywords: *Litopenaeus vannamei*, *Sargassum wightii* meal, nutrient profile, growth performance, nutrient utilization, survival

Introduction

Aquaculture is one of the rapid growing food producing sector worldwide, sharing significantly to food safety, employment generation, and economic improvement. Among cultured crustaceans, the Pacific white shrimp, *Litopenaeus vannamei*, has become the paramount shrimp species in global aquaculture due to its speedy growth, high survival, efficient feed conversion, endurance to broad salinity ranges, and high market demand. The elaboration of intensive shrimp farming, however, has augmented concerns respect to feed costs, disease occurrence, environmental degradation, and the excessive utilization of

antibiotics and synthetic growth promoters. Accordingly, the development of sustainable and functional aqua feeds has become a leading research priority in modern shrimp aquaculture (Abbas *et al.*, 2023)^[1]. Feed accounts for nearly 50-60% of the total investment in shrimp farming, and hence considerable efforts have been made to determine low cost, nutritionally sound, and eco-friendly feed ingredients. In recent years, marine macroalgae (seaweeds) have appeal attention as auspicious dietary supplements in aquaculture due to their copiousness of proteins, essential amino acids, minerals, vitamins, polysaccharides, antioxidants, and bioactive compounds. Seaweeds are reported to amend growth performance, feed utilization, immune response, gut microbiota, stress tolerance, and disease resistance in aquatic organisms (Jahromi *et al.*, 2021)^[17]

Among marine macroalgae, the brown seaweed *Sargassum wightii* is widely distributed along the Indian coastline and is well advised a precious source of bioactive compounds such as fucoidan, alginate, phenolics, carotenoids, minerals, and sulfated polysaccharides. These constituents possess antioxidant, antimicrobial, immunostimulatory, and growth acceleratory properties that may enhance shrimp health and production efficiency. Previous studies on dietary supplementation of *Sargassum* species in shrimp diets demonstrated improvements in biochemical parameters, intestinal microbiota, immunity, and survival without adverse effects on growth performance. Similarly, the red seaweed *Gracilaria edulis* is rich in protein, essential fatty acids, vitamins, agar, and sulfated galactans, making it a potency functional ingredient in aqua feeds. Species of *Gracilaria* have been successfully utilized in shrimp culture systems and feed formulations to better pellet steadiness, nutrient usage, immunity, and growth performance. Supplementation of *Gracilaria* meal in shrimp diets has also been associated with increased digestibility and advisable physiological responses in *L. vannamei* (Sarkar *et al.*, 2025)^[31]

Seaweed based feed additives are increasingly acknowledged as natural alternatives to synthetic growth promoters and antibiotics in aquaculture. Brown and red seaweeds differ considerably in their biochemical composition, and their combined dietary application may provide synergistic nutritional and physiological benefits to cultured shrimp. However, limited information is available regarding the combined utilization of *Sargassum wightii* powder and *Gracilaria edulis* meal in practical diets for *Litopenaeus vannamei*. Therefore, the present study was undertake to measure the effects of dietary expansion of brown seaweed *Sargassum wightii* powder individually and in combination with red seaweed *Gracilaria edulis* meal on the survival, growth performance, and feed utilization efficiency of *Litopenaeus vannamei*. The findings of this study may contribute to the development of sustainable and nutritionally enriched functional feeds for shrimp aquaculture.

2. Materials and Methods

2.1 Experiment design

For the research study 21 even size glass aquarium tanks with 60 cm X 25 cm X 40 cm dimensions of 60 liters capacity were used. Tanks were placed in a secured place in series by labeling as C (Control), T₁ (Treatment-1), T₂ (Treatment-2), T₃ (Treatment-3), T₄ (Treatment-4), T₅ (Treatment-5), and T₆ (Treatment-6) after proper cleansing

of all tanks with fresh water, where there was no direct sunlight and clothed by 80 mm white nylon mesh net on the top to prevent droppings of insects, lizards and entering of rodents into the tanks. Ground saline water used as source and before feeding into the aquarium tanks was gathered in the reservoir tank by arranging 20 micron filter bag at inlet of water supply pipe to avoid entry of dust particles, which cause to the water impurity and modify the water quality parameters then aerated by using air stones attached to the 1.5 HP PENT AIR - BLOWER, which made in Taiwan. The aerated saline water was dragged into aquarium tanks and furnished aeration continuously through setting up of air pipe and stones prior to stock the target shrimp species into the aquarium.

2.2 Procurement of experimental shrimps and their acclimatization

500 numbers of proactive and Specific Pathogen Free (SPF) *Litopenaeus vannamei* seed were obtained from Aqua Prime Hatchery, Koduru Beach, SPSR Nellore district, Andhra Pradesh, which has been approved by Coastal Aquaculture Authority (CAA), Chennai to produce seed. Shrimp seed were packed in double plastic bags filled with oxygen and water in the ratio of 3:1 in each bag and the density of shrimp was 250/bag. Post larvae-10 (PL-10) transported by road in plastic bags comprised 12 ppt saline water. PL transferred to the Fiber Reinforced Plastic (FRP) tanks (3000 liters capacity) of the wet laboratory, which dwell of same salinity water through following adaptation for 30 minutes and conditioning was carried out for 20 days. During acclimatization, shrimps were fed on control diet thrice daily at 07:00 AM, 12:00 PM and 05:00 PM to their satiety. The amount of shrimp seed to be jam packed in oxygen exaggerated polythene bags was calculated as per the following formula.

$$N = (DO - 2) \times V / CH$$

Where, DO: Dissolved oxygen content of water (mg/l) V: Volume of water used for transport (Lt) C: Rate of oxygen consumption of shrimp (ml/kg of shrimp) H: Duration of transport (Hours).

Twelve (12) numbers of shrimp with initial mean weight 1.09 ± 0.04 g is introduced into each tank and triplicates were retained for each treatment. Day to day water exchange of 25-30% was done every day. Left over feed, excreta and other debris were siphoned off from the bottom of the tank without disturbing the shrimps.

2.3 Preparation of brown seaweed (*Sargassum wightii*) and red seaweed (*Gracilaria edulis*) meals

Brown seaweed (*Sargassum wightii*) and red seaweed (*Gracilaria edulis*) leaves were procured from R. K. Algae Project Center, Meenavar Colony, Mandapam, Ramanathapuram District, Tamil Nadu. Collected seaweeds leaves were cleaned with fresh water to take off dust particles, afterward cleansed seaweeds leaves were shade dried for 7 days until get crispy nature without affecting the leaves colour. This dried seaweeds leaves were finely grounded and sieved to get fine particles thus the seaweeds leaf meals of brown and red seaweeds were prepared and stored in a air tight instrumentation for further use.

2.4 Formulation and preparation of practical diets

In this study, formulation for feeds with the crude protein 36% was designed. Fish meal (FM), Soya bean meal (SBM), Groundnut oil cake (GNOC), Rice flour and Wheat flour were the prime ingredients utilized for manufacture of control and experimental feeds (Table-1). The treatment diets were prepared by addition of brown seaweed (*Sargassum wightii*) separately at the rate of 2%, 4% and 6%, and in compilation of red seaweed (*Gracilaria edulis*) with equal proportions. The control diet was without seaweed meals, but T₁, T₂ and T₃ consisted of 2%, 4%, and 6% *Sargassum wightii* meal only respectively; T₄ comprised of 1% *Sargassum wightii* and 1% *Gracilaria edulis*, T₅ contained of 2% *Sargassum wightii* and 2% *Gracilaria edulis* T₆ consisted of 3% *Sargassum wightii* and 3% *Gracilaria edulis*. For all the treatments including control diets 1% Vitamin premix, 1% Mineral premix, 4% Fish oil and 1% Sunflower oil were also added. Fish meal, Soya bean meal, Groundnut oil cake, Rice flour, Wheat flour, Vitamin premix, Mineral premix, Fish oil and Sunflower oil were acquired from local market. Brown seaweed

Sargassum wightii and red seaweed, *Gracilaria edulis* were transported from R. K. Algae Project Center, Meenavar Colony, Mandapam, Ramanathapuram District, Tamil Nadu. The major ingredients used in the feed and all the experimental feeds were estimated for proximate composition (AOAC, 2000).

Requisite quantity of each ingredient was weighed and ground into powder and sieved. All the ingredients were then mixed in needful proportion and water was added at the rate of 30 ml per every 100g of feed and dough was prepared. The dough was cooked for 20 minutes in pressure cooker and then cooled. Vitamin premix, mineral premix, fish oil and sunflower oil were added. *Sargassum wightii* and *Gracilaria edulis* were added as per the requirement of respective designed feed. The homogenous dough was pressed through a pelletizer (La Monferrina S.R.L., Italy) with a sieve of 1 mm diameter. The feed was dried in shade and then in hot air oven at 55-65 °C for 14-16 hours to minify the moisture content below 10% and stored properly in dry and air tight containers and kept in cool place.

Table 1: Formulation of experimental diets

	Experimental diets						
	C	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Ingredients (%)							
FM	18	17	17	17	17	17	17
SBM	30	31	31	32	31	31	31
GNOC	25	25	25	24	25	25	25
RF	8	7	5	4	6	6	4
WF	12	11	11	10	12	10	10
BSM	0	2	4	6	0	0	0
BSM+RSM (50:50)	0	0	0	0	2	4	6
FO	4	4	4	4	4	4	4
SO	1	1	1	1	1	1	1
VP	1	1	1	1	1	1	1
MP	1	1	1	1	1	1	1
Total	100	100	100	100	100	100	100

C: Control diets (without brown and red seaweed meals); T₁: Experimental diet with 2% of *Sargassum wightii* meal; T₂: Experimental diet with 4% of *Sargassum wightii* meal; T₃: Experimental diet with 6% of *Sargassum wightii* meal; T₄: Experimental diet with 1% *Sargassum wightii* meal and 1% *Gracilaria edulis* meal; T₅: Experimental diet with 2% *Sargassum wightii* meal and 2% *Gracilaria edulis* meal; T₆: Experimental diet with 3% *Sargassum wightii* meal and 3% *Gracilaria edulis* meal.

FM: Fish meal; SBM: Soybean meal; GNOC: Groundnut oil cake; RF: Rice flour; WF: Wheat flour; BSM: Brown seaweed meal; RSM: Red seaweed meal; FO: Fish oil; SO: Sunflower oil; VP: Vitamin premix; MP: Mineral premix.

2.5 Feeding

Experimental animals were fed at the rate of 6% per body weight initial days and then reduced to 2% based on the average body weight. The pelleted feed was manufactured into small granules of 1mm size and fed four times per day (6.00AM, 10.00AM, 2.00PM and 6.00PM) during feeding trails. Regular water exchange of 25-30% was done every day. Left over feed, excreta and other debris was siphoned off from the bottom of the tank without disturbing the shrimps after two hours of feeding.

2.6 Proximate analysis of the Brown Seaweed Meal (BSM), Red Seaweed Meal (RSM) and experimental diets

Proximate investigation of Brown Seaweed Meal, Red Seaweed Meal and practical test diets were done by standard methods (AOAC, 2000) at Animal Feed Analytical and Quality Assurance Laboratory, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Namakkal, Tamil Nadu, India.

2.6.1 Moisture

The moisture content of the Brown Seaweed Meal, Red Seaweed Meal and experimental diets were calculated by taking a known weight of the sample in the petridish and drying it in a hot air oven at 55-65 °C till a invariable weight was achieved. The deviation in weight of the sample gave the moisture content of Brown Seaweed Meal, Red Seaweed Meal and prepared diets. The moisture content was deliberated by using the following formula

$$\text{Moisture (\%)} = \frac{\text{Wet weight of sample} - \text{Dried weight of sample}}{\text{Wet weight of sample}} \times 100$$

2.6.2 Crude Protein (CP)

Nitrogen content of the Brown Seaweed Meal, Red Seaweed Meal and test diets samples were ascertained quantitatively by Kjeltac semi automated system (2200 Kjeltac auto distillation, Foss Tecator and Sweden) using titration as the means for estimating nitrogen percentage. The crude protein percentage was obtained by multiplying the nitrogen percentage with a factor of 6.25.

Crude Protein (%) = N₂ (%) X 6.25

2.6.3 Ether Extract (EE)

Ether extract of Brown Seaweed Meal, Red Seaweed Meal and experimental diets samples were dictated by Soxhlet apparatus using petroleum ether (Boiling point 40-60 °C) as the solvent. The calculation was made as follows.

$$\text{EE (\%)} = \frac{\text{Initial weight of sample} - \text{Weight of sample}}{\text{Initial weight of sample}} \times 100$$

2.6.4 Ash

Ash content of the Brown Seaweed Meal, Red Seaweed Meal and shrimp diet samples were estimated by taking a known weight of dried samples in silica crucible and kept in the muffle furnace at 550 °C for 5-6 hours. The calculation was done by the following formula

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

2.6.5 Crude Fibre (CF)

The crude fibre content of the samples were estimated quantitatively by Fibretec (Foss Tecator, Sweden). Known weight of fat free sample was washed in boiling acid (1.25 N H₂SO₄) and alkali (1.25 N NaOH) to remove digestible carbohydrate and protein, respectively. The sample is then washed in distilled water and dried at 55-65 °C to remove moisture and weighed. The dried sample is ashed in muffle furnace and weighed.

$$\text{Crude fibre (\%)} = \frac{\text{Weight of crude fibre}}{\text{Original weight of sample}} \times 100$$

2.6.6 Nitrogen Free Extract (NFE)

Nitrogen free extract (NFE) of the Brown Seaweed Meal, Red Seaweed Meal and research diets were determined by subtracting the percentage of other nutrients from 100. The nitrogen free extract (NFE) was calculated by using the following formula.

$$\text{NFE (\%)} = 100 - [\text{Crude protein (\%)} + \text{Ether Extract (\%)} + \text{Ash (\%)} + \text{Crude Fibre (\%)}]$$

2.6.7 Gross Energy (GE)

Gross energy (GE) content of Brown Seaweed Meal, Red Seaweed Meal and experimental diets were measured using a Parr bomb calorimeter (Model # 1241, Moline, IL). Briefly, energy of the dried material was determined by placing a weighed sample in the ignition cup of the bomb. Oxygen was added at ~35 psi and the bomb immersed in 2 L of water. The sample was ignited and the temperature increase of the water recorded. Gross energy was calculated using a boric acid calibration standard and expressed as kcal g⁻¹ of dry matter.

2.7 Growth and nutrient utilization parameters

Sampling was done at every week (07 days) to find out growth for assess the body weight of the targeted aquatic animal. Shrimps were starved overnight before taking the weight by using the electronic balance. The parameters of interest were specific growth rate, mean weight gain, feed

conversion ratio, percentage weight gain, average daily weight gain, protein intake, protein efficiency ratio.

2.7.1 Weight Gain (WG)

$$\text{Weight Gain (WG)} = \text{Final mean weight (g)} - \text{Initial mean weight (g)}$$

2.7.2 Weight Gain Percentage (WGP)

$$\text{Weight gain (\%)} = \frac{\text{Final weight} - \text{Initial Weight}}{\text{Initial weight}} \times 100$$

2.7.3 Specific Growth Rate (SGR)

Growth performance can be calculated in terms of specific growth rate (SGR) since it is a more refined and improved growth index than absolute weight gain or percentage growth rate (Hepher, 1988)^[15]. In the present study, Specific Growth Rate was calculated by using this following formula.

$$\text{SGR} = \frac{\text{Log}_e \text{ Final weight} - \text{Log}_e \text{ Initial weight}}{\text{Number of days}} \times 100$$

2.7.4 Feed Conversion Ratio (FCR)

FCR is the ability with which an animal can convert the feed consumed into edible and other product (Devendra, 1989)^[10]. The Feed Conversion Ratio was estimated by the following formula.

$$\text{FCR} = \frac{\text{Food given (Dry Weight)}}{\text{Body Weight Gain (Wet Weight)}}$$

2.7.4 Protein Efficiency Ratio (PER)

$$\text{PER} = \frac{\text{Net Weight Gain (Wet Weight)}}{\text{Protein Fed}}$$

2.8 Survival Rate

At the end of the experiment, all the experimental aquarium tanks were drained out and number of research animals in each tank were counted and the survival rate was calculated by using following formula.

$$\text{Survival (\%)} = \frac{\text{Total number of harvested animal}}{\text{Total number of stocked}} \times 100$$

2.9 Statistical analysis

Statistical significance among different treatments was analysed using one-way analysis of variance (ANOVA) via SPSS 16.0 for windows. Duncan's multiple range test was used for post hoc resemblance of mean ($P < 0.05$) among different treatment groups. All the data presented in the text and tables are mean ± standard error and statistical significance for all statistical tests was set at $P < 0.05$.

3. Results

3.1 Nutritional profile of *Sargassum wightii* meal

The proximate composition of *Sargassum wightii* meal notified in Table-2 and explored that among the all nutrients higher levels of nitrogen free extract (40.36 ± 0.47%) found in brown seaweed meal, then crude ash, moisture, crude protein, fibre and lipid were recorded in the level of 29.52 ± 0.36%, 12.35 ± 0.34%, 9.78 ± 0.23%, 6.97 ± 0.18% and 1.02 ± 0.07% respectively.

Table 2: Proximate composition (% dry weight basis) of *Sargassum wightii* (Brown Seaweed)

Proximate components	<i>Sargassum wightii</i> (%)
Moisture	12.35±0.34
DM	87.65±0.51
CP	9.78±0.23
EE	1.02±0.07
CF	6.97±0.18
CA	29.52±0.36
NFE	40.36±0.47
GE (Kcal/Kg)	1855±3.68

Data expressed as Mean±SE; DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; CF: Crude Fiber; CA: Crude Ash; NFE: Nitrogen Free Extract; GE: Gross Energy.

3.2 Chemical composition of *Gracilaria edulis* meal

The proximate composition of *Gracilaria edulis* meal demonstrated (Table-3) that among the all nutrients the highest levels of nitrogen free extract (41.59±0.43%) found in red seaweed meal, then crude ash, crude protein, moisture, fibre and lipid were recorded in the level of 22.86±0.21%, 16.86±0.28%, 9.25±0.25%, 8.3±0.19% and 1.14±0.06% respectively.

Table 3: Proximate constituents (% dry weight basis) of *Gracilaria edulis* (Red Seaweed)

Proximate components	<i>Gracilaria edulis</i> (%)
Moisture	9.25±0.25
DM	90.75±0.31
CP	16.86±0.28
EE	1.14±0.06
CF	8.3±0.19
CA	22.86±0.21
NFE	41.59±0.43
GE (Kcal/Kg)	1598±2.76

Data expressed as Mean±SE; DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; CF: Crude Fiber; CA: Crude Ash; NFE: Nitrogen Free Extract; GE: Gross Energy.

2.3 Nutritional configuration of the experimental diets

The proximate composition of the various experimental treatment diets were represented in the Table-4. The moisture content was observed within the range of 8.71±0.33% to 9.41±0.32%. The crude protein level varied from 35.84±0.28% to 35.96±0.18%, ether extract was between 6.98±0.14% and 8.36±0.14%, whereas the ash content ranged from 9.86±0.21% to 11.18±0.22%. The crude fibre content in the diet between range of 9.86±0.19% to 11.41±0.21%. The nitrogen free extract of the diet was varied from 34.18±0.39% to 35.94±0.29%. Regarding to gross energy, it's ranged between 1586±2.88 Kcal/Kg to 1774±2.98 Kcal/Kg.

Table 4: Chemical constituents of experimental diets, which made up of with graded levels of brown seaweed *Sargassum wightii* and combination with red seaweed *Gracilaria edulis* in 50:50

	Experimental diets						
	C	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Proximate composition (%) on dry matter basis							
Moisture	8.71±0.33 ^f	9.28±0.31 ^c	8.85±0.29 ^e	9.41±0.32 ^a	9.37±0.31 ^b	8.93±0.27 ^d	8.87±0.37 ^e
DM	91.29±0.31 ^a	90.72±0.27 ^c	91.15±0.31 ^b	90.59±0.31 ^c	90.63±0.27 ^c	91.07±0.34 ^b	91.13±0.31 ^b
CP	35.92±0.18 ^a	35.84±0.28 ^a	35.92±0.12 ^a	35.94±0.13 ^a	35.88±0.28 ^a	35.91±0.14 ^a	35.96±0.18 ^a
EE	7.14±0.06 ^d	8.36±0.14 ^a	7.34±0.11 ^c	6.98±0.14 ^e	7.56±0.17 ^c	8.17±0.16 ^a	7.82±0.14 ^b
CF	11.30±0.19 ^b	11.41±0.21 ^a	10.86±0.19 ^e	11.18±0.27 ^c	10.97±0.28 ^d	10.93±0.17 ^d	11.27±0.31 ^b
CA	9.86±0.21 ^d	10.21±0.17 ^c	11.18±0.22 ^a	9.96±0.31 ^d	11.07±0.19 ^a	9.87±0.18 ^d	10.77±0.24 ^b
NFE	35.78±0.43 ^a	34.18±0.58 ^d	34.70±0.38 ^c	35.94±0.29 ^a	34.52±0.25 ^c	35.12±0.37 ^b	34.18±0.39 ^d
GE (Kcal/Kg)	1723±3.11 ^b	1774±2.98 ^a	1697±3.57 ^c	1679±2.73 ^d	1586±2.88 ^f	1591±2.71 ^f	1622±3.65 ^e

Data expressed as Mean±SE; Mean values in the same row with different superscripts differ significantly ($p < 0.05$).

C: Control diets (without brown and red seaweed meals); T₁: Experimental diet with 2% of *Sargassum wightii* meal; T₂: Experimental diet with 4% of *Sargassum wightii* meal; T₃: Experimental diet with 6% of *Sargassum wightii* meal; T₄: Experimental diet with 1% *Sargassum wightii* meal and 1% *Gracilaria edulis* meal; T₅: Experimental diet with 2% *Sargassum wightii* meal and 2% *Gracilaria edulis* meal; T₆: Experimental diet with 3% *Sargassum wightii* meal and 3% *Gracilaria edulis* meal.

DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; CF: Crude Fiber; CA: Crude Ash; NFE: Nitrogen Free Extract; GE: Gross Energy.

2.4 Growth and nutrient utilization parameters

The growth and nutrient utilization parameters were analyzed for all the treatment groups and revealed in Table-5. The higher final body weight was measured and denoted for all experimental groups and the significant differentiation ($P < 0.05$) was observed among the all treatments. The maximal final body weight 14.70±0.15g was disclosed in the group fed diet T₆, but lower value was ascertained in the control and T₄ fed diets. The weight gain and weight gain percentage were calculated and noted down for all experimental groups and significant divergence ($P < 0.05$) was detected among the treatment groups. The highest weight gain and weight gain% with values of 13.62±0.13g and 1261.11±2.11% respectively were stated in the group fed with diet T₆, whereas the lowest was identified in control and T₄ fed diets with the values of 9.10±0.09g and 9.11±0.12g belongs to weight gain respectively;

830.29±1.29% and 828.18±1.57% related to weight gain percentage respectively. Similarly, a significant fluctuation ($P < 0.05$) was discovered in specific growth rate (SGR) among the experimental groups. The highest SGR (2.61±0.03%) was investigated in group fed with diet T₆, while the lowest (2.23±0.04%) was dictated in control and T₄ diets. The feed conversion ratio (FCR) of various experimental groups also varied significantly ($P < 0.05$). The lowest FCR was registered in T₆ group with 1.71±0.04. The highest FCR was noted in control group (2.57±0.03). The group fed with diet T₆ had the highest protein efficiency ratio (PER) value of 1.73±0.02, while the lowest PER value (1.08±0.02) was observed in control diet. Group fed with control diet and T₃ had the highest feed intake followed by in T₅ and the lowest feed intake was found in T₂ group fed diet.

Table 5: Growth and nutrient utilization parameters of *Litopenaeus vannamei* fed with different levels of brown seaweed *Sargassum wightii* individually and combination with *Gracilaria edulis* containing diets.

	Experimental diets						
	C	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Growth parameters							
IBW (g)	1.10±0.02 ^a	1.09±0.05 ^b	1.09±0.03 ^b	1.10±0.02 ^a	1.10±0.03 ^a	1.09±0.02 ^b	1.08±0.04 ^c
FBW (g)	10.20±0.11 ^f	10.34±0.14 ^e	11.15±0.11 ^d	12.87±0.13 ^b	10.21±0.12 ^f	12.18±0.11 ^c	14.70±0.15 ^a
WG (g)	9.10±0.09 ^f	9.25±0.11 ^e	10.06±0.13 ^d	11.77±0.13 ^b	9.11±0.12 ^f	11.09±0.14 ^c	13.62±0.13 ^a
WG%	830.29±1.29 ^e	848.62±1.43 ^d	922.94±2.21 ^c	1070.00±2.17 ^b	828.18±1.57 ^e	1017.43±1.72 ^b	1261.11±2.11 ^a
SGR (%)	2.23±0.04 ^d	2.25±0.03 ^d	2.33±0.04 ^c	2.46±0.05 ^b	2.23±0.03 ^d	2.41±0.04 ^b	2.61±0.03 ^a
Nutrient utilization parameters							
FCR	2.57±0.03 ^a	2.52±0.04 ^b	2.21±0.03 ^c	2.06±0.04 ^d	2.54±0.06 ^b	2.18±0.04 ^c	1.71±0.04 ^e
PER	1.08±0.02 ^e	1.12±0.05 ^d	1.30±0.04 ^c	1.42±0.03 ^b	1.09±0.04 ^e	1.39±0.05 ^b	1.73±0.02 ^a
FI (g)	23.38±0.21 ^b	23.31±0.24 ^b	22.23±0.19 ^e	24.25±0.23 ^a	23.14±0.31 ^d	24.18±0.21 ^a	23.29±0.27 ^c

Data expressed as Mean±SE (n=12, r=3); Mean values in the same row with different superscripts differ significantly ($p<0.05$).

C: Control diets (without brown and red seaweed meals); T₁: Experimental diet with 2% of *Sargassum wightii* meal; T₂: Experimental diet with 4% of *Sargassum wightii* meal; T₃: Experimental diet with 6% of *Sargassum wightii* meal; T₄: Experimental diet with 1% *Sargassum wightii* meal and 1% *Gracilaria edulis* meal; T₅: Experimental diet with 2% *Sargassum wightii* meal and 2% *Gracilaria edulis* meal; T₆: Experimental diet with 3% *Sargassum wightii* meal and 3% *Gracilaria edulis* meal.

IBW: Initial Body Weight; FBW: Final Body Weight; WG: Weight Gain; WG%: Weight Gain Percentage; SGR: Specific Growth Rate; FCR: Feed Conversion Ratio; PER: Protein Efficiency Ratio; FI: Feed Intake.

3.5 Survival rates

In the present research study on *Litopenaeus vannamei* with incorporation of various levels of brown seaweed *Sargassum wightii* meal separately and in combination with red seaweed *Gracilaria edulis* meal in their diet to evaluate survival percentages were assessed and demonstrated in

Table-6. A significant variableness ($p<0.05$) was determined among the all treatment groups. The higher survival percentage was expressed in experimental animal fed diet group T₃ with value of 83.33%, whereas the lowest survival rate 63.88% was noticed in control and T₄ diet fed groups.

Table 6: Survival rate of *Litopenaeus vannamei* fed with different levels of brown seaweed *Sargassum wightii* individually and with combination of *Gracilaria edulis* containing diets at the end of experimental period

1. Treatments	2. Survival Rate (%)
3. C	4. 63.88
5. T ₁	6. 69.44
7. T ₂	8. 80.55
9. T ₃	10. 83.33
11. T ₄	12. 63.88
13. T ₅	14. 72.22
15. T ₆	16. 77.77

C: Control diets (without brown and red seaweed meals); T₁: Experimental diet with 2% of *Sargassum wightii* meal; T₂: Experimental diet with 4% of *Sargassum wightii* meal; T₃: Experimental diet with 6% of *Sargassum wightii* meal; T₄: Experimental diet with 1% *Sargassum wightii* meal and 1% *Gracilaria edulis* meal; T₅: Experimental diet with 2% *Sargassum wightii* meal and 2% *Gracilaria edulis* meal; T₆: Experimental diet with 3% *Sargassum wightii* meal and 3% *Gracilaria edulis* meal.

4. Discussion

4.1 Nutrient properties of *Sargassum wightii* meal

In the present research study, the procured *Sargassum wightii* meal was subjected to chemical reactions under nutritional laboratory to evaluate the nutritional attributes and the results were disclosed that the brown seaweed *Sargassum wightii* comprised of crude protein value at 9.78±0.23%, which was higher than 9.43±0.99% obtained from *Sargassum polycystum*, 8.00±1.38% from *Sargassum cristaefolium* and 7.04±0.68% from *Sargassum wightii* (Kurre *et al.*, 2025) [22]; also the highest than the protein contents which were found by Elangovan and Anantharaman (2019) [11] in the seaweed species of *Sargassum wightii*, *Jania rubens*, and *Chondrus crispus* with the values of 4.5%, 3.45% and 3.2% respectively; and also higher than protein value 6.43±0.39% from *Sargassum wightii* (Kumar *et al.*, 2021) [21], 8% in *Sargassum wightii* (Kumar *et al.*, 2015) [20], 5.13 g in *Sargassum wightii* (Adithiyalakshmi *et al.*, 2024) [2], but the value of protein determined in this present study of *Sargassum wightii* was lower than the protein values from *Ulva rigida* at 27.11±0.62% (Kumar *et al.*, 2021) [21], *Sargassum wightii*

and *Sargassum thunbergii* with values 10.5±1.0 and 12.3±1.0 respectively (Chatterjee and Mathew, 2023). Additionally it contained 1.02±0.07% lipids, which was least than *Sargassum wightii* with 1.22±0.19% (Kurre *et al.*, 2025) [22], *Sargassum wightii* at value 3.09±0.41% (Kumar *et al.*, 2021) [21], *Sargassum wightii* with 3.0±0.7% (Chatterjee and Mathew, 2023); but it's higher than fat values of *Sargassum wightii* with 0.21 g (Adithiyalakshmi *et al.*, 2024) [2], *Sargassum thunbergii* value of 0.8±0.1% (Chatterjee and Mathew, 2023). Also it comprised 6.97±0.18% crude fiber, which was the lowest value than that of *Sargassum wightii* with 30.72±1.45% (Kurre *et al.*, 2025) [22], *Sargassum wightii* at 24.93±0.23% (Kumar *et al.*, 2021) [21], however it higher than *Sargassum wightii* and *Ulva lactuca* with values of 24.1 g and 27.6 g respectively (Adithiyalakshmi *et al.*, 2024) [2]. In this study *Sargassum wightii* consisted of 29.52±0.36% total ash which was the highest than *Sargassum cristaefolium* (16.46±0.68%), *Sargassum polycystum* (14.94±0.37%) and *Sargassum wightii* with 14.79±0.56% (Kurre *et al.*, 2025) [22], *Sargassum wightii* and *Sargassum thunbergii* with 12.5-16.3% (Chatterjee and Mathew, 2023). Discovered

carbohydrate level in *Sargassum wightii* in this present study was $40.36 \pm 0.47\%$, which was higher than *Jania rubens*, *Sargassum wightii*, *Halimeda tuna* and *Chondrus crispus* with values ranged between 6 to 12% (Elangovan and Anantharaman, 2019) [11]; but it lowest compared to values in *Sargassum wightii* with $45.66 \pm 0.50\%$ (Kumar *et al.*, 2021) [21], Kumar *et al.*, 2015 [20] reported 48.9-57.2% total carbohydrate content in *Sargassum wightii* and Chatterjee and Mathew, 2023 were demonstrated the carbohydrate range between 65.1-67.9% in brown algae *Sargassum wightii* and *Sargassum thunbergii*. Estimated moisture value was $12.35 \pm 0.34\%$ in *Sargassum wightii* in this research work, which was the least value than that of values in *Sargassum wightii* ($18.72 \pm 0.86\%$), *Sargassum cristaeifolium* ($16.98 \pm 1.48\%$) and *Sargassum polycystum* with $15.63 \pm 1.15\%$ (Kurre *et al.*, 2025) [22]. And finally targeted candidate brown seaweed *Sargassum wightii* was exhibited gross energy value with 1855 ± 3.68 Kcal/Kg which the lowest compared to values in *Sargassum wightii*, *Sargassum cristaeifolium* and *Sargassum polycystum* with 2639.21 ± 15.42 Kcal/Kg, 2777.31 ± 11.56 Kcal/Kg and 2842.31 ± 18.74 Kcal/Kg respectively (Kurre *et al.*, 2025) [22].

4.2 Proximate components of *Gracilaria edulis* meal

The present experimental study discovered the chemical composition of red seaweed *Gracilaria edulis* meal, which dwell of $16.86 \pm 0.28\%$ crude protein level, which is higher than the previous reports of 6.68 ± 0.94 mg g⁻¹ dry weight basis (Sakthivel and Devi, 2015) [30], $5.31 \pm 0.37\%$ (Jayasankar *et al.*, 2005), $14.26 \pm 0.88\%$ (Debbarama *et al.*, 2016) [9], $14.83 \pm 0.69\%$ (Kalluri *et al.*, 2025) [19] for the same red seaweed of *Gracilaria edulis*, 2.4% in *Caulerpa sertularioides* (Porchas *et al.*, 1999) [27], 3.2% (Peñaflorida and Golez, 1996) [25] in *Kappaphycus alvarezii*, 13.69% in *Gracilaria lemaneiformis* (Niu *et al.*, 2019) [24], also higher than the protein content ($9.78 \pm 0.23\%$) of *Sargassum wightii* meal, which utilized in this study. However, it is lower in crude protein than *Gracilaria edulis* ($25.29 \pm 0.67\%$) (Rosemary *et al.*, 2019) [28], *Gracilaria heteroclada* (17.3%) (Peñaflorida and Golez, 1996) [25], *Gracilaria cervicornis* (22.9%) (Marinho-Soriano *et al.*, 2007) [23], *Ulva clathrata* with 23.4% (Cruz-Suárez *et al.*, 2009) [7], *Cryptonemia crenulata* with 21.5% and *Hypnea cervicornis* with 19.6% (Da Silva and Barbosa, 2009). In addition, it comprised $1.14 \pm 0.06\%$ fats, which is less than *Gracilaria edulis* with $4.76 \pm 0.73\%$ (Rosemary *et al.*, 2019) [28], *Gracilaria edulis* with $1.91 \pm 0.55\%$ (Debbarama *et al.*, 2016) [9], *Gracilaria heteroclada* with 1.8% (Peñaflorida and Golez, 1996) [25]; but higher than *Kappaphycus alvarezii* at 0.6% (Peñaflorida and Golez, 1996) [25], *Gracilaria cervicornis* with 0.5% (Marinho-Soriano *et al.*, 2007) [23], *Ulva clathrata* with 1.0% (Cruz-Suárez *et al.*, 2009) [7], *Cryptonemia crenulata* with 1.1% and *Hypnea cervicornis* with 1.0% (Da Silva and Barbosa, 2009) [8], 0.73 ± 0.001 to $0.93 \pm 0.00\%$ in *Gracilaria edulis*, *Ulva lactuca* and *Sargassum* sp. (Debbarama *et al.*, 2016) [9]. Also it contained of $8.3 \pm 0.19\%$ fibre which is the lowest than *Gracilaria edulis* at $10.38 \pm 1.04\%$ (Kalluri *et al.*, 2025) [19], *Gracilaria edulis* with $63.175 \pm 0.46\%$ (Debbarama *et al.*, 2016) [9]; in contrast higher than *Kappaphycus alvarezii* with 5.9% and *Gracilaria heteroclada* with 4.6% (Peñaflorida and Golez, 1996) [25], *Ulva clathrata* with 4.6% (Cruz-Suárez *et al.*, 2009) [7], *Ulva clathrata* with 0.6% (Cruz-Suárez *et al.*, 2008, June) [6]. In present study *Gracilaria edulis* comprised of $22.86 \pm 0.21\%$

total ash, which is higher than *Gracilaria edulis* at 8.7% (Sakthivel and Devi, 2015) [30], *Kappaphycus alvarezii* with 18.1% and *Gracilaria heteroclada* with 21.7% (Peñaflorida and Golez, 1996) [25], *Cryptonemia crenulata* with 13.7% and *Hypnea cervicornis* with 13.7% (Da Silva and Barbosa, 2009) [8], *Caulerpa sertularioides* with 2.2% (Porchas *et al.*, 1999) [27], *Ulva clathrata* with 4.5% (Cruz-Suárez *et al.*, 2008, June) [6]. And finally selected red seaweed *Gracilaria edulis* consisted of $41.59 \pm 0.43\%$ nitrogen free extract which is the highest than *Gracilaria edulis* with 101.61 ± 1.8 mg g⁻¹ dry weight basis (Sakthivel and Devi, 2015) [30], *Gracilaria edulis* with $4.71 \pm 0.60\%$ (Rosemary *et al.*, 2019) [28], *Hypnea cervicornis* with 41.5% (Da Silva and Barbosa, 2009) [8], *Ulva clathrata* with 3.5% (Cruz-Suárez *et al.*, 2008, June) [6]; but it is less than *Kappaphycus alvarezii* with 72.3% and *Gracilaria heteroclada* with 54.6% (Peñaflorida and Golez, 1996) [25], *Gracilaria cervicornis* with 63.1% (Marinho-Soriano *et al.*, 2007) [23], *Cryptonemia crenulata* with 44.9% (Da Silva and Barbosa, 2009) [8]. However, these difference in crude protein level may be due to the seasonal, geographical location, habitat and nutritional variations (Pereira *et al.*, 2024) [26].

4.3 Growth performance

Regarding of growth related parameters the final body weight was found with in the range of 10.20 ± 0.11 g to 14.70 ± 0.15 g for the all treatment groups including control, among these results in term of individual effect of *Sargassum wightii* meal with administration levels 2 - 6% were given significant variation in the growth parameters, that out of all the concentration levels the highest final body weight 12.87 ± 0.13 g was noticed with 6% inclusion level of *Sargassum wightii* meal, which is higher than final body weight of *Litopenaeus vannamei* 4.8 grams with *Ulva clathrata*, 4.6 grams with *Ascophyllum nodosum* and 4.3 grams with *Macrocystis pyrifera* (CRUZ-SUÁREZ *et al.*, 2009) [7]. In this study supreme final body weight and weight gain were evaluated with the values 14.70 ± 0.15 g and 13.62 ± 0.13 g respectively in T₆, which comprised of 6% mixture of *Sargassum wightii* and *Gracilaria edulis* meals in equal proportion, similar results were determined by Seyedalhosseini *et al.*, 2023 [32] in juvenile Asian seabass (*Lates calcarifer*) in the aspect of growth performance (final weight and weight gain increment) with addition up to 12% of *Sargassum* and *Gracilaria* mixture in equal proportions in the experimental animal diet. In other hand Huynh *et al.*, 2016 [16] results are also supporting the present study out comes in terms of final body weight and weight gain enhancement with the values of 1.59 ± 0.18 g and 1.51 ± 0.18 g respectively with administration level of *Sargassum microcystum* extract at 1% in the diet of *Litopenaeus vannamei* for 60 days experimental period.

The higher weight gain percentage of $1070.00 \pm 2.17\%$ and $1261.11 \pm 2.11\%$ were generated with the incorporation rate at 6% of *Sargassum wightii* individually and in combination at 6% mixture in equal ration with *Gracilaria edulis* respectively, which values were more compare to the result of $738 \pm 47.9\%$ obtained through inclusion of *Sargassum horneri* with 8% in the diet of pacific white shrimp *Litopenaeus vannamei* (Eom *et al.*, 2020) [12], the higher weight gain percentages discovered with incorporation of *Sargassum wightii* powder individually and in collaboration with *Gracilaria edulis* meal at concentration levels of 6% and 6% (equal proportion of both) in the diet of pacific

white leg shrimp in this present study were 23 and 28 times more respectively than weight gain% ($45.15 \pm 2.00\%$) dragged with inclusion rate at 6% of *Sargassum wightii* dry powder separately fed to the *Labeo rohita* (Gora et al., 2018)^[13].

The higher specific growth rate $2.61 \pm 0.03\%$ was estimated with combination of *Sargassum wightii* meal at 3% and *Gracilaria edulis* meal at 3% compared to other treatment groups in this present research work, which was supported with results of Cruz-Suárez et al., 2000^[5] that hike in growth rate at the rate of 53-68% in white shrimp *Litopenaeus vannamei* juveniles fed with diets comprising 2 or 4% incorporation levels of Mexican kelp meal (*Macrocystis pyrifera*) and 4 and 8% inclusion levels of Chilean kelp meal (*Macrocystis pyrifera*), and same result of specific growth rate was observed with an improvement in specific growth rate (SGR) of experimental animal *Litopenaeus vannamei* fed diets with increasing levels (1, 4, 7, 10%) of *Macrocystis* or *Sargassum* meals, with 10% inclusion level given the best growth rate (Gutiérrez-Leyva, 2006)^[14]. Increment of specific growth rate (SGR) was noticed with value $2.61 \pm 0.03\%$ compared to other treatment groups in this work with supplementation of T₆ test diet (6% concentration with equal amounts of mixture of *Sargassum wightii* and *Gracilaria edulis* meals) to *Litopenaeus vannamei*, similarly previous reports were supporting our findings that higher specific growth rate (2.36 ± 0.03) was found in *Lates calcarifer* diet fed with up to 12% mixture of *Gracilaria* and *Sargassum* meals (Seyedalhosseini et al., 2023)^[32], which was lower than SGR of present study, in another research work Sajina et al., 2019^[29] were expressed the SGR value of 1.19% in the rexpérimental fish species of *Labeo rohita* which fed with diet of BF (basal diet + 2% *Sargassum wightii* extract) also lower than the present study SGR value. And also the evaluated SGRs with administration of 6% *Sargassum wightii* meal solely and 6% of equal amounts of *Sargassum wightii* and *Gracilaria edulis* were 2.46 ± 0.05 and 2.61 ± 0.03 respectively in the diet fed animal *Litopenaeus vannamei*, were more than the value of SGR at 0.26 ± 0.01 , which obtained with addition of 6% *Sargassum wightii* powder to experimental animal of *Labeo rohita* (Gora et al., 2018)^[13].

4.4 Nutrient utilization

Belongs to feed conversion ratio the mixed seaweed meals of *Sargassum wightii* with 3% and *Gracilaria edulis* with 3% was revealed better feed conversion ratio (FCR) at 1.71 ± 0.04 , which is similar to FCR of 1.7 with *Ulva clathrata*, in contrast lower than 1.9 with *Ascophyllum nodosum* and 2.1 with *Macrocystis pyrifera* (CRUZ-SUÁREZ et al., 2009)^[7] diets fed to the shrimps, 2.04 ± 0.17 with administration of 13% rhodophyte algae *Cryptonemia crenulata* and *Hypnea cervicornis* in equal proportions in the diet of white leg shrimp *Litopenaeus vannamei* (da Silva and Barbosa, 2009)^[8], 1.9 with incorporation of basal diet with combination of 2% *Sargassum wightii* extract in the experimental diet to *Labeo rohita* (Sajina et al., 2019)^[29], 1.77 ± 0.16 FCR value gained with 8% administration of *Sargassum horneri* meal fed to *Litopenaeus vannamei* (Eom et al., 2020)^[12]; with compare to 0.97 FCR value with 6% inclusion of combined *Sargassum* and *Gracilaria* meals in the diet of juvenile Asian seabass (Seyedalhosseini et al., 2023)^[32], it is higher; but also sole in-corporations of *Sargassum wightii* in present

study contained higher FCR values. The feed conversion rate values at 2.06 ± 0.04 and 1.71 ± 0.04 were found through inclusion of 6% *Sargassum wightii* powder separately and 6% mixing up of *Sargassum wightii* and *Gracilaria edulis* in equal proportions respectively were the least values compare to 2.66 ± 0.12 , which denoted with influence of 6% of *Sargassum wightii* powder in the test diet of *Labeo rohita* (Gora et al., 2018)^[13].

In present study the significant highest protein efficiency ratio (PER) 1.73 ± 0.02 ascertained in diet fed of combination of *Sargassum wightii* meal (3%) and *Gracilaria edulis* meal (3%) consisted to the *Litopenaeus vannamei* than the *Ascophyllum nodosum*, which with 1.7 and *Macrocystis pyrifera* at 1.5 (CRUZ-SUÁREZ et al., 2009)^[7] fed to the shrimps, comprised greater value than 1.60 ± 0.14 with fed diet consisted of 8% *Sargassum horneri* to the pacific white leg shrimp (Eom et al., 2020)^[12], also higher than PER value of 1.51 evaluated by Sajina et al., 2019^[29] through supplementation of 2% *Sargassum wightii* extract in with mixing of basal diet to the *Labeo rohita*. The estimated protein efficiency ratios 1.42 ± 0.03 and 1.73 ± 0.02 with addition of 6% *Sargassum wightii* powder solely and mixed equal proportions of 3% *Sargassum wightii* and 3% *Gracilaria edulis* respectively were noticed as the highest values than the 0.93 ± 0.04 PER value in the experimental study conducted by Gora et al., 2018^[13] on the growth and immunity performances of *Labeo rohita* with incorporation of 6% *Sargassum wightii* powder in their diets.

4.5 Survival rate

The significant higher survival rate at 83.33% was notified in our findings of this present study on the pacific white shrimp *Litopenaeus vannamei* with 6% addition level of T₃ test diet group, which contained of *Sargassum wightii* meal singly compare to other treatment groups, which was also very higher than survival rate value of 56.7% determined by Huynh et al., 2016^[16] with inclusion level of *Sargassum microcystum* extract at 1% in the diet of *Litopenaeus vannamei* at the end of experimental period, also higher survival percentile compare to 46.3% which was gained with same seaweed meal (*Sargassum wightii* powder) at the same inclusion level (6%) in the diet of *Labeo rohita* (Gora et al., 2018)^[13]; in contrast it is the lowest rate compare to 87.5%, which acquired with inclusion of *Sargassum horneri* meal at 8% in the experimental diet of *Litopenaeus vannamei* (Eom et al., 2020)^[12].

5. Limitations of the study

This study observed that *Sargassum wightii* and *Gracilaria edulis* meals can be utilized up to 6% and 3% in combination incorporation levels beyond any doubt, which will extremely assist the growth and survival without constraint the health conditions in shrimps, but in some studies display that surpassing of inclusion levels more than 10% possess the impairment in growth, deducted the survival rates and exposed the inauspicious effect on growth, nutrient utilization and health status of aquatic animals. Identified that restricted literature available on growth and survival of specific chosen shrimp species *Litopenaeus vannamei* and no or deficient data available on usage of *Sargassum wightii* and *Gracilaria edulis* powders specific in pond culture systems of shrimps, in view of this further more research works to be done on usage of *Sargassum wightii* and *Gracilaria edulis* meals to increment

utilization of seaweed meals as alternative feed ingredients to costliest fish meal, soybean meal etc., to trim down the feed cost and gain more shrimp production with low cost feed ingredients.

6. Conclusion

In the present research study with administration of various levels at 2%, 4% and 6% of *Sargassum wightii* individually and in mixing with *Gracilaria edulis* meal in equal proportions in the diet of pacific white leg shrimp *Litopenaeus vannamei* to appraise the growth and nutrient utilization along with survival performances, the results were disclosed that 6% incorporation level of *Sargassum wightii* meal and up to 6% inclusion in combination of *Gracilaria edulis* meal in the same ration have shown the affirmative effect in the form of increase mode of growth parameters such as final body weight, weight gain, weight gain percentage and specific growth rate and efficient nutrient utilization viz., feed conversion ratio and protein efficiency ratio along with good survival rate compare to other treatments. In view of this it is concluded that seaweeds *Sargassum wightii* powder separately and in collaboration with *Gracilaria edulis* meal can be enclosed in the diets of *Litopenaeus vannamei* up to 6% for the rise of shrimp production which may not cause for adverse effect on health of shrimp and environments of culture locations.

7. Disclaimer (Artificial Intelligence)

We (Authors) declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

8. Acknowledgements

We cordially thank Officer on Special Duty, Andhra Pradesh Fisheries University, Narasapuram, West Godavari, Andhra Pradesh and Associate Dean, College of Fishery Science, Muthukur, SPSR Nellore, Andhra Pradesh for furnishing well equipped laboratories for the research work and ICAR-CIFE, Kakinada, Andhra Pradesh for technical support during laboratory works.

References

1. Abbas EM, Al-Souti AS, Sharawy ZZ, El-Haroun E, Ashour M. Impact of dietary administration of seaweed polysaccharide on growth, microbial abundance, and growth and immune-related genes expression of the Pacific whiteleg shrimp (*Litopenaeus vannamei*). Life. 2023;13(2):344.
2. Adithiyalakshmi S, Sangma SJ, Sivakami PS. From ocean depths to nutrient rich plates: A comparative study on the toxicity, nutritional composition and antioxidant potential of selected seaweeds. Int J Adv Biochem Res. 2024;8(3):36-40.
3. Association of Official Analytical Chemists. Official methods of analysis of the Association of Official Analytical Chemists. Vol. 11. Washington DC: Association of Official Analytical Chemists; 2000.
4. Chatterjee NS, Mathew S. Evaluation of the proximate composition, minerals, and heavy metals of brown seaweeds: *Sargassum wightii* and *Sargassum thunbergii* collected from the Mandapam coastal regions, Tamil Nadu. 2023.
5. Cruz-Suárez E, Ricque-Marie D, Tapia-Salazar M, Guajardo-Barbosa C. Use of kelp meal (*Macrocystis pyrifera*) in shrimp feeds. Adv Aquac Nutr. 2000.
6. Cruz-Suárez LE, León AA, Peña-Rodríguez A, Rodríguez-Peña G, Moll B, Ricque-Marie D. Shrimp and green algae co-culture to optimize commercial feed utilization. In: Proceedings of the XIII International Symposium on Nutrition and Feeding in Fish; 2008 Jun; Florianopolis. p. 1.
7. Cruz-Suárez LE, Tapia-Salazar M, Nieto-López MG, Guajardo-Barbosa C, Ricque-Marie D. Comparison of *Ulva clathrata* and the kelps *Macrocystis pyrifera* and *Ascophyllum nodosum* as ingredients in shrimp feeds. Aquac Nutr. 2009;15(4):421-430.
8. da Silva RL, Barbosa JM. Seaweed meal as a protein source for the white shrimp *Litopenaeus vannamei*. J Appl Phycol. 2009;21(2):193-197.
9. Debbarma J, Rao BM, Murthy LN, Mathew S, Venkateshwarlu G, Ravishankar CN. Nutritional profiling of the edible seaweeds *Gracilaria edulis*, *Ulva lactuca* and *Sargassum* sp. Indian J Fish. 2016;63:81-87.
10. Devendra C. Potential value of non-conventional feedstuffs for animals in Asia. Bangkok: FAO; 1989.
11. Elangovan M, Anantharaman P. Nutritional composition and phytochemistry profile of seaweeds collected from Rameshwaram coast. Int J Sci Technol Res. 2019;8:3137-3140.
12. Eom G, Shin J, Lim SJ, Lee KT, Han YS, Lee KJ. Evaluation of dietary supplementation of *Sargassum horneri* for Pacific white shrimp *Litopenaeus vannamei*. Korean J Fish Aquat Sci. 2020;53(6):909-917.
13. Gora AH, Sahu NP, Sahoo S, Rehman S, Dar SA, Ahmad I, Agarwal D. Effect of dietary *Sargassum wightii* and its fucoidan-rich extract on growth, immunity, disease resistance and antimicrobial peptide gene expression in *Labeo rohita*. Int Aquat Res. 2018;10(2):115-131.
14. Gutiérrez Leyva R. Use of *Macrocystis pyrifera* and *Sargassum* spp. meals in balanced feeds for shrimp *Litopenaeus vannamei*: effects on growth and digestibility *in vivo* [dissertation]. Mexico: National Polytechnic Institute, Interdisciplinary Center for Marine Sciences; 2006.
15. Hephher B. Nutrition of pond fishes. Cambridge: Cambridge University Press; 1988.
16. Huynh TG, Tran TG, Tran SN, Vu NU, Duong THO. Chemical composition, antioxidant activity of crude polysaccharide extracted from brown seaweed *Sargassum microcystum* and its effect on growth performance and survival of whiteleg shrimp *Litopenaeus vannamei* via dietary administration. Can Tho Univ J Sci. 2016;(4):71-80.
17. Jahromi ST, Pourmozaffar S, Jahanbakhshi A, Rameshi H, Gozari M, Khodadadi M, et al. Effect of different levels of dietary *Sargassum cristaeifolium* on growth performance, hematological parameters, histological structure of hepatopancreas and intestinal microbiota of *Litopenaeus vannamei*. Aquaculture. 2021;533:736130.
18. Jayasankar R, Ramakrishnan R, Nirmala K, Seema C. Biochemical constituents of *Gracilaria edulis* cultured from spores. Seaweed Res Util. 2005;17(1-2):39-44.
19. Kalluri S, Pandi G, Subbiah B, Nagarajan M, Bagthasingh C, Kandan D. Unveiling the nutrient and

- bioactive potential of *Gracilaria edulis* and *Ulva lactuca* as remarkable functional food ingredients. *Thalassas*. 2025;41(4):214.
20. Kumar S, Sahoo D, Levine I. Assessment of nutritional value in a brown seaweed *Sargassum wightii* and their seasonal variations. *Algal Res*. 2015;9:117-125.
 21. Kumar Y, Tarafdar A, Kumar D, Verma K, Aggarwal M, Badgujar PC. Evaluation of chemical, functional, spectral, and thermal characteristics of *Sargassum wightii* and *Ulva rigida* from Indian coast. *J Food Qual*. 2021;2021:9133464.
 22. Kurre D, Ramsare JR, Kashyap N, Banjare LK, Bhosale MM, Barik P. Assessment of nutritional composition and potential applications of *Sargassum* species along the coastal regions of Tamil Nadu, India. *Ann For Res*. 2025:47-57.
 23. Marinho-Soriano E, Camara MR, Cabral TDM, Carneiro MADA. Preliminary evaluation of the seaweed *Gracilaria cervicornis* (Rhodophyta) as a partial substitute for the industrial feeds used in shrimp (*Litopenaeus vannamei*) farming. *Aquac Res*. 2007;38(2):182-187.
 24. Niu J, Xie JJ, Guo TY, Fang HH, Zhang YM, Liao SY, et al. Comparison and evaluation of four species of macro-algae as dietary ingredients in *Litopenaeus vannamei* under normal rearing and WSSV challenge conditions: Effect on growth, immune response, and intestinal microbiota. *Front Physiol*. 2019;9:1880.
 25. Peñaflores VD, Golez NV. Use of seaweed meals from *Kappaphycus alvarezii* and *Gracilaria heteroclada* as binders in diets for juvenile shrimp *Penaeus monodon*. *Aquaculture*. 1996;143(3-4):393-401.
 26. Pereira L, Cotas J, Gonçalves AM. Seaweed proteins: A step towards sustainability? *Nutrients*. 2024;16(8):1123.
 27. Porchas Cornejo MA, Martínez Córdova L, Magallón Barajas F, Naranjo Páramo J, Portillo Clark G. Effect of the macroalgae *Caulerpa sertularioides* on the development of the shrimp *Penaeus californiensis* (Decapoda: Penaeidae). *Rev Biol Trop*. 1999;47(3):437-442.
 28. Rosemary T, Arulkumar A, Paramasivam S, Mondragon-Portocarrero A, Miranda JM. Biochemical, micronutrient and physicochemical properties of the dried red seaweeds *Gracilaria edulis* and *Gracilaria corticata*. *Molecules*. 2019;24(12):2225.
 29. Sajina KA, Sahu NP, Varghese T, Jain KK. Fucoidan-rich *Sargassum wightii* extract supplemented with α -amylase improve growth and immune responses of *Labeo rohita* (Hamilton, 1822) fingerlings. *J Appl Phycol*. 2019;31(4):2469-2480.
 30. Sakthivel R, Devi KP. Evaluation of physicochemical properties, proximate and nutritional composition of *Gracilaria edulis* collected from Palk Bay. *Food Chem*. 2015;174:68-74.
 31. Sarkar S, Ambasankar K, Raja RA, Rekha PN, Datta J, Raja RN. Red seaweed (*Gracilaria tenuistipitata*) as a source of natural binder in the diet of *Penaeus vannamei* and its effect on growth and immunity. *Aquaculture*. 2025;743420.
 32. Seyedalhosseini SH, Salati AP, Mozanzadeh MT, Parrish CC, Shahriari A. Effects of dietary seaweeds (*Gracilaria* spp. and *Sargassum* spp.) on growth, feed utilization, and resistance to acute hypoxia stress in juvenile Asian seabass (*Lates calcarifer*). *Aquac Rep*. 2023;31:101663.