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Antibacterial and Antibiofilm Activity of *Sargassum* against Pathogenic *Vibrio* spp. in Aquaculture and Seafood: A Narrative Review

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ABSTRACT

Vibriosis, caused by *Vibrio* spp., threatens shrimp and fish aquaculture and the safety of seafood. Strains of *Vibrio parahaemolyticus* that cause acute hepatopancreatic necrosis disease (AHPND) have produced heavy losses in shrimp farming, including in Indonesia, and antibiotic resistance in *Vibrio* has increased interest in natural alternatives such as the brown macroalga *Sargassum*. This narrative review examines the evidence for direct antibacterial and antibiofilm activity of *Sargassum* against *Vibrio* spp., uses *Sargassum muticum* as the anchor species, and separates direct effects from host-mediated effects in feeding trials. Eighteen studies were identified. Extracts, fractions, and polysaccharides from at least seven *Sargassum* species, and from algae identified only to genus level, inhibited *V. parahaemolyticus*, *V. harveyi*, *V. alginolyticus*, *V. vulnificus*, or *V. cholerae* in vitro. Activity was mostly weak to moderate and varied with species, season, solvent, and fraction, and reported minimum inhibitory concentrations (MICs) ranged from 64 µg/mL to 25 mg/mL. *S. muticum* was the only species with data on antibiofilm activity, seafood preservation, and a shrimp feeding trial, although part of this evidence has not yet been peer reviewed. Feeding studies improved shrimp survival after *Vibrio* challenge, but these effects were mainly attributed to immune stimulation rather than direct killing of the bacteria. The current evidence is therefore insufficient to recommend *Sargassum* as an antibacterial agent against *Vibrio*. Further research needs authenticated algal material, well-characterized strains, standardized MIC, minimum bactericidal concentration (MBC), and biofilm assays, and safety testing.

Keywords: *Sargassum*; *Vibrio parahaemolyticus*; antibiofilm; aquaculture; seafood safety

INTRODUCTION

Vibrio is a genus of Gram-negative bacteria that is widespread in marine and estuarine environments. About 12 of the more than 100 described species infect humans, usually after consumption of raw or undercooked seafood or exposure to seawater, and the incidence of vibriosis appears to be rising as sea temperatures increase [1]. *V. parahaemolyticus* is a leading cause of seafood-associated gastroenteritis, and its virulence is linked to the thermostable direct hemolysin (tdh), the TDH-related hemolysin (trh), and two type III secretion systems [2]. In aquaculture, particular strains of *V. parahaemolyticus* cause AHPND, first reported as early mortality syndrome; immersion challenge with the causative isolate reproduced the disease with 100% mortality [3]. In Indonesia, an AHPND-causing *V. parahaemolyticus* strain from Serang, Banten, caused 100% mortality in whiteleg shrimp (*Litopenaeus vannamei*) within 73 hours at 10^6–10^8 CFU/mL [4]. *V. harveyi* and *V. alginolyticus* are also important pathogens of shrimp and marine fish, and shrimp disease research has focused largely on *Vibrio* [5].

Antibiotics have been used to control vibriosis, but resistance limits their value. Among *V. parahaemolyticus* isolates from fish in Malaysia, 88% were resistant to ampicillin, imipenem-resistant isolates were found, and 70% had a multiple antibiotic resistance index above 0.2 [6]. Antibiotic residues and resistant bacteria in farm environments also raise food safety concerns. These problems have increased interest in natural antibacterial agents, including seaweed extracts. A review of seaweed extracts in aquaculture concluded that all major seaweed groups show some activity

activity against fish and shrimp pathogens, and that the brown alga *Sargassum* and the red alga *Asparagopsis* show the broadest antibacterial effects [5]. *Vibrio* species can also form biofilms on farm surfaces and on seafood, where they are less susceptible to disinfectants and antibiotics, so antibiofilm activity is a relevant target in addition to growth inhibition.

Evidence on *Sargassum* and *Vibrio* is scattered among studies that differ in algal species, extract type, test organism, and outcome. Some studies tested crude extracts in vitro, some tested purified polysaccharides or flavonoids, and others added *Sargassum* to feed and measured shrimp survival after challenge. A recent mini-review summarized the role of *Sargassum* in the non-specific immune resistance of fish and shrimp [7], but the direct antibacterial and antibiofilm evidence against *Vibrio* has not been synthesized separately. *S. muticum* is of particular interest because it is the species with antibiofilm, seafood preservation, and shrimp feeding data against *V. parahaemolyticus*, and it has also shown activity against other bacteria [8]. This review therefore assesses the evidence for antibacterial and antibiofilm activity of *Sargassum* against pathogenic *Vibrio* spp., distinguishes direct from host-mediated effects, uses *S.muticum* as the anchor species, and identifies gaps for future research.

METHODS

This article is a narrative review. The literature was searched in Google Scholar, publisher platforms (ScienceDirect, SpringerLink, MDPI, Frontiers, and IOP Publishing), and Indonesian national journal portals using the keywords "*Sargassum*", "brown algae", "seaweed", "*Vibrio*", "*Vibrio parahaemolyticus*", "*Vibrio harveyi*", "*Vibrio alginolyticus*", "*Vibrio vulnificus*", "AHPND", "vibriosis", "antibacterial", "antibiofilm", "fucoidan", "alginate", and "shrimp", including their Indonesian equivalents. The last search was performed on 28 October 2026.

Sources were included if they tested *Sargassum* extracts, fractions, or polysaccharides against any *Vibrio* species in vitro, or tested *Sargassum*-supplemented feed against a *Vibrio* challenge *in vivo*. Studies of algae identified only to genus level, conference proceedings, and preprints were included but interpreted with attention to the completeness of their methods. Studies of other brown algae and of fucoidan from non-*Sargassum* sources were excluded. The findings were synthesized qualitatively into four groups: in vitro studies of identified *Sargassum* species, studies of *S. muticum*, studies of *Sargassum* identified to genus level, and *in vivo* feeding studies. Because this is not a systematic review, the numbers of records screened and excluded were not reported; this is discussed as a limitation.

RESULTS AND DISCUSSION

Eighteen studies are summarized in Table 1. Fifteen tested extracts, fractions, or polysaccharides in vitro, and three tested *Sargassum* in shrimp feed; two of the in vitro studies also included a challenge in *Artemia* or shrimp. The relevance of each study to the review question was determined by three factors: how certain the identity of the alga is, how well the *Vibrio* strain is characterized, and whether the outcome reflects direct activity against the bacterium or an effect on the host. Only nine studies identified the alga to species level and also tested a *Vibrio* strain identified to species level.

TABLE 1: Summary of the Reviewed Studies.

Study	Material and test bacteria	Main findings	Interpretation notes
Dashtiannasab et al., 2012 [9]	Ethanolic and chloroformic extracts of *S. latifolium* (Persian Gulf); *V. alginolyticus*, *V. parahaemolyticus*, *V. harveyi*	All three sensitive by disc diffusion; chloroformic extract MIC 5, 10, and 10 mg/mL; MBC 5, 15, and 20 mg/mL	Species identified; MIC/MBC reported, but at high concentrations
Lambert et al., 2024 [10]	Hydroethanolic extract and metabolite fractions of *S. fluitans* III; *V. alginolyticus* among six strains	Crude extract MIC 0.25 mg/mL (bacteriostatic); alkaloid and coumarin fractions most active	Pelagic species; one *Vibrio* strain
Di Filippo-Herrera et al., 2018 [11]	Monthly ethanolic extracts of *S. horridum* (Gulf of California); *V. parahaemolyticus*, *V. alginolyticus*	Slight activity only in extracts from March, July, and August	Shows seasonal variation in activity
Villegas-Silva et al., 2022 [12]	Ethanolic extract and fractions of *S. lapazeanum*; *V. harveyi*, *V. parahaemolyticus*	Selective activity against *Vibrio* by disc diffusion	Zone sizes not given in the abstract
Marudhupandi & Kumar, 2013 [13]	Fucoidan from *S. wightii*; *V. cholerae*, *S.* Typhi	Zone 18.6 ± 0.32 mm against *V. cholerae*; no toxicity in brine shrimp assay	Purified polysaccharide; human pathogen
Radhika et al., 2012 [14]	Methanolic extract of *S. wightii*; *V. cholerae* and three other bacteria	Zone 4.2 ± 1 mm against *V. cholerae*; no activity against the others	Weak activity; inconsistencies in reporting

Study	Material and test bacteria	Main findings	Interpretation notes
Zheng et al., 2025 [15]	*S. muticum* extracts; *V. parahaemolyticus* biofilm; Chinese shrimp (*Penaeus chinensis*) storage	Anti-biofilm and antioxidant activity; preservation effect on stored shrimp	Only antibiofilm study of the genus against *Vibrio* found; links activity to seafood use
Irawan et al., 2026 [16]	*S. muticum* extract (North Sea); *V. parahaemolyticus*; *L. vannamei* fed 1% or 3% extract	MIC 25 mg/mL; complete inhibition at 50 mg/mL; survival 77.78% (3%) vs. 60.00% (control)	Preprint, not peer reviewed; gut *Vibrio* higher in this group
Senggagau et al., 2026 [17]	Fucoxanthin-containing extracts of *S. ilicifolium*; *V. parahaemolyticus*	Antibacterial activity attributed to hydroxyl groups (FTIR)	Preprint; mechanism inferred, not tested
Keshavarz et al., 2025 [18]	Aqueous and organic extracts of *Sargassum* sp. (Gulf of Oman); AHPND-associated *V. parahaemolyticus*, *V. alginolyticus*, *V. harveyi*	Organic extract MIC 64–128 µg/mL, MBC 128–256 µg/mL; aqueous extract MIC 128–256 µg/mL	Species not identified; lowest MICs in this review
Senggagau & Bond, 2023 [19]	Rutin, quercetin, and gallic acid fractions of *Sargassum* sp.; *V. parahaemolyticus*	Rutin fraction zone > 25 mm	Genus level; purity of isolates not shown
Assegaf & Insafitri, 2023 [20]	Methanolic extract of *Sargassum* sp. (Madura); *V. harveyi*	Zone 18.2 ± 1.15 mm at 2000 ppm (72 h)	Genus level; values differ between abstract and tables
Rozirwan et al., 2018 [21]	Extract of *Sargassum* sp. (Maspari Island); *Vibrio* spp. isolates from shrimp ponds	Zone about 7.1 mm against one isolate	Neither alga nor *Vibrio* identified to species; weak
Miranti et al., 2026 [22]	70% and 96% ethanolic extracts of *Sargassum* sp.; *Vibrio* sp. from cantang grouper	Zones 8.33–13.00 mm; solvent controls 6.67–7.33 mm	Neither organism identified to species; large solvent effect
Yudiati et al., 2022 [23]	Alginate poly- and oligosaccharides from *Sargassum* sp.; *V. parahaemolyticus*, *V. vulnificus*, *V. harveyi*; *Artemia* challenge	Maximum zones 12.96 mm (polysaccharide) and 10.25 mm (oligosaccharide)	Combines antibacterial and immunostimulant endpoints
Huyen et al., 2018 [24]	Hot-water extract of *S. microcystum* in feed (0.5–2%); *P. monodon* challenged with *V. harveyi*	Highest survival (80%) and immune parameters at 1%	Host-mediated effect; no *in vitro* test
Sivagnanavelmurugan et al., 2014 [25]	Dietary fucoidan from *S. wightii*; *P. monodon* challenged with *V. parahaemolyticus*	Enhanced growth, prophenoloxidase gene expression, and resistance	Host-mediated effect
Chin et al., 2024 [26]	2% *S. polycystum* with *Lactobacillus plantarum* L20 in feed; *P. monodon* challenged with AHPND *V. parahaemolyticus*	Highest survival and lowest *V. parahaemolyticus* count in the synbiotic group	Effect of *Sargassum* alone not separated

In vitro activity of identified *Sargassum* species

Dashtiannasab et al. tested ethanolic and chloroformic extracts of *S. latifolium* from the Persian Gulf against three shrimp pathogens. All three were sensitive in disc diffusion, and the chloroformic extract had MICs of 5 mg/mL for *V. alginolyticus* and 10 mg/mL for *V. parahaemolyticus* and *V. harveyi*, with MBCs of 5, 15, and 20 mg/mL, respectively [9]. Lambert et al. found that a hydroethanolic extract of the pelagic *S. fluitans* III had an MIC of 0.25 mg/mL against *V. alginolyticus*. The effect was bacteriostatic rather than bactericidal, and alkaloid and coumarin fractions were the most active [10].

Activity was not always present. Monthly ethanolic extracts of *S. horridum* from the Gulf of California showed only slight activity against *V. parahaemolyticus* and *V. alginolyticus*, and only in extracts collected in March, July, and August [11]. An ethanolic extract of *S. lapazeanum* and its fractions were selectively active against *V. harveyi* and *V. parahaemolyticus* [12]. Against *V. cholerae*, fucoidan from *S. wightii* produced an inhibition zone of 18.6 mm without toxicity in the brine shrimp assay [13], whereas a methanolic extract of the same species produced only a 4.2 mm zone [14].

Together, these studies show that *Sargassum* can inhibit several *Vibrio* species, but that activity depends on species, harvest season, solvent, and fraction. Most extracts needed concentrations in the milligram-per-millilitre range, which is high compared with conventional antibiotics.

Sargassum muticum as the anchor species

S. muticum is an invasive brown alga on European coasts and is native to East Asia, so it is available in large quantities. Zheng et al. reported anti-biofilm and antioxidant activities of *S. muticum* extracts and a preservation effect on Chinese shrimp (*Penaeus chinensis*) during storage [15]. This is the only study found in this review that examined the antibiofilm activity of *Sargassum* against *V. parahaemolyticus* and linked it to a seafood application. Irawan et al. tested an extract of *S. muticum* from the North Sea against *V. parahaemolyticus* and in a 28-day feeding trial with *L. vannamei* post-larvae [16]. The extract had an MIC of 25 mg/mL and completely inhibited bacterial growth at 50 mg/mL. Shrimp fed 3% extract had higher survival than the control (77.78% vs. 60.00%), but the relative abundance of *Vibrio* in their gut was also higher (29.28% vs. 14.42%), although this difference was not significant. These results come from a preprint that has not yet been peer reviewed.

Outside *Vibrio*, a methanolic extract of *S. muticum* produced inhibition zones of 19.66–25.66 mm against *Salmonella* Typhi, *Escherichia coli*, *Staphylococcus aureus*, and *Bacillus subtilis* at 300 mg/mL [8]. *S. muticum* therefore has the broadest evidence base of any single species in this review. However, the evidence against *Vibrio* comes from only two studies, one of which is a preprint, and no study has yet tested whether these effects are reproducible with other *S. muticum* populations or other *Vibrio* species. *S. muticum* is a useful reference species for comparison, not yet a proven antibacterial candidate.

Studies of *Sargassum* identified to genus level

Keshavarz et al. reported the lowest MICs in this review, 64–128 µg/mL, for an organic extract of *Sargassum* sp. from the Gulf of Oman against *Vibrio* species associated with AHPND, and the organic extract was more active than the aqueous extract [18]. The difference of about two orders of magnitude from the MICs reported for *S. latifolium* [9] and *S. muticum* [16] is more likely to reflect differences in species, extraction, and method than a true difference in potency.

Several Indonesian studies tested *Sargassum* sp. against *Vibrio*. Senggagau and Bond isolated rutin, quercetin, and gallic acid from fractions of *Sargassum* sp. and reported that rutin produced an inhibition zone of more than 25 mm against *V. parahaemolyticus* [19]. A preprint by the same group on *S. ilicifolium* reported activity of fucoxanthin-containing extracts against *V. parahaemolyticus* [17]. Assegaf and Insafitri reported a zone of 18.2 mm for a methanolic extract of *Sargassum* sp. from Madura against *V. harveyi* at 2000 ppm, although some values differ between the abstract and the tables [20]. Rozirwan et al. found that *Sargassum* sp. from Maspari Island was the only seaweed in their screening that was active against a *Vibrio* isolate from shrimp ponds, but the zone was small, about 7.1 mm [21]. Miranti et al. tested ethanolic extracts of *Sargassum* sp. against a *Vibrio* sp. isolate from cantang grouper and reported zones of 8.33–13.00 mm, while the solvent controls alone produced zones of 6.67–7.33 mm [22]. Yudiati et al. showed that alginate polysaccharides and oligosaccharides from *Sargassum* sp. inhibited *V. parahaemolyticus*, *V. vulnificus*, and *V. harveyi*, with maximum zones of 12.96 mm and 10.25 mm, and also acted as immunostimulants in *Artemia* challenge tests [23].

These studies are relevant to Indonesian aquaculture, but their results cannot be attributed to a particular *Sargassum* species. In two studies the *Vibrio* isolate was also not identified to species level, and in one the solvent control produced a zone more than half the size of the extract zone. Zones measured at a single concentration without MIC data are difficult to compare with other studies.

In vivo feeding studies: direct or host-mediated effects?

Feeding studies provide a different type of evidence. Black tiger shrimp (*Penaeus monodon*) fed a 1% hot-water extract of *S. microcystum* had higher total haemocyte counts and phenoloxidase activity and the highest survival (80%) after challenge with *V. harveyi* [24]. Fucoidan from *S. wightii* was reported to enhance growth, prophenoloxidase gene expression, and resistance of *P. monodon* to *V. parahaemolyticus* [25]. In a synbiotic diet, 2% *S. polycystum* combined with *Lactobacillus plantarum* L20 gave the highest survival of *P. monodon* after challenge with an AHPND-associated *V. parahaemolyticus* strain and the lowest *V. parahaemolyticus* counts in the cephalothorax [26].

These results are encouraging, but higher survival after challenge does not show that *Sargassum* kills *Vibrio*. In most feeding studies the effect was attributed to stimulation of non-specific immunity, and in the synbiotic study the contribution of *Sargassum* was not separated from that of the probiotic. Polysaccharides such as fucoidan and alginate act mainly as immunostimulants or prebiotics, whereas the in vitro activity of crude extracts is usually linked to phenolic and lipophilic compounds. In vitro and *in vivo* results should therefore be treated as separate lines of evidence.

Comparability of methods

Most of the reviewed studies used disc or well diffusion. The size of an inhibition zone depends on the amount of extract per disc or well, its diffusion in agar, the medium, the inoculum density, and the incubation time. Concentrations were reported in different units (ppm, percent, mg/mL, and µg/mL), and solvent controls were not always reported. For halophilic *Vibrio*, the salt content of the medium also affects growth and should be stated. Inhibition zones from different studies should therefore not be pooled.

MIC and MBC measured by broth microdilution, with reference antibiotics and solvent controls, allow more meaningful comparison. They should be accompanied by biofilm assays, because a compound may inhibit biofilm formation at concentrations below its MIC.

Chemical composition and proposed mechanisms

The compounds reported in active *Sargassum* materials include flavonoids (rutin and quercetin), gallic acid, alkaloids, coumarins, fucoxanthin, and the polysaccharides fucoidan and alginate [10,13,17,19,23]. Phenolic compounds, including the phlorotannins typical of brown algae, are often proposed to damage bacterial membranes, bind proteins, and interfere with quorum sensing and biofilm formation. However, none of the reviewed studies tested these mechanisms directly against *Vibrio*. A causal link between a compound and inhibition requires activity-guided fractionation, structure confirmation, and testing of pure compounds. Identifications based only on thin-layer chromatography, Fourier-transform infrared (FTIR) spectroscopy, or spectral library matching in gas chromatography–mass spectrometry (GC–MS) should be described as tentative.

Composition also varies with species, season, and harvest site. The seasonal variation in the activity of *S. horridum* [11] shows that a single extract cannot represent a species. Studies should therefore report harvest date and location, keep voucher specimens, and confirm taxonomy.

Safety and translational relevance

In vitro activity is not the same as safety or effectiveness in aquaculture or food. Macroalgae can accumulate arsenic, and some species, such as hijiki (*Sargassum fusiforme*), have been reported to contain high levels of inorganic arsenic [27]. This matters if *Sargassum* is used in feed or applied to seafood. In addition, *Sargassum* can itself carry *Vibrio*. Genomes of *Vibrio* isolated from pelagic *Sargassum*, plastic debris, and seawater in the Caribbean and Sargasso Seas contained genes associated with pathogenicity, and the isolates formed biofilms rapidly [28]. Raw *Sargassum* should therefore not be assumed to be free of *Vibrio*, and processing and microbial testing are required before use.

For shrimp preservation, the sensory effects, solvent residues, and regulatory status of the extract must be considered. For aquaculture, dose, palatability, growth, and effects on the gut microbiome must be measured; the higher gut *Vibrio* abundance in shrimp fed *S. muticum* [16] shows that a feed additive can have unintended effects. Until such data are available, *Sargassum* extracts cannot be recommended as a substitute for antibiotics or for good hygiene and biosecurity on farms.

Limitations of this review and research directions

This review has four limitations. First, the search was narrative and not documented systematically, so relevant publications, particularly those in Chinese, Vietnamese, or Persian, may not have been identified. Second, the studies differed in algal species, solvent, concentration, method, and outcome, so quantitative comparison is inappropriate. Third, some of the evidence came from proceedings and preprints with limited methodological detail, and for several studies only the abstract was available. Fourth, data on antibiofilm activity, quorum sensing inhibition, mechanism of action, and safety are still very limited. These conclusions are a preliminary narrative synthesis, not a definitive assessment. The main gap is not only the small number of studies but also the lack of standardized, species-level evidence. The priorities for future research are:

1. Test authenticated *Sargassum* species, with voucher specimens and documented harvest site and season, against *Vibrio* strains identified to species level, including AHPND-positive *V. parahaemolyticus*.
2. Report the extract mass per disc or well, solvent, salt content of the medium, inoculum, positive and negative controls, and replication.
3. Measure MIC and MBC by broth microdilution and compare them with reference antibiotics.
4. Measure biofilm inhibition and eradication, and quorum sensing inhibition, at concentrations below the MIC.
5. Perform activity-guided fractionation and confirm the structure of the active compounds.
6. Separate direct antibacterial effects from immunostimulatory effects in feeding trials, and measure contaminants, cytotoxicity, and effects on the gut microbiome.

CONCLUSIONS

Extracts, fractions, and polysaccharides from at least seven *Sargassum* species, and from *Sargassum* identified only to genus level, inhibit pathogenic *Vibrio* spp. in vitro, including *V. parahaemolyticus*, *V. harveyi*, *V. alginolyticus*, *V. vulnificus*, and *V. cholerae*. The activity is mostly weak to moderate and varies with species, season, solvent, and fraction. *S. muticum* is the only species with evidence on antibiofilm activity, shrimp preservation, and a shrimp feeding trial, but this evidence is still limited. Feeding studies show improved survival of shrimp after *Vibrio* challenge, mainly through immune stimulation. The current evidence is therefore insufficient to recommend *Sargassum* as an antibacterial agent against *Vibrio* in aquaculture or seafood. Future research should prioritize authenticated algae, well-characterized strains, standardized MIC, MBC, and biofilm assays, and safety evaluation. In vitro results must not be interpreted as evidence of practical benefit or as a reason to replace antibiotics or biosecurity measures.

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