CHAPTER-II
REVIEW OF LITERATURE

Seaweeds form an important renewable resource in the marine environment and have been a part of human civilization from time immemorial. Reports on the uses of seaweeds have been cited as early as 2500 years ago in Chinese literature (Tseng, 2004). The long history of seaweed utilization for a variety of purposes has led to the gradual realization that some of their constituents are more superior and valuable in comparison to their counterparts on land. There are in the nature different types of antimicrobial compounds present that play an important role in the natural defense of all kinds of living organisms (Ilhami et al., 2003). According to Hafezieh et al. (2014) among the seaweed families, Ulvaceae and Caulerpaceae belong to green algae, Sargassaceae belong to brown algae and Gracilariaceae, Gelidiaceae and Hypneaceae belong to red algae have a lot to applications in feeding industry and medical sciences fields.

*Litopenaeus vannamei* is nature to the Pacific coast of Mexico, Central and South America as far south of Peru. Scientifically known as *Litopenaeus vannamei* (Boone, 1931) and commonly known as Mexican white, Pacific white or white leg shrimp. It is translucent white in color. The body of the shrimp often has bluish hue, which are concentrated near the margins of telson and uropods and the rostrum is moderately long with 7-10 dorsal and 2-4 (occasionally 5-8) ventral teeth. It grows to about 230 mm (9 inches) in nature, where the water temperature is above 20°C normally. It lives muddy bottoms and feeds more efficiently than tiger and prefers to be an omnivorous. It is the most widely cultured shrimp in the world and is raised in at least 27 countries, with major production operations occurring in the US, Mexico, Central America, tropical South America, China, India and southeast Asia.

2.1 THE NUTRITIONAL QUALITY OF SEAWEED

Ortiz et al. (2006) estimated the nutritional composition including dietary fiber content, amino acid and fatty acid profiles along with tocopherols and tocotrienols (pro-vitamin E). Results show that *U. lactuca* contained 60.5 ± 1.5%, and *D. antarctica* 71.4 ± 1.5% (frond) and 56.4 ± 0.4% (stem) of TDF. Levels for the different amino acids ((mg/100 g protein) ranged from 0.7 ± 0.1 to 1508.4 ± 9.5 in
U. lactuca; 0.2 ± 0.0 to 2019.9 ± 5.2 (stem) and 0.3 ± 0.0 to 1052.6 ± 2.9 (leaves) of D. antarctica. The most abundant fatty acid was C18:1x9cis which was accounted 27.42 ± 2.60% in U. lactuca as well as 25.83 ± 2.52% (stem) and 25.36 ± 3.10% (leaves) in D. antarctica. In D. antarctica, 651.7 ± 5.1, 245.9 ± 3.7 and 179.4 ± 12.1 mg/kg of c-tocotrienol, d-tocopherol and a-tocopherol respectively were determined in fronds whereas 258.0 ± 7.2 mg/kg of a-tocopherol was determined in stem. U. lactuca, showed a high c-tocopherol level (963.5 ± 3.8 mg/kg).

Amino acid and fatty acid (FA) distributions and contents of protein, fat and total fibre of 34 edible seaweed products of the Laminaria sp., Undaria pinnatifida, Hizikia fusiciforme and Porphyra sp were investigated by Dawczynski et al. (2007). Result demonstrated that seaweed tested low lipid contents with 2.3 ± 1.6 g/100 g semi-dry sample weight (s.w.) proved to be a rich source of dietary fibre (46.2 ± 8.0 g/100 g s.w) and the pure protein content of seaweed products varied widely (26.6 ± 6.3 g/100 g s.w. in red algae varieties and 12.9 ± 6.2 g/100 g s.w. in brown algae varieties). All essential amino acids were detected and red algae species featured uniquely high concentrations of taurine when compared to brown algae varieties. The FA distribution of seaweed products showed high levels of n-3 FA and demonstrated a nutritionally ideal n-6/n-3 FA ratio.

Kumar and Kaladharan (2007) evaluated the amino acid profile of six tropical seaweeds (Sargassum wightii, Ulva lactuca, Kappaphycus alvarezii, Hypnea musciformis, Acanthophora spicifera and Gracilaria corticata). Results showed that all these species similar have non-essential amino acid patterns in which aspartic and glutamic acids constituted together a large part of the amino acid fraction (25.2% to 29.5%). Among these, Hypnea musciformis possessed higher amino acid content and better amino acid profile. They suggested that partial substitution of costly protein sources in animal feeds with seaweed protein may improve feed quality while reducing the cost.

Proximate composition of different groups of seaweeds like green (5 Sp.), brown (3 Sp.) and red (3 Sp.) from Vedalai coastal waters (Gulf of Mannar), Southeast coast of India were estimated by Manivannan et al. (2009). Result showed that the protein content was recorded maximum in G. acerosa and minimum in D. dichotoma; carbohydrate level was observed maximum in T. ornata and minimum in
P. pavonica and the lipid content acquired higher level in H. tuna and minimum in H. macroloba.

Gressler et al. (2010) estimated the biochemical composition (fatty acid, total lipid, soluble proteins, amino acid and ash) of four species of seaweed, Laurencia filiformis, L. intricata, Gracilaria domingensis and G. birdiae. Results showed that the total lipid content ranged from 1.1% to 6.2%; fatty acid from 0.7% to 1.0%; soluble protein from 4.6% to 18.3%, amino acid from 6.7% to 11.3% and ash from 22.5% to 38.4% (% dry weight). They concluded that all the species appear to be potential sources of dietary proteins, amino acids, lipids and essential fatty acids for humans and animals.

The fatty acid (FA) composition in lipids from seven seaweed species from the North Sea (Ulva lactuca, Chondrus crispus, Laminaria hyperborea, Fucus serratus, Undaria pinnatifida, Palmaria palmata, Ascophyllum nodosum) and two from tropical seas (Caulerpa taxifolia, Sargassum natans) was determined using GCMS by Van-Ginneken et al. (2011). Result showed that omega-3 (n-3) and omega-6 (n-6) (PUFAs), were in the concentration range of 2-14 mg/g dry matter (DM), while total lipid content ranged from 7-45 mg/g DM. The n-9 FAs of the selected seaweeds accounted for 3%-56% of total FAs, n-6 FAs for 3%-32% and n-3 FAs for 8%-63%.

Al Azad and Xiang (2012) estimated the proximate compositions of three Chlorophyta, three Phaeophyta and one Rhodophyta to evaluate their suitability for feed supplement. The highest protein level of 14% dry weight (DW) and the lowest level 0.2-0.5% of lipid were determined in Sargassum sp., the highest content of 4% (DW) lipid and 11% (DW) protein level was observed in the Dictyota while Padina minor showed 10% (DW) and 1% (DW) levels of protein and lipid respectively. Seaweed meal of these three species was prepared and mixed separately with 2% of Rhodovulum sp. and Rhodovulum sp. bacterium biomass alone was used as control diet. The preliminary feeding trial showed that the growth and survival of fin fish larvae were improved with the supplemented diet made from Dictyota meal mixed with 2% of Rhodovulum sp.

Nutrient composition (biochemical and pigment) of fifteen marine benthic algae found in the Gulf of Kutch coastline, Gujarat, India was estimated by
Chakraborty and Bhattacharya (2012). The total carbohydrate content (% dry weight) ranged from 8.6 ± 0.7% to 42.4 ± 0.7%; soluble proteins from 4.3 ± 0.4% to 32.4 ± 2.5%, lipid content from 0.9 ± 0.3% to 5.2 ± 0.4%, reducing sugar 1.9 ± 0.3 to 8.6 ± 0.1 mgg⁻¹, amino acid 26.5 ± 1.9 to 152.3 ± 4.0 mgg⁻¹, Vitamin C from 0.2 ± 0.03 to 0.4 ± 0.02 mgg⁻¹. Chlorophyll a content ranged between 0.62 ± 0.03 to 2.5 mgg⁻¹, chlorophyll b from 0.24 ± 0.03 to 1.43 ± 0.12 mgg⁻¹ and carotenoids from 15.0 ± 0.35 to 25.2 ± 1.42μgg⁻¹. The result showed there were potential source of ingredients with high nutritional values and utilization for food and pharmaceutical industries.

Rohani-Ghadikolaei et al. (2012) investigated the proximate, fatty acid and mineral composition of representative green (U. lactuca and E. intestinalis), brown (S. ilicifolium and C. sinuosa) and red (H. valentiae and G. corticata) seaweeds from the Persian Gulf of Iran as potential food. Result showed that the protein content of red or green seaweeds was significantly higher (p<0.05) compared to brown seaweeds; the fatty acid composition of various seaweed lipids varied considerably with 51.9–67.4% of saturates, 22.0–32.9% of monoenes and 9.2–19.1% of PUFA and the minerals examined (K, Mg, Fe, Mn, Cu, Zn and Co) contained higher concentrations compared to terrestrial vegetables. They concluded that seaweeds could potentially be used as a food or feed additive in Iran.

Biochemical composition such as carbohydrates, protein, lipids, vitamins, sterols, fatty acid and minerals of marine brown alga Lobophora variegata from Mandapam in the South East Coast of Tamil Nadu was estimated by Thennarasan and Murugesan (2015) using gas chromatography and flame atomic absorption spectrophotometry method. Result showed that among biochemical contents total protein were present in higher quantity 23.13 ± 0.05%, followed by total carbohydrates-19.34 ± 0.10% and total lipid-0.27± 0.5%; vitamins (especially vitamin C), Fatty acids (Omega fatty acid), and minerals (calcium) respectively. Comparatively the sterols also been noted. The results indicated that marine brown alga seen to be more valuable for the nutraceutical as well as pharmaceutical industry as a potential source.

2.2 ANTI-BACTERIAL ACTIVITY OF SEAWEED

Taskin et al. (2007) investigated in vitro antibacterial activities of methanolic extracts of six seaweeds (Corallina officinalis, Cystoseira barbata, Dictyota
dichotoma, Halopteris filicina, Cladostephus spongiosus and Ulva rigida) from the Aegean Sea (Turkey) against pathogenic microbes, 3 gram positive (Staphylococcus aureus, Micrococcus luteus and Enterococcus faecalis) and 3 gram negative (Escherichia coli, Enterobacter aerogenes and E. coli O157:H7). Results indicated that except C. officinalis all other showed inhibition against S. aureus. Highest inhibition activity among all the extracts was shown to E. aerogenes by C. officinalis. The extract from C. barbata has shown broader activity spectrum against all the test organisms.

Antibacterial activity of ethanol extracts of seaweeds against six fish bacterial pathogens (Escherichia coli, Enterobacter aerogenes, Staphylococcus aureus, Pseudomonas aeruginosa, Streptococcus faecalis and Bacillus cereus) was investigated by Kolanjinathan et al. (2009) through disc diffusion method. Results indicated that Gracilaria edulis inhibited growth of all the test organisms except B. cereus and E. aerogenes. Calorpha peltada was effective against E. coli, S. aureus and S. faecalis. Hydroclothres sp. extract inhibited the growth of P. aeruginosa.

Kolanjinathan and Stella (2011) compared antimicrobial activity of Ulva reticulata and Ulva lactuca extracts using the organic solvents viz., methanol, acetone, chloroform, hexane and ethyl acetate against human pathogens by disc diffusion method. The results indicated that among the solvents tested, methanol extract showed maximum inhibitory activity than other solvents and these seaweeds could serve as useful source of new antimicrobial agents.

Antibacterial activity of cultivated marine seaweeds Gracilaria edulis, G. verrcososa, Acanthospora spicifera, Ulva facita, U. lacta, Kappaphycus spicifera, Sargassum Ilicifolium, S. wightii, Padina tetramatica and P. gymnosporoa against fish pathogenic bacteria Vibrio harveyi was investigated by Rajasekar et al. (2012) using five different solvent. The results show that the methanolic extract of S. wightii produced a maximum zone of inhibition (1.95±0.11cm). They concluded that S. wightii may be applied for prophylaxis and therapy of bacterial fish disease in aquaculture.

Mabel et al. (2012) evaluated the anti-bacterial activity of seaweeds Enteromorpha sp. and Ulva sp. against the bacterial pathogens of Vibrio sp. infecting Penaeus monodon. Enteromorpha sp. and Ulva sp. exhibited the zone of inhibition
20mm and 18mm against *Vibrio harveyi*, while 17mm and 16mm against *Vibrio alginolyticus* respectively.

The phytochemical analysis and the antimicrobial activity of *Sargassum wightii* against different bacterial pathogens were evaluated by Karthick and Kumari (2014) using three different solvent. The qualitative phytochemical screening was done using some common and available standard tests while antimicrobial activity was done through the agar well diffusion method. The benzene extract showed maximum number of compounds such as Tannins, Flavanoids, Glycosides, Phenols, Saponins, Terpenoids. The antibacterial activity showed a maximum zone of inhibition (8.3±0.18mm) in benzene extract against *P. aeuroginosa*. Results indicated that the benzene extract of *S. wightii* proved to be an effective therapeutic agent.

Sivakumar *et al.* (2014) evaluated the *Ulva fasciata* as bio-inhibitory agent against bio-luminescent causing *Vibrio harveyi* during *Penaeus monodon* larviculture. Anti-bacterial activity was tested by agar well diffusion assay while chemical constituents were characterized by FTIR and GCMS of *U. fasciata*. They finding that 300 μg extract showed 12.3 mm of bio-inhibition. GC-MS analysis, reported to contain organic compounds such as Bis(2-ethylhexyl) phthalate as highest (88.42%), followed by 1,2- benzenedicarboxylic acid- butyl (2.47%). 300 μg extract showed 32.40% reduction in the cumulative percentage mortality on postlarvae due to *V. harveyi*. Therefore, it was concluded that *U. fasciata* may be a better bio-inhibitory agent against *V. harveyi* in shrimp larviculture.

The antibacterial activity of four green seaweeds viz. *Caulerpa sertularioides*, *Enteromorpha intestinalis*, *Ulva lactuca* and *U. reticulata* was tested against nine human bacterial pathogens by Maruthupandian *et al.* (2015). They found that ethanol extracts of four green seaweeds activity were good as compared to positive control. The results revealed use of green seaweeds as a good source of antibacterial agent.

Natrah *et al.* (2015) screened antibacterial activities of eight selected seaweed (*Dictyota dichotoma*, *Padina minor*, *Halimeda macroloba*, *Caulerpa racemosa*, *C. macrophysa*, *Ulva intestinalis*, Amphiroa fragilissima and *Sargassum duplicatatum*) and seagrass (*Thalassia hemprichii*, *Cymodocea rotundata* and *Enhalus acoroides*) from Port Dickson coastal water against six aquaculture pathogens using disc diffusion test, minimum inhibitory concentration (MIC) and minimum bactericidal
concentration (MBC). The findings suggested that seaweeds and seagrass in Port Dickson coastal water have the potential to prevent bacterial diseases particularly in aquaculture.

The antibacterial activity of *Ulva reticulata* species collected from the Kanyakumari coast of India were evaluated by Ravikumar *et al.* (2016) against *Salmonella typhi, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Vibrio cholerae, V. parahaemolyticus, Bacillus cereus* and *Listeria monocytogenes*. They observed that the n-butanol extract (25–100 mg/ml) exerted notable antibacterial activity against tested bacterial strains. The results obtained supported the traditional use of the seaweeds against various infections.

### 2.3 SEAWEED AS FEED IN AQUACULTURE

Bindu and Sobha (2004) studied the impact of replacement of fishmeal with three different types of seaweed in diets on growth, feed utilization and nutrient digestibility of *L. rohita* for 120 days. Good food conversion ratio, food assimilation efficiency, protein efficiency and better nutrient digestibility were recorded for seaweed diet fed fishes. *Ulva* based diet showed comparatively higher growth and weight increment. The result suggested the suitability of seaweeds, *Ulva fasciata, Spyridia insignis* and *Sargassum wightii* as partial substitute for fishmeal in formulated diets of *L. rohita*.

The inclusion of three seaweeds *Gracilaria bursa-pastoris* (GP), *Ulva rigida* (UR) and *G. cornea* (GC) as dietary ingredients on the performance, nutrient utilization and body composition of European sea bass juveniles (*Dicentrarchus labrax*) was evaluated by Valente *et al.* (2006). Six experimental diets were formulated containing 5% (GP-5, UR-5 and GC-5 Diets) and 10% (GP-10, UR-10 and GC-10 Diets) each of the three seaweeds and a control diet. Diets were fed to duplicate groups of 25 European sea bass juveniles (IBW=4.7 g) for 10 weeks. Growth performance was significantly reduced (P<0.05) only in fish fed the GC-10 diet, whereas the feed conversion ratio increased significantly in those fish. The results suggest that the inclusion of *G. bursa-pastoris* and *U. rigida*, up to 10%, can be considered as having no negative consequences while the inclusion of *G. cornea* should be limited to 5% of the diet.
Marinho-Soriano et al. (2007) evaluated the use of *Gracilaria cervicornis* meal as a partial substitute for the industrial feeds used in shrimp (*L. vannamei*) farming. Juveniles (0.34 g) were assigned randomly into nine experimental units at a stocking density of 10 shrimp tank⁻¹ and fed with three feed containing a commercial shrimp feed (CSF; 35% crude protein) as a control treatment, a feed made entirely of *G. cervicornis* (GCM) and a mixture of equal parts of the commercial shrimp feed and the Gracilaria meal (MIX) for 30 days. The highest growth performance was obtained in the CSF or MIX treatment groups. The results obtained in this study indicated *G. cervicornis* effective of as a partial substitute for shrimp feeds.

Immunomodulatory efficacy of methanolic extract of seaweed, *Sargassum wightii* on shrimp, *Penaeus monodon* stocked at the rate of 15 Nos/m³ in an outdoor culture in 1 tone capacity FRP tanks for a period of 90 days by Huxley and Lipton (2009). Four diets were prepared using basal shrimp feed ingredient along with seaweed, *S. wightii* extract at the rate of 0, 100, 200 and 300 mg/100g feed. The maximum survival of shrimp was recorded in 100mg and 300mg seaweed extract added diet 96.66% against the minimum survival of 83.33% in control diet. The growth parameters, haemocyte count bacterial clearance and phenol-oxidase activity were obtained high in *P. monodon* received seaweed extract added diets.

Liberal-da-Silva and Barbosa (2009) evaluated the impact of seaweed (*Hypnea cervicornis* and *Cryptonemia crenulata*) meal as a protein source for the white shrimp, *Litopenaeus vannamei*. Post larvae were stocked at rate of 20 Nos per 10L water containing plastic aquaria of four treatments and fed with four treatments diets “A” 39%; “B” 26%, “C” 13% and “D” (each treatment with five replica) without seaweed (control diet) for a period of 45 days. Final biomass, biomass gain, specific growth rate in diets “A” and “B”, with a greater content of algae, exhibited better feed conversion (1.79:1 and 1.82:1) than “C” and “D” (2.04:1 and 2.08:1). They concluded that sufficient biomass of seaweed available; it may be used as a component in the making of shrimp feed.

The effects of diet containing two seaweed species, *Ulva lactuca* and *Enteromorpha linza*, on the growth performance, feed utilization and body composition of rainbow trout were studied by Yildirim et al. (2009). Feeding trial carried out for 126 fish specimens with three treatment diets containing 10% *U. lactuca* meal, 10% *E. linza* meal and control group without seaweed ingredients for
60 days. Significant differences were observed in weight gain, specific growth rate, relative growth rate and feed utilization between experimental and control groups (P<0.05). The final levels of crude protein, crude lipid and crude ash were in higher rates in the body composition all the groups compared when compared to the initial level (P<0.05).

Qi et al. (2010) evaluated the suitability of two algae species, *Gracilaria lemaneiformis* and *Sargassum pallidum*, for use as food sources for the abalone, *Haliotis discus*. Abalones were fed one of five experimental diets: 1) Kelp *Laminaria japonica*; 2) *G. lemaneiformis*; 3) *S. pallidum*; 4) a mixed diet of *L. japonica* and *G. lemaneiformis* (1:1); and 5) a mixed diet of *L. japonica* and *S. pallidum* (1:1) for a period of 4 months. There were no significant differences in the condition index among all the treatment groups. Results suggested that *G. lemaneiformis* can be used as a partial substitute in the diet of abalone.

*In vivo* antibacterial activity of the red seaweed, *Asparagopsis* sp. against the shrimp *Vibrio* pathogens was evaluated by Manilal et al. (2012) through orally administered algal extract (rationalized with commercial shrimp feed) for different duration of time followed by the artificial bacterial challenge experiment. The results of the confirmatory dose experiment revealed that the prophylactic treatment with moderate dose of 850 mg kg\(^{-1}\) of biomass day\(^{-1}\) for four weeks followed by 14 days of post infection therapy, the percent survival index and microbiological analysis clearly show that *Asparagopsis* extract incorporated medicated feed had broad therapeutic potential for managing shrimp vibriosis.

Felix and Alan Brindo (2014) studied on the evaluation of seaweed, *Ulva lactuca* as feed ingredients in giant freshwater prawn, *Macrobrachium rosenbergii* by incorporating raw and fermented *Ulva lactuca* at three levels, 10 %, 20 % and 30 % in diets. In 15 days digestibility experiment, among the raw and fermented incorporated diets, the freshwater prawn fed with fermented *Ulva lactuca* (FU) at 30% showed maximum apparent digestibility coefficients (ADC) for dry matter (88.20 %), APD (88.57 %) and ALD (86.56 %). In the 45 days growth experiment, prawn fed with FU at 30 % showed maximum mean weight gain (2.417g), SGR (1.7892) and PER (1.0096). The results suggested that fermented *U. lactuca* could be incorporated up to 30 % level without compromising growth, digestibility and flesh quality.
The feasibility of the algae *Ulva lactuca* and *Gracilaria parvispora* meal as a partial inclusion in diets for juvenile *Litopenaeus vannamei* was investigated by Rodriguez-Gonzalez *et al.* (2014). The feeding trial was carried out with diets containing 5, 10, and 15% of both algae meal in a closed recirculating system holding 21 plastic containers filled with 40 L of filtered seawater and continuously provided with seawater at a flow rate of approximately 85 mL min$^{-1}$ for 75 day. Finding suggested that when using *U. lactuca* there were significant differences in growth among the trials (P<0.05) but no significant differences were detected when using *G. parvispora* and *U. lactuca* 5% meal (P>0.05). Result indicated that both seaweeds may be used as a component in preparing feed for juvenile *L. vannamei*.

Hafezieh *et al.* (2014) evaluated the suitability of Oman Sea *Sargassum illicifolium* meal for feeding white leg shrimp, *Litopenaeus vannamei*. The shrimps were kept in 16 plastic tanks (each with 300 L water and 30 juveniles) involving four treatments. The feeding trial was carried out with diet containing 15%; 10%, 5% and 0% of seaweed for 45 days. They found that diet containing 15% and 10% of seaweed exhibited better feed conversion (1.15:1 and 1.17:1) than diets 5% and 0% (1.30:1 and 1.33:1) (P<0.05). Result suggested that it can be used as a component in the making of shrimp feed.

The growth performance and feed utilization of juvenile white shrimp *Litopenaeus vannamei* fed with diets containing different supplement levels of hot-water extract of brown tropical macro algae, *Sargassum cristaefolium* extract by Sudaryono *et al.* (2015). Shrimp were fed with feeds containing 36% crude protein incorporated with graded levels of brown algae *S. cristaefolium* extract (0, 200, 600, 1000 and 1400 mg kg$^{-1}$). The results showed that dietary *S. cristaefolium* extract supplementation had a significant influence (P < 0.05) on feed utilization and shrimp fed 200-1000 mg algae extract kg$^{-1}$ diet had a significantly better FCR and PER (P< 0.05) than the shrimp fed the 0 mg and 1400 mg algae extract. These results suggested that supplementation of *S. cristaefolium* extract at a dose of 200-1000 mg kg$^{-1}$ can be used to get a better feed utilization performance (reduce 22% FCR and enhance 27.8% PER) of juvenile white shrimp, *L. vannamei* and 600 mg *S. cristaefolium* extract kg$^{-1}$ diet is recommended to add in diet to get a better FCR and PER performance of juvenile *L. vannamei*. 
Shapawi and Zamry (2016) evaluated the effects of three seaweeds *Kappaphycus alvarezii* (KA), *Eucheuma denticulatum* (ED) and *Sargassum polycystum* (SP) meal as dietary ingredient in the diet of Asian seabass juvenile on growth performance, feed utilization efficiency and body composition. Feeding trial was carried out by preparing total of four experimental diets with KA (5%), ED (5%), SP (5%) and control (0%) inclusion for 8-week period. Results indicated that growth performance and feed conversion ratio were not significantly affected by the seaweed inclusion in the fish diet; the total feed intake was significantly improved (P < 0.05) in fish fed with SP-Diet. Fish carcass composition varied among treatments. They concluded that these seaweeds can be considered as potential ingredients in the diets for Asian seabass juveniles.

The effect of brown seaweed-derived fucoidans at different molecular weights and purity levels towards white spot syndrome virus (WSSV) in shrimp *Litopenaeus vannamei* was evaluated by Sinurat et al. (2016). Four kinds at different molecular weights and purity levels of fucoidan were assayed for immunostimulant activity on the shrimp *Litopenaeus vannamei* infected with viral WSSV. The results showed that pure fucoidan exhibited higher activity compared with that of crude fucoidan. Sulfate and carbohydrate content of HMW fucoidan are 7.8 % and 82.54 % with an estimated molecular weight of 8.28 x10⁴ Dalton, and low molecular weight (LMW) fucoidan has 1.2% and 65.23% with an estimated molecular weight of 7.53 x10⁴ Dalton. The transcriptional level of the immunity-related genes was found higher after feeding the infected shrimps with purified and HMW fucoidan. Result suggested that fucoidan have significant role in the production of phenoloxidase.