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# Antibacterial Potential of *Sargassum crassifolium* Against *Salmonella* Typhi: A Narrative Review

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**ABSTRACT**

Typhoid fever, caused by *Salmonella enterica* serovar Typhi (*S.* Typhi), remains a global health problem, and antimicrobial resistance is narrowing treatment options. *Sargassum crassifolium*, a brown alga rich in metabolites, has been reported to have antibacterial activity, but its relevance to *S.* Typhi is unclear. This narrative review examines the evidence for the antibacterial activity of *S. crassifolium* against *Salmonella*, distinguishing direct from indirect evidence. *S. crassifolium* showed in vitro activity against several non-*Salmonella* bacteria, and the activity varied with the extraction solvent. One study reported inhibition of *Salmonella sp*. without confirming the serovar; one study tested laminaran against *S.* Typhimurium, and the studies on *S.* Typhi identified the alga only to the genus level. The current evidence is therefore insufficient to conclude that *S. crassifolium* is specifically active against *S.* Typhi. Further research needs authenticated algal material, well-defined bacterial strains, standardized methods, minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) measurements, and safety testing.

***Keywords:*** *Sargassum crassifolium*; *Salmonella* Typhi; typhoid fever

## INTRODUCTION

Typhoid fever is a systemic infection caused by *Salmonella enterica* serovar Typhi (*S.* Typhi) and transmitted through food or water contaminated with feces. Humans are the only known reservoir, including asymptomatic and chronic carriers [1]. The disease mainly burdens regions with limited access to clean water and sanitation. The 2023 Global Burden of Disease (GBD) estimates cited by the World Health Organization (WHO) indicate about 6.2 million cases, 72,000 deaths, and 5.4 million disability-adjusted life years (DALYs) worldwide [1]. These figures are model-based estimates, not the results of direct surveillance. Management of typhoid fever relies on antibiotics chosen according to guidelines and local resistance patterns. The spread of antimicrobial-resistant *S.* Typhi complicates treatment [1,2], so the search for new antibacterial candidates remains relevant. However, in vitro activity of a substance does not guarantee its safety or effectiveness in humans.

One approach to finding antibacterial candidates is to study bioactive compounds from natural resources, including macroalgae. Brown macroalgae of the genus Sargassum contain several groups of compounds, such as phenolics, lipids, sterols, terpenoids, and polysaccharides. Extracts of this genus have been reported to inhibit a number of bacteria. However, results differ between studies, which may be explained by differences in species, harvest location, type of solvent, extract concentration, test method, and the bacteria used. The antibacterial potential of Sargassum should therefore be assessed with specific attention to both the algal species and the target microorganism.

The antibacterial activity of the brown macroalgal genus Sargassum has been widely studied, but evidence on the activity of *Sargassum crassifolium* against *S.* Typhi remains limited. Studies that tested *S. crassifolium* against *Salmonella* sp. cannot explain its activity against *S.* Typhi because the serovar was not confirmed. Conversely, studies on *S.* Typhi used other Sargassum species or algae whose species were not determined, so their results cannot be generalized to *S. crassifolium*. In addition, differences in extract type, concentration, test method, and activity parameters make comparison between studies difficult. Critical synthesis is therefore needed to assess the relevant evidence, to distinguish direct from indirect evidence, and to identify research gaps on the antibacterial potential of *S. crassifolium* against *S.* Typhi.

## METHODS

This article is a narrative review. The literature was searched in PubMed, ScienceDirect, Google Scholar, and retrievable national sources using the keywords "*Sargassum crassifolium*", "*Sargassum cristaefolium*", "*Sargassum",* "brown algae", "*Salmonella* Typhi", "*Salmonella* sp.", "*Salmonella* Typhimurium", "typhoid", "antibacterial", and "antimicrobial", including their Indonesian equivalents. The last search was performed on 22 October 2026.

Sources were selected if they discussed the identity of *Sargassum* species, extracted compositions, antibacterial activity, or testing against *Salmonella.* Articles that did not test *S.* Typhi were still included as indirect evidence. Proceedings and other academic sources were interpreted with attention to the completeness of their methods. The findings were synthesized qualitatively into three evidence groups: *S. crassifolium* against non-*Salmonella* bacteria, *S. crassifolium* against *Salmonella*, and other *Sargassum* species against *S.* Typhi. 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

Nine core studies are summarized in Table 1. The relevance of each study to the review question was determined by two factors: how certain the identity of the alga is and how appropriate the test bacterium is. Studies of *S. crassifolium* on non-*Salmonella* bacteria show biological activity, but they do not answer whether the extract inhibits *S.* Typhi. *S.* Typhimurium belongs to the same genus, but it generally causes non-typhoidal salmonellosis and is therefore not equivalent to *S.* Typhi. Studies on *S.* Typhi that used *Sargassum* sp. cannot be attributed to *S. crassifolium*.

**TABLE 1:** Summary of the Reviewed Studies.

| Study | Material and test bacteria | Main findings | Interpretation notes |
|---|---|---|---|
| Albratty et al., 2021 [3] | Methanol and petroleum ether extracts of *S. crassifolium* (Red Sea); six non-*Salmonella* bacteria | Inhibition zones 7.6–18.83 mm (methanol) and 7.6–19.5 mm (petroleum ether); streptomycin as comparator | *Salmonella* not tested |
| Setyati et al., 2020 [4] | *S. crassifolium* extracts (Karimunjawa) in several solvents; *S. aureus* and multidrug-resistant (MDR) *P. aeruginosa* | Diethyl ether extracts most active; gas chromatography–mass spectrometry (GC–MS) detected, among others, eicosane and dotriacontane | *Salmonella* not tested |
| Coronado & Dionisio-Sese, 2014 [5] | Ethanol extract of *S. crassifolium*; *S. aureus*, *E. coli*, *C. albicans*, *A. niger* | Active against *S. aureus*; the other organisms were not susceptible | *Salmonella* not tested |
| Baleta et al., 2017 [6] | *S. oligocystum* and *S. crassifolium* in several solvents; aquaculture pathogens | Metabolite groups and activity differed by solvent | Relevance to *S.* Typhi is indirect |
| Kereh et al., 2018 [7] | Seaweed extracts, including *S. crassifolium*; *Salmonella* sp. | Inhibition at certain extract concentrations | Serovar not confirmed as *S.* Typhi |
| Chamidah et al., 2017 [8] | Laminaran from *S. crassifolium*; *B. subtilis*, *S. aureus*, *E. coli*, *S.* Typhimurium | Higher activity against Gram-positive bacteria | *S.* Typhimurium is not *S.* Typhi; laminaran is not a crude extract |
| Firdaus et al., 2019 [9] | Hexane extract of *Sargassum* spp.; *E. coli*, *S.* Typhi, *S. aureus*; in silico analysis | Inhibition zones against the test bacteria; candidate active components identified | Alga identified only to genus level |
| Darfiah et al., 2021 [10] | Extracts of *Sargassum* sp. and other macroalgae; *S.* Typhi | Inhibition zones of *Sargassum* sp. against *S.* Typhi, including 25.67 mm under certain test conditions | Algal species not determined |
| Kartikaningsih, 2020 [11] | Ethanol extract of *S. cristaefolium*; *E. coli* and "*Salmonella thyposa*" | Small inhibition zones; weak activity | Different algal species; non-standard bacterial name |

- **Activity Of *S. Crassifolium* Against Non-*Salmonella* Bacteria**

Albratty et al. reported that methanol and petroleum extracts of *S. crassifolium* from the Red Sea inhibited six human pathogenic bacteria: *Bacillus subtilis*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* [3]. Setyati et al. showed that the type of solvent influenced the activity of *S. crassifolium* extracts against *S. aureus* and multidrug -resistant *P. aeruginosa* strains that were resistant to several antibiotics [4]. Coronado and Dionisio-Sese reported activity against *S. aureus* but not against *E. coli*, *Candida albicans*, or *Aspergillus niger* [5]. Baleta et al. also reported differences in antimicrobial activity depending on the solvent in *S. oligocystum* and *S. crassifolium* [6]. Overall, the activity of the extracts depends on the solvent and the test bacterium. Because none of these studies tested *Salmonella*, their results serve only as supporting context.

- **Evidence for *S. crassifolium* against *Salmonella***

Kereh et al. tested seaweed extracts, including *S. crassifolium*, against *Salmonella* sp. and reported inhibition at certain concentrations [7]. This finding gives an early indication, but the name "*Salmonella* sp." does not specify the serovar or strain, so it cannot be regarded as direct evidence against *S.* Typhi.

Chamidah et al. tested laminaran from *S. crassifolium* against *S.* Typhimurium and several other bacteria [8]. The result is relevant because the test bacterium belongs to the genus *Salmonella*, but *S. Typhimurium* differs from *S.* Typhi in its epidemiology and in the disease it causes. Laminaran is also a polysaccharide fraction, so the result does not represent the activity of a crude extract. Thus, these two studies provide a basis for further research, but they have not confirmed that *S. crassifolium* inhibits *S.* Typhi.

- **Studies of *Sargassum* spp. against *S.* Typhi and the limits of comparison**

Firdaus et al. reported inhibition zones of a hexane extract of *Sargassum* spp. against *S.* Typhi, *E. coli*, and *S. aureus* [9]. Darfiah et al. reported inhibition zones of a *Sargassum* sp. extract against *S.* Typhi [10]. Kartikaningsih tested S. *cristaefolium* against *E. coli* and a bacterium written as "*Salmonella thyposa*", with weak results [11]. Because the algae in these studies were identified only to the genus level or were different species, the results support the hypothesis that some *Sargassum* species are active against *S.* Typhi, but they cannot be attributed to *S. crassifolium*.

The size of an inhibition zone is influenced by the concentration and volume of the extract, the ability of compounds to diffuse in agar, the type of medium, the inoculum density, and the incubation time. A crude extract is a mixture of compounds, whereas a reference antibiotic is a pure substance with different diffusion characteristics. A larger zone for an extract than for an antibiotic in a single experiment therefore does not mean that the extract is clinically stronger. A meaningful comparison requires standardized procedures, reporting of the extract mass per disc or well, solvent and antibiotic controls, adequate replication, and measurement of the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC). Results from different studies should not be pooled quantitatively when the methods and units are not comparable.

- **Chemical composition and proposed mechanisms**

Chemical analyses of *Sargassum* extracts have reported fatty acids, sterols, long-chain hydrocarbons, phenolics, and polysaccharides [3,4,6]. Composition is influenced by species, harvest location and season, part of the thallus, drying method, and solvent, so a single chemical profile does not represent all *S. crassifolium* samples. Gas chromatography–mass spectrometry (GC–MS) estimates the identity of a compound from its fragmentation pattern and its match with a spectral library. A library match alone does not confirm a chemical structure, so compounds identified with low confidence should be described as tentative identifications and compared with solvent blanks to exclude contamination. Fourier-transform infrared (FT-IR) spectroscopy only shows functional groups, not the definitive identity of a molecule.

Certain phenolics, fatty acids, terpenoids, and polysaccharides can be studied as candidate antimicrobial compounds. However, their presence in an extract does not prove that they cause the inhibition. A causal relationship requires activity-guided fractionation, testing of each fraction, structure elucidation, and testing of pure compounds. The mechanisms commonly proposed in the antibacterial literature, namely disruption of membrane integrity, altered permeability, or interference with metabolism, remain hypotheses for *S. crassifolium* against *S.* Typhi.

- **Safety and translational relevance**

*In vitro* activity is not the same as safety or effectiveness in humans. The use of extracts must consider cellular toxicity, solvent residues, variation in composition, and environmental contaminants. Macroalgae can accumulate arsenic, and certain species such as hijiki (*Sargassum fusiforme*) have been reported to contain high levels of inorganic arsenic [12]. This does not mean that the samples in the studies above were contaminated, but it shows that natural origin does not guarantee safety and that contaminant testing is still required.

Early-stage studies should authenticate the species, record the harvest location and time, keep voucher specimens, apply consistent processing, and test relevant contaminants. Cytotoxicity assays in mammalian cells are needed to assess the safety margin of the concentrations that inhibit bacteria. Until such data are available, *S. crassifolium* cannot be recommended as a treatment for typhoid fever or as a substitute for antibiotics.

- **Limitations of this review and research directions**

This review has four limitations. First, the search was narrative and not documented systematically, so relevant publications may not have been identified.

Second, the studies differed in algal species, solvent, concentration, method, and reporting, so quantitative comparison is inappropriate. Third, some of the evidence came from proceedings or other academic sources with limited methodological detail. Fourth, data on the specific activity of *S. crassifolium* against *S.* Typhi, its mechanism of action, and its 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 mismatch between the test bacteria and the research question. The priorities for future research are:

1) Test authenticated *S. crassifolium* against well-identified *S.* Typhi strains in a laboratory with appropriate biosafety facilities.
2) Document the harvest location and time, morphology, drying method, voucher specimens, and taxonomic confirmation.
3) Report the extract concentration and mass, volume, solvent, positive and negative controls, inoculum, replication, and measurement procedures.
4) Measure MIC and MBC with validated quantitative methods once the initial screening is reproducible.
5) Perform activity-guided fractionation and confirm the structure of the active compounds.
6) Measure contaminants, solvent residues, and cytotoxicity before translational studies.

## CONCLUSIONS

*S. crassifolium* contains interesting phytochemical components and shows in vitro antibacterial activity against several non-*Salmonella* bacteria. One study reported inhibition of *Salmonella* sp. without confirmation of the serovar; one study tested laminaran against *S.* Typhimurium; and the studies on *S.* Typhi used *Sargassum* that was not identified to the species level. Thus, the current evidence is insufficient to conclude that *S. crassifolium* is specifically active against *S.* Typhi. Future research should prioritize authentication of the alga, identification of bacterial strains, standardized and reproducible methods, MIC/MBC measurement, and safety evaluation. In vitro results must not be interpreted as evidence of clinical benefit or as a reason to replace antibiotics.

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