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Antioxidant capacity and Total phenolic compounds of some seaweeds from Jarjar oma coast, Libya

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Abstract

This study aimed to assess the antioxidant activity and total phenolic content of twelve seaweed species collected from the Jarjar Oma coastline. All evaluated extracts demonstrated notable antioxidant properties, showing their potential use in pharmaceutical applications and the food industry. The antioxidant capacity varied significantly among species, showing a strong species-specific influence. The green alga *Cladophora glomerata* exhibited the highest antioxidant activity followed by *Acetabularia acetabulum* and *Oedogonium grande*, further supporting the trend that green algae generally show stronger antioxidant properties compared to brown or red algae. In contrast, brown algae such as *Cystoseira barbata*, *Padina pavonica*, and *Dictyota dichotoma* demonstrated the lowest antioxidant activities, possibly due to seasonal variation, extraction methods, or differences in phenolic compound composition. Red algae, including *Laurencia papillosa* and *Polysiphonia lanosa*, exhibited moderate antioxidant activity. The study also revealed significant variation in total phenolic content among the seaweed species. The highest phenolic content was observed in the green alga *Oedogonium grande*, followed *Cladophora glomerata*. Brown algae such as *Cystoseira crinita*, *C. compressa*, and *C. barbata* showed moderate phenolic levels, consistent with their known richness in phlorotannins. In contrast, red algae like *Jania rubens* and *Polysiphonia lanosa* exhibited the lowest phenolic contents.

These results indicate that the phenolic content and antioxidant activity of seaweeds are strongly influenced by their taxonomic

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classification, ecological habitat, and surrounding environmental factors.

Keywords: Seaweed, Total Phenolic Content، Antioxidant capacity, Jarjar oma coast.

القدرة المضادة للأكسدة والمركبات الفينولية الكلية لبعض الأعشاب البحرية من ساحل جارجر، ليبيا

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الملخص:

هدفت هذه الدراسة إلى تقييم النشاط المضاد للأكسدة والمحتوى الفينولي الكلي لاثني عشر نوعًا من الأعشاب البحرية التي جُمعت من ساحل جارجار أمه. أظهرت جميع المستخلصات المقيّمة خصائص مضادة للأكسدة ملحوظة، مما يُظهر إمكانية استخدامها في التطبيقات الصيدلانية وصناعة الأغذية. تباينت قدرة مضادات الأكسدة بشكل كبير بين الأنواع، مما يُظهر تأثيرًا قويًا خاصًا بكل نوع. أظهر الطحلب الأخضر *Cladophora glomerata* أعلى نشاط مضاد للأكسدة، يليه *Acetabularia acetabulum* و *Oedogonium grande*، مما يدعم بشكل أكبر الاعتقاد بأن الطحالب الخضراء تُظهر عمومًا خصائص مضادة للأكسدة أقوى مقارنةً بالطحالب البنية أو الحمراء. في المقابل، أظهرت الطحالب البنية مثل *Cystoseira barbata* و *Padina pavonica* و *Dictyota dichotoma* أدنى نشاط مضاد للأكسدة، ربما بسبب التباين الموسمي أو طرق الاستخلاص أو الاختلافات في تركيب المركبات الفينولية. أظهرت الطحالب الحمراء، بما في ذلك *Laurencia papillosa* و *Polysiphonia lanosa*، نشاطًا مضادًا للأكسدة معتدلًا. كما كشفت الدراسة عن تباين كبير في المحتوى الفينولي الكلي بين أنواع الأعشاب البحرية. لوحظ أعلى محتوى فينولي في الطحلب الأخضر *Oedogonium grande*، يليه *Cladophora glomerata*. وأظهرت الطحالب البنية، مثل *Cystoseira crinita*, *C. compressa*, and *C. barbata*

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مستويات فينولية معتدلة، تتوافق مع غناها المعروف بالفلوروتانينات. في المقابل، أظهرت الطحالب الحمراء مثل *Jania rubens* و*Polysiphonia lanosa* أقل محتوى فينولي.
تشير هذه النتائج إلى أن المحتوى الفينولي ونشاط مضادات الأكسدة في الأعشاب البحرية يتأثران بشدة بتصنيفها التصنيفي، وموطنها البيئي، والعوامل البيئية المحيطة بها.

الكلمات المفتاحية: الأعشاب البحرية، المحتوى الفينولي الكلي، القدرة المضادة للأكسدة، ساحل جارجار أمه.

1. Introduction:

Macroalgae, commonly referred to as seaweeds, are photosynthetic, plant-like organisms that predominantly inhabit the benthic littoral zones of marine environments. They are taxonomically categorized into three main groups based on their pigmentation and other physiological traits: green algae (*Chlorophyta*), brown algae (*Phaeophyta*), and red algae (*Rhodophyta*) (Otero *et al*., 2018). Seaweeds are recognized for their rich nutritional profile, offering a wide range of both macronutrients and micronutrients. These include essential vitamins, minerals, proteins, carbohydrates, dietary fibers, and lipids (Ortiz *et al*., 2006; Yaich *et al*., 2015). Beyond their nutritional value, seaweeds are recognized for their richness in bioactive compounds, which provide notable health benefits and support their incorporation as functional ingredients in food products (Farideh *et al*., 2013). One of the key applications of compounds derived from seaweeds is in the production of phycocolloids such as agar, alginate, and carrageenan which function as natural thickening and gelling agents across the food, pharmaceutical, and cosmetic industries (Balboa *et a*l., 2013; Fleurence, 1999; Lordan *et al*., 2011; Marinho-Soriano et al., 2006). In addition, seaweed-based products are widely employed in fertilizers, animal feed, and various biotechnological fields due to their nutrient-rich composition and growth promoting properties. Seaweeds have also been extensively studied for their antioxidant potential. Antioxidant compounds play a critical role in neutralizing free radicals, which are reactive oxygen species associated with oxidative stress, aging, and various chronic diseases. These compounds scavenge free radicals by donating electrons or hydrogen atoms, converting them into more stable, non-radical molecules, thereby mitigating cellular damage (Kuda *et al*., 2005; Yuan and Carrington, 2006; Yamaguchi *et al*., 1998). The presence of polyphenols, sulfated polysaccharides, vitamins, and other

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bioactive molecules contributes significantly to this antioxidant activity (Farideh *et al*., 2013; Jiménez-Escrig and Sánchez-Muniz, 2000). Given the increasing demand for natural and health-promoting food sources, there is growing interest in exploring seaweeds as potential antioxidant agents. Seaweeds contain a diverse array of high-value compounds, including omega-3 polyunsaturated fatty acids, polyphenols, alkaloids, terpenes, pigments (such as chlorophylls, carotenoids, and phycobilins), and a wide variety of polysaccharides (Pereira *et al*., 2021). These constituents are associated with various biological activities, such as antioxidant, antimicrobial, anticancer, antiviral, anticoagulant, and anti-inflammatory effects (Barkia *et al*., 2019; Kosanić *et al*., 2014), making seaweeds valuable resources for both pharmaceutical and cosmetic industries (Alves *et al*., 2016). Polysaccharides represent one of the most abundant and functionally important classes of compounds in seaweeds, typically accounting for 5% to 75% of their dry weight, depending on species, age, and seasonal variations (Hentati *et al*., 2020). Interestingly, these marine-derived polysaccharides especially sulfated ones are absent from terrestrial plants and have been associated with a number of health advantages, such as the regulation of cholesterol and prebiotic effects (Ciancia and Leliaert, 2020). Different macroalgae have different compositions: green algae are known for their ulvan, red algae are known for their carrageenan, agar, and floridean starch, and brown algae are known for their alginate, laminarin, fucans, and fucoidans (De Jesus Raposo and De Morais, 2015). For instance, laminarin can constitute up to 50% of the dry weight in Laminaria species (Patil *et al*., 2018).

Therefore, the present study aims to investigate the antioxidant potential of various macroalgal species, with the objective of identifying sustainable, natural sources of bioactive compounds that may contribute to improved human health and support the development of functional foods and therapeutic agents.

2. Materials and Methods:

2.1. preparations of seaweeds extracts:

The seaweeds utilized in this study were manually harvested from the surface waters of the Jarjar Oma coast, which is 30 kilometers west of Al Baida city and close to the Qasr Libya (Olebi) area northwest of Libya's Mediterranean coast, at a depth of 0.5 to 2 meters. We sampled twelve different kinds of seaweed. To get rid

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of salt and debris, distilled water was used to rinse each sample before it was dried. A grinder was used to grind the dry samples into a fine powder after they had been cut into little pieces.

After being sieved to achieve a consistent particle size, the ground samples were sealed in an airtight container and preserved in a freezer at -200C until additional analysis was done.

2.2. Determination of antioxidant capacity by prussian blue method:

Petroleum ether was used to defatten one gram of the sample powder. Following two stirrings with 10 ml of methanol, the defatted powder was extracted successively using 10 ml of 1% hydrochloric acid: methanol (v/v). Ten milliliters of methanol were used to dissolve the residue after the three combined extracts were vacuum-evaporated. Three milliliters of pure water, three milliliters of potassium ferricyanide (K3Fe (CN)6) (0.008 M), three milliliters of 0.1M HCl, and one milliliter of 1% ferric chloride (FeCl3) were added to half a milliliter of the solution. After five minutes of letting the blue color develop, the absorbance at 720 nm is measured in comparison to the blank. (Wangensteen *et al*., 2004)

2.3. Determination of Phenolic Compound Content:

Conventional methods were employed to estimate the content of phenolic compounds, utilizing the Folin–Ciocalteu reagent.

2.3.1. Folin–Ciocalteu Method for Phenolic Compound Determination:

This method was used to quantify phenolic compounds in aqueous extracts. A volume of 10 ml of the extract was mixed with 3 ml of distilled water and the Folin–Ciocalteu reagent. Gallic acid was used as a standard according to the method described by Slinkard and Singleton.After adding the seaweed samples to the test tubes, 0.5 ml of the Folin–Ciocalteu reagent and 2 ml of 20% sodium carbonate (Na_2CO_3) were added. The mixture was incubated for one minute, followed by a 15-minute cooling period. Absorbance was then measured at 650 nm using a UV-Visible spectrophotometer. The results were expressed as milligrams of gallic acid equivalents (GAE) per gram of fresh weight.

3. Results and Discussions:

3.1. Antioxidant activity contents:

The exploration of natural sources for antioxidants, particularly macroalgae, has garnered considerable attention from both the food

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and pharmaceutical industries. Seaweeds are considered among the richest natural sources of antioxidants (Veeraperumah *et al*., 2012). We discovered in this investigation that the extract from every variety of seaweed had antioxidant qualities that may be safely utilized in pharmaceutical formulations and food processing.
The results shown in Table (1) a clear variation in antioxidant activity among the studied seaweed species, with values ranging from 1.359 ± 0.315 to 6.124 ± 0.247, indicating significant species-specific differences in antioxidant capacity.

Table (1). Antioxidant activity contents in various seaweed species from the Jarjar Oma coast (ppm).

Seaweeds Species	Antioxidant activity (ppm)
Cladophora glomerata	6.124 ± 0.247 A
Oedogonium grande	4.026 ± 0.009 C
Dasycladus vermicularis	2.635 ± 0.091 D
Acetabularia acetabulum	5.458 ± 0.460 B
Cystoseira barbata	1.852 ± 0.025FG
Cystoseira Compressa	2.062 ± 0.066 EF
Cystoseira crinita	1.694 ± 0.012 FG
Padina pavonica	1.401 ± 0.0159 G
Dictyota dichotoma	1.359 ± 0.315 G
Polysiphonia lanosa	1.825 ± 0.157 FG
Jania rubens	1.505 ± 0.015 G
Laurencia papillosa	2.452 ± 0.019 DE

Values are expressed as means ± SD; n = 3 for each species of algae. Mean values within a column not sharing common superscript letters (A, B & C) were significantly different at $P < 0.05$. whereas means superscripts with the same letters mean that there is no significant difference ($P < 0.05$).

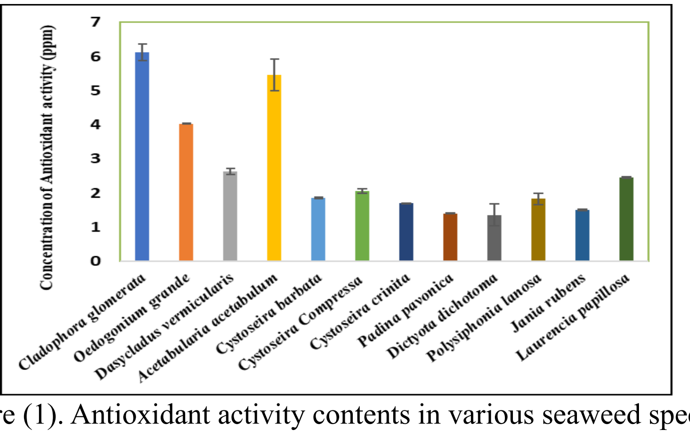

Figure (1). Antioxidant activity contents in various seaweed species from the Jarjar oma coast (ppm).

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The green alga *Cladophora glomerata* exhibited the highest antioxidant activity 6.124 ± 0.247. This result is consistent with findings by Wang *et al*. (2009) and Heo *et al*. (2005), who reported that green macroalgae can possess strong antioxidant potential due to their high content of polyphenols, flavonoids, and other bioactive compounds. Acetabularia acetabulum and *Oedogonium grande* also showed relatively high antioxidant activity, further supporting the trend that green algae tend to exhibit stronger antioxidant properties than brown or red algae. According to Kuda *et al*. (2005), This strong activity is due to its high content of phenolic compounds and flavonoids, which are well-known for their role in neutralizing free radicals. Brown algae such as *Cystoseira barbata*, *Padina pavonica*, and *Dictyota dichotoma* exhibited the lowest antioxidant activities, despite previous reports highlighting their richness in phlorotannins (Ragan & Gombitza, 1986; Catarino *et al*., 2017). The discrepancy may be attributed to factors such as seasonal variation, extraction method, or differences in molecular weight and solubility of phenolic compounds in brown algae.

Red algae, such as *Laurencia papillosa* and *Polysiphonia lanosa*, displayed moderate antioxidant activity. Similar observations were made by Yuan & Walsh (2006), who found that although red algae contain phenolic compounds, their antioxidant potential is usually lower than that of green algae.

3.2. Total phenol compound contents:

One of the most prevalent and varied classes of chemicals present in plants, phenolic compounds were identified in this investigation of the chosen seaweeds. All plants have an aromatic ring with at least one hydroxyl (phenol) substituent. According to Mahomoodally *et al*. (2013), phenols have antiviral, antibacterial, immunostimulatory, hypotensive, anticoagulant, hypocholesterolemic, antihepatocellular, and anticancer effects on mammals. According to Mahomoodally *et al*. (2013), phenols have antiviral, antibacterial, immunostimulatory, hypotensive, anticoagulant, hypocholesterolemic, antihepatocellular, and anticancer effects on mammals.

The present study demonstrated significant variation in the total phenolic content among the analyzed seaweed species from the Jarjar Oma coast, ranging from 31.61 ± 1.63 to 227.97 ± 7.63. Table (2).

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Table (2). Total Phenolic Compound Content in various seaweed species from the Jarjar Oma coast (mg GAE/g FW)

Seaweeds Species	Total Phenolic Compound (mg GAE/g FW)
Cladophora glomerata	220.17 ± 10.87 AB
Oedogonium grande	227.97 ± 7.63 A
Dasycladus vermicularis	215.0 ± 21.9 AB
Acetabularia acetabulum	42.48 ± 4.85 EF
Cystoseira barbata	179.30 ± 4.24 C
Cystoseira Compressa	195.47 ± 6.57 BC
Cystoseira crinita	199.33 ± 2.71 BC
Padina pavonica	84.73 ± 4.93 D
Dictyota dichotoma	87.06 ± 9.77 D
Polysiphonia lanosa	62.76 ± 5.91 DE
Jania rubens	31.61 ± 1.63 F
Laurencia papillosa	87.13 ± 0.13 D

Values are expressed as means ± SD; n = 3 for each species of algae. Mean values within a column not sharing common superscript letters (A, B & C) were significantly different at P < 0.05. whereas means superscripts with the same letters mean that there is no significant difference (P < 0.05)

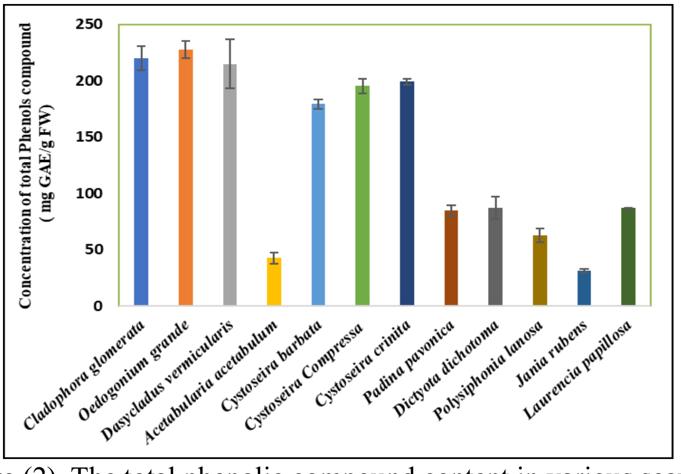

Figure (2). The total phenolic compound content in various seaweed species from the Jarjar oma coast.

These results align with previous findings indicating that phenolic content in seaweeds is species-specific and influenced by taxonomic group, habitat, and environmental conditions (Zubia *et al.*, 2007; Tierney *et al.,* 2010). The green alga *Oedogonium grande* showed the highest phenolic content (227.97 ± 7.63**)**, followed closely by *Cladophora glomerata* (220.17 ± 10.87**).** This observation is consistent with the study of Connan *et al.* (2006), which reported

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that some green macroalgae, especially filamentous forms, can accumulate high levels of phenolics as part of their defense against UV radiation and herbivory. Moderate phenolic levels were recorded in brown algae species such as *Cystoseira crinita*, *Cystoseira compressa*, and *Cystoseira barbata*, with values ranging from 179.30 to 199.33. This aligns with findings by Farvin and Jacobsen (2013), who reported that brown algae are generally rich in phlorotannins a class of phenolic compounds unique to brown seaweeds which contribute to their antioxidant properties. In contrast, Lower phenolic contents were observed in red algae like *Jania rubens* (31.61 ± 1.63) and *Polysiphonia lanosa* (62.76 ± 5.91), consistent with prior studies (Ragan and Glombitza, 1986; Li *et al*., 2011), pound differences in biosynthetic pathways.
Additionally, species like *Padina pavonica*, *Laurencia papillosa*, and *Dictyota dichotoma* had intermediate phenolic contents, which could be related to seasonal fluctuations or specific ecological pressures. As described by Abd El-Baky *et al*. (2009), environmental stressors such as light intensity and nutrient limitation can enhance phenolic production in certain seaweeds.

Conclusion:

The results of this study demonstrate that twelve different seaweeds extracts exhibit moderate to strong antioxidant activities, indicating their potential as valuable natural additives for nutritional and health-promoting purposes. Notably, certain green algae showed particularly high antioxidant potential, their promise as natural sources of antioxidants. Seaweeds also contain a diverse range of phenolic compounds, which contribute to their radical scavenging and reducing abilities. To fully understand the nutritional and therapeutic benefits of these seaweeds, further research is necessary, especially focusing on biochemical characterization and the isolation of active compounds. Such studies will help unlock their full potential for applications in pharmaceutical, cosmetic, and functional food industries.

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