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POTENTIAL USE OF GUDUCHI (*Tinospora cordifolia*) AS SHRIMP IMMUNOSTIMULANT: ARTICLE REVIEW

Potensi Tanaman Brotowali (*Tinospora cordifolia*) Sebagai Imunostimulan Pada Udang: Artikel Reviuw

Rangga Idris Affandi*, Nuri Muahiddah

Aquaculture Study Program, Faculty of Agriculture, University of Mataram

Pendidikan Street No. 37 Mataram, West Nusa Tenggara 83125, Indonesia

*Corresponding Author: ranggaidrisaffandi@unram.ac.id

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ABSTRACT

Shrimp is among the most economically important aquaculture species globally, playing a significant role in ensuring both food and economic stability. However, the development of aquaculture, particularly shrimp farming, faces several management challenges, with disease outbreaks being a major concern. One effective strategy for disease control is maintaining shrimp health through preventive measures, such as administering immunostimulants. Natural sources of immunostimulants, especially from plants, are gaining attention. One such plant is guduchi (Tinospora cordifolia), known for its rich array of bioactive compounds. Widely recognized as an ingredient in traditional bitter herbal medicine, guduchi offers various health benefits to humans and holds promise for enhancing shrimp immunity. This literature review aims to highlight the potential of guduchi as an immunostimulant for shrimp. The study applies a systematic literature review approach, involving planning, data collection, analysis, and drawing conclusions. Findings indicate that guduchi contains several compounds capable of boosting the immune response in shrimp, suggesting strong potential for further research and application in aquaculture, particularly in shrimp production.

Keywords: Aquaculture, Guduchi, Immunostimulant, Shrimp

ABSTRAK

Udang merupakan salah satu komoditas budidaya yang paling bernilai secara ekonomi di dunia dan memiliki peran penting dalam menjaga ketahanan pangan serta stabilitas ekonomi. Namun, pengembangan budidaya, khususnya budidaya udang, menghadapi berbagai tantangan dalam pengelolaannya, terutama terkait dengan serangan penyakit. Salah satu strategi efektif untuk mengendalikan penyakit adalah dengan menjaga kesehatan udang melalui tindakan pencegahan, seperti pemberian imunostimulan. Sumber imunostimulan alami, terutama dari tumbuhan, semakin banyak mendapat perhatian. Salah satu tanaman yang berpotensi sebagai imunostimulan adalah brotowali (*Tinospora cordifolia*), yang dikenal memiliki beragam senyawa bioaktif. Brotowali secara luas dikenal sebagai bahan dalam ramuan herbal pahit tradisional dan memiliki banyak manfaat kesehatan bagi manusia, serta berpotensi meningkatkan daya tahan tubuh udang. Kajian pustaka ini bertujuan untuk menyoroti potensi brotowali sebagai imunostimulan bagi udang. Penelitian ini menggunakan pendekatan tinjauan pustaka sistematis, yang mencakup tahap perencanaan, pengumpulan data, analisis data, dan penarikan kesimpulan. Hasil kajian menunjukkan bahwa brotowali mengandung sejumlah senyawa yang dapat merangsang sistem imun udang, sehingga memiliki potensi besar untuk diteliti dan dikembangkan lebih lanjut sebagai sumber imunostimulan dalam budidaya perikanan, khususnya pada komoditas udang.

Kata Kunci: Akuakultur, Brotowali, Imunostimulan, Udang

INTRODUCTION

Shrimp is one of the most valuable aquaculture species in the world and plays an important role in providing food and economic security (Knipe *et al*., 2024). Shrimp farming has become an important economic activity and the largest export industry in many aquaculture-dominated countries around the world, due to its significant role in meeting protein demand and food security. Shrimp contributes about 16.4% of the global trade in fish and fishery products in terms of value, making it the second most important commercial food commodity after tuna (M. S. Islam *et al*., 2024).

Indonesia is an archipelagic country that has very prospective fishery resource potential to be developed. This potential is not only limited to marine and inland waters, but also includes capture fisheries and aquaculture that can still be optimized (Affandi & Setyono, 2023). Aquaculture, also known as aquaculture, is an activity that produces aquatic organisms in a controlled environment for the purpose of making a profit (Affandi & Diamahesa, 2023; Affandi & Diniariwisan, 2024; Affandi & Setyono, 2024a; Muahiddah *et al*., 2023). Aquaculture, which involves the cultivation of aquatic organisms such as fish, shrimp, and shellfish, has an important role in meeting the increasing global need for animal protein (Scabra *et a*l., 2023; Affandi & Setyono, 2024a; Muahiddah & Affandi, 2023), animal protein is very much needed by humans which can be met, one of which is through aquaculture (Affandi, Setyono *et al*., 2023). One of the leading commodities of aquaculture is shrimp.

Shrimp is one of the export products of the fisheries subsector and has a high economic value. Shrimp that is popular both nationally and internationally is whiteleg shrimp (*Litopenaeus vannamei*) (Muahiddah *et al*., 2022; Saomadia *et al*., 2024). According to data from the Ministry of Marine Affairs and Fisheries (KKP), the supply of whiteleg shrimp in Japan is estimated at around 420,000 tons per year, in the United States around 560,000-570,000 tons per year, and in the European Union around 230,000-240,000 tons per year (Affandi, Fadjar *et al*., 2023). According to data from the Directorate General of Aquaculture (DJPB) of the Ministry of Marine Affairs and Fisheries (KKP), whiteleg shrimp production in Indonesia reached 884,939 tons in 2021 (Agustiyana *et al*., 2023). The development of aquaculture potential, especially shrimp cultivation, faces management challenges, especially disease problems. This condition requires attention and efforts to improve the production capacity of shrimp farming. Shrimp are aquatic organisms that constantly interact with their surrounding water environment, making them highly susceptible to pathogen infections. Disease can cause obstacles and failures in shrimp farming efforts. Disease occurs due to the interaction between three factors: the environment, the host, and the cause of the disease (Affandi, Abidin *et al*., 2023; Rahmadani *et al*., 2023).

Shrimp health management in controlling disease attacks can be done with preventive measures. One technology that has been developed to overcome this problem is the use of immunostimulants (Jasmanindar *et al*., 2020). Immunostimulants are compounds that can increase the immune system of cultivated organisms. In general, the mechanism of action of immunostimulants is to correct the imbalance of the immune system by increasing specific and non-specific immunity (Fidyandini *et al*., 2020). The use of immunostimulants does not leave residues in the shrimp body or the environment and is safe for the health of humans who consume them. Therefore, the use of immunostimulants in shrimp cultivation is very important (Razak *et al*., 2017).

Immunostimulant sources for aquaculture can be derived through chemical or biological processes. These substances can be classified according to their function and origin, which include a range of categories such as bacteria and their derivatives, yeast, complex carbohydrates, nutritional components, animal-based extracts, plant-based extracts, and synthetic pharmaceuticals (Affandi *et al*., 2019). The content in natural plant products acts as an antistress, growth stimulant, appetite stimulant, tonic and immunostimulant, and antimicrobial for fish and shrimp. The main components in natural plants that have these functions include alkaloids, flavonoids, pigments, phenolics, terpenoids, steroids, essential oils, and sulfate polysaccharides (Jasmanindar *et al*., 2020).

One source of immunostimulants from plants that can be used to increase shrimp immunity is the guduchi (*Tinospora cordifolia*). Guduchi is widely recognized as a key ingredient in the production of bitter herbal remedies, valued for its numerous health benefits due to its rich composition. Hence, a literature review is necessary to present a comprehensive overview of guduchi's potential as an immunostimulant to stakeholders in aquaculture, particularly researchers interested in exploring its potential further.

METHODS

Place and Time of Research

This literature review was carried out in Mataram during the period of April to May 2025.

Tools and Materials

The equipment and materials utilized in this literature review research consisted of a laptop, a charger, a mouse, and digital versions of scientific articles.

Research Procedure

Access to relevant information for this article was obtained through platforms such as Google Scholar, ProQuest, and Elsevier. The sources used consisted of 63 journal articles, 2 conference proceedings, and 2 books. The research method applied in this article is a systematic literature review, which involves a structured process of collecting library-based data, reading and taking notes, as well as analyzing and managing research materials in an objective, systematic, analytical, and critical manner regarding the potential of guduchi as an immunostimulant for shrimp. Although the preparation of this literature-based article follows the general structure of scientific articles, the data collection relies entirely on literature sources. This involves gathering information from libraries, followed by a process of reading, documenting, and processing research materials from studies that explore guduchi's potential as an immunostimulant in shrimp. The literature review aims to conduct a thorough and detailed analysis to produce objective conclusions about guduchi's role in shrimp immunostimulation. All data used are secondary data, including findings from books, journals, and other relevant scholarly articles (Affandi & Diamahesa, 2023).

Data Analysis

The data analysis method used in this article is content analysis. The process starts by examining research findings that are categorized as highly relevant, relevant, or moderately relevant. The researcher reviews the abstract of each study to determine if the issues addressed align with the focus of the current research. Key and relevant sections related to the research problem are then identified and noted, and the analysis concludes with the formulation of conclusions based on the gathered information (Affandi & Setyono, 2023, 2024a, 2024b).

RESULTS

Active Compound Content in Guduchi

In general, every part of herbal plants—including the leaves, stems, roots, fruits, buds, and flowers—is abundant in natural bioactive compounds such as carotenoids, phenolic acids, flavonoids, coumarins, alkaloids, polyacetylenes, tannins, saponins, and terpenoids. These compounds offer a wide range of biological activities, including antioxidant, antibacterial, antiviral, antifungal, antiparasitic, anti-inflammatory, and antiallergic effects, among others (Chandrasekara & Shahidi, 2018). An example of a medicinal plant abundant in active compounds is guduchi (*Tinospora cordifolia*). According to the literature review carried out, the specific active compounds present in guduchi are summarized in Table 1.

Table 1. Active Compound Content in Guduchi

Compounds in Guduchi	Reference
Steroids, glycosides, alkaloids, polysaccharides, diterpenoid lactones, and aliphatic compounds	(Rauf *et al.*, 2025)
Alkaloids, glycosides, sesquiterpenoids, phenolics, diterpenoids, steroids, aliphatic compounds, polysaccharides, liquiritin, Plastoquinone 3, and Shoyuflavone A	(Amrutha *et al.*, 2025)
Alkaloids, diterpenoids, glycosides, steroids, sesquiterpenoids, phenolics, polysaccharides, and aliphatic compounds	(Lekkala *et al.*, 2025)
Flavonoids, terpenoids, lignins, alkaloids, phenols, tannins, and sterols	(Das *et al.*, 2025)
Aliphatic compounds, alkaloids, steroids, glycosides, diterpenoid lactones, fatty acid mixtures, essential oils, polysaccharides, and berberine.	(S. M. Singh *et al.*, 2025)
Glycosides, steroids terpenoids, phenolics, polysaccharides, aliphatic compounds, alkaloids, tannins, sesquiterpenoids, flavonoids, essential oils, and fatty acids	(Annisa *et al.*, 2025)
Steroids, alkaloids, glycosides, diterpenoid lactones, sesquiterpenoids, and aliphatic compounds	(Chaudhary *et al.*, 2024)
Saponins, flavonoids, aglycones, alkaloids, terpenoids, phenols, guaiacol, eugenol, and syringol	(Jaya *et al.*, 2024)
Alkaloids, diterpenoid lactones, terpenoids, glycosides, steroids, and aliphatic compounds	(A. Islam *et al.*, 2024)
Alkaloids, glycosides, flavonoids, terpenoids, and polysaccharides	(Krishna *et al.*, 2024)
Flavonoids, phenolics, steroids, sesquiterpenoids, terpenoids, tannins, glycosides, furanoditerpenes, lactones, lignans, alkaloids, kalopiptin, d-Lirioferrin (lirioferrin), moupinamide, piperanine, and yuanhunin	(Royani, Hanafi, Julistiono, *et al.*, 2023)
N-trans-feruloyltyramine (moupinamide)	(Royani, Hanafi, Dewi N. Lotulung, *et al.*, 2023)
Tinosporin, tinosporide, tinosporasid, cordifolide, cordifol,	(Nath *et al.*, 2023)

Compounds in Guduchi	Reference
heptacosanol, clerodana furano diterpene, diterpenoid furanolactone tinosporidine, columbine, β-sitosterol, berberine, palmatine, tembertarine, magniflorine, and choline	
Alkaloids, flavonoids, steroids, furano diterpenoids, norditerpenoids, sesquiterpenoids, phenolics, lignin, sterols, aliphatic compounds, polysaccharides, essential oils, and fatty acids	(Kumar *et al*., 2023)
Diterpenoid lactones, sesquiterpenoids, glycosides, alkaloids, steroids, phenolics, and tinosporasid	(Mishra *et al*., 2023)
Steroids, terpenoids, alkaloids, polyphenols, fatty acids (oleic acid, lauric acid, palmitic acid, linoleic acid), and aldehydes (cinnamaldehyde)	(Gaurav *et al*., 2022)
Berberine, furanolactone, tinosporone, tinosporic acid, cordifolicides A to E, giloin, gilenin, giloininand crude, polysaccharide arabinogalactan, picrotene, bergenin, gilosterol, tinosporol, tinosporidin, sitosterol, cordifol, heptacosanol, octacosone, tinosporide, columbine, chasmanthin, palmarin, palmatoside C and F, amritoside, cordioside, tinosponone, ekdysterone, makisterone A, hydroxyecdysone, magnoflorine, tembetarin, siringin, glucan, siringin apiosyl glucoside, isocolumbine, palmatin, tetrahydropalmatine, and jatrorrhizine	(Sanmugarajah *et al*., 2022)
polysaccharides, steroids, phenolics, aliphatic compounds, alkaloids, steroids, phosphorus, calcium, and proteins	(Murshid *et al*., 2022)
Columbine, alkaloids, bitter substances picroretin, picroretoside, palmatin, tannins, starch, saponins, and triterpenoids	(Disi, 2022)
Diterpenoids (cordifolide), alkaloids (berberine, palmatin, reticulin, jatrorizin, magnoflorin, menisperin, tinoscorside A, and tinoscorside B), steroids (b-sitosterol derivatives), and polysaccharides (glucose, arabinose, xylose, galactose, rhamnose, and mannose)	(Yates *et al*., 2021)
Alkaloids, steroids, glycosides, and polysaccharides	(Latha *et al*., 2020)
Alkaloids, flavonoids, flavone glycosides, triterpenes, diterpenes and diterpene glycosides, cis clerodane-typefurano diterpenoids, lactones, sterols, lignans, nucleosides, steroids, terpenoids, saponins, phenolics, soft resins, starch, glycosides picroretoside, bitter substances picroretin, harsa, berberine, palmatine, columbine, and tannins	(Wiratno *et al*., 2019)
Alkaloids, lactones, steroids, diterpenoids, and glycosides	(Upreti & Chauhan, 2018)
Alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoids, cordiosides, cordifoliosides, and cordiols	(Stratev *et al*., 2018)
Cordioside, cordifolioside A, magnoflorine (alkaloid), tinocordiside (glycoside), 1,4-alpha-D-glucan, and syringin	(Sharma *et al*., 2017)
N-formylannonaine, cordifolioside A, magnoflorine,	(B. Singh *et al*., 2016)

Compounds in Guduchi	Reference
tinocordiside, syringing, phenols, tannins, flavonoids, saponins and polyphenols	
Alkaloids, terpenes, glycosides, polyphenols, steroids, tannins, sugar, starch, flavonoids, phenolics, proteins, calcium, phosphorus, diterpenoids, lactones, sesquiterpenoids, aliphatic and some polysaccharides	(Anita *et al*., 2016)
Alkaloids, soft resin, starch, glycosides, picroretoside, harsa, bitter substances picroretin, tinocrisposide, berberine, palmatin, columbine and caoculin or picrotoxin	(Malik, 2015)

The Role of Active Compounds in Guduchi

Researchers have increased their focus on utilizing natural products, including medicinal plants, to develop alternative food supplements aimed at enhancing growth, health, and immune function in farmed shrimp. Medicinal plants show great potential as sources of immunostimulants due to their roles as appetite enhancers, growth promoters, antiparasitic, antimicrobial, antioxidant, and immune-boosting agents in both in vitro and in vivo studies (Syahidah *et al*., 2015). In this literature review, we provide a summary of the application of guduchi in shrimp farming. The functions of the active compounds found in guduchi are detailed in Table 2.

Table 2. The Role of Active Compounds in Guduchi

The Role of Guduchi Compounds	Reference
Anti-viral, anti-inflammatory, vasorelaxant, anti-microbial, antifungal, antibacterial, anti-proliferative, antioxidant, anti-apoptotic, and immunomodulatory	(Rauf *et al*., 2025)
Immunomodulatory, anti-inflammatory, antioxidant, hepatoprotective, anti-hyperglycemic, anti-microbial, antihyperlipidemic, antipyretic, cardioprotective, neuroprotective, osteoprotective, and anti-apoptotic	(Amrutha *et al*., 2025)
Antioxidant, anti-inflammatory, antibacterial, antibiofilm, antimicrobial, antispasmodic, antipyretic, hypolipidemic, hypoglycemic, immunomodulating, and hepatoprotective	(Lekkala *et al*., 2025)
Anti-arthritic, anti-allergic, antihepatotoxic, antipyretic, anti-inflammatory, antibacterial, antimicrobial, antiviral, analgesic, anti-toxic, antistress, immunomodulating, and antioxidant	(Das *et al*., 2025)
Antioxidant and immunostimulant	(S. M. Singh *et al*., 2025)
Antioxidant, antiallergic, anti-inflammatory, antimicrobial, antiviral, antidotal, and antispasmodic	(Annisa *et al*., 2025)
Anti-inflammatory, analgesic, antispasmodic, antioxidant, anti-allergic, anti-stress, anti-arthritic, immunomodulatory, antiviral, antimicrobial, antibacterial, antiulcer, antitoxic,	(Chaudhary *et al*., 2024)

The Role of Guduchi Compounds	Reference
antipyretic, and cardioprotective	
Antioxidant, hypoglycemic, antiglycation, anti-inflammatory, antipyretic, and antimicrobial	(Jaya *et al*., 2024)
Immunomodulatory, hypoglycemic, vasorelaxant, antimicrobial, anti-inflammatory, antiviral, neuroprotective, hepatoprotective, antioxidant, gastroprotective, antiulcer, analgesic, and antibacterial	(A. Islam *et al*., 2024)
Anti-inflammatory, antioxidant, immunomodulatory, antimicrobial, and cytotoxic	(Krishna *et al*., 2024)
Antioxidant, antibacterial, and antimicrobial	(Royani, Hanafi, Julistiono, *et al*., 2023)
Antioxidant, antibacterial, antimicrobial, anti-inflammatory, and cytotoxic	(Royani, Hanafi, Dewi N. Lotulung, *et al*., 2023)
Antimicrobial, antioxidant, antibacterial, and antifungal	(Nath *et al*., 2023)
Anti-inflammatory, analgesic, hepatoprotective, antiulcer, antioxidant, antipyretic, cytotoxic, and immunomodulatory	(Kumar *et al*., 2023)
Antimicrobial, antifungal, antioxidant, antibacterial, antistress, anti-inflammatory, antiviral, and immunomodulator	(Sanmugarajah *et al*., 2022)
Antioxidant, antimicrobial, antibacterial, antifungal, antistress, and immunomodulator	(Murshid *et al*., 2022)
Antioxidant and immunostimulant	(Latha *et al*., 2020)
Antibacterial, antiviral, and immunostimulant	(Elumalai *et al*., 2020)
Antifungal, antibacterial, antiviral, antioxidant, and immunomodulator	(Wiratno *et al*., 2019)
Immunostimulant	(Upreti & Chauhan, 2018)
Antibacterial, antiviral, and immunostimulant	(Stratev *et al*., 2018)
Immunostimulant	(Sharma *et al*., 2017)
Antibacterial, and immunostimulant	(Miriam *et al*., 2017)
Immunostimulant	(Awad & Awaad, 2017)
Antimicrobial, anti-inflammatory, antioxidant, and immunomodulator	(B. Singh *et al*., 2016)
Antistress, antibacterial, anti-inflammatory, immunostimulant, and immunomodulator	(Anita *et al*., 2016)
Antistress, antibacterial, and immunostimulant	(Syahidah *et al*., 2015)
Antimicrobial, antibacterial, antifungal, antioxidant, and immunomodulator	(Salkar *et al*., 2015)
Anti-inflammatory	(Malik, 2015)

Use of Guduchi in Shrimp Cultivation

A major focus of many aquaculture studies is enhancing shrimp immunity through the use of immunostimulants. Elumalai *et al*., (2020) stated that among the immunostimulants used in aquaculture, herbs show great promise due to their ability to enhance growth performance, boost immunity, provide antimicrobial effects, and serve as a viable alternative to chemical and antibiotic treatments. Medicinal plants are eco-friendly, cost-efficient, and have minimal side effects. Therefore, this literature review was conducted to explore the potential of the guduchi medicinal plant as an immune enhancer in shrimp farming. To date, no recent studies (within the last 5 years) have been identified, but three earlier publications (older than 5 years) related to the use of guduchi in shrimp cultivation were found, as summarized in Table 3.

Table 3. Use of Guduchi in Shrimp Cultivation

Shrimp	Method	Results	Disease Resistant	Reference
Tiger shrimp (*Penaeus monodon*)	Oral	The best dose is the addition of 300 mg/100 g of guduchi extract to feed, which increases: 1. Production 2. Feed conversion ratio (FCR) 3. Feed conversion efficiency (FCE) 4. Specific growth rate (SGR) 5. Absolute growth rate (AGR) 6. Growth 7. Total hemocyte count (THC) 8. Phenoloxidase activity (PO) 9. Superoxide anion activity 10. Lysozyme activity 11. Plasma protein content 12. Bactericidal activity	-	(Chandran *et al.*, 2016)
Indian shrimp (*Fenneropenaeus indicus*)	Oral	The best dose is the addition of 2000 mg/kg of guduchi extract to feed which increases: 1. Survival rate (SR) 2. Length and weight growth 3. Specific growth rate (SGR) 4. Total hemocyte count (THC) 5. Phagocytic activity 6. Phenoloxidase activity (PO)	*Vibrio harveyi*	(Rajeswari *et al.*, 2012)
Tiger shrimp (*Penaeus*	Oral	The best dose is the addition of 800 mg/kg of	White Spot	(Citarasu *et al.*, 2006)

Shrimp	Method	Results	Disease Resistant	Reference
monodon)		guduchi extract to feed which increases: 1. Survival rate (SR) 2. Total hemocyte count (THC) 3. Pro Phenoloxidase (ProPO) Activity 4. Intracellular superoxide anion production	Syndrome Virus (WSSV)	

DISCUSSION

Tinospora cordifolia is a flowering plant that belongs to the Menispermaceae family, classified under the division Magnoliophyta, class Magnoliopsida, and order Ranunculales. Commonly referred to as "heart leaf moon seed," this plant is known by various regional names. Its Latin name is *Tinospora cordifolia* (Miers) Hook. F. & Thomson; in Sanskrit, it is called Guduchi, Madhuparni, Amrita, Chinnaruha, Vatsadaani, Tantrika, and Kundalini; in Nepal, it is known as Gurjo; in Hindi, as Giloya or Guduchi; and in Bengali, as Gulancha. *T. cordifolia* is a fast-growing, broad-leaved shrub with smooth, glabrous stems, featuring multiple whorled branches reaching about 3-4 feet in height and roughly 1 foot in length. The stem is grayish-brown to black, bitter in taste, soft and woody, cylindrical, and has annual rings ranging from 5 to 25 mm. Its leaves are simple, alternate, measuring 5-10 cm long with long petioles (2.5-7 cm), round with multilayered reticulated leaf sheaths. The plant produces long, tentacle-like roots emerging from the branches. The bark is thin, grayish, and soft, resembling cream in texture. The small flowers are yellow or greenish-yellow. The fruit is compound, red, fleshy, with broad drupelets attached to thick stalks that have a bordered sub-terminal shape and are dark red in color. The seeds are curved, which is characteristic of this plant and the reason why the Menispermaceae family is known as the moonseed family. The curved shape of the seeds also influences the shape of the embryo inside (Modi *et al*., 2021). Essentially, this plant is a herbaceous vine classified under the Kingdom Plantae, Division Magnoliophyta, Class Magnoliopsida, Order Ranunculales, Family Menispermaceae, Genus Tinospora, and Species *T. cordifolia*. It commonly grows in deciduous and dry forests across regions such as India, Myanmar, Sri Lanka, China, Thailand, the Philippines, Indonesia, Malaysia, Kalimantan, Vietnam, Bangladesh, as well as parts of North, West, and South Africa, typically at elevations up to 1000 feet (Kaur & Monika, 2021).

According to the literature review summarized in Table 1, guduchi contains a variety of bioactive compounds, with alkaloids consistently identified as a key component in all the sources examined. According to Maisarah *et al*., (2023), alkaloids are a class of basic secondary metabolites containing one or more nitrogen atoms, usually arranged in a cyclic structure. They can be found in various parts of plants, including flowers, seeds, leaves, stems, roots, and bark. Typically present in small quantities, alkaloids need to be isolated from complex mixtures within plant tissues. These compounds act as active plant substances with medicinal properties and serve as powerful stimulators of immune cells capable of destroying bacteria, viruses, fungi, and cancer cells. Alkaloids exhibit antimicrobial effects by inhibiting enzymes such as esterase, as well as DNA and RNA polymerases, and disrupting cellular respiration. They also play a role in DNA intercalation and can damage cell membranes by binding strongly to ergosterol, creating pores that cause leakage. This leads to irreversible cell damage and ultimately cell death. Kotala & Kurnia (2022) added that Alkaloids play a role in enhancing the immune response. Their mechanism as immunomodulators involves increasing the activity of IL-2 (interleukin 2) and promoting the proliferation of lymphocytes. Activated Th1 (T helper 1) cells influence SMAF (Specific Macrophage Arming Factor), which includes molecules like IFNγ (interferon gamma) that stimulate macrophage activation. When an antigen, such as bacteria, enters the body, macrophages and T lymphocytes work together to eliminate it. Macrophages engulf the bacteria through phagocytosis, while T lymphocytes differentiate into CD^{4+} and CD^{8+} cells.

According to the literature review presented in Table 2, the bioactive compounds in guduchi exhibit multiple functions, including antibacterial, antiviral, antifungal, antiparasitic, and more. These findings suggest that guduchi has the potential to be utilized as an immunostimulant ingredient in shrimp farming. According to Armin et al. (2023), active compounds like alkaloids are believed to effectively stimulate and enhance the immune system of shrimp. Alkaloids function as immunomodulators that help in managing diseases. Toolingo *et al*., (2023) added that alkaloids have demonstrated properties as growth enhancers, anti-stress agents, immunostimulants, and antibacterials in fish, shrimp, and shellfish larvae. These compounds boost shrimp immunity by activating bodily cells and repairing cell structures, which leads to improved immune function. According to Fauziah *et al*., (2023), immunity is commonly understood as the organism's ability to react to external threats, such as pathogens or other foreign substances (antigens), which trigger a response within the body.

According to the literature review shown in Table 3, three studies have been published on the use of guduchi medicinal plants in shrimp farming. The shrimp species tested in these studies were tiger shrimp and Indian shrimp. The alkaloids found in guduchi are believed to function similarly to the cytokine IFN-γ by supporting the immune system and enhancing the non-specific immune response, such as increasing leukocyte activity, as well as the specific immune response by activating macrophages to carry out phagocytosis of invading pathogens (Badia *et al*., 2024).

Alkaloids function as antibacterials by inhibiting free radical chain reactions. They also promote the production of hemocyte cells, which are then released into the haemolymph. Hemocytes serve as the cellular defense system in shrimp, responsible for processes such as phagocytosis, nodulation, and encapsulation. A higher hemocyte count reflects better shrimp health. The increase in total hemocytes represents a cellular immune response in shrimp. Additionally, alkaloids are toxic to microbes, making them effective against bacteria and viruses. Administering guduchi extract to shrimp acts as an immunostimulant by enhancing macrophage activity (Serina D. *et al*., 2022). Based on the findings from the literature review, additional research is necessary on other shrimp species, such as whiteleg shrimp (*Litopenaeus vannamei*), to evaluate the effectiveness of guduchi as an immunostimulant. This will help support its potential use on a larger scale and enable mass production.

CONCLUSION

Guduchi (*Tinospora cordifolia*) holds significant potential for further research to develop it as an effective immunostimulant for shrimp farming, with appropriate dosage determination, allowing for its application on a larger, field-scale basis.

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