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Seaweed and its antioxidant content at Batu Layar beach, Senggigi, West Lombok Regency

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ABSTRACT

Seaweed is macro algae that it one of export commodity at Indonesia. In addition to having economic value, macroalgae also have an important role in aquatic ecosystems. macroalgae play a role as primary producers because of their ability to photosynthesize, produce organic matter, and oxygen in the aquatic environment. Waters on Lombok Island that are overgrown with seaweed include Batu Layar beach. Batu Layar sub-district is part of the tourism area located in the coastal area. Batu Layar sub-district includes a cultivation area consisting of a variety of land uses ranging from agriculture, livestock, fishing and so on. This study aimed to analyze the diversity of seaweed species in the coastal waters of Batulayar, Senggigi, West Lombok Regency along with antioxidant and chlorophyll-a content. The research was conducted in November 2023 in the waters of Batu Layar, Senggigi, West Lombok Regency. The research methods used in this study were survey methods and method explanation of antioxidant content and chlorophyll was carried out in the laboratory, by taking random samples based on the boundaries of the predetermined area as many as 4 stations. The result of this research are identified species of seaweed including *Sargassum sp., Padina, Caulerpa, Galaxaura, Ulva, Gelidium, Acanthophora, Iaxaura, Halimeda, Boergesenia forbesii, Corallina, and Turbinaria. Padina* antioxidant levels reached 81,31% and chlorophyll 14,35 mg/l. It can be concluded that there are 12 types of seaweed that grow wild consisting of four species each of green, brown, and red alga. *Padina* has the highest antioxidant content of 81,31%.

Introduction

Seaweed is a macroalgae consisting of *Chlorophyta*, (*Phaeophyta*), and (*Rhodophyta*). Taxonomically seaweed belongs to the division Thallophyta, because indistinguishable clearly different the roots, stems and leaves. The shape of the thalus is diverse, some are round like tubes and bags, some are flat, flat, or some are like hair. Part of the body is called thalus, the part that resembles a root where it attaches to the substrate is called holdfast, the part that resembles a stem is called stipe, the part that resembles a leaf for photosynthesis is called blades (Kim *et al*., 2022). Cotas *et al*., (2023; Akbar & Hasan, 2024) seaweed grows at the bottom of ocean waters, at the bottom of the food chain. Seaweed lives in the water column that still gets sunlight to take place the process of photosynthesis. The ecological role of seaweed is to produce oxygen, as food for herbivore biota and as a habitat for marine biota.

Indonesia has diverse biodiversity including macroalgae which number 782 species, with a marine area of 5,8 million km^2 (Mushlihah *et al*., 2020). Species from the Rhodophyceae is the highest species, around 452 species, followed by the Chlorophyceae (green algae) class of around 196 species and the Phaeophyceae (brown algae) class of around 134 species (Ate *et al*., 2017). According Dharmayanti *et al*., (2019) seaweeds are primary producers, so their diversity and presence are important to the waters. Seaweed contains bioactive ingredients that are used as food, drug and cosmetics. Seaweed, which belongs to the macroalgae group, is a marine biodiversity that has been utilized by the people of Indonesia as one of the livelihoods, even

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some areas make it the main livelihood (Khasanah, 2013; Akbar & Khairunnisa, 2024). According Burhani *et al*., (2023) using *Gracilaria* and *Halimenia* as filler in *Hidrophobic-High Density Polyethylene* (HDPE) composite. According Vicente *et al*., (2023) seaweed is one of sources of bioacvtive compound, used in industries cosmetic, food, medicine, pharmaceutical, fisheries and agriculture. According Yang *et al*., (2021), the presence of bioactive compound in seaweed depend on species, geographical area and environment.

According to the Marine and Fisheries Service of West Nusa Tenggara Province (2020), seaweed production on Lombok Island in particular and in NTB in general has decreased in recent years. Seaweed production fluctuated from 2011 to 2020, ranging from 207,827.87 tons to 243,000 tons in 2011 and the highest in 2015 with a production of 311,451.15 tons. After 2015 there was a decrease in production until 2019, which amounted to 212,928.76 tons, but again increased to 243,000 tons. The diversity of types of seaweed that grow in Indonesia, seaweed is a marine commodity export, can be cultivate and low capital costs. In addition to having economic value, macroalgae also have an important role in aquatic ecosystems. In terms of ecology, macroalgae (seaweed) communities act as a place of life as well as a place of enlargement and protection for certain types of fish and are natural food for fish and other herbivorous animals. While in terms of biology, macroalgae play a role as primary producers because of their ability to photosynthesize, produce organic matter, and oxygen in the aquatic environment. Erlania & Radiarta, (2017) 3 species dominant at Labuanbua Sumbawa are *Padina*, *Gracilaria salicornia* and *Dyctyota*. Lombok Island that are overgrown with seaweed include Batulayar beach. Batulayar sub-district is part of the tourism area located in the coastal area.

Batu Layar sub-district includes a cultivation area consisting of a variety of land uses ranging from agriculture, livestock, and tourism. Seaweed species that grow wild in the waters of Batu Layar Beach need to be inventoried. Inventory needs to be done to determine the potential of seaweed that grows wild and its changes over time due to environmental changes and climate change. Batu Layar is located in the Senggigi Beach tourism area, so it is prone to changes in the quality of the aquatic environment due to tourism activities. The potential of seaweed owned by these waters must be known for its sustainability and development of its utilization. Antioxidants play an important role in human needs, especially in the fields of health and cosmetics. The importance of analyzing antioxidant content is to determine the bioactive compounds contained in seaweed, such as alkaloids, flavonoids, triterpenoids, and saponins and also to determine the potential of seaweed to be developed in the field of functional food (Akbar & Mustari, 2024). According Ross *et al*., (2023), climate change can cause the extinction of wild seaweed and damage to seaweed cultivation. The important thing to do to reduce the impact of climate change on the aquatic environment is to maintain the existence of wild seaweed and develop its cultivation. The research objectives was to analysis seaweed an antioxidant content at Batulayar beach, Senggigi, West Lombok Regency.

Materials and Methods

Place and time

The research was conducted in November 2023 at Batu Layar beach, Senggigi, West Lombok Regency. (Figure 1) is reasearch location. The research methods used in this study were survey methods and laboratory experiments. The survey was conducted for direct observation of samples in the field. The experimental method was to identify the type of seaweed, chlorophyll content and antioxidant content.

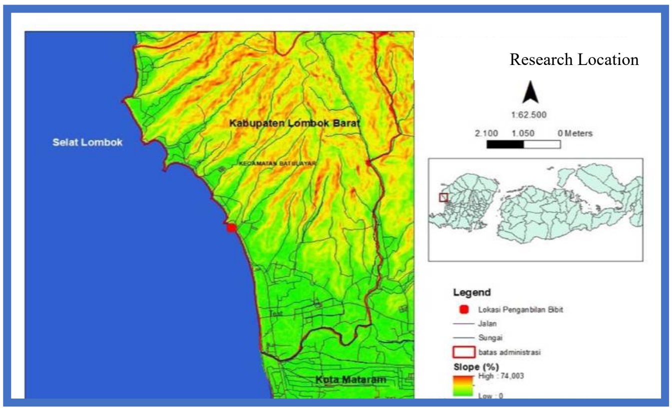

Figure 1. Map of the research location

Tools and materials

The equipment used are digital camera smartphone, pH meter, refractometer, lux meter, Dissolved Oxygen, test kit (nitrate, phosphate, ammonia), measuring board, plastic clip, label and stationery.

Procedures

Seaweed sampling

This research uses purposive sampling method by taking samples that represent the research location which is done by taking random samples based on the boundaries of the predetermined area as many as 4 stations. Sampling was conducted at the lowest low

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tide during the study time period. The survey method used was a cruising survey without transects. According Tuiyo (2014) explained that the cruising survey was carried out by taking each macroalgae species found at the observation location. At each observation station, at least three individuals of the same macroalgae species were taken. Samples are directly photographed at the research site, to get images with their original shape, colour and freshness. Furthermore, the sample is put into a plastic sample bag to be taken to the laboratory. Morphological and taxonomic identification is carried out in the laboratory based on the reference algae base. Samples were then analysed for antioxidant and chlorophyll content.

Antioxidant analysis

Antioxidant activity of seaweed was tested with UV-Vis spectropotometer DPPH method. Samples were used as much as 1 g, the sample used was added to 9 ml methanol then vortexed and macerated for 24 hours. After maceration, sample was filtered using Whatman paper to separate the residue from the filtrate. The filtered sample was taken 1 ml and then added 2 ml of 0.1 mM DPPH solution. The mixture was shaken until homogeneous covered with aluminum foil then incubated in a dark room for 30 minutes. Then measure the absorbance at a wavelength of 517 nm and record the absorbance measurement results. following formula according to (Hartanto & Sutriningsih, 2018).

$$\%\ \text{Inhibisi} = \frac{(\text{Abs blanko} - \text{Abs sampel})}{\text{Abs blanko}} = 100\ \%$$

Chlorophyll analysis

Samples of seaweed in wet conditions, blended and taken as much as 2 g which has been mashed using a mortar. Then dissolved using 100% acetone. The liquid is taken, if the liquid is cloudy filtered so that the clear filtrate is obtained. The clear filtrate was taken as much as 10 mL, in the room in the cuvette and then measured the absorbance value using a spectrophometer. To determine the chlorophyll content, a standard solution of chlorophyll-a was made and measured with the same wavelength. According to Riyono (2006) in Dewanto *et al*., (2015), chlorophyll-a content is calculated using the formula:

$$Klorofil\text{-}a\ (mg/L) = 11.93\ (A664) - 1.93\ (A647)$$

Description: A= Absorbance at each wavelength

Results

Batu Layar is beach that has the potential wild seaweed, there is no utilization because Batu Layar beach is tourism area. Here is the seaweed on the beach of Batu Layar, Senggigi, West Lombok Regency as shown be:

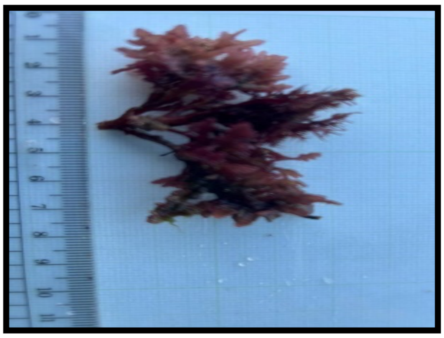
a. *Sargassum* sp.

b. *Padina*

c. *Caulerpa* sp.

d. *Galaxaura* sp.

e. *Ulva lactuca*



f. *Gelidium* sp.

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g. *Acanthophora spicifera*

h. *Iaxaura* sp

i. *Halimeda*

j. *Boergesenia forbesii*

k. *Corallina*

l. *Turbinaria ornata*

Figure 2. Types of Seaweed

Antioxidant Analysis

Seaweed has antioxidant potential, which can be used in the health and food industries. Every species of seaweed had different level of antioxidant (Table 1).

Table 1. Antioxidant content of seaweed

No	Seaweeds	Antioxidant Levels (%)	Chlorophyll-A Levels (mg/l)
1	*Sargassum* sp.	19.95	14.39
2	*Padina*	81.31	14.35
3	*Caulerpa* sp.	4.03	6.19
4	*Galaxaura*	17.71	13.74
5	*Ulva lactuca*	23.61	8.80
6	*Gelidium* sp.	15.56	9.84
7	*Acanthophora*	19.05	11.22
8	*Iaxaura*	8.59	9.69
9	*Halimeda*	28.74	13.64
10	*Boergesenia forbesii*	7.15	8.40
11	*Corallina*	24.60	11.18
12	*Turbinaria ornata*	25.94	14.42

Water Quality

Water quality is important parameter for seaweed growth and its component. The water quality of Batulayar Senggigi waters in West Lombok district is as shown in (Table 2).

Table 2. Water quality measurement results

Parameters	Value	Feasibility
Temperature (°C)	28.1 – 28.6	27-32 (Anton, 2017)
pH	7.8 – 7.9	7-9 (Atmanisa *et al.*, 2020)
Dissolved Oxygen (mg/l)	6.5 – 7.2	≥4 (Atmanisa *et al.*, 2020)
Salinity (ppt)	30 - 32	28-34 (Atmanisa *et al.*, 2020)
Phosphate (mg/l)	0.1-0.5	0.05-1 (Dewi & Suryaningtyas, 2020)
Nitrate (mg/l)	3.1-3.3	0.9-3.5 (Asni, 2015)
Light Intensity (lux)	86-203	500-100 (Sitorus *et al.*, 2020)

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Discussion

Sargassum in (Figure 2a) has a sprawling thalus shape, many branching that resembles trees on land, wide leaf shape, oval like a sword, has air bubbles that are generally solitary, the main stem is slightly rough, and the holdfast (the part used for attachment) is disc-shaped. The leaf margins are sparsely serrated, rippled, and the tips are curved or tapered. *Sargassum* is brown species due to the dominance of fikosantin pigments that cover chlorophyll pigments so that these algae look brown. *Sargassum* had economic importance and export commodity (Sulistiyani *et al*., 2022). According Tu, (2020) *Sargassum* is distributed in tidal area and marine waters with calm waves.

In addition, this seaweed has several benefits in the form of substances that can be extracted as alginate, which is a salt of alginic acid containing sodium, calcium and barium ions. *Sargassum* sp. has been widely used as a raw material in the food industry, pharmaceuticals, cosmetics, animal feed, fertilizers, textiles, and paper. According Pakidi & Suwoyo (2016) that the extraction of *Sargassum* sp. used by the food industry to strengthen the texture or stability of processed products, such as ice cream, fruit juice, stuffed pastels, and cakes. *Sargassum* sp. has also been utilized in the pharmaceutical and livestock fields. According Damayanti *et al*., (2021), maked *Sargassum* juice as a functional beverage that improve health status and prevent certain diseases. According Kamisyah *et al*., (2020) that alginate has been widely used in various industrial fields, namely the food, pharmaceutical, textile, cosmetic, paint, ceramic, rubber and paper industries. According Wulandari and Situmerang, (2022) that apart from being a sauce for seaweed such as carrageenan, it is widely used as a raw material for producing Sargassum capsule shells, stabilizers, emulsifiers, fertilizers, shampoos, hair dyes and soaps.

Padina in (Figure 2b) has morphological characteristics, namely sheet-shaped thalus that resembles a fan and is light brown to white. Has a width of up to 4-7 cm. has radial lines that form partitions/segments in each sheet. Thalus sheets widen towards the top and conical at the base and flat on the edges. This seaweed is found from a distance ranging from 2-20 m from the shoreline, in areas that are always flooded. Root-like organs (holdfast) attach to rocks along the coast. According Hidayati *et al*., (2022) *Padina* lives in the intertidal zone and has high adaptability. *Padina* attaches to the substrate of sand, dead coral, muddy sand and sandy mud. *Padina* produces active compounds flavonoids, phenols, triterpenoids, tannins, saponins and alkaloids. These compounds have potential as antioxidants, antibacterials, antifungals, anticancer, and anti-inflammatory. *Padina* is known to have therapeutic activities including antioxidant, anti-inflammatory, antibacterial, antidiabetic, antihypertensive, and larvicidal effects. *Padina* sp. seaweed has the ability to produce natural antioxidants (Hidayati *et al*., 2022). This type of seaweed has distinctive active compounds, namely the presence of fucoxanthin and fucoidan, which have potential pharmacological effects. Fucoxanthin is the most abundant carotenoid found in *Padina australis*, while fucoidan is a compound that can only be found in brown seaweed. Fucoidan is one component that has various benefits in health aspects such as antioxidants, anticoagulants, immunostimulants, anti-cancer and its potential as anti-atherosclerosis (Sadvika *et al*., 2022). According Husni *et al*., (2014) that marine algae species *Padina* sp. has prospects as a natural preservative for fishery products. *Padina* sp. extract has inhibitory activity against bacterial growth. *Padina* sp. extract can used to freshness of red Tilapia filets.

Caulerpa in (Figure 2c) is included in the type of green algae (Chlorophyta), namely *Caulerpa*, has morphological characteristics, namely green has a round thalus. It grows in shallow marine with calm water flow at sand and rock substrates. Seaweed has various types of components that can be utilized for human life such as cosmetics and in the food industry. *Caulerpa* has various types of pigments such as chlorophyll and each pigment has specific health benefits such as antioxidants. *Caulerpa* sp. is a green seaweed as a source of natural antioxidants (Hidayat *et al*., 2020). Chlorophyll pigments utilized in the food, beverage, medicine and household industries. Chlorophyll is also useful as a nutrient absorber, increasing endurance, energy source, cleaning the circulatory system, helping the liver in producing red blood cells, maintaining the body's acid-base balance, reducing bad breath and maintaining a healthy digestive system (Samad *et al*., 2021). Antioxidants are components that can slow down and prevent the oxidation process. Antioxidants are very beneficial for health and food products. The health benefits of antioxidants include preventing cancer and tumors, narrowing of blood vessels and anti-aging. In food products, it can prevent oxidation that causes the product to be damaged, such as changing color and aroma and physical damage (Samad *et al*., 2021). According Stuthmann *et al*., (2023) *Caulerpa* can be consumed fresh as a functional food, containing polyunsaturated fatty acids (PUFA). *Caulerpa* is starting to be cultivated for market demand.

According Puspita *et al*., (2019) that *Caulerpa recemosa* is one type of seaweed that is usually used as a fresh product. One of the efforts to utilize *Caulerpa recemosa* is to process it into instant cream soup. Its production using vacuum drying oven, which has the characteristics of green color and seaweed aroma. According Tapotubun *et al*., (2021) stated that *Caulerpa* can be processed into a product in the form of jelly candy and this jelly candy can also be used as a health supplement.

Galaxaura in (Figure 2d) has morphological characteristics, namely cylindrical thalus with short books (about 1-1,5 cm). Irregular dichotomous branching forms lush clumps at the top. The tip of the thalus is blunt and slightly hollow. Clump height can reach about 5-7 cm, blond thalus color, growing attached to the rock on the inside and outside of the reef flat. Based on the morphological characteristics of seaweed, this seaweed is included in the type of red algae (Rhodophyta), namely *Galaxaura* rugosa. According Abdel-Raouf *et al*., (2017) *Galaxuara* habitat is an aquatic environment that is exposed to sunlight and has much dissolved oxygen content. These conditions can lead to the formation of free radicals and other oxidizing agents. Another utilization of seaweed is as a natural antioxidant that can be used as an additive to cosmetics and medicines. Red seaweed contains polyphenol compounds (Ananda, 2019), phenolics and flavonoids (Yanuarti *et al*., 2017), that act as natural antioxidants. Red seaweed is also known as one of the most potential sources of antioxidants. Antioxidants are compounds that are able to delay, minimize, or inhibit the oxidation reaction of free radical reactions. Antioxidants can neutralize free radicals so that metabolic processes in the body run normally (Bhernama *et al*., 2021). Seaweed contains various metabolites that are beneficial to humans. Red seaweed contains more primary and secondary metabolite compounds, namely phytocolloids such as agarose, agar, carrageenan, and other important secondary metabolites. Seaweed contains fiber, carbohydrates, low fat, minerals, vitamins, and amino acids making it suitable as food and beneficial for health (Amaranggana & Wathoni, 2017).

Ulva lactuca in (Figure 2e) including the type of green algae (Clorophyta) has morphological characteristics, namely green color with membranous thalus in the form of thin and smooth leaf-like sheets that can reach 3 cm wide. The edge of the sheet is wavy and the thalus height reaches 4 cm. the shape of the thalus resembles an elongated rectangle, found abundantly in areas close to the shoreline up to a distance of 7 m from the shoreline at the lowest tide. The disc-shaped holdfast, which is attached to rocks and corals, has high antioxidant properties, thus protecting the body from various diseases.

Ulva lactuca is green algae that is has antioxidant, antibacterial, anti-fungal, and anti-tumor content (Arbi *et al*., 2017). Besides being used in the health industry, *Ulva lactuca* seaweed can also be used in the food sector such as cake making as a source of fiber (Cokrowati *et al*., 2020) and can also be used in the non-feed sector such as for making fish feed (Tarigan and Tega, 2022). *Ulva lactuca* can be used as an organic fertilizer that is rich in nutrient content and is beneficial for plants and does not damage the environment (Rozalina, 2021). Seaweed can be used as a plant substrate additive, and is not a risk to the environment. Seaweed has been used as an organic fertilizer on farmland. *Ulva* can be used in human health products, agriculture, and biomaterials (Kidgell *et al*., 2019).

Gelidium sp. in (Figure 2f) is approximately 20 cm long and 1,5 mm wide. The thalus is red, brown, green-brown or blond in color. The reproductive organs are macroscopic. The cystocarp has small holes (osteolo) on both sides of the thalus, tetraspores divide into cruciate or tetrahedral. The cruciate is one of the spore arrays. Traditionally, *Gelidium sp.* is widely consumed as a vegetable and raw material for making agar jelly. Decoction water from *Gelidium sp.* seaweed has been widely used by the community as a medicine for hemorhoids and digestive disorders such as diarrhea. *Gelidium sp.* is useful as antibacterial, antifungal, and internal disorders (Ardiyanto *et al*., 2020). The advantage of seaweed is the presence of minerals, vitamins, phenols, polysaccharides, and sterols. These compounds have antioxidant, anti-inflammatory, anti-cancer, antimicrobial, and anti-diabetic activities (El-Beltagi *et al*., 2022). According Shobir *et al*., (2019) that the *Gelidium* genus is efficacious for internal disorders, antifungal, antibacterial and antiviral and *Gelidium* anursii treats stomach pain. One source of bioactive compounds that also comes from red algae is *Gelidium* which has bioactive compound components in the form of alkaloids, saponins, phytosterols, phenolic compounds, and flavonoids (Elsie & Rajan,D., 2010). According Riandinata, (2018) seaweed is said to have bioactive compounds that can inhibit cancer cell proliferation, one of which is *Gelidium sp.*

Acanthophora in (Figure 2g) is a type of Rhodophyta seaweed that has a dark red color and tends to be almost brownish. The structure of the rigid thalus with dichotomous branching, there is a kind of short spines with blunt ends, and tapered at

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the ends, such as the structure of pinnate leaf bones in true plants. This species grows in clumps attached to corals. According Samrit *et al*., (2024) *Acanthophora* has the ability to grow quickly, so its availability in marine waters is quite abundant. This type of seaweed can be used for waste treatment because of its bioactive ingredients.

Iaxaura sp. in (Figure 2h) has morphological characteristics that are hard cylindrical thalus shape with fine hairs on the surface, impressed soft. This seaweed forms dense clumps as if clumped at the top. The tip of the thalus tread is perforated with brown-purple color. Grows attached to the rock substrate in the reef flat area which is generally always inundated with water.

Halimeda in (Figure 2i) is a filamentous green algae that has a rigid shape attached to a dead coral substrate or on a hard substrate, other characteristics of *Halimeda* are lush thalus, stiff and calcareous blade, holdfast like an elongated tuber. The thalus of this algae is green and when dry it has a yellowish green color, its habitat is on the coral substrate (Setiawati & Sari, 2017). According Asih *et al*., (2019) that *Halimeda* contains high amounts of extracellular calcium aragonite, making it the largest contributor of calcium carbonate in the ocean and Halimeda has potential as a natural source of calcium that can be used as fortification. In addition, *Halimeda* seaweed also has antioxidant bioactivity. This seaweed lives on the beach, contains various bioactive compounds that have various beneficial roles, namely antioxidants. Antioxidants can increase endurance and prevent chronic diseases (Nufus *et al*., 2019). According Latifah *et al*., (2020) *Halimeda* has the most active compounds against pathogenic bacteria in humans, fish and shrimp. Therefore, *Halimeda* can be used as a conventional medicine in aquaculture.

Borgesinia forbesii in (Figure 2j) is a green algae that has the characteristics of thalus forming like a balloon, cylindrical, thin-walled and transparent, the inside contains water content and looks shiny. Light green thalus, rhizoid holdfast. According Gazali *et al*., (2023) *Borgesinia* is green in color, has vesicles, the talus is bubbly and resembles grapes. Its habitat is dead coral, muddy and sandy. According Melati, (2021) that green algae *Boergesenia forbesii* contains antioxidants which have role in treating various diseases such as cytotoxic and anti- aging. The function of antioxidants is to prevent degenerative diseases such as cancer, tumors, premature aging, osteoporosis, heart disease and artherosclerosis

Corallina officinalis L. (Figure 2k) is characterized by a hard and stiff structure. In addition, this seaweed is in the form of sheets that are branched and threaded in one plane, pinnate or irregular. *Corallina officinalis L.* has a cylindrical or flat stem. The color of the grass is pink to dark red with a substrate of rocks and dead coral (Asih *et al*., 2019). According Rendina *et al*., (2019) explained that *Coralina* is a habitat-forming species, so if there is a decrease in the abundance of this algae, there is a shift in biodiversity in coastal ecosystems. *Corralina* is sensitive to changes in temperature and salinity. It contains photosynthetic pigments such as chlorophyll a, phycobiliproteins (phycoerythrin and phycocyanin), which give it a distinctive reddish color and allow it to perform photosynthesis efficiently even in low-light conditions underwater

Seaweed in (Figure 2l) is a type of brown algae (Phaeophyta), namely *Turbinaria* ornata, which has characteristics such as having a hard, stiff, thick thalus structure and resembles a jagged lip shape. *Turbinaria ornata* can be found on reef flats that are more exposed to waves. The edge of the blade (part that resembles a leaf) forms a lip with the center of the blade curved inward (Sarita *et al*., 2021). According Riry et al., (2022) explained that *Turbinaria ornata* has a body structure including a structure that resembles a root (holdfast) which functions to attach the body to the substrate, a structure that resembles a stem (stipe), a structure that resembles a leaf (filoid), and a structure that resembles an air bubble (pyrenoid). The edges of the phylloids are sharply serrated. *T. ornata* lives on coral and sandy coral substrates. According Moubayed *et al*., (2022) *Turbinaria* is a brown alga that has a mutualistic association with bacteria. *Turbinaria* as a host that provides nutrients for bacterial cells, and bacteria that provide defense mechanisms for the host against harmful colonization of other microorganisms. According Nurjanah *et al*., (2017) that brown seaweed including *Turbinaria* has higher antioxidants compared to red and green seaweed types. *Turbinaria* contains active substances including phenol hydroquinone, flavonoids, triterpenoids, steroids, and saponins that can be used as raw materials for sunscreen creams, vitamins, phenols, fucoidan, alginates and antioxidants used to inhibit skin aging and skin disorders, and raw materials for lipbalm.

Antioxidant Levels

Sargassum cristaefolium has an antioxidant, reached 19.95%. *Sargassum cristaefolium* has an antioxidant, reached 19.95%. *Sargassum cristaefolium* in Meninting Beach has not been utilised, but at low tide, there is an expanse of *Sargassum cristaefolium* in the tidal area. Although it has not been utilised, it is important to know its abundance for conservation and future aquaculture development. According Same *et al.*, (2009) *in* Sandapare *et al.*, (2015), stated that *Sargassum* is one type of brown seaweed from Indonesia that has potential as an antioxidant because it contains active substances such as fucoidan, and phenolic components. The type of phenolic component that is commonly found in brown marine algae is phlorotanin which ranges from 0.74% to 5.06%. Polysaccharides are an important component of marine algae. One type of polysaccharide that is widely found in brown algae is fucoidan. Fucoidan is a complex polysaccharide in seaweed cell walls. According El-Beltagi *et al.*, (2022) *S. polycystum* is a genus of *Sargassum*, and biochemical components have been identified.

Ulva seaweed with antioxidant levels reaching 23.61%. *Ulva lactuca* was found in the waters of Meninting Beach with low abundance. However, in the Sekotong waters of Central Lombok, *Ulva lactuca* appears in abundance at the end of the dry season. *Ulva lactuca* is still in Lombok waters, still untapped. In 2023, seaweed buyers began to purchase this species in dry form. According Ulfa *et al.*, (2014) that a material has antioxidant activity if it has an IC50 value of less than 200 ppm. A compound is a very strong antioxidant if IC50 is less than 50 ppm, strong for IC50 of 50-100 ppm, moderate if IC50 is 100-150 ppm, and weak if IC50 is 151-200 ppm. According Khamidinal *et al.*, (2007) stated that oil or fat damage caused by antioxidant reactions can inhibit the formation of free radicals at the initiation stage and inhibit the continuation of the autooxidation reaction at the stage of low activation energy to release one hydrogen atom to fat radicals, so that further oxidation stages can be prevented. *Ulva lactuca* is a natural therapy for treating this condition due to its various nutrients, antioxidants, and sterols (Arini *et al.*, 2023).

Achantopora is a type of red seaweed that has potential as an antioxidant, reached 19.05%. According Mardawati *et al.*, (2008), that a compound is said to be a very strong antioxidant if the IC50 value is less than 50 ppm and very weak if more than 200 ppm. According Jensen *et al.*, (2001) stated that each location has characteristics and the value of environmental parameters of the sampling location such as depth, temperature and sunlight intensity will affect the composition of lipids and pigments in a sample so that it affects the vitamin and antioxidant content. The biosynthesis process of antioxidant compounds will produce optimal compounds if the environmental conditions are favorable.

Gelidium can be used as a raw material for making agar and in the pharmaceutical field as a basic ingredient for antioxidants. Based on the results of antioxidant analysis obtained, the antioxidant content of *Gelidium* seaweed reached 15.56%. According Ku *et al.*, (2007), that *Gelidium* contains catechin compounds that are strong antioxidants, stronger than vitamins E, C, and betacarotene. *Gelidium* in the classification of antioxidant activity of *Gelidium* seaweed extract is classified as strong in n-hexane solvent extract. While the methanol solvent extract is classified as very weak. The different results between methanol and n-hexane extracts are expected, because the samples tested are crude extracts. Extracts that are not pure still contain other compounds derived from the sea such as salts, nutrients, and minerals that can inhibit the work of antioxidant compounds. This is supported by research conducted by (Wikanta *et al.*, 2005), that the low antioxidant activity can be due to the presence of impurities contained in the extract is still high. Bioactive compounds found in seaweed, especially *Gelidium*, include total phenolic content (TPC), carotenoids, total flavonoids, ascorbic acid, tannins, and antioxidant activity through total antioxidant content (TAC), 1,1-diphenyl-2-picrylhydrazyl (DPPH). free radical scavenging activity, and iron reducing antioxidant power (FRAP) were measured (El-Majnaoui *et al.*, 2023).

The potential type of seaweed to be developed is *Codium sp.* because it has a fairly high nutritional content as a source of vegetable protein, minerals, and vitamins. This type of seaweed contains 15.6% protein, 7.1% fat, and 1.4% total fiber (Meiyasa *et al.*, 2023). *Codium sp.* has antioxidant levels of 7,15%. The rich polysaccharide content in *Codium sp.* as a source of antibacterial and antioxidant activity (Ilhamdy *et al.*, 2021). Ilhamdy *et al.*, (2021) stated that *Codium sp.* polysaccharide showed an inhibition zone of 19 mm against Bacillus cereus and 12 mm from the inhibition zone of *Xanthomonas sp., Codium sp.* seaweed has the potential to be used as a free radical prevention agent with antioxidant content of 85.53 ± 0.25% and DPPH radical test value of 71.18 ± 0.54%.

Caulerpa has pharmacological activities of antiproliferative, antiviral, anticoagulant, antioxidant, anti-inflammatory, antimicrobial, antifungal, anticancer and antirheumatic (Jumsurizal *et al.*, 2021). *Caulerpa* has antioxidant levels of 4,03%. *Caulerpa* sea grapes have the ability to produce antioxidant activity. The nature of *Caulerpa* is safe for consumption utilized by the community as fresh vegetables and consumed raw, this allows *Caulerpa* sea grapes to be utilized as a source of natural antioxidants. According Zuhdi *et al.*, (2018) explained that antioxidants are compounds that can inhibit oxidation reactions, by binding free radicals. According Aryudhani (2007) in Mokoginta *et al*., (2021), *Caulerpa racemosa* sea grapes produce primary and secondary metabolites, one type of secondary metabolite is antioxidants. *Caulerpa* contains phenol compounds as non-nutritional components, these components are thought to function as antioxidants. Free radical is a molecule that is highly reactive and unstable, can cause damage to proteins, Deoxyribose Nucleic Acid (DNA), and cell membranes, and can trigger a degenerative diseases.The damages can be prevented by natural or synthetic antioxidant compounds. *Caulerpa* sp. a green seaweed as a potential source of natural antioxidants (Hidayat *et al*., 2020).

Galaxaura is a species of red algae (*Rhodophyceae*) with cylindrical thalus with short books (about 1-1,5 cm). Based on antioxidant analysis, *Galaxaura* has an antioxidant content of 17.71%. According Bhernama *et al*., (2021), *Galaxaura* seaweed has potential as an antioxidant, *Galaxaura* is a type of red seaweed (*Rhodophyta*) that has secondary metabolite compounds that have the ability as antioxidants and antibacterial. The group of compounds that are thought to have potential as antioxidants in the ethanol extract of *Galaxaura* red seaweed include alkaloids, flavonoids, saponins, steroids, and polyphenols. According Lisi *et al*., (2017), phytochemical compounds such as phenolics, flavonoids, alkaloids, steroids and saponins have antioxidant activity that is quite good.

The antioxidant content of *Padina* reached 81,31%. According Hidayati *et al*., (2017), *Padina sp.* has the potential as a natural antioxidant and contains active compounds in it such as flavonoids, alkaloids, tannins, triterpenoids, saponins, phenolics and pigments such as chlorophyll a, chlorophyll c, carotenoids, fucosantin, fukoxantol and β-carotene. *Padina* seaweed can be utilized for medical purposes. According Handayani *et al*., (2017), the potential activity of *Padina* as an anticancer is associated with the presence of fucosantin. Fucosantin has activity in reducing cell size. Reduction of cell number by certain agents (*cytotoxicity*) can generally be explained by cell killing and/or inhibition of cell proliferation. The potential activity of *Padina* as an antibacterial is associated with the content of phenol compounds and their derivatives (*flavonoids*). These compounds can inhibit bacterial growth by disrupting the function of the cytoplasmic membrane. The presence of phenolic compounds causes damage to the cytoplasmic membrane. H ions from phenols and their derivatives (*flavonoids*) will attack polar groups (phosphate groups) so that phospholipid molecules in the bacterial cell wall will be destroyed into glycerol, carboxylic acid and phosphoric acid. The potential activity of Padina as an antioxidant is associated with the content of compounds capable of capturing free radicals. Free radicals are unstable atoms and therefore, to become stable, radicals will look for donor molecules. If the donor molecule has given its electrons, the donor molecule will become an unstable molecule, then this molecule will seek electrons from other molecules and so on. One type of macroalgae that has the potential as an antioxidant is *Padina* sp. (Hidayati *et al*., 2022).

The principle of antioxidants is to donate hydrogen to radical compounds so that later a non-radical compound is formed. In addition, *Padina* seaweed can also be utilized as a cosmetic ingredient. According Maharany *et al*., (2017), *Padina* extract contains tannins which are also potential substances for sunscreen cream raw materials. *Padina* extract contains alkaloids, flavonoids, triterpenoids, saponins, phenol hydroquinone, and tannins. Flavonoids are one of the polyphenols, have a major role in tyrosinase activity because they contain phenol groups and pyren rings. The structure of flavonoids is in principle suitable as a substrate and is able to compete so that it can become a tyrosinase inhibitor. Tannins are active secondary metabolite compounds that are useful as astringents, antidiarrheal, antibacterial and antioxidants. Tannins are also known to protect against free radical damage caused by UV rays. According Kalalo *et al*., (2014), Padina seaweed contains chlorophyll-a, chlorophyll-b and chlorophyll-c. Chlorophyll-a pigment is the main pigment in the photosynthesis process.

Chlorophyll-a levels

Chlorophyll is a pigment owned by seaweed, one of which is seaweed species *S. cristaefolium*. Based on the analysis of chlorophyll-a levels obtained from seaweed species *S. cristaefolium* reached 14.39 mg/L. High and low values of chlorophyll levels one of which is influenced by the intensity of light. According Gross (1991) in Resita *et al*., (2010) that chlorophyll is very easily degraded by temperature, light and oxygen. Chlorophyll can be degraded into derivatives both in vivo (naturally) and in vitro (in the laboratory). Natural transformation occurs during biosynthesis which produces chlorophyll in large quantities and some of its derivatives in relatively small quantities. Laboratory transformation occurs when chlorophyll is subjected to several treatments, including exposure to light, heating, drying, salting and storage for a long period of time.

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Chlorophyll levels in *Ulva* reached 8.80 mg/l. According Chakraborty & Santra (2008), that *Ulva* is one type of green seaweed that contains a lot of chlorophyll and has special benefits for health. Chlorophyll can also be damaged by ultraviolet radiation. According Arnold *et al*., (2014) stated that chlorophyll has a weakness, which is less stable to heat, light or acid treatment. Chlorophyll can turn into feofitin, pyropheofitin and feoforbid in food processing involving heat and acid (Sun *et al*., 2024). Chlorophyll has health benefits. According Prangdimurti *et al*., (2006), that chlorophyll pigments have been studied to have biological effects to improve health, including antioxidants, anti-inflammatory and anticancer.

Acanthophora is red algae capable of photosynthesis because it has chlorophyll-a. Chlorophyll levels of seaweed type *Acanthophora* reached 11.22 mg/l. According Zhao *et al*., (2022), that chlorophyll-a levels in red seaweed showed the smallest value compared with green and brown seaweed. According Sedjati *et al*., (2012), states that chlorophyll including no-polar pigments so that it can dissolve in non-polar solvents. *Acanthophora muscoides* is potentially used as a natural antioxidant (Akbar *et al*., 2018).

Gelidium has the ability to photosynthesize, converting energy from the sun into energy that can be used as food. The ability to photosynthesize is caused by the chlorophyll content in its cells. Chlorophyll-a levels of *Gelidium* seaweed reached 11.18 mg/l. According Hariyati, (2008), that *Gelidium* generally has photosynthetic pigments namely chlorophyll a and b as well as pigment accessories in the form of fikocyanin, ficoeritrin and carotenoids. *Gelidium* is captured by the pigments ficoeritrin and fikocyanin and forwarded to chlorophyll. Chlorophyll is excited, chlorophyll electrons become more energized so that electron transfer will occur which is used to reduce NADP to NADPH. This NADPH is used to reduce CO2 so that it will produce food reserves in the form of glucose.

Caulerpa has a chlorophyll content of 6.19 mg/l. Dimara *et al*., (2018), Chlorophyll pigments contained in *C. racemosa* has given a characteristic green color to this type of seaweed, and important in the process of photosynthesis. In these physiological functions, chlorophyll has been widely used as a natural coloring material for food and beverages, medicinal materials, sensitizers (cancer therapy), bioinsecticides, and natural dyes in the household industry. Chlorophyll is able to capture 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals produced during the oil autooxidation process, so as to break the oxidation chain. Chlorophyll is easily degraded by external influences such as light, heat, acid, and oxygen reactions, or a combination of these reactions. Therefore, this study is directed at the identification of chlorophyll-derived compounds and the effect of photodegradation of *C. Racemosa.*

Water Quality

The temperature measurement results obtained ranged from 28.1 ºC-28.6ºC, this indicates that the waters in Batu Layar still have a good temperature value range for seaweed growth. According to Alwi *et al*., (2023) the optimum temperature for seaweed growth ranges from 20-31 ºC. According Anton, (2017) that temperatures around 27-32 ºC is a decent temperature range for seaweed growth. Temperature can affect the growth of seaweed because temperature has a relationship with photosynthesis, metabolism, and respiration. According Visch *et al*., (2020), the average water surface temperature to a depth of 10 m near seaweed farms ranged from 7.0 ± 4.2 °C.

The degree of acidity (pH) is one of the chemical factors of seawater that can determine the growth of seaweed. The results of pH measurements obtained ranged from 7.8 -7.9, the value indicates that the pH levels can be said to be normal for seaweed growth. According Atmanisa *et al*., (2020) that the optimal value of pH is 7.3 – 8.2 so it can be said that the pH range obtained is good to support the growth of seaweed.

Dissolved oxygen content was obtained in the range of 6.5-7.2 mg/l. Dissolved oxygen required in seaweed cultivation is 2-4 mg /l, but this seaweed will grow well in the range of dissolved oxygen above 4 mg /l (Atmanisa *et al*., 2020). According Susilowati *et al*., (2012) *in* Andreyan *et al*., (2021) that the dissolved oxygen content to support seaweed aquaculture is 3-8 mg /l. Dissolved oxygen is needed for metabolic processes. Dissolved oxygen is needed for metabolic processes, growth and reproduction.

The salinity value obtained is in the range of 30-32 ppt which value is already good to support the growth of seaweed. According Indarkasi *et al*., (2023) good salinity conditions for seaweed growth is 15-35 ppt. According Atmanisa *et al*., (2020), that the salinity between 28-34 ppt is already including good to support seaweed cultivation activities while the optimal salinity value in seaweed cultivation activities is 33 ppt. According Visch *et al*., (2020), the average salinity of the water surface to a depth of 10 m near the seaweed cultivation site ranged from 27.6 ± 3.3 psu.

Phosphate is a water quality parameter that important in the growth of seaweed because it is a nutrient for seaweed. The range of phosphate values obtained ranged from < 1-1 mg/l. According Dewi and Suryaningtyas, (2020) that to support the growth of seaweed, phosphate values ranging from 0,05-1 mg/l is the optimal value. According Kaprun (1978) *in* Asni, (2015) that to support the growth of seaweed, phosphate values ranging from 0.1-3.5 mg /l is the optimal value.

In addition, the nutrient needed by seaweed is nitrate. The nitrate value obtained is < 10 mg/l. Optimal nitrate levels for seaweed growth are around 0.9-3.5 mg/l, but if the levels are less than 0.1 or exceed 4.5 mg/l it will have an unfavorable impact on seaweed Asni, (2015). According Aslan (2011) in Nikhlani and Kusumaningrum, (2021), that the nitrate concentration of good waters for seaweed growth is 0.007-0.017 mg/l.

Light intensity plays an important role in the photosynthesis process that will affect the acceleration of growth. Light intensity obtained ranged from 86-203 lux. According Sitorus *et al*., (2020) that the value of light intensity that supports the growth of seaweed ranges from 500-1000 lux. While the good for grass growth is above <3000 lux (Rosnawati *et al*., 2022). Light availability is determined by the amount of radiation reaching the ocean surface, the optical characteristics of the water, and self-shading within the algal assemblage. The first two variables determine the light field above the underwater canopy and the maximum photosynthetic rate of macroalgae (Kotta *et al*., 2022).

Conclusion

The conclusion of this research is that in the coastal waters of Batu Layar, Senggigi, West Lombok Regency, there are 12 types of seaweed that grow wild consisting of 4 types of green algae (*Chlorophyta*), 4 types of brown algae (*Phaeophyta*) and 4 types of red algae (*Rhodophyta*). Types of green algae (*Chlorophyta*) are *Caulerpa*, *Ulva*, *Boergesenia forbesii* and *Halimeda*. Types of brown algae (*Phaeophyta*) are *Sargassum*, *Turbinaria*, *Padina* and *Iaxaura* sp. While red algae (*Rhodophyta*) are *Galaxaura*, *Gelidium*, *Acanthophora* and *Corallina*. *Padina* has the highest antioxidant content of 81,31%. The diversity of seaweed found can support efforts to develop seaweed-based industries as a natural resource that can produce natural antioxidants.

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