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EVALUATION OF ANTIOXIDANT ACTIVITIES OF SOME ABUNDANT MARINE MACROALGAE, EGYPT

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This study investigated the antioxidant scavenging activity of nine marine macroalgae extracts collected from different Egyptian coasts. The extracts were tested using the DPPH assay to exhibit various antioxidant activities. All extracts showed lower DPPH free radical scavenging compared to ascorbic acid. Antioxidant effects increased with extract concentration, with brown algae exhibiting the highest activity among green and red algae. Specifically, the brown alga Polycladia myrica extract was most effective against DPPH free radicals, while the green alga Ulva fasciata demonstrated the lowest scavenging effect. At a concentration of 1000ug/ml, the most effective species against DPPH free radicals were brown macroalgae (Polycladia myrica > Turbinaria turbinata > Hormophysa cuneiformis), followed by red macroalgae (Jania rubens > Hypnea cornuta > Galaxura rugosa), whereas the green macroalgae showed the lowest scavenging effect (Caulerpa racemosa > Halimeda tuna > Ulva fasciata). The IC50 values indicated that Ulva fasciata, Halimeda tuna, and Caulerpa racemosa had the highest antioxidant activity, then red algae Galaxura rugosa> Hypnea cornuta> Jania rubens while brown algae Hormophysa cuneiformis, Turbinaria turbinata, and Polycladia myrica recorded the lowest values. Overall, the studied macroalgae species demonstrated significant antioxidant potential due to bioactive compounds like polyphenols, saponins, and tannins. Caulerpa racemosa exhibited the highest polyphenol concentration, while Galaxura rugosa had the lowest. Ulva fasciata, Hormophysa cuneiformis and Polycladia myrica showed the highest total saponins content, while Hypnea cornuta registered the highest total tannins content. These findings suggest that macroalgae could serve as dietary alternatives due to their strong antioxidant capabilities.

Keywords: *Abundant marine macroalgae, Egyptian coasts, Ascorbic acid, Antioxidant activity, DPPH scavenging*

INTRODUCTION

Macroalgae, found in marine environments, are recognized for their beneficial impact on human health due to a wide range of naturally occurring compounds, both organic and inorganic[1]. Marine algae are abundant sources of diverse bioactive compounds such as carotenoids, dietary fibers, proteins, essential fatty acids, vitamins, and minerals, offering various health benefits[2]. These compounds exhibit a range of biological activities including antimicrobial, antiviral, antioxidant, antitumor, and anti-inflammatory properties[3,4].

With approximately 6000 identified species, macroalgae are categorized into different groups such as Chlorophyta, Phaeophyta, and Rhodophyta, providing a rich array of natural compounds, particularly as natural antioxidants[2,5]. Consequently, there has been a growing interest in marine algae for their potential application in the food and pharmaceutical industries, particularly in the development of antioxidants from natural sources. Researchers have conducted numerous studies on antioxidants derived from various seaweed species, while others have explored the impact of extraction solvents on their antioxidant activity[6].

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While humans are unable to synthesize vitamin C (ascorbic acid/ascorbate) internally, it is essential for their well-being and is obtained through the diet [7]. Vitamin C is readily absorbed and distributed throughout the human body, with higher concentrations found in the brain, eye, and adrenal gland[8]. Its functions include collagen synthesis, iron metabolism, tissue growth, vascular functions, as well as the biosynthesis of carnitine and antioxidant reactions, such as the inhibition of lipid peroxidation[9]. As a reductant, vitamin C is converted into dehydroascorbic acid upon oxidation[10]. In addition to its well-known role in preventing scurvy, vitamin C may also play a preventive role in cardiovascular diseases and certain forms of cancer[11].

Previous studies have demonstrated that seaweed is rich sources of vitamin C[12-14], with the vitamin C content of various species being determined. Vitamin C, one of the most abundant water-soluble antioxidants synthesized by plants, is present in all red, brown, and green seaweeds. It offers several health benefits, such as radical scavenging abilities, anti-aging properties, and immune-stimulant activity.

Egypt needs to benefit from a high biodiversity of marine macroalgal species, owing to the abundance of macroalgae near its coasts in the Mediterranean Sea, Suez Canal, and Red Sea. This wealth of marine macroalgae serves as an important source of bioactive chemical compounds. Therefore, the objective of this study was to evaluate the antioxidant activity of extracts from nine abundant marine macroalgae species belonging to three taxa (Chlorophyta, Phaeophyta, and Rhodophyta), which were harvested from the coasts of Port Said (Mediterranean Sea), Ismailia (Suez Canal), and Hurghada (Red Sea) in Egypt. The ethanolic extracts of these macroalgae were prepared and subjected to a DPPH-scavenging assay to assess their ascorbic acid and similar antioxidant content.

MATERIALS AND METHODS

Marine Macroalgal collection and identification

The macroalgae samples were collected from three sites at the intertidal zone from different locations during low tide on November-December 2022, in Egypt. The collection sites, areas and GPS *coordinates* for each sampling site (Table, 1) are as follows:

- **Site I:** The Hunting Club, Port Said, Mediterranean Sea (31.26941" N, 32.31513" E)
- **Site II:** Aldunfah Beach Club, Ismailia, Suez Canal (30.58973" N, 32.30508" E)
- **Site III:** El Ahyaa District, Hurghada, Red Sea (27.1703" N, 33.4618" E)

Identification of the macroalgal samples was performed by Gihan Ahmed El Shoubaky, Professor of Phycology, Botany Department, Faculty of Science, Suez Canal University referring to the works of A. Gribb and A. Aleem[15&18] Photo (1).

Preparation of Macroalgae Extracts

A total of nine diverse marine macroalgal samples, representing three different taxa (Chlorophyta, Phaeophyta, and Rhodophyta), were collected from the designated areas (as indicated in Table 1). To ensure their cleanliness, the samples underwent a thorough washing process, initially with seawater and then with fresh water, to eliminate any epiphytes or debris. Subsequently, the samples were promptly transported to the laboratory in an ice box and subjected to shade-aided air drying at room temperature for a period of 3-4 days. Following drying, the samples were homogenized using an electric mixer and stored at 4 ºC for subsequent analysis.

Extraction procedure of antioxidant

The powdered macroalgal samples (100 gm) were mixed with 1000 ml of 85% methanol and homogenized for 2 hrs. The mixture was then macerated in a stoppered container at room temperature for 24 hrs for conventional extraction. Subsequently, the extract and powdered samples were sonicated at 4°C for 30 min. Afterward, the extract was filtered and concentrated under vacuum at 40°C using a Rota vapor to obtain the crude extract (gm) as described by [47].

Photo 1: The selected abundant marine macroalgal samples (H1-H9) belonging to three divisions (Chlorophyta, Phaeophyta and Rhodophyta).

Table 1: The abundant samples of the macroalgal species in the selected areas.

Sample No.	Macroalgal species	Area
	Chlorophyta	
H1	***Caulerpa racemosa*** (Forsskål) J. Agardh	Hurghada, Red Sea
H2	***Ulva fasciata*** Delile	Port Said, Mediterranean Sea
H3	***Halimeda tuna*** (J.Ellis & Solander) J.V.Lamouroux	Hurghada, Red Sea
	Rhodophyta	
H4	***Galaxaura rugosa*** (J. Ellis & Solander) J.V.Lamouroux	Hurghada, Red Sea
H5	***Hypnea cornuta*** (Kützing) J. Agardh C	Ismailia, Suez Canal
H6	***Jania rubens*** (Linnaeus) J.V. Lamouroux	Hurghada, Red Sea
	Phaeophyta	
H7	***Turbinaria turbinata*** (Linnaeus) Kuntze	Hurghada, Red Sea
H8	***Hormophysa cuneiformis*** (J.F. Gmelin) P.C.Silva	Hurghada, Red Sea
H9	***Polycladia myrica*** (S.G. Gmelin) Draima, Ballesteros, F.Rousseau & T. Thibaut	Hurghada, Red Sea

Assessment of antioxidant activity using the DPPH assay

The antioxidant activity of the macroalgae sample extracts was assessed using a modified DPPH assay, as described by[19]. The DPPH assay measures the ability of different macroalgal extracts to scavenge free radicals by reacting with 2,2-diphenyl-1-picryl hydrazyl (DPPH).

To conduct the assay, a 0.1 mM solution of DPPH in ethanol was prepared. Next, 1 mL of this solution was added to 3 mL of various macroalgal extracts dissolved in ethanol at different concentrations (3.9, 7.8, 15.62, 31.25, 62.5, 125, 250, 500, 1000 µg/mL). Only the extracts soluble in ethanol were used, and their concentrations were prepared by dilution. The DPPH/extract mixture was vigorously shaken and left at room temperature for 30 min. The absorbance (optical density) was then measured at 517 nm using a UV-visible spectrophotometer (Milton Roy). Ascorbic acid was used as a reference compound, and each experiment was performed in triplicate.

The inhibitory concentration (IC_{50}) value of each extract, representing the concentration required to scavenge 50% of the DPPH free radicals, was determined using a logarithmic dose inhibition curve. A lower absorbance at 517 nm indicated a lower free radical scavenging activity. The percentage of DPPH scavenging effect (% inhibition) was calculated using the following equation:

$$\% \text{ inhibition} = (A0 - A1) / A0 \times 100\%$$

where A0 is the absorbance at 517 nm of the control DPPH sample, and A1 is the absorbance at 517 nm of the sample after treatment with the algal extract.

The extract concentration at which 50% inhibition (IC_{50}) occurred for each algal species was determined from the plotted graph of % inhibition versus extract concentration. As a positive control, an ethanolic solution of ascorbic acid was used.

The chemicals used in the study, including ascorbic acid, Folin-Ciocalteu reagent, and ethanol, were purchased from Merck Company (Darmstadt, Germany). The DPPH analysis was performed at the Ultra Advanced Biotechnology Research Laboratory.

Estimation of total polyphenols

Dry Macroalgal materials (500gm) were macerated with 2.5 liters of 85% methanol at room temperature for 3 days with shaking. For conventional extraction, the extract underwent sonication at 40°C for 60 min. After filtration and vacuum concentration at 40°C using a Rota vapor, the crude extract was obtained [47].

HPLC analysis was performed using an Agilent 1260 series with an Eclipse C18 column (4.6 mm x 250 mm i.d., 5 µm). The multi-wavelength detector monitored the samples at 280 nm, with an injection volume of 5 µl for each solution. The column temperature was maintained at 40°C. The concentration of polyphenols (phenolic acids and flavonoids) was calculated as area %.

Total condensed tannins content

Tannin contents were measured using Tannic as a reference compound. A 400µl volume of the extract was mixed with 3ml of vanillin solution (4% in methanol) and 1.5ml of concentrated hydrochloric acid. After 15 min of incubation, the absorbance was read at 500 nm using a Biosystem 310 spectrophotometer, following blank zeroing [40].

Total Saponins Content (TSC) Assay

Saponin contents were determined using the Modified Vanillin-Sulphuric Acid method. A standard curve was prepared using aescin, a natural mixture of triterpenoid saponins. A 15 mg/ml aescin stock solution was made by dissolving 150.0 mg of aescin in 10 ml of methanol. Serial dilutions were then performed in triplicate using methanol as a solvent blank[39]. The solutions' absorbance was measured at 560 nm using a Biosystem 310 spectrophotometer after zeroing with the blank. The obtained absorbance values were plotted against concentrations to create the standard curve:

$$\text{Total saponin content} = A/b \times (1 - (\text{moisture } \%/100))$$

Where: A = weight of saponins in the extract (mg) B = weight of the powder (g)

The TSC was expressed as mg aescin equivalents per gram dry weight of the powder (AE/gm).

Statistical analysis

The antioxidant activity analyses were conducted in triplicate. The data were presented as the mean ± standard deviation (SD) and processed using Excel and Microcal Origin 6. Statistical analysis was performed using SPSS 17.0.

RESULTS AND DISCUSSION

Results

The concentration of all samples (H1-H9) had a significant impact on their scavenging activity towards the DPPH radical. The percentage scavenging activity of DPPH of the different ethanolic macroalgae sample extracts were estimated at serial concentrations as shown in **Fig. (1)** and **Table (2)**. There was a steady increase of scavenging ability with increased concentration of the extract (3.9, 7.8, 15.62, 31.25, 62.5, 125, 250, 500, 1000 µg/mL). The most effective scavenging activities (% inhibitions listed) against DPPH was recorded using sample concentrations of 1000 µg/mL of extracts derived from brown macroalgae (*P. myrica* H9 (86.1 ± 0.009) > *Turbinaria turbinata* H7 (81.3 ± 0.003) > *H. cuneiformis* H8 (80.4 ± 0.004)), followed by red macroalgae *(J. rubens* H6 (79.4 ± 0.002) > *H. cornuta* H5 (74.7 ± 0.003) > *Galaxaura rugosa* H4 (72.3 ± 0.003)). The extracts from green macroalgae demonstrated the lowest scavenging effects among those studied (*C. racemosa* H1 (77.6 ± 0.004) > *H. tuna* H3 (69.8 ± 0.003) > *U. fasciata* H2 (67.4 ± 0.003).

Generally, the extract from the brown alga *P. myrica* was the most effective against DPPH, whereas that from the green alga *U. fasciata* demonstrated the lowest scavenging effect. The scavenging effects of all the extracts on DPPH were found to be less potent compared to the standard ascorbic acid. However, it was observed that the inhibitory effects of each extract on DPPH radicals increased proportionally with higher concentrations, as depicted in **Table 2**.

Table 2: DPPH free radical scavenging activity (%) of serial concentrations of nine sample extracts used in comparison to standard ascorbic acid.

Conc.	standard ascorbic acid	H1	H2	H3	H4	H5	H6	H7	H8	H9
µg/mL	DPPH %	DPPH %	DPPH %	DPPH %	DPPH %	DPPH %	DPPH %	DPPH %	DPPH %	DPPH %
1000	95.5 ± 0.002	77.6 ± 0.004	67.4 ± 0.003	69.8 ± 0.003	72.3 ± 0.003	74.7 ± 0.003	79.4 ± 0.002	81.3 ± 0.003	80.4 ± 0.004	86.1 ± 0.009
500	92.9 ± 0.004	69.9 ± 0.002	60.3 ± 0.003	63.5 ± 0.008	65.6 ± 0.003	67.8 ± 0.006	72.6 ± 0.003	74.8 ± 0.003	74.1 ± 0.005	79.4 ± 0.002
250	91.1 ± 0.005	63.2 ± 0.004	53.8 ± 0.002	58.3 ± 0.002	58.9 ± 0.003	60.9 ± 0.002	65.6 ± 0.003	67.4 ± 0.007	66.6 ± 0.007	72.3 ± 0.002
125	84.9 ± 0.006	57.7 ± 0.003	47.0 ± 0.003	52.0 ± 0.002	53.3 ± 0.005	54.3 ± 0.004	58.9 ± 0.003	60.6 ± 0.010	59.5 ± 0.003	66.5 ± 0.004
62.5	76.4 ± 0.006	50.6 ± 0.002	40.6 ± 0.003	45.1 ± 0.003	47.6 ± 0.001	48.3 ± 0.003	51.8 ± 0.003	53.6 ± 0.002	52.7 ± 0.001	59.7 ± 0.002
31.25	69.6 ± 0.004	48.6 ± 0.005	36.8 ± 0.005	38.6 ± 0.002	41.0 ± 0.003	41.9 ± 0.003	45.0 ± 0.003	47.8 ± 0.003	46.3 ± 0.003	52.9 ± 0.004
15.625	62.6 ± 0.005	40.8 ± 0.007	29.6 ± 0.005	33.1 ± 0.004	35.7 ± 0.004	36.2 ± 0.003	38.6 ± 0.002	41.0 ± 0.004	39.6 ± 0.001	46.3 ± 0.003
7.8125	54.7 ± 0.003	35.4 ± 0.003	22.5 ± 0.005	26.6 ± 0.004	28.9 ± 0.006	29.1 ± 0.002	35.0 ± 0.005	35.9 ± 0.005	32.3 ± 0.005	39.8 ± 0.004
3.9	44.3 ± 0.002	28.2 ± 0.002	15.3 ± 0.002	23.1 ± 0.007	23.5 ± 0.007	24.0 ± 0.004	27.9 ± 0.003	29.8 ± 0.002	26.4 ± 0.003	35.0 ± 0.004
1.95	40.2 ± 0.007	22.6 ± 0.009	9.0 ± 0.004	16.2 ± 0.001	16.8 ± 0.007	19.1 ± 0.004	21.3 ± 0.004	24.6 ± 0.004	19.6 ± 0.002	28.4 ± 0.004
0	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004	0.0 ± 0.004

All the values are mean ± standard deviation.

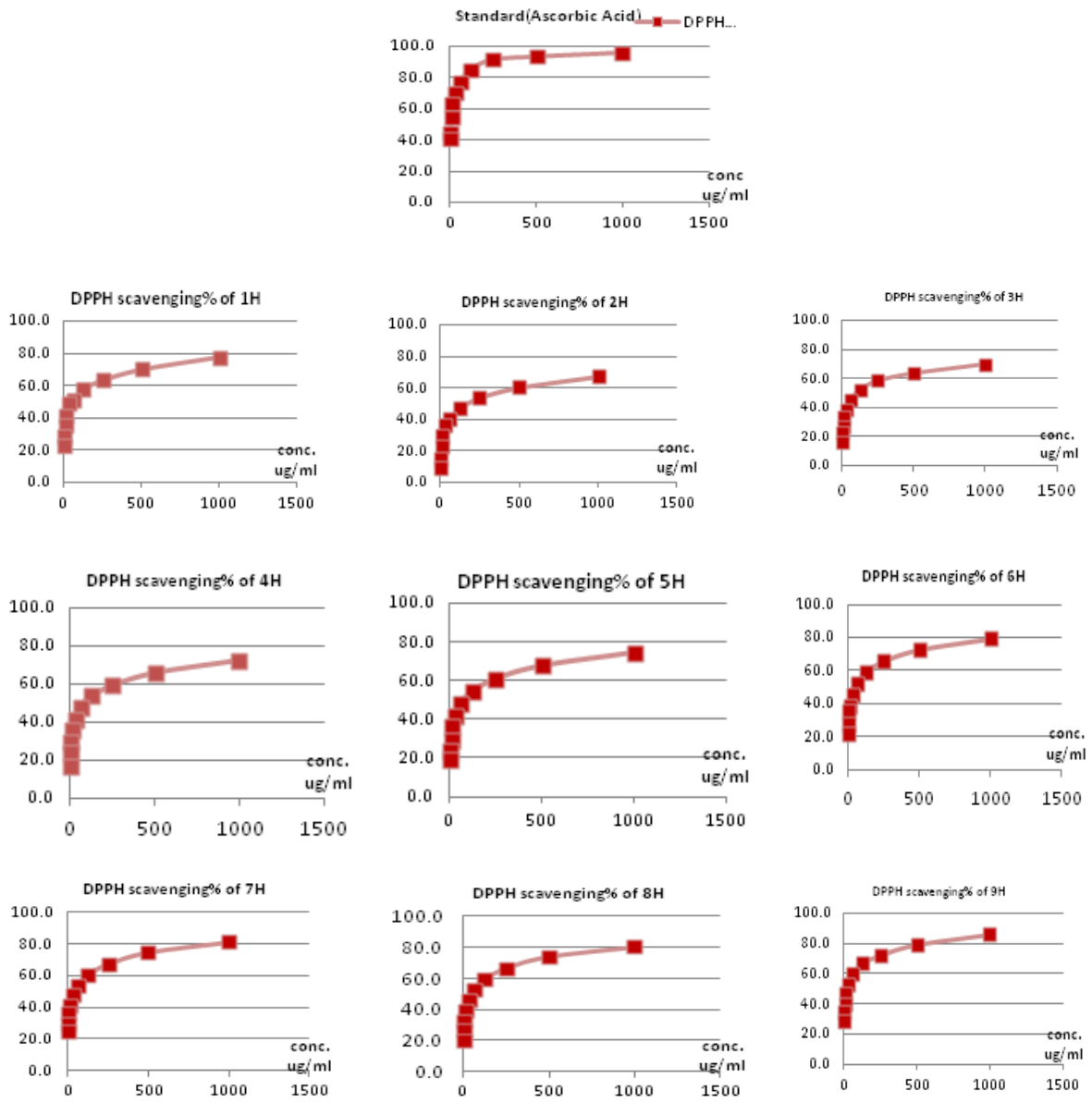

Fig. 1: Graphs of DPPH scavenging activity (%) of standard ascorbic acid and the macroalgalsamples H1-H9 with serial extract concentrations.

In this study, the antioxidant capability of ethanol extracts was assessed using the DPPH radical scavenging activity assay. The IC_{50} values were employed to compare the antioxidant activity of the macroalgal extracts, with lower values indicating higher activity. **Fig. 2** summarizes the IC_{50} values (µg/mL) of the macroalgal extracts in relation to the standard ascorbic acid. Among the extracts, the green algae *U. fasciata* (H2), *H. tuna* (H3), and *C. racemosa* (H1) exhibited the least efficient free radical scavenging effect, as evidenced by their highest IC_{50} values (158.8 µg/mL, 104 µg/mL, and 47.1 µg/mL, respectively). Following them were the red algae *Galaxaura rugosa* (H4), *H. cornuta* (H5), and *J. rubens* (H6) with IC_{50} values of 84.15 µg/mL, 46.17 µg/mL, and 72.01 µg/mL, respectively. Lastly, the brown algae *H. cuneiformis* (H8), *T. turbinata*(H7), and *P. myrica* demonstrated the lowest IC_{50} values, indicating the most efficient antioxidant activity (45.36 µg/mL, 36.73 µg/mL, and 21.58 µg/mL, respectively).

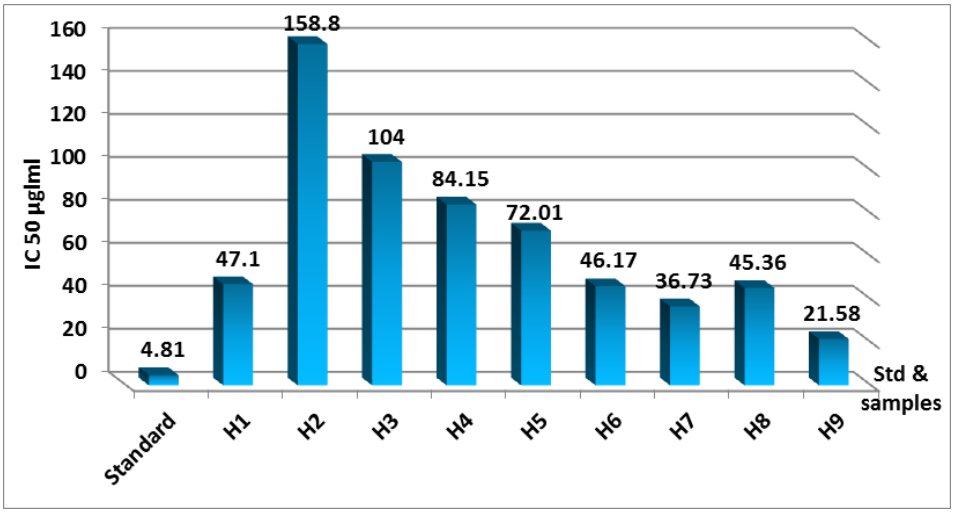

Fig. 2 : DPPH radical scavenging activities (IC50 µg/ml) of the macroalgal extracts in comparison with the standard ascorbic acid (Std).

As a result, *P. myrica*, a brown alga, exhibited the highest efficacy in combating the DPPH free radical. Conversely, *Ulva fasciata*, a green alga, showed the least scavenging effect compared to the analyzed extracts. The extracts derived from red algae demonstrated a moderate level of activity.

Polyphenols (phenolic acids & flavonoids), saponins, and tannins were estimated in the selected species as shown in Table (3). Among Chlorophytes, *C. racemosa* had the highest polyphenol content (81.73%), followed by *H. tuna* (43.28%) and *U. fasciata* (27.19%). In Rhodophytes, *H. cornuta* and *J. rubens* showed higher values (31.92% & 31.31%, respectively) than *G. rugosa* (29.41%). Within Phaeophytes, *T. turbinata* had the highest content (66.81%), followed by *P. myrica* (37.40%) and *H. cuneiformis* (32.95%). Overall, *C. racemosa* recorded the maximum polyphenol concentration among all samples, while *G. rugosa* had the lowest concentration among the red macroalgae.

U. fasciata H2 had a relatively high total saponins content (2.52 mg AE/gm) compared to other green samples. In the Phaeophytes group, *H. cuneiformis* and P. myrica showed high total saponins content (2.30 and 2.06 mg AE/gm, respectively). The three macroalgae samples in the Rhodophytes group had similar low amounts of total saponins content compared to other groups. Overall, *U. fasciata*, *H. cuneiformis*, and *P. myrica* exhibited the highest total saponins content, as presented in Table (3). *H. cornuta* (128.8µg/gm), *H. cuneiformis* (119.1µg/gm), and *J. rubens* (107.8µg/gm) had high total tannins content, while the brown alga *P. myrica* recorded the lowest level of tannins (20.3µg/gm).

Table 3: The bioactive components concentration of polyphenols, saponins and tannins in the selected macroalgal species.

Bioactive compound / macroalgal Species	Polyphenols Conc. %	Total saponins (Mg AE/gm)	Total Tannins (µg/gm)
H1	81.73	1.60±0.055	54.0±1.0
H2	27.19	2.52±0.032	93.0±1.2
H3	43.28	1.90±0.015	55.1±0.4
H4	29.41	1.74±0.040	68.8±0.3
H5	31.92	1.89±0.021	128.8±0.4
H6	31.31	1.94±0.012	107.8±0.6
H7	66.81	1.99±0.025	19.8±0.3
H8	32.95	2.30±0.031	119.1±0.9
H9	37.40	2.06±0.030	20.3±0.1

Discussion

Seaweeds (macroalgae) contain antioxidant substances that play a vital role in the organism's internal defense mechanism against external stressful conditions[20]. One such compound is DPPH (2,2-diphenyl-1-picrylhydrazyl), a stable free radical with an unpaired electron at its nitrogen center, which can be effectively neutralized by scavenging free radicals. To evaluate the antioxidative properties of various compounds, a DPPH-based assay was employed, wherein their ability to act as antioxidants through hydrogen atom donation was examined[21]. In a recent study by Aydin[22], it was suggested that a wide range of algae species have the potential to serve as abundant natural sources of antioxidants.

The findings of our study revealed significant DPPH antioxidant scavenging activity in the extracts of all macroalgae investigated. For the DPPH scavenging activity assay, ethanol was employed as the solvent. Akbary[23] previously demonstrated that ethanol exhibits higher efficacy in extracting phenolic compounds when compared to water or an ethanol/water mixture. Consequently, the aforementioned seaweeds hold potential as valuable sources of natural antioxidants for dietary purposes. Therefore, it is recommended to further evaluate their antioxidant activities in authentic food systems. Various surveys have consistently affirmed the efficient antioxidant activities of ethanol extracts[24&25].

The ethanol-based extracts derived from brown macroalgae *P. myrica*, *Turbinaria turbinata*, and *H. cuneiformis* exhibited notable efficacy in scavenging DPPH radicals, as evidenced by their low IC_{50} values. These findings align with the results reported by[26]. The scavenging potential of the extracts was determined by assessing the decolorization of the DPPH purple solution, where lower IC_{50} values indicated higher antioxidant activity. Tran *et al*.[27] highlighted that, among the various algae tested, brown algae demonstrated the highest statistical activity in terms of total antioxidant capacity and ferric reducing activity. In our study, specifically, the green alga *C. racemosa* (H1) exhibited superior DPPH scavenging activity compared to the other selected green algae samples, establishing a positive linear relationship between the total phenolic content and antioxidant activities.

The presence of hydrophilic polyphenols in seaweeds, such as phlorotannins, which are polar molecules and mostly found in brown seaweeds, could function as antioxidative components and thus assist the algae to overcome oxidative stress [28]. In our results, the antioxidant activities of all extracts were lower than that of standard ascorbic acid. This result is in agreement with those reported by [26-30].

In our study, IC_{50} values for DPPH scavenging in all macroalgal sample extracts showed that the brown macroalgae (*P. myrica* > *Turbinaria turbinata* > *H. cuneiformis*). may develop an effective antioxidant defense system followed by red macroalgae (*J. rubens* > *H. cornuta* > *Galaxaura rugosa*) and finally the green macroalgae (*C. racemosa* > *H. tuna* > *Ulva fasciata*).

According to[31], *Ulva faciata* and *Gracilaria corticata* have been identified as potential sources of natural antioxidants and can be effectively utilized as nutraceuticals. Sivaramakrishnan *et al*. [32] reported that among the species studied, H. tuna exhibited the highest IC_{50} value, indicating a lower ability to scavenge DPPH radicals. However, there was no significant difference observed among the other three species, namely *Halimeda macroloba*, *Enteromorpha* sp., and Acetabularia acetabulum, suggesting that these three species possessed similar potential in quenching the DPPH radical. Sivaramakrishnan *et al.* [32] suggested that extracts from green macroalgae could serve as valuable and promising sources of natural antioxidants, with potential benefits in reducing the risks associated with cancer, inflammation, obesity, and more, potentially replacing synthetic antioxidants. El-Sheekh *et al*. [33] demonstrated that the in vitro antioxidant activities of different solvents for seaweeds such as *Taonia atomaria* (Phaeophyta), *Padina pavonica* (Phaeophyta), *J. rubens* (Rhodophyta), and *Corallina elongata* (Rhodophyta) exhibited a dose-dependent relationship.

The capability of the DPPH test to distinguish between various phenolic compounds commonly found in natural systems, known for their antioxidant properties, is a notable feature. These natural compounds have demonstrated remarkable scavenging

abilities, highlighting their potential in inhibiting free radicals. The differences observed in DPPH radical scavenging activity could be attributed to variations in extraction methods and solvents employed across different studies, as these factors can influence the antioxidant effectiveness[32].

According to a study by Farasat *et al.*[34], *Ulva clathrata* demonstrated significant antioxidant activity with low IC_{50} values, followed by *Ulva intestinalis*, *Ulva linza*, and *Ulva flexuosa*. Antioxidant activity in algae is attributed to various processes and compounds, including lipophilic scavengers (carotenoids), enzymatic scavengers (catalase, superoxide dismutase, and peroxidase), and polyphenols [35&36]. The effectiveness of these compounds' antioxidant properties is primarily influenced by structural details, such as the arrangement, number, and positions of hydroxyl groups, as well as the substitution of aromatic rings[37].

This study estimated bioactive compounds, including polyphenols (phenolic acids & flavonoids), saponins, and tannins, in the tested samples, showing high occurrence. *C. racemosa* had the highest concentration of polyphenols among the green macroalgae, while *G. rugosa* had the lowest among the red macroalgae.[43] confirmed the positive association of phenolic compounds with antioxidant ability, attributing 99% of antioxidant activity to this group. [45] highlighted the beneficial antioxidant properties of polyphenols, making them valuable for potential therapeutic applications in neurological diseases. Studies also reveal that macroalgae compounds, such as tannins, flavonoids, saponins, steroids, alkaloids, triterpenoids, and phenolics, act as neuroprotectors[48]. Other research shows these compounds can inhibit butyrylcholineesterase and acetylcholineesterase[40]. These findings suggest that marine macroalgae-derived polyphenols could be promising for drug development to improve the lives of patients with neurological diseases.

H. cornuta, H. cuneiformis, and *J. rubens* had high total tannins content, while P. myrica had the lowest level of tannins. The tannin compounds act as antioxidants by chelating iron ions and slowing down oxidation[42]. *U. fasciata, H. cuneiformis,* and *P. myrica* showed the highest total saponins content, which aligns with[41] who highlighted saponins' various biological uses as antioxidants, anticancer, antiobesity, antibacterial, and antidiabetic agents. [44] also studied the ability of saponins from the brown macroalga Padina japonica to reduce heart failure risks.

Conclusion

A variety of antioxidant activities were observed in the nine marine macroalgae species collected from Port Said, Ismailia, and Hurghada, Egypt. However, the DPPH free radical scavenging ability of all the extracts was lower compared to that of the standard ascorbic acid. The inhibitory effects of each extract on DPPH radicals increased with higher concentrations. Notably, the brown algae exhibited the highest antioxidant activity statistically, followed by the red algae and then the green algae. Among the extracts tested, the brown alga *P. myrica* extract demonstrated the most effective scavenging ability against DPPH, while the green alga *U. fasciata* exhibited the lowest scavenging effect. The IC_{50} values obtained from the macroalgal sample extracts serve as a valuable measure of their radical scavenging ability. Due to their natural antioxidant content, marine macroalgae hold great potential as a biosource for the production of dietary or medicinal supplements. Further research can focus on exploring the nutraceutical applications of these algae. The selected macroalgal samples were assessed for bioactive compounds, including polyphenols (phenolic acids & flavonoids), saponins, and tannins. Further research is necessary as marine macroalgae are abundant in natural antioxidants, making them potential biosources for antioxidant supplements production.

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تقييم أنشطة كسح مضادات الأكسدة لبعض الطحالب البحرية الوفيرة، مصر

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تهدف هذه الدراسة الى تقييم نشاط كسح مضادات الأكسدة لتسعة مستخلصات من الطحالب البحرية من أقسام الكلوروفيتا والرودوفيتا والفيوفيتا. تم اختبار المستخلصات باستخدام مقايسة DPPH. تم جمع المستخلصات من سواحل مصرية مختلفة، وأظهرت العديد من الأنشطة المضادة للأكسدة. فقد أظهرت جميع المستخلصات انخفاض كسح الجذور الحرة DPPH مقارنة بحمض الأسكوربيك. وزادت التأثيرات المضادة للأكسدة مع تركيز المستخلص، حيث أظهرت الطحالب البنية أعلى نشاط بين الطحالب الخضراء والحمراء. على وجه الخصوص، كان مستخلص الطحلب البنيى *Polycladia. myrica* أكثر فعالية ضد الجذور الحرة DPPH ، في حين أظهر الطحلب الأخضر *Ulva fasciata* أقل تأثير كسح. وقد كانت الأنواع الأكثر فعالية ضد الجذور الحرة DPPH هي الطحالب البنية (*Polycladia myrica* > *Turbinaria turbinata* > *Hormophysa cuneiformis*)، تليها الطحالب الحمراء الكبيرة (*Jania rubens*> *Hypnea cornuta* > *Galaxura rugosa*). وأظهرت الطحالب الخضراء الكبيرة أقل تأثير للكسح بتركيز ١٠٠٠ ميكروجرام / مل ، (*Caulerpa racemosa* > *Halimeda tuna* > *Ulva fasciata*). وأشارت قيم IC50 إلى أن *Ulva fasciata* و *Halimeda tuna* و *Caulerpa racemosa* كان لها أعلى نشاط مضاد للأكسدة، ثم سجلت الطحالب الحمراء *Galaxura rugosa* و> *Hypnea cornuta* >و *Jania rubens* بينما سجلت الطحالب البنية *Polycladia myrica, Turbinaria turbinata, Hormophysa cuneiformis* أدنى القيم وبشكل عام أظهرت أنواع الطحالب الكبيرة المدروسة إمكانات كبيرة مضادة للأكسدة بسبب المركبات النشطة بيولوجيا مثل البوليفينول والصابونين والدباغيات. فقد أظهرت *Caulerpa racemosa* أعلى تركيز للبوليفينول، بينما كان لدى *Galaxura rugosa* أدنى تركيز. وأظهرت *Ulva fasciata* و *Hormophysa cuneiformis* و *Polycladea myrica* أعلى محتوى إجمالي من الصابونين، بينما سجلت *Hypnea cornuta* أعلى محتوى إجمالي من الدباغيات. وتشير هذه النتائج إلى أن الطحالب الكبيرة يمكن أن تكون بمثابة بدائل غذائية بسبب قدراتها القوية المضادة للأكسدة.