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Original Article

Biomedical properties, characterization of seaweeds species and antimicrobial activity

Propriedades biomédicas, caracterização de espécies de algas marinhas e atividade antimicrobiana

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Abstract

Marine organisms produce a variety of compounds with pharmacological activities. In order to better comprehend the medicinal value of five particular seaweed orders Ulvales (*Ulva intestinalis*), Bryopsidales (*Codium decorticatum*), Ectocarpales (*Iyengaria stellata*), Dictyotales (*Spatoglossum aspermum*) and Gigartinales (*Hypnea musciformis*), a bioactive analysis including the screening of phytochemical components, antioxidant and antimicrobial activities was the aim of the investigation. The species include *U. intestinalis* was collected from Sandspit, while *C. decorticatum*, *I. stellata*, *S. aspermum*, and *H. musciformis* were gathered from Buleji. These species evaluated for their ability to inhibit human infectious gram positive pathogens *Staphylococcus aureus*, *Staphylococcus epidermidis* as well as gram negative bacteria *Escherichia coli*. Additionally vegetable pathogen *Fusarium oxysporum*, and fruit pathogens (*Aspergillus niger* and *Aspergillus flavus*) were evaluated to determine the zone of inhibition. Two organic solvents, ethanol and methanol, were used to prepare seaweed extract. The disc diffusion method was utilized to quantify the zone of inhibition and the DPPH method was employed to measure the antioxidant activity. The study unveiled various phyto-constituents in the tested seaweeds, with flavonoids, tannins, and proteins found in all selected species, while saponins, terpenoids, and carbohydrates were absent in *I. stellata* and *S. aspermum*. Notably, ethanolic extracts of *I. stellata* and *S. aspermum* demonstrated superior higher antioxidant activity, with increasing percentages of inhibition from 1 to 6 mg/ml. Furthermore, the findings indicated that the ethanolic extract of *U. intestinalis* displayed the highest resistance against *F. oxysporum* and *A. flavous* among other seaweeds. Meanwhile, the ethanolic extract of *C. decorticatum* exhibited the highest resistance against *A. Niger*. Additionally, the ethanolic extract of *I. stellata* and *H. musciformis* displayed the highest resistance against the gram-negative bacteria *E. coli* and the gram-positive bacteria *S. epidermidis*, whereas the methanolic extract of *U. intestinalis* demonstrated the highest resistance against the gram-positive bacteria *S. aureus*. The findings of this investigation show that a range of bioactive compounds with antioxidant properties are involved in the antimicrobial activities of disease-causing pathogens.

Keywords: phytochemicals, seaweeds antioxidant, antimicrobial activity.

Resumo

Os organismos marinhos produzem uma variedade de compostos com atividades farmacológicas. Para melhor compreender o valor medicinal de cinco ordens específicas de algas marinhas – Ulvales (*Ulva intestinalis*), Bryopsidales (*Codium decorticatum*), Ectocarpales (*Iyengaria stellata*), Dictyotales (*Spatoglossum aspermum*) e Gigartinales (*Hypnea musciformis*) –, o objetivo desta investigação foi fazer uma análise bioativa, incluindo a triagem de componentes fitoquímicos, atividades antioxidantes e antimicrobianas. As espécies *U. intestinalis* foram coletadas em Sandspit, enquanto *C. decorticatum*, *I. stellata*, *S. aspermum* e *H. musciformis* foram coletadas em Buleji. Estas espécies foram avaliadas quanto à sua capacidade de inibir os patógenos Gram-positivos infecciosos humanos

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Staphylococcus aureus e *Staphylococcus epidermidis*, bem como as bactérias Gram-negativas *Escherichia coli*. Além disso, o patógeno vegetal *Fusarium oxysporum* e os patógenos de frutas *Aspergillus niger* e *Aspergillus flavus* foram avaliados para determinar a zona de inibição. Dois solventes orgânicos, etanol e metanol, foram utilizados para preparar o extrato de algas marinhas. O método de difusão em disco foi utilizado para quantificar a zona de inibição, e o método DPPH foi empregado para medir a atividade antioxidante. O estudo revelou vários fitoconstituintes nas algas testadas, com flavonoides, taninos e proteínas encontrados em todas as espécies selecionadas, enquanto saponinas, terpenoides e carboidratos estavam ausentes em *I. stellata* e *S. aspermum*. Notavelmente, os extratos etanólicos de *I. stellata* e *S. aspermum* demonstraram maior atividade antioxidante, com percentagens crescentes de inibição de 1 a 6 mg/ml. Além disso, os resultados indicaram que o extrato etanólico de *U. intestinalis* apresentou a maior resistência contra *F. oxysporum* e *A. flavus,* entre outras algas marinhas. Enquanto isso, o extrato etanólico de *C. decorticatum* teve maior resistência contra *A. Niger*. Além disso, o extrato etanólico de *I. stellata* e *H. musciformis* apresentou a maior resistência contra as bactérias Gram-negativas *E. coli* e as bactérias Gram-positivas *S. epidermidis*, enquanto o extrato metanólico de *U. intestinalis* demonstrou a maior resistência contra a bactéria Gram-positiva *S. aureus*. Os resultados desta investigação mostram que uma série de compostos bioativos com propriedades antioxidantes está envolvida nas atividades antimicrobianas de patógenos causadores de doenças.

Palavras-chave: fitoquímicos, antioxidante de algas marinhas, atividade antimicrobiana.

1. Introduction

Rhodophyta (Red algae), Chlorophyta (Green algae), and Phaeophyceae (Brown algae) are the three main subgroups of marine macroalgae. These aquatic organisms have several challenges for example strong tidal currents, hypersaline water, temperature fluctuations, and strong solar radiation while considering the habitat challenges (Balasubramaniam et al., 2020). Seaweeds are the most primitive group of vegetation and they have gained great importance as a promising source of bioactive compounds that can be used for drug development (Belattmania et al., 2016). With a wide range of metabolites like polysaccharides, phlorotannins, glycoproteins, terpenoids, alkaloids, lectins, pigments, and ketones, seaweeds have contributed to numerous pharmaceutical applications on gall stones, renal disorders, cancer heart disease, asthma, psoriasis, and antibacterial, antifungal, and antiviral effects over the past three decades (Abdelwahab, 2017; Sanniyasi et al., 2023). In many regions of Asia, seaweed is still a widely used culinary ingredient. It is also a significant source of high-value hydrocolloids including agar, alginates, and carrageenan. Seaweeds are also becoming more widely used in the nutraceutical, pharmaceutical, and cosmetic industries because to their growing recognition for their health-promoting properties. Additionally, prior research has demonstrated that chemicals and extracts derived from seaweed have a variety of intriguing bioactivities, including, anti-diabetic, anti-cancer anti-obesity, and anti-inflammatory characteristics. The variety of antioxidant chemicals present in seaweeds may play a role in the observed actions. Many environmental conditions that encourage the production of free radicals and potent oxidising agents in seaweeds. Seaweeds are extremely resistant to oxidative damage as a result of these challenging environmental factors, which may be facilitated by the antioxidant chemicals present in their cells. The presence of polyphenols or other antioxidant substances like carotenoids may be the cause of the health advantages seen in the ethanol extracts (Balasubramaniam et al., 2020).

Seaweeds are used to make fertiliser and food all around the world. Additionally, seaweeds are employed in various industrial fields (García-Poza et al., 2020). Proteins, carbohydrates, fats, and fibres are all abundant in seaweeds. The global seaweed sector is growing quickly because to the significant economic benefits. According to estimates, the amount of seaweed produced globally has already surpassed 32.4 million tonnes, which is three times the amount produced in 2000. Only 2.9% of the world's seaweed production (about 97.1%) is derived from wild sources. The remainder originates from offshore and onshore cultivation locations. It's remarkable that the majority of the world's 99.6% production of seaweed is produced in eastern and south-eastern Asia. Only China makes up around 58% of the world's seaweed production. However, seaweed is also produced in other nations, including Indonesia, the Philippines, South Korea, Japan, and North Korea (Ahmed et al., 2022). Seaweeds have antioxidant properties and are a significant source of bioactive chemicals (Choudhary et al., 2021). Seaweed is a great source of many different types of drugs because of the wide variety of bioactive chemicals it produces. The majority of medications used today come from natural sources or are semi-synthetic derivatives of natural substances, most of which are employed in conventional medical practices (Rama et al., 2023).

Thus, the present study aimed to investigate the phytochemical screening, and antioxidant activities of dominated selected coastal seaweeds (*Codium decorticatum*, *U. intestinalis*, *I. stellata*, S. *aspermum* and *H. musciformis)* and their potential resistance to disease causing pathogens. These seaweeds are crucial components of coastal ecosystem, they support wide variety of marine organisms and increase coastal biodiversity.

2. Material and Methods

2.1. Collection site 1

Southwest of Karachi, close to the fishing village of Buleji, at 24 50 N, 66 48'. A triangular platform, the Buleji rocky ledge juts out into the Arabian Sea. The right side of the ledge, which confronts the open sea and its strongest wave action, typically has a diverse range of plants and animals. Small boulders and relatively flat rocks make up the middle and bottom portion of the rocky ledge. Compared to the right side of the ledge, the left side offers less wave activity. The triangular ledge's main body is made up of small and big tide pools that act as barriers

to various benthic species and other benthic life due to an abundance of algae growth.

2.2. Collection site 2

The Sandspit Backwater is renowned as a spawning area for numerous fish and shellfish species. It is situated at 24°50' N and 66°56' E, approximately southwest of Karachi, between Manora and Hawks Bay. Manora Channel connects the backwater to the Arabian Sea.

2.3. Collection of seaweeds

From the intertidal region of Buleji *C. decorticatum*, *I. stellata*, *S. aspermum*, and *H. musciformis* were collected, while the *U. Intestinalis* was collected from Sandspit Backwater (Figure 1).

2.4. Microbes collection, identification, and isolation

Identified pathogen strains were collected from the Department of Microbiology, University of Karachi. *F. oxysporum*, *A. flavous*, and *A. nigar* are the pathogens of rotten potatos, apples and lemons respectively. While *E. coli*, *S. aureus* and *S. epidermi* were the human pathogens pure isolated strains (Figures 2 and 3).

2.5. Preparation of seaweed extracts

To get rid of the epiphytes sands particles and other associated debris, collected seaweeds of *U. intestinalis*, *C. decorticatum*, *I. stellata*, *S. aspermum*, and *H. musciformis* were washed in a lab. To make the seaweed air dry, we kept it in the lab for a month. To extract the solvent for the extraction, 50 grams of seaweeds were extracted and mixed with 150 mL of ethanol (95.5%) and methanol (95.5%). A rotary vacuum evaporator was used to dry the extracts by vaporising them.

2.6. Antimicrobial assay by Agar disk-diffusion method

Agar plates were inoculated with bacterial and fungal species inoculums. On the agar surface, filter paper discs (about 5 mm in diameter) dipped in seaweed extracts. The Petri dishes were kept at 37 °C for 24 hours for incubation. The diameters of the growth-inhibiting zones were then determined in millimeters.

2.7. DPPH radical scavenging activity

According to the technique developed by Yen and Chen (1995), the activity of 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) to scavenge free radicals was assessed. Combine 1 g of powdered seaweed with 25 mL of 99% methanol in a conical flask, seal it with cork, and shake the mixture for 2.5 hours at room temperature. Prepared 1 M DPPH solution (4 mg of DPPH added to 100 mL of 99% methanol) covered with cork and kept cool. After 2.5 hours, remove the seaweed sample from the water bath and placed it in a centrifuge tube, where it will be

Figure 1. Study site (a) collected seaweeds; (b) *C. decorticatum*; (c) *U. intestinalis*; (d) *I. stellate*; (e) *S. aspermum*; (f) *H. musciformis*.

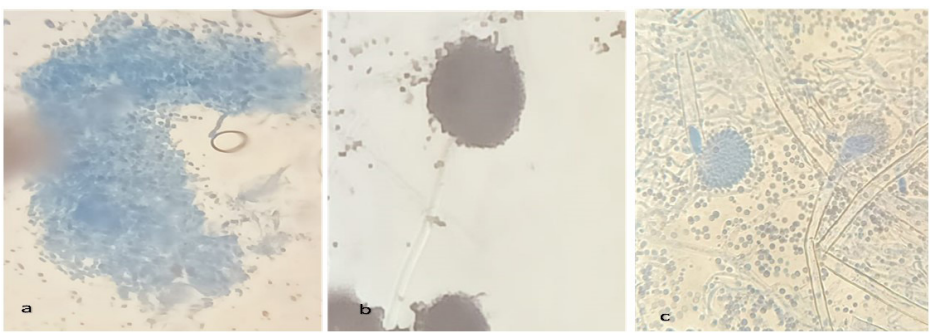

Figure 2. Microscopic view of disease causing isolated fungal pathogens cells (a) *F. oxysporum*; (b) *A. nigar*; (c) .

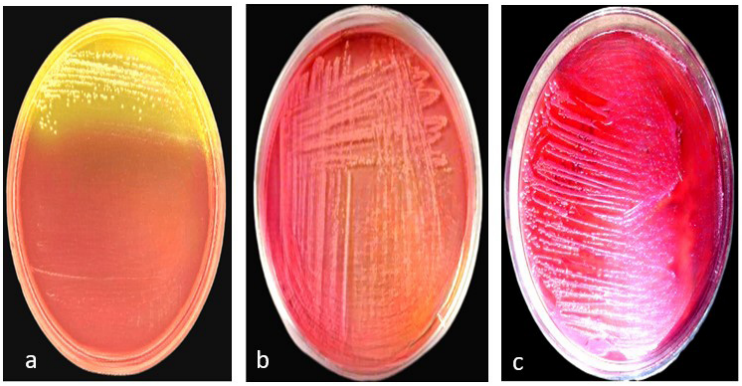

Figure 3. Disease causing bacterial isolated pathogens on Mackonkey agar (a) *S. aureus*; (b) *S.epidermidis*; (c) *E. coli*.

spun for 15 minutes between 6000 and 8000 rpm. Then run filter paper through the top solution of the sample. Ethanol and methanol are used to make the solution series. Absorbance was taken in a spectrophotometer (JENWAY 6305 UV/Visible) at 517 nm.

2.8. Phytochemical screening:

A phytochemical screening of flavonoids, saponin, tannin, terpenoids, proteins, and carbohydrates was performed on all seaweeds using the method of Pant et al. (2017).

3. Results

The scavenging activity of *C. decorticatum*, *U. intestinalis*, *S. aspermum*, *H. musciformis*, and *I. stellata* was assessed using a DPPH test. The DPPH test measures the ability of a substance to scavenge free radicals by converting DPPH to a stable compound (DPPH-H) when it accepts hydrogen radicals from the tested nanomaterials. The colour changes from violet to a faint yellow as a result of this conversion, showing that the examined material has reduced DPPH and trapped radicals.

Figures 4 and 5 shows the DPPH test scavenging activity (%) of the listed seaweeds. With an increase in antioxidant concentration, the scavenging efficiency improves. The activity was increased in ethanol in the following order: *I. stellata* (17.73-49.29%) >*S. aspermum* (26.49-47.80%) >*C. decorticatum* (17.06-44.91%) >*H. musciformis* (15.16-38.18%) >*U. intestinalis* (14.74-25.87%). In methanol, the scavenging activity showed the following order: *S. aspermum* (25.01-48.20%) >*I. stellata* (13.30-47.50%) >*H. musciformis* (15.16-38.18%) >*C. decorticatum* (9.70-30.64%) >*U. intestinalis* (10.58-25.83%). According to these findings, *I. stellata* in ethanol and *S. asperum* in methanol displayed more antioxidant activity than the other samples.

The tested seaweeds contain various classes of phyto constituents (Table 1). Flavonoids, tannins, and proteins were found in all of the tested seaweeds. However, saponins, terpenoids, and carbohydrates were absent in *I. stellata* and *S. aspermum*.

The presence or absence of specific phyto constituents can vary among different species of seaweeds and can also be influenced by factors such as environmental conditions.

The antimicrobial activities of the fractions from the ethanol crude extracts of five seaweed species, namely *I. stellata*, *S. aspermum*, *C. decorticatum*, *U. intestinalis*, and *H. musciformis*, were determined using the disc diffusion method. These extracts were tested against three bacterial and three fungal strains.

Specifically, the methanolic extract of *U. intestinalis* and the ethanolic extract of *H. musciformis* exhibited antimicrobial effects. Gram-positive bacteria were resistant to the methanol extract of *U. intestinalis*, with inhibition zones of 16 ± 2.7 mm *H. musciformis* for *S. aureus* and 12.5 ± 1.9 mm for *S. epidermidis*. Additionally, the ethanolic extract of *I. stellata* exhibited inhibitory effects on Gram-negative bacteria, specifically against *E. coli* with an inhibition zone of 10 ± 2.9 mm. The ethanolic extract of *U. intestinalis* showed inhibitory capacity against *F. oxysporum* with an inhibition zone of 13 ± 3.3 mm. Furthermore, the ethanolic extract of *C. decorticatum* displayed activity against *A. niger* with an inhibition zone of 15 ± 0.9 mm, while the ethanolic extract of *U. intestinalis* exhibited a high inhibitory effect on *A. flavous* with an inhibition zone of 15 ± 1.9 mm (Figures 6 and 7) along Tables 2, 3, 4, 5 and 6.

4. Discussion

The current study aims to conduct a bioactive analysis, covering the detection of phytochemical components, antioxidant, and antibacterial activities of seaweeds from the coastal area of Karachi, including Ulvales, Bryopsidales, Ectocarpales, Dictyotales, and Gigartinales.

The findings demonstrated that *E. intestinalis* methanolic extract had favourable antibacterial activity against the investigated bacteria, producing an inhibition zone (Ibrahim and Lim, 2015). According to reports, *S. aureus*, *Bacillus cereus*, *Salmonella typhimurium*, *Listeria monocytogenes*, *E. coli*, and *Pseudomonas aeruginosa* were all inhibited by an ethanol extract of *Ulva rigida* that was obtained from the Vona Bay coast in Perşembe, Ordu (Turkey). Similar to this, it has been observed that *U. rigida* diethyl ether extracts had bactericidal efficacy against harmful bacteria like *Enterococcus faecalis*, *E. coli*, *S. aureus*, *S. epidermidis*, *E. coli*, and *P. aeruginosa* (Sahnouni et al., 2016). Similar to earlier investigations (Abdel-Khaliq et al., 2014; Berber et al.,

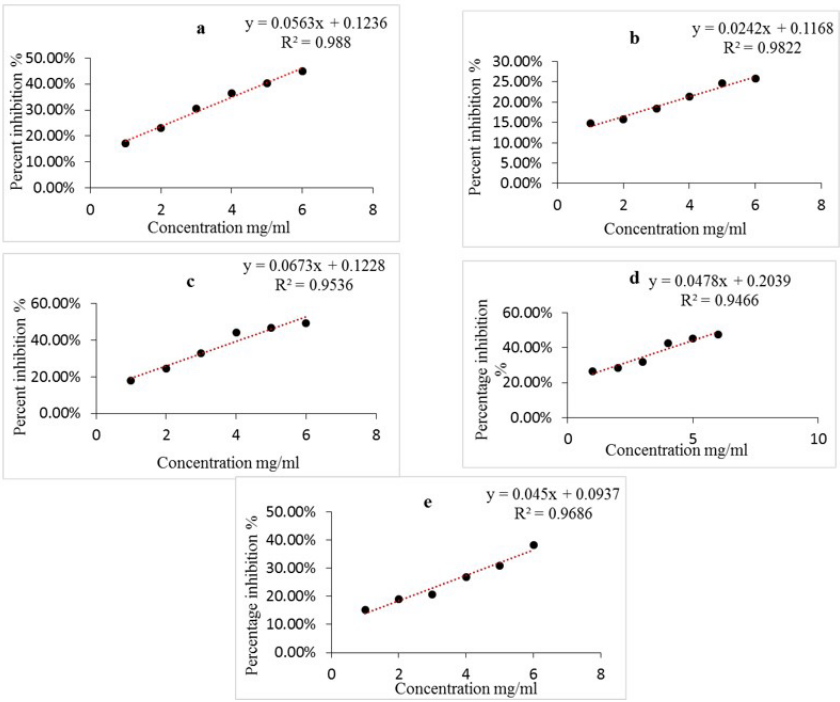

Figure 4. The graphed figure displayed the coefficient correlation between percentage inhibition of ethanolic extracts of (a) *C. decorticatum*; (b) *U. intestinalis*; (c) *I. stellate*; (d) *S. aspermum*; (e) *H. musciformis* seaweeds by the DPPH technique.

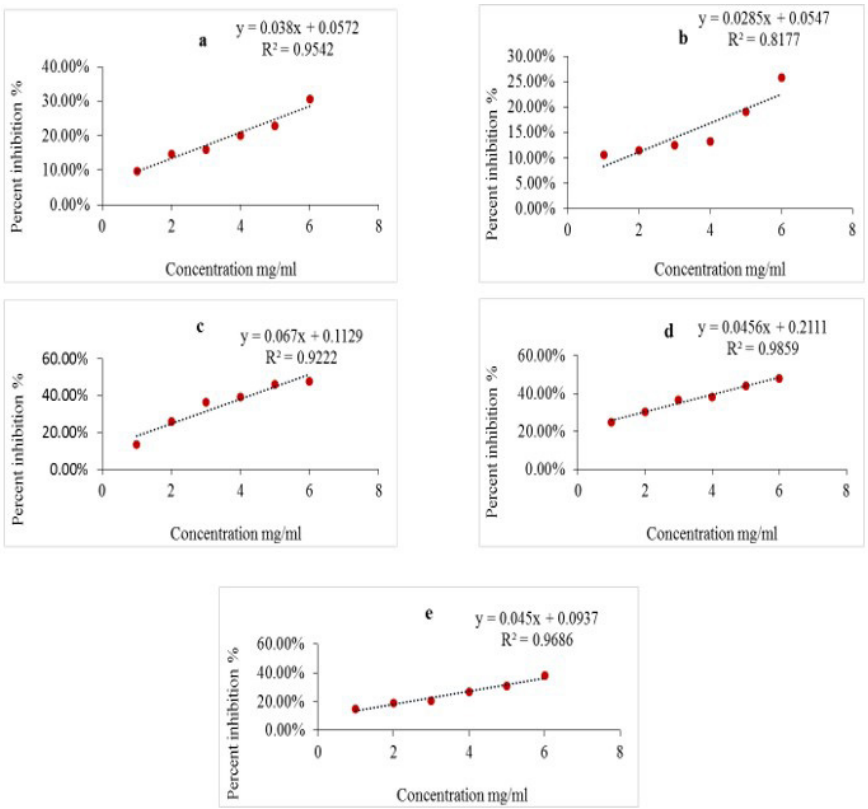

Figure 5. The graphed figure displayed the coefficient correlation between percentage inhibition of methanolic extracts of (a) *C. decorticatum*; (b) *U. intestinalis*; (c) *I. stellate*; (d) *S. aspermum*; (e) *H. musciformis* seaweeds by the DPPH technique.

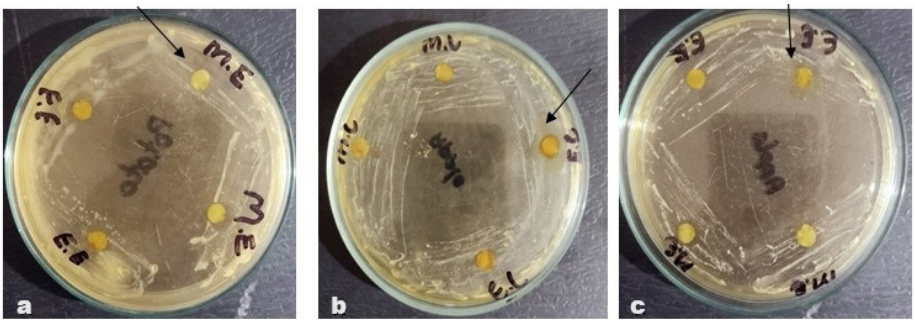

Figure 6. Showed (a) methanolic extract of *U. intestinalis* showed inhibitory effect on *S. aureus*; (b) ethanolic effect of *H. musciformis* showed inhibition against *S. epidermisdis*; (c) ethanolic extract of *I. stellate* showed inhibition against *E. coli*.

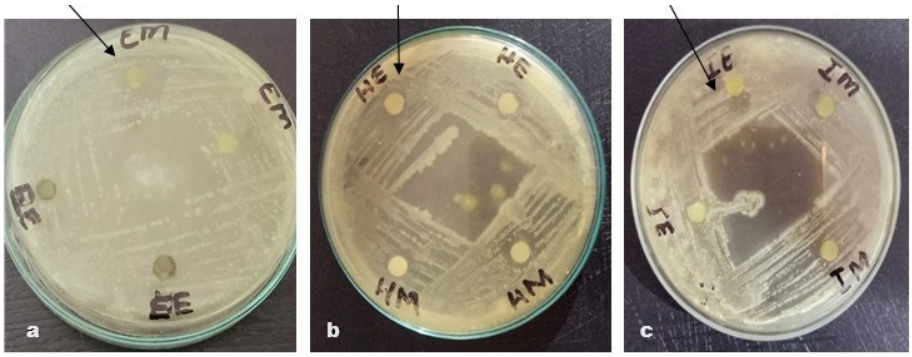

Figure 7. Showed (a) ethanolic extract of *U. intestinalis* showed inhibitory effect on *F. oxisporium* (b) ethanolic effect of *C. dicorticatum* showed inhibition against *A. niger*, (c) ethanolic extract of *U. intestinalis* showed inhibition against *A. flavus*.

Table 1. Represents phytochemical compound analysis of different seaweeds.

S.NO.	Test	Species				
		C. decorticatum	*U. intestinalis*	*I. stellata*	*S. aspermum*	*H. musciformis*
1	Flavonoid	+	+	+	+	+
2	Saponin	+	+	-	-	+
3	Tannin	+	+	+	+	+
4	Terpenoids	+	+	-	-	+
5	Carbohydrate	+	+	-	-	+
6	Protein	+	+	+	+	+

+ represent presence of compounds; - shows absence of compounds.

Table 2. Represents Antifungal activity of ethanolic extracts of seaweeds.

S.NO.	Pathogens	Species				
		C. decorticatum	*U. intestinalis*	*I. stellata*	*S. aspermum*	*H. musciformis*
1	*F. oxisporum*	10 ± 1.3	13 ± 3.3	12 ± 2.6	10 ± 1.9	11 ± 3.1
2	*A. niger*	15 ± 0.9	10 ± 2.4	10 ± 3.3	11 ± 3.2	11 ± 0.9
3	*A. flavus*	11 ± 2.1	15 ± 1.9	10 ± 4.1	13 ± 1.4	12 ± 0.4

Table 3. Represents Antifungal activity of methanolic extracts of seaweeds.

S.NO.	Pathogens	Species				
		C. decorticatum	*U. intestinalis*	*I. stellata*	*S. aspermum*	*H. musciformis*
1	*F. oxisporum*	11 ± 2.2	11 ± 2.1	8 ± 0.9	9 ± 0.3	9 ± 2.5
2	*A. niger*	14 ± 1.4	9 ± 0.5	9 ± 3.1	12 ± 2.8	9 ± 3.5
3	*A. flavus*	11 ± 2.1	12 ± 1.6	9 ± 2.2	10 ± 3.9	13 ± 4.1

Table 4. Represents Antibacterial activity of ethanolic extracts of seaweeds.

S.NO.	Pathogens	Species				
		C. decorticatum	*U. intestinalis*	*I. stellata*	*S. aspermum*	*H. musciformis*
1	*S. aureus*	13 ± 3.3	10 ± 1.5	7 ± 2.3	0 ± 0.9	0 ± 0
2	*S. epidermidis*	11 ± 2.5	11 ± 1.7	8 ± 1.8	8 ± 3.2	12.5 ± 1.9
3	*E. coli*	8 ± 0.9	0 ± 0.3	10 ± 2.9	7 ± 1.9	0 ± 0

Table 5. Represents Antibacterial activity of methanolic extracts of seaweeds.

S.NO.	Pathogens	Species				
		C. decorticatum	*U. intestinalis*	*I. stellata*	*S. aspermum*	*H. musciformis*
1	*S. aureus*	0 ± 0.1	16 ± 2.7	7 ± 3.3	10 ± 1.2	9 ± 2.3
2	*S. epidermidis*	7 ± 0.7	9 ± 4.2	10 ± 2.9	0 ± 0	11 ± 1.8
3	*E. coli*	0 ± 0	0 ± 0.9	7 ± 4.1	0 ± 1.3	0 ± 0.1

Table 6. Represents inhibition of pathogen against ethanol and methanol.

S.NO.	Pathogens	Species					
		S. aureus	*S. epidermidis*	*E. coli*	*F. oxisporum*	*A. niger*	*A. flavus*
1	*Ethanol*	3.8 ± 0.8	4.1 ± 1.7	1.5 ± 1.3	3.2 ± 1.2	3.3 ± 1.3	2.6 ± 1.3
2	*Methanol*	4.4 ± 0.5	3.4 ± 2.2	0 ± 1.9	2.5 ± 0.6	2.6 ± 1.5	3.2 ± 1.1

2015; Srikong et al., 2015), it has been discovered that *U. intestinalis* extract has a significant antibacterial activity. It was shown that compared to the other bacteria under study, *E. coli*, *S. pyogenes*, and *S. epidermidis* bacteria were more vulnerable to *U. intestinalis* extract. The variation in results can be attributed to a number of variables, including the geographical sample zone, the species of algae, the season in which they were gathered, the stages of algal growth, the intraspecific variation in secondary metabolite synthesis etc (Srikong et al., 2017). Additionally, it has been claimed that *I. stellata* extract was quite effective against and *E. coli* and *S. aureus* (Rehman et al., 2020). As stated by Rizwan et al. (2020) *U. Intestinalis* had no effect on the gram-positive infectious pathogens *S. aureus* and *S. epidermidis* but had an inhibitory zone on the gram-negative pathogen *Shigella* sp. In contrast to our investigation, *U. intestinalis* significantly inhibited the growth of *S. aureus* and *S. epidermidis*. Although the ethanolic extract of *I. stellata* has demonstrated potential in limiting the development of the gram-negative bacterium *E. coli*. The reports demonstrated that *A. flavus*, with the exception of *U. reticulata*, demonstrated high sensitivity to all of the investigated chlorophytes' extracts. *A. flavus*, which was found to be more resistant to other algal extracts was only significantly inhibited by the acetone extract of *U. lactuca*, it was noted Sheikh et al. (2018). Our findings indicated that ethanolic extract of *U. intestinalis* was highly effective at inhibiting the growth of *A. flavus*.

C. intricatum methanol extract was tested for its antibacterial properties against a variety of bacterial infections. *C. intricatum* demonstrated a wide range of inhibitory action against Methicillin-Resistant *Staphylococcus aureus* (MRSA) (Arguelles, 2020). Additionally, no *S. mutans* showed any inhibitory effects,

which is consistent with findings made by Lomartire and Gonçalves (2023) and Ibtissam et al. (2009), regarding *E. coli*, *P. aeruginosa*, and *Klebsiella pneumoniae*. Nevertheless, in some research, like that by Demirel et al. (2009), antibacterial activity of *C. Fragile* extract against *E. Aerogenes*, *E. Coli*, and *B. Subtilis* was noted Arguelles (2020). The ethanol extract of *C. decorticatum* effectively inhibited both gram positive (*S. aureus* and *S. epidermis*) and gram negative (*E. coli*) bacteria, according to our findings.

Khanzada et al. (2015) reported *A. flavus* was subjected to 75% *Codium* inhibitory activity in ethyl acetate extract and 72% in methanol extract. However, the results of the current investigation indicated that *C. decorticatum* was marginally more effective at resisting *A. niger* than *A. flavous*.

C. fragile did not display any antioxidant activity when tested using the DPPH assay (Demirel et al., 2009). As a result of our findings, *C. Decorticatum* ethanolic extract demonstrated antioxidant activity in comparison to *C. Decorticatum* methanolic extract.

In contrast to *P. Boryana*, *I. stellata* displayed the greatest zone of inhibition when used against *Protea mirabilis*, demonstrating antibacterial action against *S. aureus*. In comparison to *I. Stellata*, *P. boryana* exhibited DPPH radical scavenging activity Lomartire and Gonçalves (2022). Our research revealed that *I. stellate* ethanolic extract had a high efficacy against *E. coli* growth whereas *I. stellata* ethanolic extract had a good efficacy against *F. oxisporum* growth.

H. *musciformis* were not exhibited any antibacterial action against *E. coli*, *P. aeruginosa*, or *S. enteritidis*. However, forced a decline in *S. aureus* and *C. albicans* growth. *H. musciformis* demonstrated negligible antioxidant activity in the ORAC assay and no antioxidant activity in the DPPH technique, RP method, or Hydrogen peroxide assay Ibtissam et al. (2009). Our research revealed that a methanolic extract of *H. musciformis* effectively inhibited the development of *S. aureus* while an ethanolic extract of *H. musciformis* effectively inhibited the growth of *S. epidermidis*. While *H. musciformis* methanolic extract effectively slowed the growth of *A. flavus*.

In our investigation *I. stellata* and *S. aspermum* ethanolic extracts showed better antioxidant activity. Moreover, among other seaweeds, the results showed that the ethanolic extract of *U. intestinalis* had the strongest resistance against *F. oxysporum* and *A. flavous*. In contrast, ethanolic extract of *C. decorticatum* showed the strongest resistance against *A. Niger*. Furthermore, the methanolic extract of *U. intestinalis* showed the highest resistance against the gram-positive bacteria *S. aureus*, while the ethanolic extracts of *I. stellata* and *H. musciformis* showed the highest resistance against the gram-negative bacteria *E. coli* and the gram-positive bacteria *S. epidermidis* respectively.

5. Conclusion

Subsequently, our research revealed that the five coastal seaweeds that we studied have interesting phytochemical profiles, antioxidant properties, and possible resistance to pathogens that cause disease. However, *U. intestinalis*, *C. decorticatum*, *I. stellata*, *S. aspermum*, and *H. musciformis* have their potential efficacy to resist growth of harmful pathogens. These results demonstrate the potential of seaweeds as excellent natural sources of antioxidants and antibacterial agents, which may find use in the food, cosmetics, and pharmaceutical industries, among other sectors. The mechanisms underlying these bioactivities should be investigated further in order to fully utilise the chemicals generated from seaweed for a variety of purposes.

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