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الطحالب البنية (سرجاسم سبريبانديم) الموجودة على شواطئ البحر الأبيض المتوسط في مصر مصدرًا هاما للمركبات النشطة بيولوجيًا

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Abstract:

The goal of this research is to evaluate the antioxidant activity and quantity of bioactive components in extracts from brown algae (Sargassum subrepandum). According to information relating to the elements included in brown algae powder, the greatest ingredient (54.91 g/100 g) was found to be carbohydrates, which were followed in size by ash (20.67 g/100 g), crude fiber (9.02 g/100 g), total protein (6.09 g/100 g), and crude fat (1.08 g/100 g). Additionally, the bioactive chemical composition of the brown algae extracts showed that the greatest element in all of the extracts was polysaccharides, which were followed in order by polyphenols, triterpenoids, tannins, flavonoids, carotenoids, kaempherol, and anthocyanins. Compared to the other extracts (hexane and aquatic), the ethanol extract of brown algae showed a greater concentration of all assessed bioactive components. A number of highly significant biological activities were also detected in the various extracts of brown algae specimens, especially the ethanolic ones. These activities included antioxidant capacity, scavenging of free radicals (Peroxyl radical, ROO-), and suppression of low density lipoprotein oxidation (anti-atherosclerotic). These significant biological impacts may have a significant impact on methods for preventing, treating, and battling a variety of illnesses, particularly those for which oxidative stress is a component of the underlying causes, like cancer, diabetes, obesity, atherosclerosis, cardiovascular disease, and aging-related disorders. As a result, the current research has suggested that brown algae extracts be added to our regular meals, beverages, dietary supplements, and pharmaceutical preparations.

Keywords:

proximate composition, *Sargassum subrepandum*, antioxidant, peroxyl radical scavenging, inhibition of LDL oxidation.

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مستخلص البحث:

تهدف الدراسة الحالية إلى تحديد محتوى المركبات النشطة بيولوجيا وفعاليتها المضادة للأكسدة في مستخلصات الطحالب البنية (Sargassum subrepandum). أشارت بيانات التركيب الكيميائى لمسحوق الطحالب البنية إلى أن الكربوهيدرات كانت أكبر المركبات (54.91 جم / 100 جم)، يليه الرماد (20.67 جم / 100 جم)، والألياف الخام (9.02 جم / 100 جم)، والبروتين الكلي (6.09 .(جم/100 جم)، والدهون الخام (1.08 جم/100 جم). كما أشار محتوى المركبات النشطة بيولوجيا لمستخلصات الطحالب البنية إلى أن السكريات العديدة كانت أكبر نسبة لمركب في جميع المستخلصات تليها البوليفينول، التراي تيربينويدات، التانينات، الفلافونويدات، الكاروتينات، الكايمفيرول والأنثوسيانين على التوالي .سجل مستخلص الإيثانول للطحالب البنية محتوى أعلى من جميع المكونات النشطة بيولوجيا التي تم اختبارها مقارنة بالمستخلصات الأخرى (المائية والهكسان) . كما سجلت المستخلصات المختلفة لعينات الطحالب البنية وخاصة الإيثانولية عدة أنشطة بيولوجية عالية جدًا والتي تشمل نشاط مضادات الأكسدة ونشاط الكسحى للجذور الحرة (جذر البيروكسيل، -ROO) وتثبيط أكسدة البروتين الدهني منخفض الكثافة (مضاد لتصلب الشرايين) . ولعل مثل هذه التأثيرات البيولوجية المهمة يمكن أن تلعب أدوارًا مهمة في استراتيجيات مكافحة / الوقاية / علاج العديد من الأمراض، خاصة تلك التي يكون الإجهاد التأكسدي أحد آليات حدوثها مثل السمنة والسكري والسرطان وتصلب الشرايين والقلب وأمراض الشيخوخة وما إلى ذلك .أوصت الدراسة الحالية بإدراج مستخلصات الطحالب البنية في نظامنا الغذائي اليومي والمشروبات والمكملات الغذائية والصيغ الدوائية

الكلمات المفتاحية:

سرجاسم سيربريبانديم ، التركيب الكيميائى، مضادات الأكسدة، النشاط الكسحى للجذور الحرة ، تثبيط أكسدة البروتين الدهني منخفضة الكثافة.

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Introduction

The majority of nations, like Egypt, are now experiencing a significant food and medication gap, meaning is an imbalance between the amount of food and medication required and the number of the population (Madi, 2014). In order to close the gap in food and pharmaceutical supplies and prevent the appearance of undernutrition and inability to cure multiple illnesses among certain social groups, the governments imports medicine and food from outside to make up for the lack. To close the gap between medicine and food, one suggested option that has garnered a lot of traction both locally and internationally is to look for novel sources of both. Algae are the most abundant plant organisms found in these sources because of their ability to grow and reproduce quickly in a variety of climates, their lack of need for special care, and their abundance in vital nutrient groups like protein, healthy fats, minerals, and vitamins (Stojkovic *et al.*, 2014; Sumaira *et al*, 2016). However, besides to the health risks and harmful adverse reactions that come with using them, it is abundant in a variety of types of bioactive substances with significant biological functions that serve as essential natural sources of medicine in place of expensive, chemically developed treatments and medications. Algae are a prospective source of medicinal chemicals and an inexpensive and easily available source of nutritious components due to these and other qualities (Abd Elalal et al., 2021; Abdelrahman, 2022; Gad Alla, 2023; Elhassaneen et al., 2023).

The eukaryotic class known as Heterokontophyta, which includes brown algae, is characterized by a significant number of organisms with four membranes around their chloroplasts. This characteristic suggests that the group originated from a symbiotic interaction between another eukaryotic creature and a basal eukaryote. Fucoxanthin, a pigment found in many brown algae, is what gives them their characteristic greenish-brown color and name. Their reproduction is by producing gametes and flagellated spores that mimic the cells of other heterokonts, but they are distinct between heterokonts in that they mature into multicellular shapes with differentiated tissues. Based on genetic research, yellow-green algae are their closest relatives (Mann and Martin, 2002). Additionally, a vast group of predominantly marine multicellular algae, called the brown algae family (Family Phaeophyceae), which includes several seaweeds, may be found in many nations, involving Egypt. Many individuals are also familiar with some forms of brown algae as sources of nourishment and habitats. In contrast to this, brown algae are part of a wide and varied world of algae that are vital to our survival as well as helpful to it (Guiry, 2001 Although the abundance of herbivorous predators, brown algae are also commonly found as the predominant flora in shallow water subtropical and tropical ecosystems in Egypt (Gerwick *et al.*, 1981). Brown algae are now the most common category in the littoral zone along the Egyptian coast. There are about 2000 identified species of brown in the globe. In the subtropical and tropical seas of the Mediterranean and Red Seas, certain species, as those owing to the Sargassum genus, form distinctive floating seaweed mats that function as homes for several species (Mann and Martin, 2002; Rushdi et al., 2020). They are significant for commercial application since they are now the focus of in-depth research on their own (El-Gamal, 2020; Elhassaneen et al., 2020; Rushdi et al., 2020; Fayez, 2021; Gad Alla, 2023). According to these research, brown algae are a good source of lipids, proteins, fibers, minerals, and essential amino and fatty acids, among other nutrients.Brown algae is consumed fresh in salads, rolls, stews, and rice dishes; it is also consumed dried in condiment and soup bases. It is believed that some classical Asian diets' general composition lowers the risk of malignancy, especially cancers of the breast (Kanke *et al.*, 1998; Funahashi *et al.*, 2001and Lawson, 2001). Further investigation is still required to determine what other functions brown algae, an essential nutritional source, may have, despite the fact that all of these and other earlier research have focused on the various nutritional advantages of brown algae. Thus, the objective of this investigation is to quantify the bioactive chemicals present in the brown algae genus Sargassum that is located along Egypt's Mediterranean Sea coast. Furthermore, these bioactive chemicals' biological effects (also known as antioxidant properties) will be covered in this study.

Materials and Methods

Ethical approval

The Scientific Research Ethics Committee (Animal Care and Use), Faculty of Home Economics, Menoufia University, Shebin El-Kom, Egypt, granted ethical approval for the utilization of rats as a biological model in the experimental design of the research (Approval number. 05- SREC- 01-2020).

Materials

Brown algae samples

Samples of brown algae (Sargassum subrepandum) were gathered from the Mediterranean Sea coastlines of Alexandria, Alexandria Governorate, Egypt. After being removed from the water, the specimens were examined by staff members at the Faculty of Agriculture, Alexandria University, Alexandria, Egypt.

Chemicals

Standard bioactive chemicals, such as α-tocopherol, butylated hydroxytoluene (BHT), and gallic acid (GA), as well as 2,2′-Azobis(2-methylpropionamidine) dihydrochloride and $CuSO_4$, were acquired from Sigma Chemical Co., located in St.

Louis, MO. All additional chemicals (except from those specifically mentioned), reagents, and solvents were obtained from El-Ghomhorya Company for Trading Medicines, Chemicals, and Medical Instruments in Cairo, Egypt, and were of analytical quality.

Biological model

Through careful scheduling, 140g of adult male Sprague Dawley strain albinos were procured from Laboratory Animal Colony, Vaccine and Immunity Organization, Cairo, Egypt. Rats were housed, cared for, and kept in typical, healthy circumstances in compliance with the guidelines set out by the Commission on Life Sciences, Institute of Laboratory Animal Resources, National Research Council (NRC, 1996). The protocol as stated by AIN (1993) was followed in preparing the basic meal for feeding rats.

Methods

Preparation of brown algae powder and extracts

Brown algae extracts and powder were made based on the procedure illustrated by Abd Elalal et al. in 2021. To put it briefly, brown algae samples were manually cleaned, sorted, and dried until the final product had around 8% moisture. The dehydrated samples were finely powdered, and the portion that made it through an 80 mesh filter was saved for usage in the manufacture of extracts and analysis. Twenty grams of dry brown algae powder and 180 milliliters of water were homogenized, then put in a beaker and shaken at 200 rpm in an orbital shaker (Unimax 1010, Heidolph Instruments GmbH & Co. KG, Germany) for a full hour at room temperature in order to prepare the extracts. Next, the extract was filtered utilizing Whatman No. 1 filter paper to remove the residue. After again extracting the residue that remained, the two extracts were mixed. The remaining water was evaporated at 55°C utilizing a rotary evaporator (Laborata 4000; Heidolph Instruments GmbH & Co. KG, Germany) and decreased pressure. The same process was carried out, substituting ethanol (80%, v/v) and hexane (99%, v/v) for the extraction medium. A rotary evaporator was utilized to extract the remaining solvent at low pressure and 45°C.

Chemical analysis of brown algae powder

The proximate composition involving moisture, protein of brown algae powder samples was examined utilizing semiautomated apparatus from Velp Company, Italy (T.N. × 6.25, micro-Kjeldahl technique), fat (soxhelt miautomatic apparatus Velp Company, Italy, petroleum ether solvent), fiber contents, and ash were calculated utilizing the techniques outlined in the AOAC (1995). Carbohydrates (%) = 100 - (% protein + % moisture + % ash + % fat + % fiber) is the formula for calculating carbohydrates based on differences.

Bioactive constituents

Utilizing the UV-160A; Shimadzu Corporation, Kyoto, Japan, absorbance for several assays was determined over the course of this investigation. Utilizing the Folin-Ciocalteu reagent, the total phenolics in brown algae powder were calculated in accordance with Singleton and Rossi (1965) and Wolfe et al. (2003), and were expressed as gallic acid equivalents (GAE). Utilizing a colorimetric technique as published by Zhisen et al. (1999), the total flavonoid levels were calculated and represented as catechin equivalent, or CAE. The technique of Vazirian et al. (2014) was utilized to quantify total polysaccharides, which were then represented as milligrams of starch equivalents. The Litchenthaler (1987) technique was employed to calculate the total carotenoids. Tannins were quantified as catechine equivalents via the Van-Burden and Robinson (1981) technique. The Ghorai et al. (2012) technique was applied to quantify total terpenoids, which were then represented in milligrams of linalool equivalents. Measurements of kaempherol were conducted using the protocol outlined in Fouda et al. (2019). The technique of Schneider et al. (2009) was utilized for assessing total triterpenoids, which were then quantified in milligrams of ursolic acid equivalents.

Biological activity determination

Antioxidant activity

Using a modified version of Marco's 1968 protocol, the antioxidant activity (AA) of brown algal extracts and standards (BHT and α-tocopherol) was assessed using the β-carotene bleaching (BCB) assessment.

Peroxyl radical (ROO^-)-scavenging activity

Using an enhanced oxygen radical absorbance capacity (ORAC) test like the one reported by Ou et al. (2001), peroxyl radical-scavenging activity was assessed. To summarize, the first fluorescence intensity was observed after 5 minutes of incubation at 37 0C with 200 µl of sample extract, 3.5 ml phosphate buffer (75 mM, pH 7.4), and 100 µl of fluorescein (FL, 35 nM) mixed together. To initiate the reaction, (200 µl, 75 g/l) of 2,2-azobis (2-amidinopropane) dihydrochloride (AAPH) was added. Till the fluorescence intensity reached zero, measurements of the fluorescence were obtained every three minutes. The wavelengths of emission and excitation were 515 and 493 nm, respectively. Trolox was further employed as a guide to adjust the ultimate outcomes.

Inhibition of low density lipoprotein (LDL) oxidation

Using the Princen et al., (1992) technique, the inhibition of the oxidation of LDL was examined. The concentration of rat serum was diluted to 0.6% using phosphate buffer (50 mM, pH 7.4). A mixture of 5.0 ml diluted serum and either 10 µl DMSO or 10 µl DMSO with different amounts of all the examined brown algae extracts was combined. Initiating the reaction required 20 µl of CuSO4 solution (2.5 mM). The absorbance at 234 nm was assessed, and measurements were performed for 140 minutes every 20 minutes at room temperature. The computation of the net area under the curve (AUC) was utilized to express the last findings.

Statistical Analysis

Every measurement and test was conducted in triplicate, and the results were reported as mean ± SD. Statistical analysis was carried out utilizing MINITAB 12 computer program (Minitab Inc., State College, PA) and Student t-test.

Results and Discussion

Proximate composition of brown algae powder

Proximate composition of brown algae (Sargassum subrepandum) powder was revealed in Table (1). Such information might reveal that carbohydrates is the greatest compound (54.91 ± 3.45 g/100) followed by ash, crude fiber, total protein and crude fat which recorded 20.67 ± 1.17, 9.02 ± 2.26, 6.09 ±1.03 and 1.08 ± 0.11 g/`100g, respectively. The study's findings are consistent with what was noticed by several studies carried out in brown algae samples collected from Egyptian Mediterranean beaches (Abd Elalal et al., 2021; Elhassaneen et al., 2021; Abdelrahman, 2022; Gad Alla, 2023; Elhassaneen et al., 2023-a). While brown algae samples are low in calories, they typically include a large amount of carbohydrates, which can account for up to 70% of their dry weight (Lahaye, 1991). According to Holdt and Kraan (2011), brown algae powder has a high concentration of storage, functional, and structural polysaccharides, and according to the species, the total carbohydrate content can vary from 20% to 76% of dry weight. According to related studies (Dawczynski et al., 2007; Antonopoulou et al., 2005; Mendis and Kim, 2011; Rodrigues et al., 2015), the fat content of brown algae varied from 0.9 to 4% of dry weight. Data from the current study and others indicated that the chemical composition of the brown algae powder were affected by the following factors: site, species, water temperature, season, depth, nutrients in water, light intensity, salinity, pH, or/and mixature of these parameters (Guschina and Harwood, 2006; El-Gamal, 2020; Abd Elalal et al., 2021; Abdelrahman, 2022; Gad Alla, 2023; Elhassaneen et al., 2023).

Table 1. Proximate composition of brown algae (*Sargassum subrepandum*) powder (**g/100g)**

Component	Range	Mean ±SD
Moisture	7.03-9.95	8.23±0.76
Total protein	5.01- 7.04	6.09 ±1.03
Crude fat	0.92-1.65	1.08 ± 0.11
Ash	18.17-21.63	20.67 ± 1.17
Crude Fiber	7.11-10.74	9.02 ± 2.26
Carbohydrate	57.43-66.62	54.91 ± 3.45

Every value represents the mean of three replicates ±SD.

Bioactive constituents of brown algae

Bioactive constituents of brown algae extracts were demonstrated in Table (2). It was evident from the information provided that polysaccharides were the greatest component in all brown algae extracts followed by polyphenols, triterpenoids, tannins, flavonoids, carotenoids, kaempherol and anthocyanins. Ethanol extract of the brown algae recorded the higher content of the tested bioactive constituents than the other extracts (aquatic and hexane). The findings match those that have been recorded by many studies carried out in brown algae samples collected from Egyptian Mediterranean beaches (El-Gamal, 2020; Abd Elalal et al., 2021; Elhassaneen et al., 2021; Abdelrahman, 2022; Gad Alla, 2023; Elhassaneen et al., 2023-a). According to Helen (2003) and Chapman and Chapman (1980), polysaccharides that involve alginates, cellulose, and sulfated polysaccharides as laminarins and fucoidans, are the main bioactive elements in brown algae. The main reason for the noticed fluctuations in the concentration of bioactive chemicals in the brown algae extracts is the differing polarity of the extraction solvents. Sulaiman et al. (2011) state that the solubility and extraction yield of chemical components in a sample may be impacted by the polarity differences of the extracting solvents. The present data confirmed that brown algae almost bioactive components were found in lipophilic phase i.e. in line with the established rule "like dissolves like" which meaning that substances with similar chemical characteristics of polarity will dissolve in each other. Therefore, one of the most important steps in enhancing the recovery of the bioactive components from extracts, such as total phenols, flavonoids, terpenoids, triterpenoids, carotenoids, etc., is identifying a suitable solvent technique.

All of the bioactive substances found in brown algae generally have important functions in the preparation of food, consumption by humans, and medicinal uses. These functions include: The biological roles of polysaccharides involve antithrombotic, anticoagulant, anti-obesity, anti-inflammatory, antiviral, anti-osteoporosis, antimicrobial, antioxidant, and hypolipidemic and hypocholesterolemic responses. Polysaccharides are used as gelling, and thickening agents, and stabilizers of emulsion (Burtin, 2003; Helen, 2003; Fitton et al., 2008; Bixler and Porse, 2011; Nagaoka et al., 2000; El-Gamal, 2020; Elhassaneen et al., 2020; 2021; 2023; Abd Elalal et al., 2021; Gad Alla, 2023), 2) Phenolics, carotenoids, flavonoids, and anthocyanins all have significant biological roles, such as scavenging and acting as antioxidants, in addition to preventing the low-density lipoproteins oxidation (Elhassaneen and Sanad, 2009; Elhassaneen et al., 2016 a-c, 2019, Abd Elalal et al, 2021; Gharib et al., 2022; Gad Alla, 2023), 3) Triterpenoids have demonstrated protective properties against xenobiotic-induced liver damage and can be used as a foundation for the production of more powerful bioactive derivatives, including experimental anticancer medicines (Liu, 1999 and Zhou et al., 2002; Ma et al., 2005), 4) Kaempferol strengthens the body's antioxidant response versus free radicals, lowers the risk of chronic illnesses, involving malignancy, and modifies angiogenesis, inflammation, metastasis, and apoptosis (Allen and Yi 2013), 5) Tannins are utilized as a preservation agent for food and for packaging goals in the food business. They have also been revealed to be effective antibacterial, anti-inflammatory, antidiabetic, anticancer, cardioprotective, antioxidant, antiviral, and biopesticide agents. (Rajak et al., 2023). All of the above with the others have courage several researchers to use successively brown algae with applications related to the processing of food and human medicinal nutrition (Bixler and Porse, 2011; Mohamed, 2020; Elhassaneen et al., 2020; Gad Alla, 2023).

Table 4. Bioactive constituents of brown algae on dry weight basis

Component	AEBA	HEBA	EEBA
Polyphenols (mg gallic acid equivalent.g^{-1})	17.19±2.34^{c}	68.65±3.89^{b}	101.24±5.02^{a}
Anthocyanin's (mg Cyanidin 3-glucoside, CCy3G equivalent.g^{-1}).	1.05±0.07^{c}	3.53±0.09^{b}	5.41±1.02^{a}
Carotenoids (mg.g^{-1})	5.44±0.77^{b}	3.60±0.34^{c}	8.62±1.09^{a}
Kaempherol (mg.g^{-1})	4.53±0.98^{a}	4.24±0.88^{a}	5.61±0.76^{a}
Polysaccharides (mg starch.g^{-1})	48.37±5.04^{b}	64.00±4.13^{b}	117.63±3.09^{a}
Terpenoids (mg linalol. g^{-1})	2.07 ±13.56^{b}	1.90±10.56^{c}	2.98±20.54^{a}

Triterpenoids (mg ursolic acid.g-1)	55.04±3.98 [ab]	46.20±1.67 [b]	59.99±5.62 [a]
Flavonoids (mg catechin equivalent. g^{-1})	2.63±0.23 [b]	11.19±1.54 [a]	14.36±2.09 [a]
Tannins (mg catechine equivalent. g^{-1})	9.15±0.76 [b]	5.34±0.68 [c]	14.42±1.65 [a]

*Every value represents the mean of three replicates ±SD.

Biological activities of brown algae extracts

Antioxidant activities

Antioxidant activity (AA) of brown algae extracts and standards were revealed in Table (5). Such information suggested that EEBA showed the highest antioxidant activity (AA, 89.25 ± 2.59 %) followed by HEBA (61.33 ± 1.9%) and AEBA (49.15 ± 2.21%). The increasing of antioxidant activity in all brown algae is correlated with its reasonable content of various bioactive components involving flavonoids, polysaccharides, phenolics, carotenoids, tannins etc. The variation in the antioxidant activity values in different brown algae extracts may be possible because of the existence of different amounts of such specific bioactive constituents (El-Gamal, 2020; Abd Elalal et al., 2021; Elhassaneen et al., 2023-a). Such studies also noted that brown algae are rich in and bioactive compounds (polyphenols, polysaccharides, triterpenoids, tannins, flavonoids, carotenoids, kaempherol and anthocyanin's subsequently antioxidant activities. Also, Abd Elalal et al., (2021) and Gad Alla, (2023) noted that brown algae contain a huge quantity of unique vitamins and minerals which exhibited different biological roles including the antioxidant activity.

Table (8). Antioxidant activity (AA) of brown algae extracts and standards

Extract	Value (Mean ±SD)
Aquatic extract of BA (AEBA)	49.15 ± 2.21 [d]
Hexane extract of BA (HEBA)	61.33 ± 1.9[c]
Ethanol extract of BA (EEBA)	89.25 ± 2.59 [b]
α-tocopherol (Standard, 50 mg/L)	98.91 ± 0.50[a]
Butalyted hydroxyl toluene (BHT,Standard, 50 mg/L)	88.12 ± 0.11[b]
Butalyted hydroxyl toluene (BHT, Standard, 200mg/L)	97.90 ± 0.13[a]

* The mean of 10 replicates ±SD is shown for every value. At the p≤0.05 level, mean values in the same column with distinct superscript letters indicate a significant difference.

Peroxyl radical (ROO^-)-scavenging activity

Peroxyl radical (ROO-)-scavenging role of brown algae was illustrated in Figure (2). According to these findings, the EEBA, HEBA, and AEBA functioned more significantly in their preventative ability against ROO-formation/scavenging activity than the brown algae extracts did. When it came to forming/scavenging the ROO-, the EEBA seemed to be more successful than the other extracts. Under oxidative stress in live cells, lipid oxidation leads to the creation of ROO-. Generally, the peroxyl radicals (ROO-) prevention capacity assay was utilized to evaluate the preventive potential of brown algae extracts against ROO-. This assay depends on the extract(s) tested's ability to chelate metals, which is connected to the extract's capacity against ROO-. Fluorescein is utilized as the sensitive probe for free radical attack in this experiment, and the reagent 2,2'-Azobis(2-amidinopropane) dihydrochloride (AAPH) is used to create ROO- (Li et al., 2006). These outcomes are in same line with what other writers have written on algae and various plant parts (Aly et al., 2018; Abd Elalal et al., 2021; Elhassaneen et al., 2021and 2023; Fayez, 2021; Gad Alla, 2023). Therefore, by scavenging some of the free radicals formed throughout that process, the current study's data suggested that brown algae extracts, in particular EEBA, could be effectively applied as a promising tool in either the prevention or treatment of certain illnesses whose mechanisms of development involve oxidative stress. These diseases include obesity, diabetes, heart disease, liver disease, and aging (Chan, 1996; Dröge, 2002; Elhassaneen et al., 2023 a and b; El-Hawary, 2023; Mahran and Elhassaneen, 2023; Gad Alla, 2023).

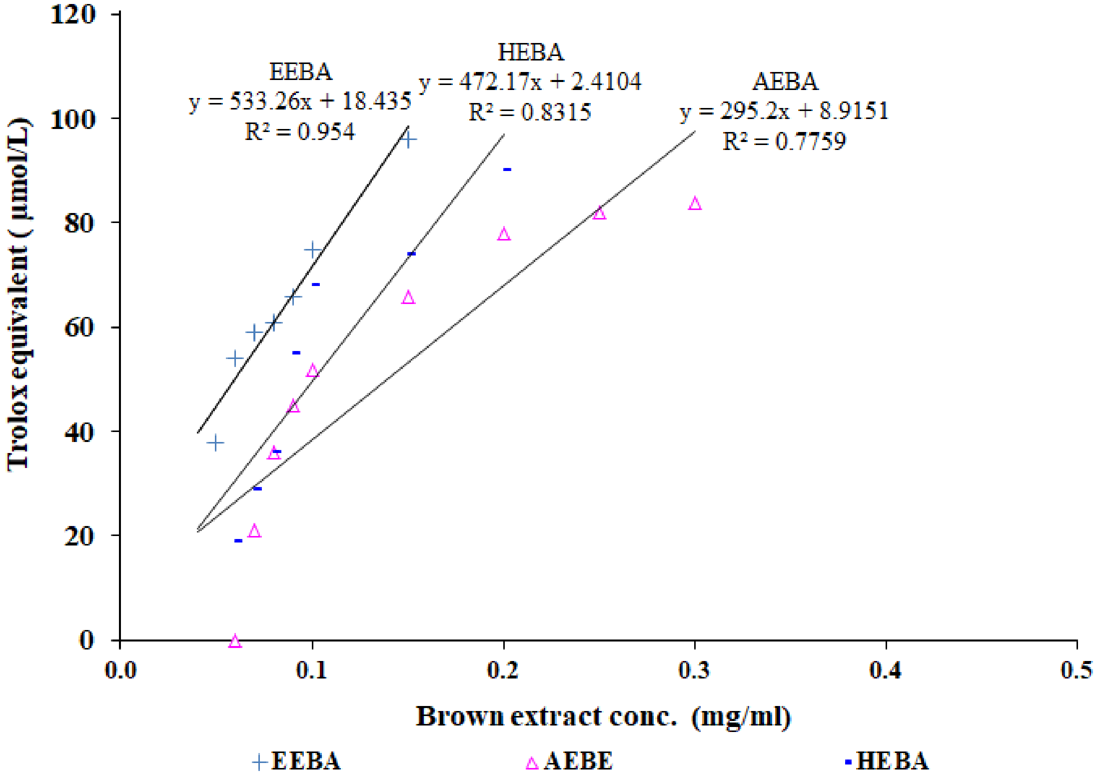

Figure 4. Dose-dependent ROO^- scavenging capacity of brown algae as assessed by enhanced oxygen radical absorbance capacity (ORAC) assay. EEBA , ethanol extract, HEBA, hexane extract and AEBAE, water extract.

Inhibition of low density lipoprotein (LDL) oxidation

Figure (2) depicts the dose-dependent suppression of CuSO4-induced low density lipoprotein (LDL) oxidation in vitro by extracts from brown algae. These results demonstrated the inhibitory effect of all brown algae extracts against CuSO4-induced LDL oxidation, as demonstrated by a dose-dependent decline in the generation of conjugated dienes. A comparative analysis of the brown algae extracts revealed that the AEBA, EEBA, and EEBA had a greater protective effect on LDL against oxidation. The sequence of the brown algae extracts that protected LDL against oxidative activity was EEBA > EEBA > AEBA. The current research demonstrated that the many bioactive chemicals (polysaccharides, carotenoids, flavonoids, anthocyanins, terpenoids, phenolics, tannins, triterpenoids, etc.) that brown algae extracts contain function as antioxidants to protect low-density lipoproteins (LDLs) against oxidation (Plaza et al., 2010; Shinichi, 2011; El-Gamal, 2020; Fayez, 2021; Gad Alla, 2023). Relative findings was recorded by Elhassaneen et al., (2023-a) with the extracts of brown algae samples collected from the Egyptian Mediterranean beaches. In this way, several authors observed that different plant parts extracts involved similar bioactive constituents in brown algae prevent oxidation of LDL in vitro (Aviram et al., 2000; and Li et al., 2006; Aly et al., 2018). Rises in glutathione reductase (GSH-Rd) and reduced glutathione (GSH) in the lungs and liver, in addition to a rise in the prevention of NADPH-dependent lipid peroxidation, may be the processes by which brown algae bioactive compounds protect LDL from oxidation (Majid et al., 1991; Elbasouny et al., 2019; El-Gamal, 2020; Elhassaneen et al., 2023; Gad Alla, 2023; El-Hawary, 2023). According to Aviram et al. (2000) and Chisolm and Steinberg (2000), the "oxidative modification of lipoproteins" theory, which depends on the oxidation of lipoproteins, is essential in the early stages of atherosclerosis. Since oxidized lipoproteins have cytotoxic impacts on artery cells, which encourage monocyte adhesion to the endothelium and result in the creation of atheromatous plaques, they are atherogenic (Hong and Cam, 2015). The outcomes of this investigation illustrated that by blocking the oxidation of lipoproteins, extracts from brown algae might be a useful weapon in the fight against atherosclerosis.

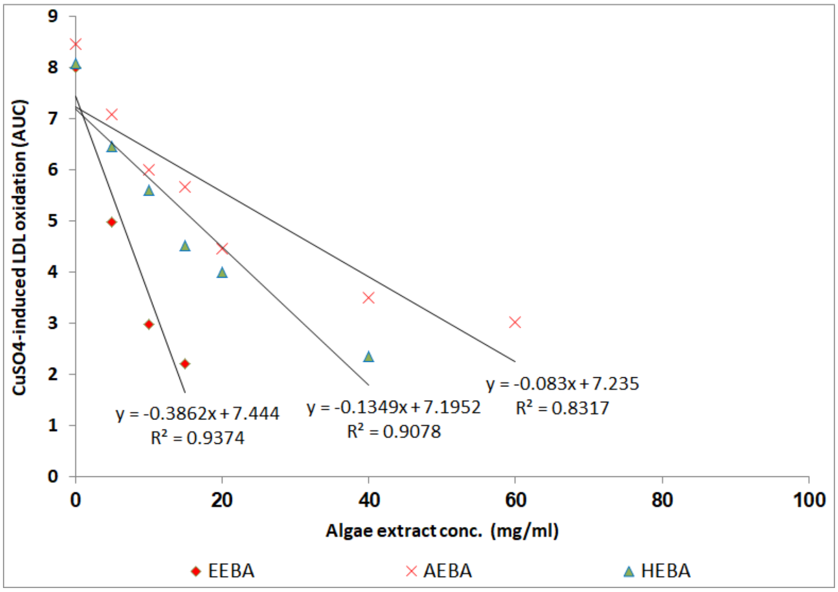

Figure 2. Brown algae extract exhibit dose-dependent suppression of CuSO4-induced low density lipoprotein (LDL) oxidation in vitro. The area under the curve (AUC) is the outcome of measuring the conjugated diene production as the absorbance at 234 nm.

Conclusion

Our hypothesis was validated by the results of the research, which showed that brown algae are composed of various bioactive components, such as polysaccharides, polyphenols, triterpenoids, tannins, flavonoids, carotenoids, kaempherol, and anthocyanins, among others, which are responsible for their distinct biological functions. This study examined several biological and antioxidant activities, such as the rate of beta-carotene bleaching, the ability of ROO-radical scavenging, and the prevention of low-density lipoprotein (LDL) oxidation. These significant biological processes may have a significant impact on methods for preventing, treating, and battling a variety of illnesses, particularly those for which oxidative stress is a component of the underlying causes (obesity, cancer, diabetes, atherosclerosis, cardiovascular diseases, aging disorders, etc.). As a result, the current research suggested that we use such brown algae extracts into our regular meals, beverages, food supplements, and prescription formulations.

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Conflict of Interests

None.

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