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Antioxidant activity of brown algae extract (Sargassum sp): A review

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ABSTRACT

Free radicals are compounds that trigger oxidative stress and harm human health. Uncontrolled oxidative stress causes several degenerative diseases. Antioxidants are needed to prevent or reduce oxidative stress. One of the plants with a high content of antioxidant compounds is brown algae (Sargassum sp). The study aimed to examine Sargassum sp.'s antioxidant activity, which is expressed in the IC50 value using the DPPH method as measured by a UV-Vis spectrophotometer. It is a narrative review, with literature searches from the Science Direct, Pubmed, and Google Scholar databases. The results showed that the methanol extract of Sargassum sp. has strong antioxidant activity consisting of phenolic compounds, flavonoids, and carotenoids. This review concludes that Sargassum sp extract has antioxidant activity.

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INTRODUCTION

Radicals are atoms or molecules that contain one or more unpaired electrons in their outer orbit. Highly reactive free radicals can bind electrons from other compounds to achieve stability. High concentrations of free radicals can induce oxidative and nitrosative stress, damaging biomolecules, including fat, protein, and DNA (Pizzino et al., 2017). Oxidative stress is associated with several degenerative diseases, such as rheumatoid arthritis (RA), Alzheimer's, Parkinson's, cardiovascular disorders, immune system dysfunction, diabetes, and cancer. The antioxidant is needed to limit oxidative stress in the human body. It can inhibit oxidation reactions, even if only in small concentrations (Leyane et al., 2022).

In biological systems, enzymatic and non-enzymatic antioxidants can control damage caused by free radicals. Enzymatic antioxidants include superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), while non-enzymatic antioxidants include bilirubin and albumin. When the body is exposed to large amounts of free radicals, endogenous antioxidants are insufficient for optimal antioxidant activity (Sharifi-Rad et al., 2020). Therefore, to increase the amounts of antioxidants in the body, it is necessary to obtain exogenous antioxidants from food and supplements.

Several antioxidants, such as vitamins C and E, have been widely used daily. However, excessive use and large doses can cause several side effects to the body (Salehi et al., 2018). Therefore, alternative natural antioxidants are needed from natural ingredients to be utilized in the health sector.

Sargassum sp. is a seaweed species belonging to the brown algae (Phaeophyceae). Sargassum sp. contains sulfated polysaccharides such as fucoidan, which can act as anticancer, antibacterial, anticoagulant, anti-inflammatory, antioxidant, antiviral, and hepatoprotective. Brown algae, one of which is Sargassum sp., contains secondary metabolites, especially phenolic and terpenoid compounds with strong antioxidant bioactivity. Brown algae also contain carotenoids, laminarin, alginate, fucoidan, phlorotannin, and phenolic compounds as a source of antioxidants (Arsianti et al., 2020).

The IC50 value can express antioxidant activity. Based on the IC50 value, antioxidant activity can be classified into strong and weak antioxidants. One method that can be used to measure antioxidant activity is the DPPH method using a UV-Vis spectrophotometer. The DPPH (2,2-diphenyl-1 pikrilhidrazyl) method is an antioxidant test method based on electron transfer. It is a simple, easy, fast, and sensitive method (de Menezes et al., 2021).

Previous studies have reported the antioxidant activity of Sargassum sp using the IC50 parameter. However, the results obtained did not show clear consistency. Therefore, this study was conducted to test the antioxidant activity of Sargassum sp, by DPPH method using UV-Vis spectrophotometer instrument. This method was chosen to provide a deeper understanding of the antioxidant potential of Sargassum sp, with the hope of providing a more consistent and detailed understanding of its antioxidant properties. The expected benefits, especially in the research field, of this study are an increased understanding of the antioxidant potential of Sargassum sp extracts, identification of active compounds responsible for antioxidant activity, development of more effective antioxidant formulations, as well as encouragement for further research in the field of natural antioxidant sources. Thus, a more thorough analysis may provide a clearer view of the role of Sargassum sp in the context of antioxidant activity.

The antioxidant activity of brown seaweed extract from the Sargassum species has been discovered. The extract contains various antioxidant compounds such as polyphenols, carotenoids, and phytosterols, which contribute to its antioxidant properties (Catarino et al., 2023). Furthermore, the extract has been proven to possess high total phenolic content and scavenging activity against free radicals, as demonstrated by its ability to inhibit 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals and iron-reducing antioxidant power (FRAP) (Sanger et al., 2022). In addition, the extract has been formulated into nanoparticles, which have been discovered to inhibit oxidative stress and boost the activity of antioxidant enzymes in rats fed a high-fat diet (Zaidan et al., 2022). The brown algae extract also contains UV-absorbing compounds that protect against UV radiation-induced cell damage and exhibit potential antiviral activity (Polo & Chow, 2022). Overall, the antioxidant activity of brown algae extract from Sargassum species makes it a promising natural source of antioxidants for various applications in food, health, and biotechnology (Veerichetty & Rafi, 2022).

Oxidative stress is linked to a range of degenerative conditions like rheumatoid arthritis, Alzheimer's, Parkinson's, cardiovascular disorders, immune system dysfunction, diabetes, and cancer. Free radicals, which possess unpaired electrons, have the potential to induce oxidative and nitrosative stress, leading to damage to biomolecules such as lipids, proteins, and DNA. To counteract the detrimental impacts of oxidative stress, the body necessitates antioxidants.

Enzymatic antioxidants such as superoxide dismutase, catalase, and glutathione peroxidase, as well as non-enzymatic antioxidants such as bilirubin and albumin, play a crucial role in neutralizing free radicals. However, when the body is exposed to high levels of free radicals, endogenous antioxidants may not be sufficient to provide optimal protection. Therefore, obtaining exogenous antioxidants from food sources such as Sargassum sp extract can help enhance the body's antioxidant defense system.

The extract of Sargassum sp, rich in compounds such as flavonoids, phenols, carotenoids, and other bioactive molecules, demonstrates strong antioxidant activity. Incorporating Sargassum sp extract into the diet may provide potential health benefits by reducing oxidative stress and protecting against various chronic diseases. Research on the antioxidant activity of brown algae extract, particularly Sargassum sp, provides insight into the potential of natural antioxidant sources in promoting health and combating oxidative damage in the human body. Therefore, this study aims to present a comprehensive review of the antioxidant activity of Sargassum sp brown algae extract based on previous research, as well as to provide direction for further research in this field.

RESEARCH METHOD

It was a narrative review to assess the antioxidant activity of brown algae extract (Sargassum sp.) using DPPH method with spectrophotometer UV-Vis. This review was conducted by seeking information through libraries such as Science Direct, Researchgate, National Center for Biotechnology Information (NCBI), Multidisciplinary Digital Publishing Institute (MDPI), and Google Scholar. The literature search used the keywords "Sargassum sp," "DPPH method," "antioxidant," "UV-Vis spectrophotometer," and "IC50 value". Article inclusion criteria for review are: (a) Journals in Indonesian and English; (b) discuss the antioxidant activity of Sargassum sp., which is expressed by the IC50 value and tested by the DPPH method using a UV-Vis spectrophotometer; (c) articles published between 2010 - 2020.

RESULTS AND DISCUSSIONS

Based on a literature search, studies were obtained regarding the antioxidant activity of Sargassum sp. with various solvents. Antioxidant activity of aqueous extract of Sargassum sp was shown in Table 1.

Table 1. Antioxidant activity of aqueous extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant Classification	Reference
Sargassum aquifolium	Indonesia	Maceration	-	5381,2750	Weak	
Sargassum plagyophyllum	Indonesia	Maceration (multilevel)	Terpenoid, saponin, phlobatannin, phenol, flavonoid	2.670	Weak	(Edison et al., 2020)

Antioxidant activity of methanol extract of *Sargassum sp* was shown in Table 2

Table 2. Antioxidant activity of methanol extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant classification	Reference
Sargassum aquifolium	Indonesia	Maceration	-	66, 1554 851,4833*	Strong Weak*	(Firdaus, 2013)
Sargassum cristaefolium	Indonesia		Pigmen karotenoid, phycocyanin, chlorophil	1603	Weak	(Rohimat et al., 2014)
Sargassum angustifolium	Iran		Tanin, alkaloid, saponin, sterol dan triterpenoid, flavonoid, antrakuinon	231	Weak	(Yegdaneh et al., 2016)

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant classification	Reference
Sargassum oligocystum			Tanin, alkaloid, saponin, sterol dan triterpenoid, flavonoid, glycoside cardiac, antraquinon	610	Weak	
Sargassum boveanum			Tanin, alkaloid, saponin, sterol dan triterpenoid, flavonoid, antrakuinon	489	Weak	
Sargassum sp.	Indonesia		Flavonoid, phenol hidroquinon, triterpenoid	57,050	Strong	(Noorjahan et al., 2019)
			Pigment chlorophyl a, b, dan carotenoid	69,27	Strong	(Sedjati et al., 2018)
Sargassum polycystum	India, Indonesia	-	Phenol, flavonoid	214,59	Weak	(Johnson et al., 2019)
		Maceration (multilevel)	Phenol, terpenoid, steroid	491,02	Weak	(Sami et al., 2019)
Sargassum duplicatum	India	-	Phenol, flavonoid	251,25	Weak	(Johnson et al., 2019)
Sargassum tenerrimum	India	-	Alkaloid, flavonoid, tanin, terpenoid, reduction sugar	84 ± 0,58	Strong	(Noorjahan et al., 2019)
Sargassum plagyophyllum	Indonesia	Maceration (multilevel)	Alkaloid, steroid/triterpenoid, saponin, phenolic	777,79±16,82	Weak	(Edison et al., 2020)
Sargassum coriifolium	Bangladesh	Maceration	Terpenoid, saponin, glikosida cardiac, phenol, flavonoid	1.030	Weak	(Sobuj et al., 2021)

Antioxidant activity of ethanol extract of *Sargassum sp* was shown in Table 3

Table 3. Antioxidant activity of ethanol extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant classification	Reference
Sargassum aquifolium	Indonesia	Maceration	-	2048,0810	Weak	(Firdaus, 2013)
			-	1260, 9660*	Weak*	
Sargassum cinereum	India	-	Fucoxanthin (Carotenoid)	60	Strong	(Sivasankara et al., 2016)
Sargassum polycystum	India	-	Fucoidan	759,60	Weak	(Palanisamy et al., 2017)
	Indonesia	-	Flavonoid, saponin, steroid, alkaloid	77,58±0,27	Strong	(Manteu & Nurjanah, 2018)
	Indonesia	Maceration	Flavonoid, steroid, glycoside	624,76	Weak	(Arsianti et al., 2020)
Sargassum sp.	Indonesia		Alkaloid, triterpenoid	239,51±10,60	Weak	(Gazali et al., 2018)
Sargassum coriifolium	Bangladesh		Terpenoid, saponin, glycoside cardiac, phenol, flavonoid	1.420	Weak	(Sobuj et al., 2021)

Antioxidant activity of aceton extract of *Sargassum sp* was shown in Table 4.

Table 4. Antioxidant activity of aceton extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant Classification	Reference
Sargassum aquifolium	Indonesia	Maceration	-	4065,6250*	Weak*	(Firdaus, 2013)
Sargassum polycystum	India	-	phenol, flavonoid	183,82	Weak	(Johnson *et al.*, 2019)
Sargassum duplicatum				225,22	Weak	

Antioxidant activity of ethyl acetate extract of *Sargassum sp* was shown in Table 5.

Table 5. Antioxidant activity of ethyl acetate extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant classification	Reference
Sargassum sp.	Indonesia	Maceration	Phenol hidroquinon	68,89±5,36	Strong	(Gazali et al., 2018)
Sargassum polycystum	Indonesia	Maceration (multilevel)	Phenol, terpenoid, steroid	411,80	Weak	(Sami et al., 2019)
	Indonesia	Maceration	Flavonoid, steroid, glycoside	298,52	Weak	(Arsianti et al., 2020)
Sargassum plagyophyllum	Indonesia	Maceration (multilevel)	Alkaloid, flavonoid, steroid/triterpenoid, saponin, Phenolic	532,42±7,80	Weak	(Edison et al., 2020)

Antioxidant activity of chloroform extract of *Sargassum sp* was shown in Table 6.

Table 6. Antioxidant activity of chlorform extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant Classification	Reference
Sargassum polycystum	India	-	Phenol, flavonoid	192,30	Weak	(Johnson et al., 2019)
Sargassum duplicatum				231,48	Weak	

Antioxidant activity of petroleum ether extract of *Sargassum sp* was shown in Table 7.

Table 7. Antioxidant activity of petroleum ether extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant Classification	Reference
Sargassum polycystum	India	-	Phenol, flavonoid	211,86	Weak	(Johnson et al., 2019)
Sargassum duplicatum				287,35	Weak	

Antioxidant activity of n-hexane of *Sargassum sp* was shown in Table 8.

Table 8. Antioxidant activity of n-hexane extract of *Sargassum sp*

Species	Country	Extraction Method	Content	IC_{50} (ppm)	Antioxidant Classification	Reference
Sargassum sp.	Indonesia	Maceration	Alkaloid, triterpenoid	148.16±2,50	Moderate	(Gazali et al., 2018)
Sargassum polycystum	Indonesia	Maceration (multilevel)	Terpenoid, steroid	502,70	Weak	(Sami et al., 2019)
Sargassum	Indonesia		Steroid/triterpenoid	1105,58±16,62	Weak	(Edison et

plagyophyllum al., 2020)

Antioxidant activity with the DPPH method was assessed based on the IC50 value. The IC50 (Inhibitory Concentration) value is the concentration of the extract (Sargassum sp.), which can cause a 50% reduction in DPPH activity (de Menezes et al., 2021). From the IC50 value, it can be assessed whether the type or group of antioxidants is strong or weak. Based on the IC50 value, it can be classified into very strong antioxidant activity with an IC50 value of less than 50 µg/mL, a strong antioxidant with an IC50 value of 50 – 100 µg/mL, a moderate antioxidant with an IC50 value of 101 – 150 µg/mL and a weak antioxidant with an IC50 value of more of 150 µg/mL (Olugbami et al., 2014). The solvents from the literature search results based on the polarity of the most polar include water, methanol, ethanol, acetone, ethyl acetate, chloroform, petroleum ether, and n-hexane. Polar solvents include water, methanol, and ethanol. Semi-polar solvents include acetone and ethyl acetate, while non-polar solvents include chloroform, petroleum ether, and n-hexane (Nawaz et al., 2020).

Differences in solvent polarity can affect antioxidant activity. Polar solvents can extract phenolic compounds from brown algae, and semi-polar solvents can extract phenolic compounds, terpenoids, alkaloids, aglycones, and glycosides. In contrast, non-polar solvents can extract chemical compounds such as waxes, lipids/fats, and volatile oils (Kaczorová et al., 2021). Based on the group of strong antioxidants and the solvents used, the results showed that the solvents with strong antioxidant groups were methanol (29%), ethanol (25%) and ethyl acetate (25%). Based on these three solvents, methanol has the strongest antioxidant among the other three solvents and this was also proven in Noorjahan et al, with an IC50 value of 57,050 µg/ml (Noorjahan et al., 2019). Methanol solvent shows strong antioxidant activity, but Firdaus's research, showed weak and strong antioxidant activity (Firdaus, 2013). It is because the methanol solvent used is methanol (strong yield) and 80% methanol (weak yield). 80% methanol solvent consists of 80% methanol and 20% water. Water can extract proteins and carbohydrates where since they have high solubility in water. Furthermore, proteins and carbohydrates are primary metabolites, so it is possible to influence the results of antioxidant activity (Yousefi & Abbasi, 2022).

Methanol solvent shows strong antioxidant activity, however based on Firdaus's findings, (Firdaus, 2013) showed weak and strong antioxidant activity. It is because the methanol solvent used is methanol (strong yield) and 80% methanol (weak yield). 80% methanol solvent consists of 80% methanol and 20% water. Water can extract proteins and carbohydrates and influence of antioxidant activity. The strength or weakness of an antioxidant activity can be related to the content of metabolite compounds in the extract and the chemical structure. Overall, the results of a literature search showed that the extract of Sargassum sp. has a wide range of secondary metabolites such as carotenoids, chlorophyll, tannins, alkaloids, saponins, steroids, terpenoids, flavonoids, anthraquinones, glycosides, phenols, fucoidans and so on. Based on the strong antioxidant class, the secondary metabolites that play the most role in the antioxidant activity of Sargassum sp., namely phenolic compounds, flavonoids, and carotenoids (Baek et al., 2021).

Phenol compounds can reduce or inhibit free radicals by transferring hydrogen atoms from hydroxyl groups with a reaction mechanism donating hydrogen atoms as cations from phenol to free radicals. According to Jimenez-Lopez et al, the hydroxyl group (-OH) is a hydrogen and electron donor, so its number and position affect the antioxidant activity of phenol compounds (Jimenez-Lopez et al., 2021). Phenolic compounds that can act as hydrogen donors include HPMC (trolox), hydroxylyrosol, gallic acid, caffeic acid, and epicatechin, while phenolic compounds that act as electron donors are kaemferol and resveratrol (Platzer et al., 2022). Flavonoids are polyphenolic compounds that have 15 carbon atoms arranged in a C6-C3-C6 configuration, meaning they have a carbon skeleton consisting of two C6 groups or a benzene ring connected by three carbon atoms (C3) in an aliphatic chain. Typical chemical structures of flavonoids related to antioxidant activity include hydroxyl, ortho-dihydroxy groups in ring B, C2=C3 double bonds and

combinations with C-4 carbonyl groups in ring C and O-methylation. The chemical structures of flavonoids that play a role in antioxidant activity include catechol, O-methylation, C2=C3, 3-OH, and 4-carbonyl (Platzer et al., 2022).

Carotenoids act as antioxidants with three mechanisms, namely single electron transfer (SET), forming new formations, and transferring hydrogen atoms, but in general, the antioxidant properties of carotenoids are related to their high capacity to donate electrons. In Sargassum sp., the dominant carotenoid content is fucoxanthin which consists of alcohol groups, alkanes, alkenes, methyl, esters, and aromatic alkenes. The alcohol and aromatic groups play a role in the mechanism of antioxidant activity. In addition, carotenoids have a long linear C40 chain consisting of up to 11 conjugated bonds (allenic bonds) that can play a role in antioxidant activity through excessive energy transfer from singlet oxygen (O•) (Balasubramaniam et al., 2020).

CONCLUSION

From this review that has been carried out regarding the antioxidant activity of Sargassum sp., which is stated in the IC50 value and carried out by the DPPH method using a UV-Vis spectrophotometer, it can be concluded that the extract of Sargassum sp. has strong antioxidant activity using methanol as a solvent and contains phenolic compounds, flavonoids, and carotenoids which contribute the most to antioxidant activity. The study's implication is that the extract of Sargassum sp brown algae has the potential to serve as a natural source of antioxidants for various health and nutrition applications. This research contributes to enhancing the understanding of the antioxidant activity of the extract, synthesizing previous research findings to highlight its potential health benefits in combating oxidative stress and chronic diseases. Additionally, the study aims to identify specific bioactive compounds within the extract, which could potentially lead to the development of targeted antioxidant formulations. By exploring the antioxidant activity of the extract, this research provides insights into potential health applications and guides future research directions in the field of natural antioxidants, with the goal of advancing knowledge and promoting innovation in antioxidant research.

The limitations of this study are related to sample size, methodological bias, study duration, extraction techniques, and specificity to certain species, which may impact the generalizability and robustness of the findings. Future research could involve conducting broader studies with larger sample sizes, diverse species, mechanistic studies, clinical trials, formulation development, and comparative studies to validate and expand the current findings. This would enhance the understanding of antioxidant mechanisms, evaluate efficacy in clinical settings, optimize formulations, and compare antioxidant potential with other compounds, thus advancing the potential application of Sargassum sp as a natural antioxidant source in healthcare and nutrition.

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