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Phytochemical and Biological Activities of Ulva intestinalis from the Red Sea, Sudan

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Abstract

Marine macroalgae have attracted increasing scientific attention because of their rich nutritional composition and diverse bioactive compounds with potential pharmaceutical and nutraceutical applications. This study aimed to investigate the physicochemical characteristics, phytochemical composition, mineral profile, and biological activities of *Enteromorpha (Ulva) intestinalis* collected from the Red Sea. The dried algal samples were subjected to proximate composition analysis, phytochemical screening, gas chromatography–mass spectrometry (GC–MS), and inductively coupled plasma optical emission spectrometry (ICP–OES) to determine their nutritional value, bioactive constituents, and mineral content. The antioxidant activity of the algal extracts was evaluated using standard free radical scavenging assays, while antimicrobial activity was assessed against selected pathogenic microorganisms using established microbiological techniques. The results demonstrated that *U. intestinalis* contains valuable nutritional components, including carbohydrates, proteins, lipids, ash, and dietary fiber, together with several essential minerals. Phytochemical screening confirmed the presence of biologically active secondary metabolites, including phenolic compounds, flavonoids, tannins, alkaloids, and saponins. GC–MS analysis identified several bioactive compounds that may contribute to the observed biological activities. The extracts exhibited considerable antioxidant capacity and inhibitory effects against selected bacterial strains, indicating promising antimicrobial potential. These findings suggest that *U. intestinalis* represents a valuable natural source of nutritional and pharmacologically active compounds with potential applications in food, pharmaceutical, and nutraceutical industries. Further studies are recommended to isolate, characterize, and evaluate the therapeutic efficacy and safety of the identified bioactive constituents through in vivo and clinical investigations.

Keywords: Ulva intestinalis, Red Sea, Phytochemical screening, Antimicrobial activity, Bioactive compounds.

1. Introduction

Marine macroalgae are important renewable marine resources that have attracted considerable scientific attention because of their nutritional value and diverse bioactive compounds with applications in food, pharmaceuticals, cosmetics, agriculture, and biotechnology (Holdt & Kraan, 2011). Seaweeds are generally classified into three major groups based on pigmentation: Chlorophyta (green algae), Phaeophyta (brown algae), and Rhodophyta (red algae). Among these groups, green algae have gained increasing attention due to their abundance of biologically active metabolites, including phenolic compounds, flavonoids, polysaccharides, alkaloids, and terpenoids, which exhibit antioxidant, antimicrobial, anti-inflammatory, antiviral, and anticancer properties (Khalid *et al*., 2018).

Enteromorpha intestinalis, currently accepted taxonomically as *Ulva intestinalis*, belongs to the family Ulvaceae and is widely distributed in coastal and estuarine ecosystems worldwide, including the Red Sea. This species is characterized by rapid growth, ecological adaptability, and high nutritional value. Previous studies have demonstrated that *U. intestinalis* is rich in carbohydrates, proteins, dietary fiber, essential amino acids, vitamins, minerals, and several secondary metabolites that contribute to its biological activities (Ortiz *et al.,* 2006; Holdt & Kraan, 2011; Talukder *et al*,. 2020).

The increasing demand for natural antioxidants and environmentally friendly antimicrobial agents has stimulated interest in marine algae as alternative sources of bioactive compounds. Oxidative stress caused by excessive production of reactive oxygen species has been associated with the development of numerous chronic diseases, including cardiovascular disorders, diabetes, neurodegenerative diseases, and cancer. Natural antioxidants obtained from marine organisms have therefore become an important area of pharmaceutical and nutraceutical research (Cornish & Garbary, 2010). Likewise, numerous investigations have demonstrated that seaweed extracts possess inhibitory activity against several pathogenic microorganisms, highlighting their potential as natural antimicrobial agents for pharmaceutical and food preservation applications (Cox *et al*., 2010; Nifa *et al*., 2026).

Marine algae are also recognized as excellent sources of essential minerals, including calcium, potassium, magnesium, sodium, iron, zinc, manganese, and phosphorus. Their mineral composition is influenced by environmental conditions, geographical location, seasonal variation, and seawater chemistry (Circuncisão *et al*., 2018; Ratul *et al*., 2025). Therefore, comprehensive physicochemical characterization is necessary to determine their nutritional quality and industrial potential. The Red Sea represents one of the world's most distinctive marine ecosystems because of its high biodiversity and unique environmental characteristics. Despite the ecological importance of Red Sea macroalgae, limited information is available regarding the physicochemical composition, phytochemical constituents, and biological activities of *U. intestinalis* from this region. Comprehensive evaluation of this species is essential to support its sustainable utilization as a natural source of valuable bioactive compounds. Therefore, the present study aimed to investigate the physicochemical characteristics, phytochemical profile, mineral composition, antioxidant activity, and antimicrobial potential of *Enteromorpha (Ulva) intestinalis* collected from the Red Sea. The findings provide valuable scientific evidence supporting its potential application in food, pharmaceutical, and nutraceutical industries.

2. Materials and Methods

Study Area and Sample Collection

Fresh samples of *Enteromorpha (Ulva) intestinalis* were collected from the coastal region of the Red Sea. Healthy algal thalli were manually harvested from the intertidal zone during low tide. The collected samples were transported to the laboratory in sterile polyethylene bags and washed thoroughly with seawater followed by distilled water to remove sand particles, epiphytes, salts, and other impurities. The cleaned samples were shade-dried at room temperature until a constant weight was achieved, pulverized using a laboratory grinder, and stored in airtight containers for subsequent analyses (AOAC, 2019).

Preparation of Algal Extracts

The dried algal powder was extracted following the procedure described in the original experimental protocol. The crude extracts were filtered and concentrated under reduced pressure using a rotary evaporator before storage at 4°C until further phytochemical and biological analyses were performed.

Physicochemical Analysis

Proximate composition, including moisture, ash, crude protein, crude lipid, crude fiber, and carbohydrate contents, was determined according to the standard methods of the Association of Official Analytical Chemists (AOAC, 2019). All measurements were performed in triplicate, and the results were expressed as mean ± standard deviation.

Phytochemical Screening

Qualitative phytochemical screening was carried out using standard analytical procedures to detect the presence of alkaloids, flavonoids, tannins, phenolic compounds, saponins, glycosides, steroids, and terpenoids as previously described by (Harborne, 1998; Sofowora, 2008).

GC–MS Analysis

Gas chromatography–mass spectrometry (GC–MS) analysis was performed to identify volatile and semi-volatile bioactive constituents present in the algal extracts. The detected compounds were identified by comparing their mass spectra with those available in the National Institute of Standards and Technology (NIST) spectral database (NIST, 2023).

Mineral Analysis

The mineral composition of the algal samples was determined using inductively coupled plasma–optical emission spectrometry (ICP–OES). Acid digestion of dried samples was carried out prior to instrumental analysis following standard analytical procedures for elemental determination (AOAC, 2019).

Determination of Antioxidant Activity

The antioxidant activity of the algal extracts was evaluated using the DPPH free radical scavenging assay following the method described by Brand-Williams *et al.* (1995). The percentage inhibition was calculated at different extract concentrations, and antioxidant activity was compared with a standard antioxidant.

Antimicrobial Activity

The antimicrobial activity of the algal extracts was evaluated against selected pathogenic microorganisms using the agar well diffusion method following the Clinical and Laboratory Standards Institute (CLSI, 2021) guidelines. Antimicrobial activity was expressed as the diameter of inhibition zones (mm).

Statistical Analysis

All experiments were performed in triplicate, and the results were expressed as mean ± standard deviation (SD). Statistical analyses were conducted using appropriate statistical software, and differences among groups were considered statistically significant at $p < .05$.

3. Results and Discussion

Extractable matters content

Upon successive extraction of the *E. Intestinalis*, with petroleum ether and ethanol, the yield was found to be (0.812%) and (4.36%) for the solvents, respectively.

Table 1: Phytochemical screening *E. Intestinalis* ethanolic extract.

Test	Observation	Result
Test for alkaloids Mayer's reagent Dragendoroff's reagent Wagner's reagent	Precipitate formation	Presences of alkaloids
Test for saponin Foam test	Persistent foam Development	Presences of Saponins
Test for phenols (tannins) Ferric chloride test	Blackish-green color formation	Presences of phenolic compounds
Test for anthraquinone (Borntrager's test)	No red or pink color formed	Anthraquinones were not present
Test for flavanoids Potassium hydroxide test	Yellow color development	Flavanoids were present
Test of cardiac glycoside Killer killiane test	Reddish brown ring formed at the interphase	Presences of cardiac glycosides
Test for steroids Liebermann's test	Red violet ring formed at the interphase	Presences of Steroids
Test for bitter principles Potassium hydroxide test	Red color development	Presence of bitter principles

Phytochemical screening of *E. intestinalis* from the Red Sea, Eastern Sudan, was consistent with findings from India, confirming flavonoids, alkaloids, steroids, saponins, and phenols. The results also agree with previous studies reporting tannins, glycosides, and cardiac glycosides (Shankhadarwar S. D., 2015).

GC-MS analysis of pet. ether extract

The gas chromatogram of pet. ether extract of *E. Intestinalis* showed detection of 15 compounds (**Fig. 1**). Their identification based on their mass spectra. The identified compounds with their percentages are shown in **Table 2**.

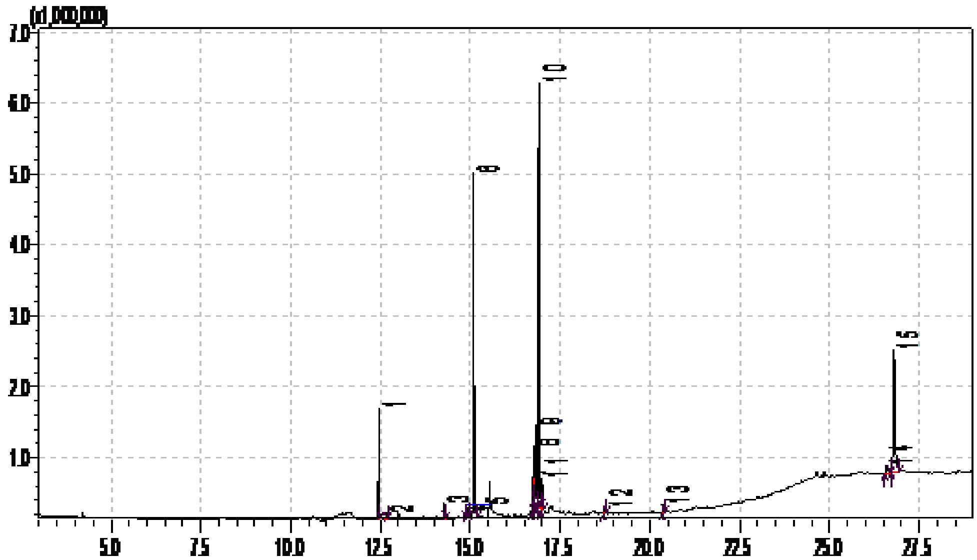


Fig. 1: The gas chromatogram of pet. ether extract.

Table 2: Petroleum ether extracts composition of *E. Intestinalis.*

ID#	Name	Ret. Time	Area	Area%
1.	8-Heptadecene	12.450	2496989	7.15
2.	Heptadecane	12.666	171452	0.49
3.	Hexahydrofarnesyl acetone	14.277	384754	1.10
4.	7-Hexadecenoic acid, methyl ester, (Z)-	14.849	153459	0.44
5.	Palmitoleic acid (9-Hexadecenoic acid) methyl ester	14.893	332192	0.95
6.	Palmitic acid (Hexadecanoic acid), methyl ester	15.086	8885046	25.45
7.	Linoleic acid (9,12-Octadecadienoic acid (Z,Z), methyl ester	16.732	769761	2.20
8.	10-Octadecenoic acid (Z)-, methyl ester	16.775	1268042	3.63
9.	11-Octadecenoic acid, methyl ester	16.825	2116398	6.06
10.	Phytol	16.906	10179889	29.16
11.	Methyl stearate, Stearic acid, methyl ester	16.998	820938	2.35
12.	Arachidic acid (Eicosanoic acid), methyl ester	18.755	135889	0.39
13.	Behenic acid (Docosanoic acid), methyl ester	20.371	227743	0.65
14.	γ-Sitosterol (Stigmast-5-en-3-ol, (3α)-)	26.592	545206	1.56
15.	Fucosterol (Stigmasta-5,24(28)-dien-3α-ol, (E)-)	26.791	6430284	18.42

The petroleum ether extract was mainly composed of phytol (29.16%), palmitic acid methyl ester (25.45%), and fucosterol (18.42%). Phytol has reported antioxidant, anti-inflammatory, antiallergic, and immunostimulant activities. Fucosterol exhibits antioxidant and hepatoprotective effects. Other detected compounds included stearic acid (2.35%), linoleic acid (2.20%), palmitoleic acid (0.95%), behenic acid (0.65%), arachidic acid (0.39%), and heptadecane isomers (7.54%). Linoleic acid is also known for anti-inflammatory and skin-moisturizing properties (Santos *et al,* 2013).

Proximate analysis

Proximate analysis of *E. Intestinalis* is shown in **Table 3**.

Table 3: Proximate Composition of *E. Intestinalis.*

Chemical Composition	Percentage composition
Moisture	7.731%
Ash	31.072%
Protein	16.625%
Fat	0.864%
Fiber	5.710%
Carbohydrates	37.998%
Total:	**100%**

The nutritional composition of *E. intestinalis* from the Red Sea, Sudan, was comparable to samples from Southern Thailand and Mexico in protein and ash content, but had lower crude fiber. Previous studies reported protein (14.6–19.5%), lipid (2.1–8.7%), ash (25.9–28.6%), soluble fiber (25.3–39.6%), insoluble fiber (21.8–33.5%), and total dietary fiber (51.3–62.2%) on a dry-weight basis.

Mineral content

Detection of minerals content of E. Intestinalis by (ICPES) revealed the presence of macro elements like K, Na, and S **Table 4**.

Table 4: Elemental composition of *E. Intestinalis*.

Elements detected	Concentration
Rb	7.8 ppm
K	4.8ppb
Na	160ppb
S	100ppb
Si	159ppb

E. intestinalis contained the macroelements K, Na, and S, as well as the trace element Si. This agrees with Benjama and Masniyom (2011), who reported that *U. intestinalis* is rich in Mg, K, Cl, Na, and Ca.

Antimicrobial activity screening

The crude alcoholic extract of *E. Intestinalis* was investigated to evaluate its antibacterial activity against two strains of Gram-positive bacteria (*Staphylococcus aureus* and *Bacillus subtilis*) and two strains of Gram-negative bacteria (*Escherichia coli and Pseudomonas aeruginosa*) and one fungal strain (*Candida albicans*)using cup-plate method. Evaluation of the activity of the extract against the different strains is recorded in **Table 5** and illustrated in **Fig. 3**.

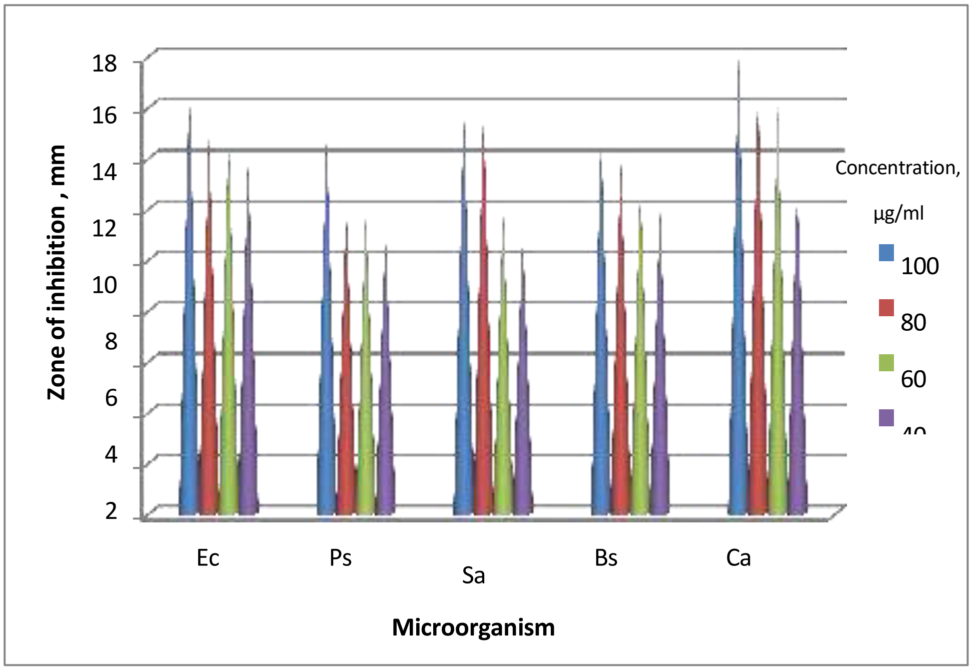
Table 5: Antimicrobial activity of *E. Intestinalis* ethanolic extract.

Concentration, µg/ml	Zone of inhibition, mm				
	E. coli	*P. aeruginosa*	*S. aureus*	*B. subtilis,*	*C. albicans*
100	17	15	16	15	18
80	15	12	16	14	17
60	15	12	12	13	16
40	14	11	11	12	13

The antibacterial activity ((NCCLS, 1990):

- <9mm zone is considered as inactive
- 9-12mm is considered as partially active
- 13-18mm is considered as active
- >18mm is considered as very active

E. intestinalis showed considerable antimicrobial activity against both Gram-positive and Gram-negative bacteria and pronounced activity against *C. albicans*. This activity may be attributed to phenolics, flavonoids, tannins, saponins, and fatty acids. Phenolic compounds can disrupt microbial membranes and cellular proteins, while saponins also contribute to antimicrobial effects. Fatty acids may inhibit microorganisms by disrupting cell membranes, interfering with cellular energy production, and inhibiting intracellular processes (Desbois & Smith, 2010; Akter *et al*., 2025). The antimicrobial activity of polyunsaturated fatty acids has also been demonstrated against bacteria (Kankaanpää *et al.,* 2001).



Sa. = *Staphylococcus aureus*, Bs =*Bacillus subtilis,*
Ec = *Escherichia coli*, Ps= *Pseudomonas aeruginosa*
ca = *Candida albicans*

Fig. 2: Antimicrobial activity screening of *E. intestinalis.*

Antioxidant activity screening

The antioxidant activity of *E. Intestinalis* ethanolic extract was investigated using DPPH radical scavenging assay **Table 6**.

Table 6: Antioxidant activity of E. *Intestinalis* ethanolic extract.

Sample	%RSA±SD (DPPH)
E. Intestinalis extract	20±0.01
Standard (Propyl gallate)	90±0.01

The ethanolic extract of *E. intestinalis* showed moderate reducing and free-radical scavenging activities. These effects may be attributed to its phenolic compounds, fucosterol, and phytol, which are known for their antioxidant properties

4. Conclusion

Enteromorpha (Ulva) intestinalis collected from the Red Sea possesses significant phytochemical, nutritional, and biological properties. It contains valuable bioactive compounds, essential minerals, and nutritional components that contribute to its antimicrobial and antioxidant activities. These findings indicate that the species has promising potential for use as a natural source of pharmaceutical, nutraceutical, and functional food ingredients. Further investigations on the isolation, characterization, and pharmacological evaluation of its active constituents are recommended.

5. Ethics Approval

Not applicable, as this study did not involve human participants or experimental animals.

6. Data Availability

The data generated and analyzed during this study are available from the corresponding author upon reasonable request.

7. Acknowledgement

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8. Conflicts of Interest

The author declares no conflicts interests.

9. References

Abdul Q. A., Choi, R. J., Jung, H. A., & Choi, J. S. (2016). Health benefits of fucosterol from marine algae: A review. *Journal of the Science of Food and Agriculture*.

Akter MR, Alam MR, and Sany ZA. (2025). Phytochemical and antimicrobial evaluation of Eichhornia crassipes extracts against clinical and hospital effluent pathogens in Savar, Bangladesh, *Eur. J. Med. Health Sci.,* **7**(6), 593-609. https://doi.org/10.34104/ejmhs.025.05930609

Benjama, O., & Masniyom, P. (2011). Nutritional composition and physicochemical properties of two green seaweeds (*Ulva pertusa* and *Ulva intestinalis*). *Songklanakarin Journal of Science and Technology,* **33**(5), 575–583.

Blomster, J., Maggs, C. A., & Stanhope, M. J. (1998). Molecular and morphological analysis of Enteromorpha intestinalis and Enteromorpha compressa (Chlorophyta) in the British Isles. *Journal of Phycology*.

Chakraborty, S., Bhattacharya, T., *et al.* (2014). Benthic macroalgae as biological indicators of heavy metal pollution in marine environments: A biomonitoring approach for pollution assessment. *Ecotoxicology and Environmental Safety*.

Desbois, A. P., & Smith, V. J. (2010). Antibacterial free fatty acids: Activities, mechanisms of action and biotechnological potential. *Applied Microbiology and Biotechnology,* **85**, 1629.

Kumar, S. K. (2018). Seaweeds: Distribution, production and uses. In Bioprospecting of algae (pp. 59–78). *Society for Plant Research*.

Lee, S., Lee, Y. S., Jung, S. H., *et al*. (2003). Antioxidant activities of fucosterol from the marine algae *Pelvetia siliquosa*. *Archives of Pharmacal Research,* **26**, 719–722. https://doi.org/10.1007/BF02976680

Metin, C., & Baygar, M. (2018). Determination of nutritional composition of *Enteromorpha intestinalis* and investigation of its usage as food. *Ege Journal of Fisheries and Aquatic Sciences*.

Miles, A. A., Misra, S. S., & Irwin, J. O. (1938). The estimation of the bactericidal power of the blood. *Epidemiology and Infection,* **38**(6), 732–749. https://doi.org/10.1017/S002217240001158X

Nakamura, T., Nagayama, K., Uchida, K., & Tanaka, R. (1996). Antioxidant activity of phlorotannins isolated from the brown alga *Eisenia bicyclis*. *Fisheries Science,* **62**, 923–926.

Nifa MSA, Abdullah M, Islam MA, Sheikh MR, Uddin ME, Matin MN, (2026). Phyto-chemical characterization, pharmacological activities, and in silico analysis of the methanolic extract of reishi mushroom (*Ganoderma lucidum*), *Journal of Ethnopharmacology*, **373**, 2027, 122298. https://doi.org/10.1016/j.jep.2026.122298

Ratul MSA, Rokeya B, and Tusher MMH. (2025). Elucidation of phytochemicals and antidiabetic activity of methanolic ex-tract of Piper betle leaves on nSTZ-induced type 2 diabetic model Rats, *Eur. J. Med. Health Sci.,* **7**(1), 428-441. https://doi.org/10.34104/ejmhs.025.04280441

Ryu, K. R., Choi, J. Y., & Kim, D. H. (2011). Anti-scratching behavioral effect of the essential oil and phytol isolated from *Artemisia princeps* Pamp. in mice. *Planta Medica,* **77**, 22–26.

Santos, C. C. M. P., Salvadori, M. S., *et al.* (2013). Antinociceptive and antioxidant activities of phytol in in vivo and in vitro models. *Neuroscience Journal*, Article 949452.

Shankhadarwar, S. D. (2015). Phytochemical screening of marine algae *Ulva lacuta* (Linn.) and *Enteromorpha intestinalis* (Linn.). *Journal of Chemical and Pharmaceutical Research*.

Srikonga, W., Bovornreungroj, N., *et al.* (2017). Antibacterial and antioxidant activities of differential solvent extractions from the green seaweed *Ulva intestinalis*. *Journal of Applied Phycology*.

Talukder S, Uddin MS, and Baral PK. (2020). Phytochemical screening and bioactivity determination of ethyl acetate and methanolic extracts of leaf and bark of the plant *Nyctanthes arbortristis L*., *Eur. J. Med. Health Sci.,* **2**(6), 145-151. https://doi.org/10.34104/ejmhs.020.01450151

Tiwari, B. K., Valdramidis, V. P., & Cullen, P. (2009). Application of natural antimicrobials for food preservation. *Journal of Agricultural and Food Chemistry*.

Citation: Farah MH. (2026). Phytochemical and biological activities of Ulva intestinalis from the Red Sea, Sudan, *Eur. J. Med. Health Sci*., **8**(5), 676-683. https://doi.org/10.34104/ejmhs.026.06760683