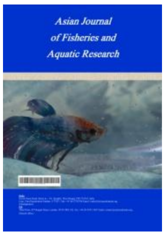

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Antimicrobial Potential of *Sonneratia alba* and *Sonneratia caseolaris* against Shrimp Pathogens

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Disease is one of the obstacles in shrimp farming. Many countries have experienced economic losses due to disease in shrimp caused by microbes. Many strategies are being used to overcome the problem such as antibiotics, formalin, probiotics, prebiotics, synbiotics, and others. However, the use antibiotics in long term can cause negative effects. So that, the development of potential new natural compounds is required to overcome this problem. This review article aims to explain the nutritional content, bioactive compounds, antimicrobial potential, and the effect of *S. alba* and *S. caseolaris* on shrimp survival. *Sonneratia alba* and *Sonneratia caseolaris* are plants that have many bioactive compounds such as alkaloids, flavonoids, terpenoids, and phenolics. They have also been shown to inhibit the growth of bacteria such as *Vibrio harveyi*, *Escherichia coli, Staphylococcus aureus, Saprolegnia* sp., and others. Application of *S. alba* and *S. caseolaris* can also increase the survival rate of infected shrimps. *S. alba* and *S. caseolaris* have the potential to be used as antimicrobial agents and can be used to protect shrimp from microbial pathogens.

Keywords: Sonneratia alba; sonneratia caseolaris; antimicrobial; survival rate.

1. INTRODUCTION

Shrimp is a popular seafood commodity among global communities. Based on data from Research and Markets [1], the number of shrimps being traded reaches 8.12 million tons in 2021. Demand for shrimp is estimated to continue to increase and reach a value of US $

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24.1 billion with a volume reaching 10.7 million in 2026. The major countries that produce shrimp are China, India, Vietnam, and Indonesia. While the United States is the largest consumer. Two of the most popular and produced shrimp commodities are *Penaeus monodon* and *Litopenaeus vannamei*. In Indonesia*, L. vannamei* is the main export commodity compared to other fishery commodities. In 2011, shrimp exports contributed around USD 1.5 billion, while fish exports amounted to 1 billion and seaweed was 0.2 billion [2].

However, shrimp farming also has various obstacles. One of the obstacles is the presence of diseases caused by bacteria or viruses such as white feces disease (WFD), white spot syndrome virus (WSSV), epizootic ulcerative syndrome (EUS), and acute hepatopancreatic necrosis disease (AHPND). Disease attack on shrimp production has caused economic losses in various countries. During 2010-2017, the economic loss on Mahachai Market, Thailand was estimated at US $ 7.38 billion. The economic losses due to AHPND in VietNam's Mekong Delta in 2015 were estimated at more than US $ 26 million, and the WSSV resulted in loss of more than US $ 11 million [3].

White feces disease (WFD) is caused by bacteria from the genus Vibrio such as *V. parahaemolyticus, V. fluvialis, V. vulnificus, V. mimicus, V. alginolyticus, V. cholera* [4] and *V. Harveyi* [5]. This disease can cause mortality in *L. vannamei* shrimp as much as 30% [4]. Symptoms of this disease are discoloration of hepatopancreas and white feces, floating on the water surface, and white intestine [5]. White spot syndrome virus (WSSV) has caused mass mortality in the shrimp culture industry. This virus can cause white spots on the carapace, loose cuticles, decreased feed intake [6], weakness, pale hepatopancreas, unstable swimming, and redness of the abdomen [7]. Acute hepatopancreatic necrosis disease can can cause the death of 100% of postlarvae shrimp in the pond within 20-30 days. The symptoms that arise in shrimp infected with these bacteria are empty intestine, atrophy, and pale hepatopancreas [8].

Cultivators prevent disease attacks in various ways, namely formalin, antibiotics [9] probiotics, prebiotics, synbiotics [10]. Formalin has been proved that effective for controlling WSSV in water [11]. However, giving antibiotics in large doses, and long term can cause resistance to pathogens. Antibiotics can also accumulate in the body of shrimp [9]. Therefore, the search for alternative natural materials to prevent and treat various pathogens that cause shrimp disease needs to be done.

Sonneratia alba and S. caseolaris are natural ingredients that have potential as antibacterial and antiviral. Both of these plants live in the mangrove ecosystem. Both of these plants contain various bioactive compounds such as phenolic compounds, saponins, tannins and steroids [12-13]. This article aims to describe the content of the compounds in various parts of *S. alba* and *S. caseolaris* and their potential as antimicrobials as a prevention of disease infection in shrimp.

2. CHEMICAL COMPOSITION OF *Sonneratia alba*

Sonneratia alba is an evergreen tree that is classified as a true mangrove plant. Its height can reach 15 m with a trunk diameter of 30-40 cm. Brown bark. Leaves about 5-12 cm long, and 4-8 cm wide. The flowers are white and bisexual. Globular green fruit surrounded by sepals [14-15]. *S. alba* is surrounded by thick and numerous pneumatophores [16].

Various useful chemical compounds are contained in various parts of *S. alba*. The bark has been shown to contain phenolic compounds with a lactone ring [17], triterpenoids [18]. The leaves contain saponins, tannins, phenols [19], and steroids [12]. The fruit contains phenolic compounds, flavonoids, triterpenoids, tannins, steroids [20]. *S. alba* fruit is known to contain 0.93 mg/g protein,14.9 mg/100 g of total sugar, 40 mg/100 grams of vitamin C, and 52.78%, 0.063 mg/g of Mn, 0.72 mg/g of Zn, and 0.51 mg/g of Fe [21]. Young *S. alba* fruit flour contains 8.735% protein, 1.44% fat, and 74.12% carbohydrate. The old S. alba fruit flour contains 8.34% protein, 1.54% fat, and 75.1% carbohydrate [22]. Table 1 shows the various chemical compounds in various parts of the *S. alba* plant.

3. CHEMICAL COMPOSITION OF *Sonneratia caseolaris*

Sonneratia caseolaris is also an evergreen tree that is included in true mangroves. It can reach 20 m in height with a trunk diameter of 30 cm. This plant also has pneumatophores or aerial roots. It has red flowers with green sepals. The fruit is round and contains a lot of seeds [26].

Sonneratia caseolaris fruit is known to contain 46.58 mg/100 grams of total sugar, 187.46 mg/100 grams of vitamin C, and 52.78% protein [27]. Another study conducted by Dari et al (2020) [28] showed that *S. caseolaris* fruit juice contained 0.67% carbohydrate, 0.28% protein, 0.06% ash content, 0.32% fiber, and 15% vitamin C levels. *S. caseolaris* fruit juice was also proven to have 90.19% antioxidant activity. The ethanol extract of the fruit contains saponins, sapogenins, terpenoids, flavonoids, tannins, and polyphenols [13]. Meanwhile, the acetate extract contains flavonoids, saponins, tannins, and phenolics. In the ethanol extract found alkaloids, saponins, and phenolics [29]. The leaves of Sonneratia caseolaris contain alkaloids, flavonoids, tannins, phenolics, steroids, triterpenoids [30], saponins [31]. The stem contains steroids [31]. The methanol extract of the bark is proven to contain saponins, tannins, flavonoids, alkaloids, steroids [32]. Table 2 shows the various chemical compounds in various parts of the *S. caseolaris*.

4. ANTIBACTERIAL POTENTIAL OF *Sonneratia alba* AND *Sonneratia caseolaris*

With various secondary metabolite contents, these two types of mangroves trees have the potential to be used as antimicrobials that fight various disease-causing pathogens in shrimp and other pathogenic bacteria. Flavonoids contained in these two types of mangroves are known to inhibit bacteria by damaging the permeability of bacterial cell walls, binding to functional cell proteins and bacterial DNA so that growth does not occur [34], inhibits cell wall formation, cell membrane formation, and respiration [35]. The phenolic mechanism in inhibiting bacteria is to damage cell membranes, cell nucleus leakage, and damage cell content [34]. The mechanism of terpenoids in inhibiting bacteria is by causing membrane disruption [36]. Alkaloids can inhibit the bacterial nucleic acid synthesis and bacterial cell division [37]. Saponins can reduce cell surface tension thereby increasing cell permeability and leakage of cells [38]. Tannins can inhibit bacterial growth by inhibiting extracellular microbial enzymes and inhibiting the oxidative phosphorylation process [39].

Several studies have shown that *S. alba* leaves can inhibit the growth of *Staphylococcus aureus, Escherichia coli, Vibrio harveyi, Aeromonas hydrophila, and Saprolegnia* sp*. [40], and Salmonella* sp*.* [41]. The fruit of *S. caseolaris* is known to inhibit the growth of *E.coli, V. Cholerae, S.typhimurium, Bacillus subtilis [42].* while the leaf methanol extract can inhibit *Shigella dysenteriae, Enterobacter cloacae, Klebsiella pneumonia, Enterobacter sakazaki, E. brevis, Chryseobacterium indologenes. Stenotrophomas maltphila, A. hydrophilia* [43]. Table 3 shows *S. alba* inhibition zone and Table 4 shows the *S. caseolaris* inhibition zone against various bacteria.

5. THE EFFECT OF *Sonneratia alba* AND *Sonneratia caseolaris* AGAINST BACTERIAL INFECTION ON SHRIMP

Application of *S. caseolaris* to shrimp has been shown to increase the survival rate in shrimp infected with disease-causing bacteria. Arifuddin et al. [46] conducted a study by injecting hydroquinone extracted from *S. caseolaris* into the Penaeus monodon muscle. Shrimp were infected by *V. harveyi* at two test times, namely the day before hydroquinone administration and 7 days after hydroquinone administration. The results showed that the survival rate of shrimp given hydroquinone extract *S. caseolaris* was higher than the control. The total number of *V. harveyi* bacteria in the shrimp body increased the day after infection by bacteria, but the number of bacteria decreased after being given hydroquinone extract from *S. caseolaris*. Similar results were obtained in the study of Maryani et al. [47] which examined the effect of *S. caseolaris* calyx and fruit extracts on V. harveyi infection in *P. monodon* shrimp. Application of *S. caseolaris* petal and fruit extracts can increase the survival rate of shrimp. The administration of this extract also increases the resistance of shrimp after infected by bacteria *V. harveyi* and decreasing of bacteria level in the body of shrimp.

Application 20 ppm of *S. alba* fruit extract to giant tiger prawn postlarvae through a feed of Artemia salina can increase the survival rate in shrimp infected with *V. harveyi*. The survival rate reached 78.33% [34]. Freshwater ethanol extract, and saline water of *S. alba* can also inhibit the growth of *Saprolegnia sp* in shrimp. This can be seen based on the survival rate value of shrimp given *S. alba* higher than control [48].

Table 1. Compound content in various parts of *S. alba*

Part of Plant	Solvent	Bioactive compound	Reference
Leaf	Methanol	Phenolics, saponins, tannins, and steroids	[12]
	Ethyl acetate	Phenolics, tannins, steroids	
	N-hexane	Steroids	
Leaf	Methanol	Lupeol (1), Oleanic acid (2), β-Sitosterol (3), β-stigmasterol (4), and Sitost-4-en-3-one	[23]
Leaf	Dichloromethane	ursolic acid, squalene	[24]
Leaf	Ethanol	Saponins, tannins, Phenolics	[19]
	Water	Tannins, phenolics	
Fruit	Methanol	alkaloids, flavonoids, phenolics, tannins, steroids	[25]
Fruit	N-hexane	Phenolics, flavonoids, steroids, trithepenoids	[20]
	Ethyl acetate	Phenolic, flavonoids, tannins, tritepenoids	
	Water	phenolics, flavonoids, tannins, steroids	
	Methanol	phenolics, flavonoids, tannins, steroids	
Fruit	Dichloromethane	oleanolic acid, ursolic acid (1b), α-amyrin cinnamate, β-amyrin cinnamate, β-sitosterol, and stigmasterol.	[24]
Bark	Methanol	Phenolic with lactone rings	[17]
Bark	N-hexane, ethyl acetate and Methanol	3β-hydroxy-lup-9(11),12–diene, 28-oic acid, lupeol, lupan-3β-ol (3)	[18]

Table 2. Compound content in various parts of *S. caseolaris*

Part of Plant	Solvent	Bioactive compound	Reference
Fruit	Ethanol	Saponins, sapogenins, terpenoids, flavonoids, tannins, polyphenols	[13]
Fruit	Acetate	Flavonoids, saponins, tannins, and phenolics.	[30]
Fruit	Ethanol	Alkaloids, saponins, and phenolic	[29]
Leaf	Ethanol	alkaloid, flavonoid, tannins, phenolic, steroid, triterpenoid	[30]
Leaf	Ethanol	Saponins	[31]
Stem	Ethanol	Steroids	[31]
Bark	Methanol	saponins, tannins, flavonoids, alkaloids, steroids	[32]
Bark	Ethyl acetate	Flavonoids	[33]

Table 3. Inhibition zone of *S. alba* extract to microbe

Bacterial strains	Extract	Concentration	Inhibition zone (mm)	Reference
Vibrio harveyi	Ethanol	1000 ppm	12.67	[40]
V. harveyi	Water	1000 ppm	10.67	[40]
V. harveyi	Seawater	1000 ppm	12.33	[40]
Staphylococcus aureus	Ethanol	1000 ppm	13.00	[40]
S. aureus	Water	1000 ppm	11.67	[40]
S. aureus	Seawater	1000 ppm	13.32	[40]
S. aureus	Ethyl acetate	100%	35.6	[41]
S. aureus	Methanol	1,5 mg	12.5	[44]
Escherichia coli	Ethanol	1000 ppm	12.67	[40]
E. coli	Water	1000 ppm	11.00	[40]
E. coli	Seawater	1000 ppm	12.33	[40]
E. coli	Ethyl acetate	100%	36.2	[41]
E. coli	Methanol	1.5 mg	17.5	[44]
Saprolegnia sp.	Ethanol	1000 ppm	12.00	[40]
Saprolegnia sp.	Water	1000 ppm	11.33	[40]
Saprolegnia sp.	Seawater	1000 ppm	11.67	[40]
Aeromonas hydrophila	Ethanol	1000 ppm	13.00	[40]
hydrophila	Water	1000 ppm	11.67	[40]
A. hydrophila	Seawater	1000 ppm	12.67	[40]
Salmonella sp.	Ethyl acetate	100%	40.3	[41]
Bacillus cereus	Methanol	1.5 mg	12.5	[44]
Cryptococcus neoformans	Methanol	1.5 mg	11.00	[44]

Table 4. Inhibition zone of *Sonneratia caseolaris* extract to microbe

Bacterial strains	Extract	Concentration	Inhibition zone (mm)	Reference
Escherichia coli	Methanol	15%	7.17	[45]
Escherichia coli	Fruit juice	100 µl	21	[42]
Staphylococcus aureus	Methanol	80%	8.81	[45]
Candida albicans	Methanol	30%	7.03	[45]
Shigella dysenteriae	Methanol	500 mg	21	[43]
Enterobacter cloacae	Methanol	500 mg	16	[43]
Klebsiella pneumonia	Methanol	500 mg	18	[43]
Enterobacter sakazaki	Methanol	500 mg	21	[43]
Chriseobacterium indologenes	Methanol	500 mg	19	[43]
Stenotrophomas maltphila	Methanol	500 mg	19	[43]
Aeromonas hydrophilia	Methanol	500 mg	19	[43]
Vibrio cholerae	Fruit juice	100 µl	35	[45]
Salmonella.typhimurium	Fruit juice	100 µl	27	[45]
Bacillus subtilis	Fruit juice	100 µl	29	[45]

6. CONCLUSION

In conclusion, *Sonneratia alba and Sonneratia caseolaris contains* a lot of nutrition and bioactive compounds such as protein, carbohydrate, alkaloid, flavonoid, tannins, terpenoid, saponin, phenolic, and steroid. They can inhibit the growth of bacterial strains. *Sonneratia alba and Sonneratia caseolaris* can also increase the survival rate of shrimps. So, these plants may be an excellent source to develop antibacterial agents to prevent and cure pathogenic diseases in shrimp.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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