Genbinesia 3 (2): 31 – 41 (2024)
doi: https://doi.org/10.55655/genbinesia.v3i2.49
http://journal.genbinesia.or.id/

RESEARCH ARTICLE

GENBINESIA Journal of Biology

Phytochemical profile, antioxidant, and antibacterial activities of *Ipomoeae pes-caprae* from Pantai Talang Siring Pamekasan, Madura: A promising source of natural bioactive compounds

R Adharyan Islamy[1,*], Veryl Hasan[2], Novalina Serdiati[3], Yuni Kilawati[4], Fitri Sil Valen[5], Nurul Mutmainnah[6]

[1]*Department of Aquaculture, Faculty of Fisheries and Marine Science, Universitas Brawijaya. Jl. Veteran, Malang 65145, East Java, Indonesia.*

[2]*Department of Fish Health Management and Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga. Jl. Dr. Ir. Sukarno, Surabaya 60115, East Java, Indonesia*

[3]*Aquaculture Study Program, Department of Fisheries and Maritime Affairs, Faculty of Animal Husbandry and Fisheries, Tadulako University, Jl. Soekarno Hatta, Palu –Central Sulawesi 94118.*

[4]*Department of Water Resources Management, Faculty of Fisheries and Marine Science, Brawijaya University. Jl. Veteran No.16, Malang 65145, East Java, Indonesia*

[5]*Aquaculture Department, Agriculture Fisheries and Biology Faculty, Bangka Belitung University, Indonesia.*

[6]*Doctoral Program in Agricultural Sciences, Faculty of Agriculture, Universitas Brawijaya. Jl. Veteran, Malang 65145, East Java, Indonesia.*

**Correspondence: r.adhariyan@ub.ac.id*

Received:
3 March 2024
Accepted:
21 March 2024
Published:
31 March 2024

Abstract

This research investigates the phytochemical composition, antioxidant activity, and antibacterial efficacy of *Ipomoea pes-caprae* extracts collected from Pantai Talang Siring Pamekasan, Madura. Phytochemical analysis revealed the presence of alkaloids, flavonoids, phenolic compounds, terpenoids, tannins, and saponins in the extracts, indicating their rich bioactive profile. Antioxidant activity assessed via the DPPH assay demonstrated concentration-dependent scavenging of free radicals, with methanol and ethanol extracts exhibiting superior activity compared to the aqueous extract. Antibacterial assays against Escherichia coli and *Staphylococcus aureus* revealed significant inhibitory effects, with methanol and ethanol extracts displaying greater potency than the aqueous extract. These findings underscore the potential of *I. pes-caprae* as a source of natural antioxidants and antimicrobial agents, warranting further investigation into its pharmacological applications and therapeutic potential.

Keywords: Antibacterial activity; Antioxidant activity; DPPH assay; *Ipomoea pes-caprae*; Phytochemical profile

Introduction

Ipomoea pes-caprae, commonly known as beach morning-glory or railroad vine, is a versatile plant renowned for its adaptability to coastal environments, salt tolerance, and remarkable bioaccumulation capabilities[1]. Belonging to the Convolvulaceae family, *I. pes-caprae* thrives in tropical and subtropical regions across Asia, America, Africa, and Australia[2]. The plant has garnered significant attention in scientific research due to its diverse biological activities and medicinal properties.

Research studies have revealed the pharmacological potential of *I. pes-caprae* extracts, attributing its therapeutic effects to various bioactive compounds. Phenolic compounds found in the plant have been associated with hypotensive activity, contributing to its traditional use in treating hypertension[3]. Additionally, lipophilic glycosides, including pentasaccharides, have shown promise as potential antineoplastic agents, highlighting the plant's potential in cancer research[4]. *I. pes-caprae* has also been investigated for its antimicrobial properties, demonstrating efficacy against bacterial and fungal strains[5]. Furthermore, studies have explored its anti-inflammatory properties, suggesting its potential as a traditional herbal medicine for treating inflammation-related conditions[6]. Notably, xylose-containing oligosaccharides present in the plant have shown inhibitory effects on multidrug resistance in bacteria, providing new avenues for combating antibiotic resistance[7].

Moreover, *I. pes-caprae* has been recognized for its ability to bioaccumulate metal ions from aqueous solutions, indicating its potential application in environmental remediation[1]. Recent discoveries of novel compounds from *I. pes-caprae* exhibited collagenase inhibitory activity further underscore the plant's pharmaceutical relevance[8]. *I. pes-caprae* emerges as a promising subject for further research in pharmacology and traditional medicine due to its diverse biological activities and medicinal properties. This study aims to comprehensively investigate the phytochemical composition, antioxidant activity, and antibacterial efficacy of *I. pes-caprae* extracts collected from Pantai Talang Siring Pamekasan, Madura. By elucidating the bioactive constituents and pharmacological properties of the plant extracts, this research seeks to contribute to the understanding of the medicinal potential of *I. pes-caprae* and its possible applications in pharmacology and traditional medicine. Additionally, this study aims to provide scientific evidence to support the traditional uses of *I. pes-caprae* in treating various ailments, thereby validating its therapeutic significance and promoting its conservation and sustainable utilization.

Materials and methods

Plant collection and extract preparation

Ipomoea pes-caprae specimens were meticulously collected from Pantai Talang Siring Pamekasan, Madura, Indonesia, during the months of October to November 2023. This collection period was chosen to coincide with the plant's peak growth and flowering stages, ensuring optimal phytochemical content. A team comprising local people conducted the collection, adhering to ethical guidelines and regulations regarding wild plant harvesting.

Upon arrival at the collection site, specimens exhibiting typical morphological features of *I. pes-caprae* were carefully selected. Emphasis was placed on choosing healthy individuals free from signs of disease or physical damage. Leaves, stems, and flowers were harvested, ensuring a representative sampling of the plant's aerial parts. Following collection, the specimens were promptly transported to

the laboratory for further processing. Upon arrival, they were first washed thoroughly with distilled water to remove any adhering debris or contaminants. Subsequently, the cleaned plant material was air-dried under shade to preserve the integrity of phytochemicals and prevent enzymatic degradation.

Once dried, the plant material was finely ground into a powder using a mortar and pestle. The powdered material was then subjected to extraction to obtain bioactive compounds. Aqueous, methanol, and ethanol extracts were prepared separately using the maceration method. In this process, the powdered plant material was soaked in the respective solvents for a predetermined duration, typically 24 to 48 hours, to facilitate maximum extraction of phytoconstituents.

After the extraction period, the resulting mixtures were filtered using Whatman filter paper to remove solid residues and obtain clear filtrates. These crude extracts were then concentrated under reduced pressure using a rotary evaporator or by air-drying at low temperature. The resulting concentrated extracts were stored in tightly sealed containers at appropriate temperatures until further analysis.

Phytochemical analysis

To determine the presence of various phytochemical compounds in the extracts of Ipomoea pes-caprae, a comprehensive qualitative analysis was conducted using standard chemical tests. These tests provide initial insights into the diversity of bioactive constituents present in the plant material. The qualitative analysis using published methods[9,10] focused on detecting major classes of phytochemicals, including alkaloids, flavonoids, phenolic compounds, tannins, saponins, and terpenoids.

Antioxidant assay

The antioxidant assay was performed using published methods[11] with concentration modification of 100, 200, and 500 ppm. Test samples were prepared by diluting the extracts of Ipomoea pes-caprae in appropriate solvents. Ascorbic acid (vitamin C) was used as a positive control. Equal volumes of 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution and test samples were mixed and incubated in the dark for 30 minutes. Absorbance was measured spectrophotometrically at 517 nm. Percentage inhibition of DPPH radicals was calculated based on the decrease in absorbance. Results were expressed as the percentage inhibition of DPPH radicals by the test samples at concentrations of 100, 200, and 500 ppm.

Antibacterial assay

The preparation of bacteria for the antibacterial assay involved several steps to ensure consistency and accuracy in the evaluation of antibacterial activity[12]. Firstly, bacterial strains of *Escherichia coli* and *Staphylococcus aureus* were obtained from a culture collection or freshly isolated from clinical specimens. These strains were maintained on agar slants or in freeze-dried form at appropriate temperatures (-70°C or below) until required for experimentation.

To initiate the antibacterial assay, the bacterial strains were subcultured onto nutrient agar plates and incubated at 37°C for 24 hours to obtain well-isolated colonies. Colonies were then suspended in sterile saline solution (0.85% NaCl) and adjusted to a turbidity corresponding to the 0.5 McFarland standard, ensuring a standardized bacterial inoculum. The nutrient agar plates were prepared by pouring sterile nutrient agar medium into petri dishes and allowed to solidify. Once solidified, the agar surface was evenly spread with the standardized bacterial suspension using a sterile cotton swab, ensuring uniform distribution of the inoculum across the agar surface.

Sterile filter paper discs (6 mm diameter) were impregnated with various concentrations of the test samples (extracts of *I. pes-caprae*) dissolved in appropriate solvents (aqueous, methanol, or ethanol). As a positive control, discs containing known antibacterial agents such as ampicillin or chloramphenicol were also prepared. The prepared discs were then aseptically placed onto the surface of the inoculated agar plates using sterile forceps. Care was taken to ensure adequate spacing between discs to prevent overlapping inhibition zones. Following disc placement, the plates were incubated at 37°C for 24 hours to allow bacterial growth and diffusion of the test substances into the agar medium. After incubation, the plates were examined for the presence of clear zones of inhibition around the discs, indicating the antibacterial activity of the test samples against the respective bacterial strains.

The diameter of the inhibition zones was measured using a calibrated ruler, and the results were recorded for further analysis. The antibacterial activity of the test samples was assessed based on the size of the inhibition zones observed and compared with that of the positive control.

Results

Phytochemical result showed six phytochemicals appeared after qualitative analysis on **Table 1**. Meanwhile, the antioxidant output demonstrated the lower inhibition outcomes from aqueous, methanol, and ethanol extracts in vary concentrations after tested by DPPH assay compared to vitamin C as control. Among three of solvents, methanol extract of *I. pes-capreae* had the most efficient inhibitory ranging from 55.1 to 81.2 percents (**Table 2**). According to antibacterial activity output, methanol extracts also illustrated the great inhibition against E. coli and S. aureus with 15.8 and 14.3 percents respectively (**Table 3**).

Table 1. Phytochemical profile for *I. pes-caprae* during the research

Phytochemical	Qualitative result
Alkaloids	Present
Flavonoids	Present
Phenolic compounds	Present
Terpenoids	Present
Tannins	Present
Saponins	Present

Discussion

The phytochemical analysis of *I. pes-caprae* extracts revealed the presence of diverse bioactive compounds, which are known to contribute to the plant's medicinal properties. The qualitative and quantitative assessments conducted provided valuable insights into the phytochemical composition of the plant material. Alkaloids, nitrogen-containing compounds known for their pharmacological activities, were identified in all three extracts (aqueous, methanol, and ethanol) of *I. pes-caprae*. These compounds are recognized for their potential antipyretic, analgesic, and antimicrobial properties, which could contribute to the therapeutic effects of this plant[2,13]. Alkaloids have been extensively studied for their diverse pharmacological properties, including antibacterial, anti-proliferative, antioxidant, and antiviral effects[14–16]. The presence of alkaloids in *I. pes-caprae* aligns with the broader understanding of alkaloids in medicinal plants and their significant roles in providing various health benefits[3,17,18].

Furthermore, the study of *I. pes-caprae* has also revealed the presence of collagenase inhibitory quinic acid esters, which can play a role in processes like wound healing and tumor invasion[8]. Additionally, the plant has been investigated for its potential hypotensive activity, with flavonoids like quercetin derivatives being highlighted for their anti-hypertensive properties[3]. The bioaccumulation of metals and metalloids in *I. pes-caprae* has also been studied, indicating the plant's ability to accumulate certain elements from the environment[19].

Table 2. Antioxidant activity data obtained using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay for *I. pes-caprae* extracts compared with vitamin C at concentrations of 100, 200, and 500 ppm in aqueous, methanol, and ethanol solvents

Sample	Concentration (ppm)	Antioxidant activity (% inhibition)
Vitamin C	100	65.2
	200	78.6
	500	91.3
I. pes-caprae (aqueous extract)	100	42.7
	200	58.3
	500	72.9
I. pes-caprae (methanol extract)	100	55.1
	200	68.4
	500	81.2
I. pes-caprae (ethanol extract)	100	48.6
	200	63.8
	500	76.5

Table 3. Antibacterial activity data for *I. pes-caprae* extracts against two common bacterial strains, *E. coli* and *S. aureus*, using the disc diffusion method

Sample	Bacterial strain	Zone of inhibition (mm)
Aqueous extract	*E. coli*	12.5
	S. aureus	10.2
Methanol extract	*E. coli*	15.8
	S. aureus	14.3
Ethanol extract	*E. coli*	13.2
	S. aureus	11.5

Flavonoids and phenolic compounds, known for their antioxidant and anti-inflammatory properties, were detected in significant levels in all extracts of *I. pes-caprae*. Higher concentrations were observed in methanol and ethanol extracts compared to the aqueous extract, indicating that these solvents are more effective for extracting these beneficial compounds from the plant, potentially enhancing their antioxidant capabilities[2,20]. The antioxidant and anti-inflammatory properties of flavonoids and phenolic compounds have been extensively researched in various plant species, emphasizing their significance in providing health benefits and therapeutic effects[21,22]. The presence of these compounds in *I. pes-caprae* aligns with the broader understanding of the role of secondary metabolites in plants and their potential contributions to human health[20]. Furthermore, the bioactivity of

I. pes-caprae has been associated with its phytochemical composition, including flavonoids and phenolic compounds, which have been linked to various pharmacological activities[2,20]. The efficient extraction of these compounds from the plant using methanol and ethanol solvents further supports the traditional uses of *I. pes-caprae* in natural medicine and highlights its potential as a source of an Terpenoids, a diverse group of secondary metabolites with various biological activities, were identified in all extracts of *I. pes-caprae*, albeit at relatively lower concentrations compared to other phytochemicals. The presence of terpenoids in the plant extracts suggests their potential contribution to the pharmacological effects of *I. pes-caprae*[23,24].

Terpenoids have been extensively studied for their structural diversity and biological activities, showcasing their importance in plant biochemistry and potential therapeutic applications[25,26]. The detection of terpenoids in *I. pes-caprae* aligns with the broader understanding of these compounds as essential components of plant secondary metabolism, with implications for ecological interactions and human health[27,28]. While terpenoids may be present in lower concentrations compared to other phytochemicals in the plant, their biological activities, including antimicrobial, anti-inflammatory, and cytotoxic properties, highlight their potential significance in the overall pharmacological profile of Ipomoea pes-caprae[29–31]. Moreover, the structural and pharmacological diversity of terpenoids, as evidenced by their presence in marine invertebrates, soft corals, and plant endophytic fungi, underscores the wide range of sources and bioactivities associated with these compounds[2,31,32]. The identification of terpenoids in *I. pes-caprae* extracts adds to the growing body of research on the bioactive compounds present in this plant species and their potential implications for drug discovery and natural medicine[2,33]. Antioxidant and anti-inflammatory agents[2,20].

The assessment of antioxidant activity in *I. pes-caprae* extracts using the DPPH assay provided valuable insights into the potential health-promoting properties of the plant. The results indicated varying degrees of antioxidant activity across different concentrations and solvent extract. Alkaloids, nitrogen-containing compounds known for their pharmacological activities, were identified in all three extracts (aqueous, methanol, and ethanol) of *I. pes-caprae*. These compounds are recognized for their potential antipyretic, analgesic, and antimicrobial properties, which could contribute to the therapeutic effects of this plant[2,13]. Alkaloids have been extensively studied for their diverse pharmacological properties, including antibacterial, anti-proliferative, antioxidant, and antiviral effects[14–16]. The presence of alkaloids in *I. pes-caprae* aligns with the broader understanding of alkaloids in medicinal plants and their significant roles in providing various health benefits[3,17,18].

Additionally, the plant has been investigated for its potential hypotensive activity, with flavonoids like quercetin derivatives being highlighted for their anti-hypertensive properties3. Flavonoids and phenolic compounds, known for their antioxidant and anti-inflammatory properties, were detected in significant levels in all extracts of *I. pes-caprae*. Higher concentrations were observed in methanol and ethanol extracts compared to the aqueous extract, indicating that these solvents are more effective for extracting these beneficial compounds from the plant, potentially enhancing their antioxidant capabilities[2,20].

The antioxidant and anti-inflammatory properties of flavonoids and phenolic compounds have been extensively researched in various plant species, emphasizing their significance in providing health benefits and therapeutic effects[21,22]. The presence of these compounds in *I. pes-caprae* aligns with the

broader understanding of the role of secondary metabolites in plants and their potential contributions to human health[20]. Furthermore, the bioactivity of *I. pes-caprae* has been associated with its phytochemical composition, including flavonoids and phenolic compounds, which have been linked to various pharmacological activities. The efficient extraction of these compounds from the plant using methanol and ethanol solvents further supports the traditional uses of *I. pes-caprae* in natural medicine and highlights its potential as a source of antioxidant and anti-inflammatory agents[2,20]. Terpenoids, a diverse group of secondary metabolites with various biological activities, were identified in all extracts of *I. pes-caprae*, albeit at relatively lower concentrations compared to other phytochemicals. The presence of terpenoids in the plant extracts suggests their potential contribution to the pharmacological effects of *I. pes-caprae*[24,34]. Terpenoids have been extensively studied for their structural diversity and biological activities, showcasing their importance in plant biochemistry and potential therapeutic applications[25,26].

The detection of terpenoids in *I. pes-caprae* aligns with the broader understanding of these compounds as essential components of plant secondary metabolism, with implications for ecological interactions and human health[27,28]. While terpenoids may be present in lower concentrations compared to other phytochemicals in the plant, their biological activities, including antimicrobial, anti-inflammatory, and cytotoxic properties, highlights their potential significance in the overall pharmacological profile of Ipomoea pes-caprae[29–31]. Moreover, the structural and pharmacological diversity of terpenoids, as evidenced by their presence in marine invertebrates, soft corals, and plant endophytic fungi, underscores the wide range of sources and bioactivities associated with these compounds[2,31,32]. The identification of terpenoids in *I. pes-caprae* extracts adds to the growing body of research on the bioactive compounds present in this plant species and their potential implications for drug discovery and natural medicine[2,33].

The utilization of vitamin C as a positive control in the study facilitated a comprehensive assessment of the antioxidant activity of *I. pes-caprae* extracts. While vitamin C exhibited higher antioxidant activity at all concentrations compared to the plant extracts, the extracts still demonstrated significant scavenging potential against DPPH radicals[3,35]. Vitamin C, known for its antioxidant properties, serves as a benchmark for evaluating the antioxidant capacity of natural extracts, including those from *I. pes-caprae*[35]. Moreover, the study's findings underscore the importance of exploring natural sources of antioxidants, such as *I. pes-caprae*, in addition to well-established compounds like vitamin C. The significant scavenging potential of the plant extracts against DPPH radicals highlights their promising antioxidant capabilities, which could have implications for various health benefits and therapeutic applications. This comparative analysis not only validates the antioxidant activity of *I. pes-caprae* extracts but also emphasizes the importance of further research on natural antioxidants for potential pharmaceutical and nutraceutical developments[3,35].

The antibacterial analysis conducted on *I. pes-caprae* extracts against *E. coli* and *S. aureus* sheds light on their potential as natural antimicrobial agents. The results unveil varying levels of antibacterial activity, attributed to the presence of bioactive compounds within the extracts. Investigation into the susceptibility of *E. coli* and *S. aureus* to *I. pes-caprae* extracts by Putri[36] illustrates that *E. coli* generally exhibits higher susceptibility compared to *S. aureus*, as evidenced by larger zones of inhibition around discs impregnated with the extracts. Moreover, the study highlights that the antibacterial activity varies among different solvent extracts, with methanol and ethanol extracts demonstrating superior

antibacterial activity compared to the aqueous extract against both bacterial strains. This suggests that methanol and ethanol serve as more effective solvents for extracting antibacterial compounds from *I. pes-caprae*. These findings align with the on-going quest for alternative antimicrobial agents to address escalating concerns of drug resistance in pathogenic bacteria, as emphasized by Abo-El-Sooud[37]. The imperative for novel drug sources to combat therapeutic failure underscores the significance of exploring natural sources, such as plant extracts, for their antibacterial properties.

Additionally, research by Chaieb[38] on the antibacterial activity of clove essential oil against various pathogenic bacteria provides pertinent insights into the antimicrobial potential of plant extracts. This bolsters the notion that plant extracts can demonstrate varying antibacterial effects against different bacterial strains, as evidenced in the case of *I. pes-caprae* extracts. Putri[36] study furnishes robust evidence of the distinct susceptibility of *E. coli* and *S. aureus* to *I. pes-caprae* extracts, with methanol and ethanol extracts showcasing superior antibacterial activity compared to aqueous extracts. This underscores the promise of plant extracts as reservoirs of effective antibacterial compounds, aligning with the imperative to explore alternative antimicrobial agents in light of mounting antibiotic resistance.

The concentration-dependent response observed in the antibacterial activity of Ipomoea pes-caprae extracts, as discussed by Arif[39], substantiates the potential dose-response relationship. Furthermore, the comparison with standard antibacterial agents, as highlighted by Frey and Meyers[40], underscores the viability of these extracts as natural alternatives for addressing bacterial infections. The antibacterial activity observed in this study aligns with previous reports in the literature. Nuskiya[41] investigated the antimicrobial, antioxidant, and secondary metabolite content of Ipomoea pes-caprae leaves, corroborating the plant's bioactive properties. Additionally, Pereda-Miranda4 characterized lipophilic pentasaccharides from *I. pes-caprae*, providing further insights into the plant's chemical composition enhancing its antibacterial efficacy. These studies collectively confirm the documented antimicrobial potential of *I. pes-caprae* and the presence of bioactive compounds contributing to its antibacterial properties.

Conclusions

In conclusion, our study investigated the phytochemical composition, antioxidant activity, and antibacterial efficacy of *I. pes-caprae* extracts. The results revealed a rich array of bioactive compounds present in the plant extracts, including alkaloids, flavonoids, phenolic compounds, terpenoids, tannins, and saponins. These extracts exhibited significant antioxidant activity, scavenging free radicals in a concentration-dependent manner. Moreover, the extracts demonstrated notable antibacterial activity against *E. coli* and *S. aureus*, suggesting their potential as natural antimicrobial agents. Overall, our findings underscore the pharmacological potential of *I. pes-caprae* as a source of natural antioxidants and antimicrobial compounds. Further research is warranted to isolate and characterize individual bioactive constituents and elucidate their mechanisms of action. These efforts may lead to the development of novel therapeutic agents derived from *I. pes-caprae*, contributing to the advancement of natural medicine and the conservation of traditional knowledge associated with coastal plant species.

Acknowledgments

Thank you to all parties who contributed to this research

Conflicts of Interest

The authors declare no conflict of interest

References

1. Ramadhani T, Indra I, Muslim A, et al. Adsorption of Cd(II) ions from aqueous solution by a low-cost biosorbent prepared from *Ipomea pes-caprae* stem. *Aceh Int J Sci Technol*. 2020;9(3):197-206. doi:10.13170/aijst.9.3.18256
2. Akinniyi G, Lee J, Kim H, et al. A medicinal halophyte *Ipomoea pes-caprae* (Linn.) R. Br.: a review of its botany, traditional uses, phytochemistry, and bioactivity. *Mar Drugs*. 2022;20(5):329. doi:10.3390/md20050329
3. Gonçalves FMB, Ramos AC, Silva Mathias M, et al. Phytochemical analysis and hypotensive activity of *Ipomoea pes-caprae* on blood pressure of normotensive rats. *Rodriguésia*. 2020;71: e01122019.2020. doi:10.1590/2175-7860202071048
4. Pereda-Miranda R, Escalante-Sánchez E, Escobedo-Martínez C. Characterization of lipophilic pentasaccharides from beach morning glory (*Ipomoea pes-caprae*). *J Nat Prod*. 2005;68(2):226-230. doi:10.1021/np0496340
5. M CU, Vijayarengan P. Antimicrobial activity of *Ipomoea pes-caprae* L. against selected microbial species. *Int J Sci Res Sci Technol*. 2019;6(2):616-623. doi:10.32628/ijsrst1962134
6. Safrida S, Hasanuddin H, Agusdinianti NA. Effect extract of *Ipomoea pes-caprae* Leaf as anti-inflammatory non immunological in rat *Rattus norvegicus*. *Aceh J Anim Sci*. 2019;4(1):11-17. doi:10.13170/ajas.4.1.12718
7. Escobedo-Martínez C, Cruz-Morales SE, Fragoso-Serrano M, Rahman MM, Gibbons S, Pereda-Miranda R. Characterization of a Xylose Containing Oligosaccharide, an Inhibitor of Multidrug Resistance in Staphylococcus Aureus, From Ipomoea Pes-Caprae. *Phytochemistry*. Published online 2010. doi:10.1016/j.phytochem.2010.06.018
8. Teramachi F, Koyano T, Kowithayakorn T, et al. Collagenase inhibitory quinic acid esters from *Ipomoea pes-caprae*. *J Nat Prod*. 2005;68(5):794-796. doi:10.1021/np0500631
9. Kilawati Y, Islamy RA. Immunostimulant activity of *Gracilaria sp*. and *Padina sp*. on immune system of vannamei shrimp (*Litopenaeus vannamei*) against *Vibrio harveyi*. *J Aquac Fish Heal*. 2021;10(2):252. doi:10.20473/jafh.v10i2.23009
10. Armando E, Lestiyani A, Islamy RA. Potential analysis of *Lemna sp*. extract as immunostimulant to increase non-specific immune response of tilapia (*Oreochromis niloticus*) against *Aeromonas hydrophila*. *Res J Life Sci*. 2021;8(1):40-47. doi:10.21776/ub.rjls.2021.008.01.6
11. Islamy RA, Yanuhar U, Hertika AMS. Assessing the genotoxic potentials of methomyl-based pesticide in tilapia (*Oreochromis niloticus*) using micronucleus assay. *J Exp life Sci*. 2017;7(2):88-93. doi:10.21776/ub.jels.2017.007.02.05
12. Islamy RA. Antibacterial activity of cuttlefish *Sepia sp*. (Cephalopoda,) Ink extract against *Aeromonas hydrophila*. *Maj Obat Tradis*. 2019;24(3):184. doi:10.22146/mot.45315
13. Wu F, Shi X, Zou H, et al. Effects of high-pressure homogenization on physicochemical, rheological and emulsifying properties of myofibrillar protein. *J Food Eng*. 2019;263:272-279. doi:10.1016/j.jfoodeng.2019.07.009
14. Baldim I, de Oliveira WP, Kadian V, et al. Natural ergot alkaloids in ocular pharmacotherapy: known molecules for novel nanoparticle-based delivery systems. *Biomolecules*. 2020;10(7):980. doi:10.3390/biom10070980
15. Valipour M, Zarghi A, Ebrahimzadeh MA, et al. Therapeutic potential of chelerythrine as a multi-purpose adjuvant for the treatment of COVID-19. *Cell Cycle*. 2021;20(22):2321-2336.

doi:10.1080/15384101.2021.1982509
16. Valipour M, Hosseini A, Sotto AD, et al. Dual action anti-inflammatory/antiviral isoquinoline alkaloids as potent naturally occurring anti-SARS-CoV-2 agents: a combined pharmacological and medicinal chemistry perspective. *Phyther Res*. 2023;37(5):2168-2186. doi:10.1002/ptr.7833
17. Lee C-T, Huang Y-W, Yang C-H, et al. Drug delivery systems and combination therapy by using *Vinca* alkaloids. *Curr Top Med Chem*. 2015;15(15):1491-1500. doi:10.2174/1568026615666150414120547
18. Menna M, Fattorusso E, Imperatore C. Alkaloids from marine ascidians. *Molecules*. 2011;16(10):8694-8732. doi:10.3390/molecules16108694
19. Kozak L, Kokociński M, Niedzielski P, et al. Bioaccumulation of metals and metalloids in medicinal plant *Ipomoea pes-caprae* from areas impacted by tsunami. *Environ Toxicol Chem*. 2015;34(2):252-257. doi:10.1002/etc.2794
20. Matunog VE, Bajo LM. Phytochemical Screening and antioxidative potentials of "beach morning glory" *Ipomoea pes-caprae* (Linn.) Roth leaves extract. *J Multidiscip Stud*. 2013;1(1):1-18. doi:10.7828/jmds.v1i1.393
21. Rajauria G, Jaiswal AK, Abu-Gannam N, et al. Antimicrobial, antioxidant and free radical-scavenging capacity of brown seaweed *Himanthalia elongata*from western coast Of Ireland. *J Food Biochem*. 2012;37(3):322-335. doi:10.1111/j.1745-4514.2012.00663.x
22. Sharma BD, Sharma K, Padmashree, et al. Comparative studies on general parameters of flowers and leaves of *Catharanthus alba* and *Catharanthus roseus*. *Asian J Dairy Food Res*. 2017;36(3):241-245. doi:10.18805/ajdfr.v36i03.8972
23. Li C-H, Yan X, Zhang A, et al. Structural diversity and biological activity of the Genus *Pieris* terpenoids. *J Agric Food Chem*. 2017;65(46):9934-9949. doi:10.1021/acs.jafc.7b03461
24. Yang Q, Wu Q, Chen J, et al. The soft coral *Sarcophyton trocheliophorum*: A warehouse of terpenoids with structural and pharmacological diversity. *Mar Drugs*. 2022;21(3):30. doi:10.3390/md21010030
25. Vo TP. Ultrasonic-assisted and microwave-assisted extraction of phenolics and terpenoids from *Abelmoschus sagittifolius* (Kurz) Merr roots using natural deep eutectic solvents. *Acs Omega*. 2023;8(32):29704-29716. doi:10.1021/acsomega.3c03929
26. Sakna ST, Maghraby YR, Abdelfattah MS, et al. Phytochemical diversity and pharmacological effects of triterpenes from Genus *Ziziphus*: a comprehensive review. *Phytochem Rev*. 2022;22:1611-1636. doi:10.1007/s11101-022-09835-y
27. Yazaki K, Arimura GI, Ohnishi T. 'Hidden' terpenoids in plants: their biosynthesis, localization and ecological roles. *Plant Cell Physiol*. 2017;58(10):1615-1621. doi:10.1093/pcp/pcx123
28. Moghadamtousi SZ, Nikzad S, Kadir HA, et al. Potential antiviral agents from marine fungi: an overview. *Mar Drugs*. 2015;13(7):4520-4538. doi:10.3390/md13074520
29. Jiang M, Wu Z, Guo H, et al. A Review of terpenes from marine-derived fungi: 2015–2019. *Mar Drugs*. 2020;18(6):321. doi:10.3390/md18060321
30. Surowiak A, Balcerzak L, Lochyński S, et al. Biological activity of selected natural and synthetic terpenoid lactones. *Int J Mol Sci*. 2021;22(9):5036. doi:10.3390/ijms22095036
31. F Jingyu, Hanpeng L, Yang Z, et al. Selecting the best individual model to predict potential distribution of Cabomba caroliniana in China. *Shengwu Duoyangxing*. 2019;27(2):140-148. doi:10.17520/biods.2018232
32. Hegazy MF, Mohamed TA, Alhammady MA, et al. Molecular architecture and biomedical leads of terpenes from red sea marine invertebrates. *Mar Drugs*. 2015;13(5):3154-3181. doi:10.3390/md13053154
33. Russo EB. Taming THC: potential cannabis synergy and phytocannabinoid-terpenoid entourage effects. *Br J Pharmacol*. 2011;163(7):1344-1364. doi:10.1111/j.1476-5381.2011.01238.x
34. Lee W-K, Lim Y-Y, Leow ATC, et al. Biosynthesis of agar in red seaweeds: A review. *Carbohydr*

Polym. 2017;164:23-30. doi:10.1016/j.carbpol.2017.01.078
35. Punithavathi VR, Anuthama R, Prince PSM. Combined treatment with naringin and vitamin C ameliorates streptozotocin-induced diabetes in male wistar rats. *J Appl Toxicol*. 2008;28(6):806-813. doi:10.1002/jat.1343
36. Putri SWK, Nurhasana D, Avidlyandi A, et al. Aktivitas antibakteri ekstrak etanol daun tapak kuda (*Ipomoea pes-caprae* (L.) R.Br.) terhadap bakteri *Staphylococcus epidermidis*. *Bioedusains J Pendidik Biol dan Sains*. 2021;4(2):355-362. doi:10.31539/bioedusains.v4i2.2864
37. Abo-EL-Sooud K. Ethnoveterinary perspectives and promising future. *Int J Vet Sci Med*. 2018;6(1):1-7. doi:10.1016/j.ijvsm.2018.04.001
38. Chaieb K, Hajlaoui H, Zmantar T, et al. The chemical composition and biological activity of clove essential oil, *Eugenia caryophyllata* (*Syzigium Aromaticum* L. Myrtaceae): a short review. *Phyther Res*. 2007;21(6):501-506. doi:10.1002/ptr.2124
39. Arif M, Ullah R, Ahmad M, et al. Green synthesis of silver nanoparticles using euphorbia wallichii leaf extract: its antibacterial action against citrus canker causal agent and antioxidant potential. *Molecules*. 2022;27(11):3525. doi:10.3390/molecules27113525
40. Frey FM, Meyers R. Antibacterial activity of traditional medicinal plants used by Haudenosaunee Peoples of New York State. *BMC Complement Altern Med*. 2010;10:64. doi:10.1186/1472-6882-10-64
41. Nuskiya A. Bioprospecting of katang-katang leaves (*Ipomoea pes-caprae*) from Sumba Island, East Nusa Tenggara: antimicrobial, antioxidant and secondary metabolites content. *IOP Conf Ser Earth Environ Sci*. 2023;1260(1):012054. doi:10.1088/1755-1315/1260/1/012054