Jurnal Natur Indonesia
22(2), October 2024: 84-91

p-ISSN 1410-9379
e-ISSN 2503-0345

Wild Seaweed at Kerandangan Senggigi Beach, Batu Layar District, West Lombok Regency

Rumput Laut Liar di Pantai Kerandangan Senggigi, Kecamatan Batu Layar Kabupaten Lombok Barat

Nunik Cokrowati[1*], Nur Yatin[1], Jayusri[1], Irika Devi Anggraini[2]
[1]Department of Aquaculture, Faculty of Agriculture, University of Mataram, Mataram 83115 Indonesia
[2]Research Technology & Innovation, PT. Pertamina Indonesia, Jakarta 10110, Indonesia
*Correspondent Author: nunikcokrowati@unram.ac.id

ABSTRACT

Seaweed algae is a type of marine plant classified as benthic macroalgae and mostly lives on the bottom of the water. Algae are seaweeds that live in the sea and belong to the thallophyta group. Seaweed contains many nutrients such as carbohydrates, vitamins, fats, minerals, and others that have great potential for development in various industries. As a maritime country, Indonesia has potential coastal and marine natural resources that can be utilized to improve the welfare of coastal communities. Seaweed is one of the many coastal and marine natural resources found along the coast of the Indonesian oceans. West Nusa Tenggara (NTB) is one of the seaweed-producing areas. One of the areas that can be seen is seaweed, especially wild seaweed, in the Senggigi area, Batu Layar District, West Lombok, precisely on Kerandangan Beach. This study aimed to analyze the types of seaweed and the phytochemical content of seaweed growing on Kerandangan Beach, Senggigi, West Lombok. This study uses the purposive sampling method by taking samples that are considered representative of the research location, which is done by taking samples randomly based on the boundaries of the area that has been determined. The results of this study are There are several types of seaweed in Kerandangan Beach *Borgesenia forbesii, Corallina, Gelidium, Caulerpa taxifolia, Padina, Chondrus crispus, Sargassum cristaefolium, Galaxaura rugosa, Acanthopora spicifera, Ulva intestinalis, Halimeda opuntia,* and *Turbinaria decurrens.* This research concludes that the type with the highest antioxidant content is Padina sp., which is 81.31% and has a chlorophyll content of 14.39 mg/L.

Keywords: Antioxidant, Cultivation, Diversity, Chlorophyll, Seaweed

ABSTRAK

Rumput laut adalah jenis tumbuhan laut yang tergolong makroalga bentik dan sebagian besar hidup di dasar perairan. Rumput laut mengandung nutrisi seperti karbohidrat, vitamin, lemak, dan mineral yang memiliki potensi untuk dikembangkan dalam berbagai industri. Sebagai negara maritim, Indonesia memiliki potensi sumber daya alam pesisir dan laut yang dapat dimanfaatkan untuk meningkatkan kesejahteraan masyarakat pesisir. Sumber daya alam pesisir dan laut yang banyak ditemukan di sepanjang pesisir lautan Indonesia adalah rumput laut. Nusa Tenggara Barat (NTB) merupakan daerah penghasil rumput laut, salah satu daerah yang dapat dijumpai rumput laut khususnya rumput laut liar adalah di daerah Senggigi, Kecamatan Batu Layar, Lombok Barat, tepatnya di Pantai Kerandangan. Tujuan penelitian ini adalah untuk menganalisa jenis rumput laut dan kandungan fitokimia rumput laut yang tumbuh di Pantai Kerandangan Senggigi Lombok Barat. Penelitian ini menggunakan metode purposive sampling dengan mengambil sampel yang dianggap mewakili lokasi penelitian yang dilakukan dengan cara mengambil sampel secara acak berdasarkan batas-batas wilayah yang telah ditentukan. Hasil penelitian ini adalah jenis rumput laut yang ada di Pantai Kerandangan *Borgesenia forbesii, Corallina, Gelidium, Caulerpa taxifolia, Padina, Chondrus crispus, Sargassum cristaefolium, Galaxaura rugosa, Acanthopora spicifera, Ulva intestinalis, Halimeda opuntia* dan *Turbinaria decurrens.* Kesimpulan penelitian ini adalah Jenis yang memiliki kandungan antioxidant tertinggi adalah *Padina* sp. yaitu 81.31% dengan kandungan klorofil 14,39 mg/L.

Kata Kunci: Antioksidan, Budidaya, Keanekaragaman, Klorofil, Rumput Laut

Received: 18 August 2024
Accepted: 14 September 2024

INTRODUCTION

Algae is a marine plant classified as benthic macroalgae and mostly lives at the bottom of the water. Algae is a seaweed that lives in the sea and is included in the thallophyte group. Seaweed contains many nutrients such as carbohydrates, vitamins, fats, minerals, and others that have great potential for development in various industries. Seaweed is a low-level plant whose appearance (habitat) is relatively complex, and it is difficult to distinguish between the roots, stems, and leaves. The whole body is called the talus. Since 1670, China and Japan have consumed seaweed, which can be used as medicine, food additives, cosmetics, animal feed, and organic fertilizer. Seaweed has been used as daily food in Japan, China, and Korea, and in 2005, the value of seaweed consumption reached 2 billion dollars (Gazali, 2018).

As a maritime country, Indonesia has potential coastal and marine natural resources that can be utilized to improve the welfare of coastal communities. One of the coastal and marine natural resources commonly found along the coast of the Indonesian oceans is seaweed. Seaweed is spread in tropical, subtropical, and cold waters (Malkab et al., 2021). Currently, the government has made seaweed a superior product because it has economic value that can change the financial sector at the level of farmers, producers, processors, and users (Halimah et al., 2021)

West Nusa Tenggara (NTB) is one of the seaweed-producing areas. One of the areas that can be found seaweed, especially wild seaweed, is in the Senggigi area, Batu Layar District, West Lombok, precisely on Kerandangan Beach. Batu Layar sub-district has an area of 3,411 ha with the potential for seaweed cultivation development, which is quite potential because the waters are quite good. So that seaweed plants are found in many types that can live on the beach. The research objective was to analyze the types of seaweed and the phytochemical content of seaweed growing on Kerandangan Beach, Senggigi, West Lombok.

MATERIALS AND METHOD

Time and place of research

The research was conducted in February 2024. This research location is Kerandangan Senggigi Beach, Batu Layar District, West Lombok Regency.

Methods

This study uses the purposive sampling method by taking samples that are considered to represent the research location randomly based on the boundaries of the area that has been determined. At each location point, types of seaweed were found and then identified based on color, shape, and place of life. The most common way of determining is based on color: green algae (Chlorophyceae), blue-green algae (Cyanophyyceae), brown algae (Phaecophyceae) and red algae (Rhodophyceae). Furthermore, the indication stage by matching based on https://www.algaebase.org/

The instruments used in this research include culture bottles, analytical balances, pH meters, pinsets, scalpel handles, micropipettes, magnetic stirrers, autoclaves, ovens, Laminar Air Flow (LAF), binocular microscope, and other supporting tools. The materials used in this research include nodal vanilla explants, a medium of Murashige Skoog (MS), Benzyl Amino Purine (BAP), coconut water, sugar, gel, and other supporting materials.

Antioxidant activity

The antioxidant activity of seaweed was tested using the UV-Vis spectrophotometer DPPH method. Samples were used as much as 1 g; the sample was added to 9 mL methanol, then vortexed and macerated for 24 hours. After maceration, the sample was filtered using Whatman filter paper to separate the residue from the filtrate. The filtered sample was taken 1 mL, and then 2 mL of 0.1 mM DPPH solution was added. The mixture was shaken until homogeneous, covered with aluminum foil, and 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, Yahya & Nurrosyidah, (2020)**:**

$$\% \text{ Inhibition} = \frac{(\text{Abs blank} - \text{Abs sample})}{\text{Abs blank}} \times 100\ \%$$

Chlorophyll analysis

Seaweed samples in wet conditions were blended and taken in as much as 2 g, which was mashed using a

mortar and then dissolved using 100% acetone. The liquid is taken if the liquid is cloudy and filtered to obtain the clear filtrate. The clear filtrate was taken in as much as 10 mL in the room in the cuvette, and then the absorbance value was measured using a spectrophotometer. A standard solution of chlorophyll-a was made and measured with the same wavelength to determine the chlorophyll content. According to Mahardika in Zunnuraini et al. (2023), chlorophyll-a content is calculated using the formula:

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

Description: An absorbance at each wavelength.

RESULT AND DISCUSSION

Figure 1 shows some seaweed on the beach Kerandangan Senggigi West Lombok Regency:

Figure 1. Seaweed on the beach Kerandangan Senggigi

Boergesenia forbesii has green morphological characteristics with an elongated spherical talus that widens at the tip and cones at the base. The spherical talus stores water content, and its size reaches 3 cm in height and 1 cm in width. Root-like organs are attached to rocky sand. According to Asih et al. (2019), *B. forbesii* is a seaweed with water content. It is not resistant to dry conditions and can be found in the substrate of sand, coral, and so on.

Generally, the characteristics of this genus are thalus, which is round to oval; the blades are erect by forming slightly flattened spheres, numbering 8-16 ramuli, with a diameter of 2.92 mm. The distance between branches is 5 mm. *B.forbesi* has a dark yellowish-green color and grows relatively sparsely.

Corallina officinalis consists of calcareous, branching, segmented fronds, usually erect, up to 12 cm high, but often much shorter. Fronds rise from a calcareous crustose, disk-shaped, holdfast about 70 mm in diameter. Fronds consist of a jointed chain of calcareous segments, each becoming wedge-shaped higher up the frond. Branches are opposite, resulting in a feather-like appearance. Color varied: purple, red, pink, or yellowish with white knuckles and extremities. Asih et al. (2019), *C. officinalis* L. has a complex and calcareous thallus, rigid structure, joint-jointed sheets in one plane, branching, pinnate or irregular, *C. officinalis* has cylindrical or flat stems with a disc-shaped root-like base structure. The color of this algae is whitish to pinkish. They live on rocks with varying shapes and often grow stunted.

Gelidium sp is approximately 20 cm long and 1.5 mm wide. The thallus is red, brown, green-brown, or blonde with a bush-like shape. *Gelidium* sp is primarily found in craggy waters. According to Darmawati et al. (2023), *Gelidium* sp has a length of approximately 20 cm and a width of 1.5 mm. Thallus was red, brown, green-brown, or blond. *Gelidium* sp seaweed is an agar-producing red algae. There are two main types of substrates used as a place of life for seaweed, namely soft substrates, which include mud, sand, or a mixture of sand and dirt, and rigid substrates, which include dead coral, live coral, and rocks (Linthin & Pong-Masak, 2023).

Caulerpa taxifolia seaweed is a type of green algae or chlorophyta. With morphological characteristics, the clump is formed from various branching, ranging from simple to complex. This seaweed grows in shallow seas with calm water flow and sticks to the sand. Darli et al. (2020), The results of morphological identification of *C.taxifolia* seaweed show the characteristics of branch-like, flat, and erect hairs 3-5 cm high and 1-2 mm in diameter. Rhizoids are attached to the substrate. The opposite branchlets are connected to the midrib, slightly curved upwards, and tapered at the base and tip. The midrib is slightly flattened and light green-yellow.

Padina is characterized by a fan-like sheet-shaped talus that is light brown to white. The size of the talus is about 4 to 7 cm, with radial lines in the form of bulkheads or segments on each sheet. The talus of this seaweed widens towards the top and cones at the base. Padina lives in areas that are constantly inundated with water. The root-like part is attached to the rocks along the coastal region. Asih et al. (2019), *Padina pavonica* L. has a thallus morphology like a 3-4 cm diameter fan that grows in concentric circles. *P. pavonica* L. has potential as a natural antioxidant and has several active compounds (flavonoids, alkaloids, tannins, triterpenoids, saponins, and phenolics) and pigments (chlorophyll a, chlorophyll c, carotenoids, fucoxanthin, fucoxantol, and β-carotene).

Chondrus crispus is a relatively small marine algae reaching over 20 cm long. It grows from a disk-shaped, branching substrate. Its morphology varies greatly, especially the breadth of the thalli. The branches are 2-15 mm wide and firm in texture. They range in color from bright green at the water surface to deep red at greater depths. Chondrus crispus is a red seaweed commonly found on rocky shores (Liu et al., 2013).

Sargassum cristaefolium is one of the genera of Phaeophyta division. *S. cristaefolium* generally has a brown color with a height that can reach more than 1 meter. The top of this plant resembles a bush with a cylindrical main talus, bilateral or radial branching, and a disk-like holdfast shape. *S. cristaefolium* grows in waters with hard or rough substrates such as rocks, dead corals, volcanic rocks, etc. The main content of this algae is alginate, cellulose, and fucoidan. In addition, *S. cristaefolium* also has antioxidant content (Gazali et al., 2023). Prasedya et al. (2021), All thalli had tough stalks, blades, and air sacs that favor floating. Blades were thick with serrated edges. The top blade crown of the air sac was serrated, and the air sac had a stalk rod connected to a side branch.

Galaxaura rugosa has morphological characteristics including dense, stiff, compact thallus, forming hemispherical mounds, talus height of 8 cm, dark red-brown talus color, and dichotomous branching. Cylindrical branches have a holdfast to attach to the substrate (Lestari et al., 2023). Nyunt & See-Htun (2008) state that the thallus is bushy and caespitose, from 3-7cm tall or more and 2.5-6 cm in diameter. Thallus is lightly calcified, dark red, soft, and attached by a small disc-like holdfast. The stipe is very short, and internodal segments are 3-6mm long and 1-2 mm wide. The branching type is regularly dichotomous at a wide angle, and the angle of dichotomy is 10˚-50˚; the tip of the branch is obtuse. In the transverse section, the mature thallus consists of 2 to 3 layers of cells; the shape of the cortex cell is roundish papillae, 28-32 µm or more in length and 16-20 µmin broad.

Acanthophora spicifera has a short thallus; the talus height is only about 1-5 cm, green-brown in color, branched, shaped like a thorn, and cylindrical. This alga lives in the sea, often found on the coast. The holdfast (rhizoid) part is fibrous and found attached to corals living in colonies (Ramdan & Nuraeni 2021). Mendoza-Becerril et al. (2023), This red alga is sparingly branched, lacking spines; if they are present, they are only in

meager numbers or solitary on main axes. On indeterminate branches, spines are crowded and smaller towards the apex, and those on the branchlets are mostly grouped at the apices.

Ulva intenstinalis is a conspicuous bright green seaweed consisting of irregularly inflated and constricted tubular leaves that grow from the bottom of the water and form small disks. Leaves are usually unbranched. The fronds can be 10-30 cm long or more and 6-18 mm in diameter, and the tip is generally rounded. According to Shobir et al. (2019), the thallus is long and slender, strikingly green, and the leaf thallus is typically unbranched. The thallus is 10-30 cm long and 6-18 mm wide. Like other species of the Ulva, *U. intestinalis* is a macroalgae that thrives throughout the year. This seaweed can be found on coral and sand. Mohebbi & Zarezadeh (2023), the thallus is green to dark or yellowish green. Plants up to 50 cm tall, tubular or with compressed apical part, narrowly to broadly cuneate in outline, surface often wrinkled. Cells in no definite order in surface view, rounded, 6-12 µm in diameter; chloroplast situated against the distal radial cell wall, with one pyrenoid. The thallus membrane (one cell layer) varies in thickness from 17 µm near the apex to 30 µm in the upper basal region.

Halimeda opuntia is a macroalga with an erect thallus and branched segments. The segment forms a triangle that appears on the basal part of the macroalgae. Thallus *H.opuntia* is about 6-10 cm tall and is accompanied by an adhesive tool to stick to the substrate (Meiyasa & Tarigan 2021). Wizemann et al. (2015), *H.opuntia* is a cosmopolitan marine macro-alga of tropical shallow seas. Macro-algae of the genus *Halimeda* exhibit a segmented, branched growth habit whereby the algae form calcareous segments of the $CaCO_3$ polymorph aragonite and possess thin root-like filaments that can attach primarily to rigid substrates. Thus, *Halimeda* species of the lineage Opuntia are often found in coral reef environments.

Turbinaria decurrents have brown morphological characteristics, a rather hard or stiff thallus structure, and a thick and upright body. Thallus characteristics with leaf shape resemble a jagged triangular cone. Disc-shaped roots (holdfast) can grow on the outer reef flat or in places more exposed to direct waves (Sarita et al., 2021). Sami & Nur (2022), *Turbinaria* is included in the genus brown seaweed (Phaeophyta). The brown color of this type is influenced by color pigments such as fucoxanthin, xanthophyll, carotenoids, and chlorophyll.

Table 1. Antioxidant levels and Chlorophyll-a levels

No	Types of seaweed	Antioxidant levels (%)	Chlorophyll-a levels (mg/L)
1	*Padina* sp.	81.31	14.39
2	*Chrondrus crispus*	29.46	15.70
3	*Sargassum cristaefolium*	29.61	8.10
4	*Caulerpa taxifolia*	31.36	6.50
5	*Ulva intestinalis*	41.59	15.08
6	*Halimeda opuntia*	1.79	8.83
7	*Acanthophora*	19.05	11.22
8	*Gelidium*	15,56	9,84
9	*Corallina*	24,60	11,18
10	*Boergesenia forbesii*	7,15	8,40
11	*Galaxaura*	17,71	13,74
12	*Turbinaria* sp.	25.94	14.42

Antioxidants

Based on the results of antioxidant activity tests that have been carried out, the highest antioxidant content value is obtained by *Padina* sp. seaweed, which is 81.31%, and the lowest antioxidant content is obtained by *Halimeda opuntia* seaweed. Antioxidants are compounds that can inhibit the work of free radicals by donating one or more electrons. Free radicals are atoms, molecules, or compounds with unpaired electrons that react readily with other substances such as proteins, fats, and DNA. Hidayati et al. (2017), *Padina* sp. has the potential as a natural antioxidant and contains active compounds such as flavonoids, alkaloids, tannins, triterpenoids, saponins, phenolics and pigments such as chlorophyll a, chlorophyll c, carotenoids, fucosantin, fukoxantol, and β-carotene. One of the compounds that act as antioxidants from seaweed is phenolic compounds. This compound is the largest group of compounds that act as natural antioxidants in plants and is also widely found in almost all types of seaweed. Phenolic compounds can function as anti-ultraviolet radiation because these compounds have bonds that are conjugated in the benzene core so that resonance will occur by transferring electrons (Loho et al., 2021). The high and low content of antioxidants obtained in seaweed is thought to be influenced by environmental factors. According to Indahyani et al. (2019), the bioactive content in seaweed is influenced by seasonal conditions and geographical areas and species, ecological changes such as sunlight, nutrients, contaminants, salinity, CO_2, pH, temperature, and biotic interactions.

Chlorophyll-a

Chlorophyll is a green substance found in the leaves of various plant organisms and is one of the molecules that play an important role in photosynthesis. During cultivation activities, high chlorophyll levels can increase seed growth. Based on the results of the highest chlorophyll content activities found in seaweed species *Chrondrus crispus* with a value of 15.70 mg/L, while the lowest chlorophyll content in the species of *Caulerpa taxifolia* with a value of 6.50 mg/L. In contrast to the results of research by Haryani et al. (2022), the chlorophyll content contained in the seaweed *Chrondrus crispus* amounted to 6.91514 mg/g; this may be caused by environmental conditions where the seaweed cultivation area and the number of cultivators can affect the chlorophyll content. In addition to environmental conditions, water quality can also affect the chlorophyll content in seaweed. Following the opinion of Widyastuti et al. (2022), Water quality can affect the presence of chlorophyll-a concentrations in dense, medium, and small seaweed cultivation areas in waters such as current velocity, temperature, dissolved solids and current, such as current velocity, temperature, dissolved oxygen, and light.

Water Quality

Water quality parameters are important factors that can be benchmarks for water quality standards suitable for seaweed growth. Among those measured during the study were temperature and light intensity. Physical parameters of water quality during the study were at the tolerance limit for seaweed growth. The research results show that the temperature range at the location of the seaweed sampling amounted to 29-30^{0}C. The temperature range is a very feasible value for the growth of seaweed as Maradhy et al. (2021) state that a suitable temperature for supporting the survival and growth of seaweed is 26-32^{0}C, so the temperature in these waters can be said to include the optimal temperature for seaweed growth.

Table 3. Result of water quality measurement

Parameters	Value	Feasibility
Temperature (°C)	28,2	24 – 31 (Mulyadi, 2023)
pH	7,8	6,8 – 9,6 (Rukka et al., 2022)
Dissolved oxygen (mg/L)	6,0	4 – 6 (Hardan et al., 2020)
Salinity (ppt)	31	28 – 34 (Astriana et al., 2019)
phosphate (mg/L)	1	0,05 – 1 (Wiyoto & Effendi, 2020)
Nitrate (mg/L)	< 10	0,9 – 3,5 (Maradhy et al., 2021)
Light intensity (lux)	119	500 – 1000 (Maradhy et al., 2021)

In addition to physical parameters, water quality chemical parameters were also measured at the seaweed sampling location and showed that water quality chemical parameters, including phosphate, nitrate, ammonia, dissolved oxygen, salinity, and pH were in a suitable condition for grass growth, where in the sampling area the phosphate value was 1 mg/L, nitrate was <10 mg/L, dissolved oxygen was 6.7 mg/L, salinity was 30 ppt, and pH value was 7.4. The ideal water quality chemical parameters for grass growth are ammonia in the range of 0.3 mg/l (Wiyoto & Effendi, 2020); phosphate in the range of >0.1 mg/L; pH range of 7.5-8.5; salinity in the range of 28-34 ppt; nitrate in the range of 0.1-0.7 mg/L and the optimum Dissolved Oxygen for seaweed growth is in the range of 5.48-8.39 mg/L, while the most optimal dissolved oxygen is >5 mg/L (Maradhy et al., 2021). Strengthened by Malkab et al. (2021), dissolved oxygen is feasible for seaweed growth at 4-6 mg/L. Hardan et al. (2020) also reported that seaweed can live at optimum dissolved oxygen levels of >6 mg/L.

CONCLUSION

The conclusions obtained are that 12 species of seaweed grow on the beach of Senggigi, with the highest antioxidant content found in *Padina* sp. and the lowest in *H.opuntia* species. Furthermore, the highest chlorophyll content is in Chrondrus crispus, and the lowest is in *C. taxifolia*.

ACKNOWLEDGEMENT

The authors thank PT Pertamina Indonesia for funding this research in 2024.

REFERENCES

Asih, T., Khayuridlo, M., Noor, R., Muhfahroyin, M. 2019. Biodiversity and potential use of macroalgae in Pesisir Barat Lampung. *Biosaintifika*, 11(1): 100–107.

Astriana, B.H., Lestari, D.P., Junaidi, M., Marzuki, M., 2019. Pengaruh kedalaman penanaman terhadap

pertumbuhan *Kappaphycus alvarezii* hasil kultur jaringan di Perairan Desaseriwe, Lombok Timur. *Jurnal Perikanan*, 9(1): 17–29.

Darli, K.Z.N., Angga, W.P., War, N.S., Samuel, N.A., Amin, A.M., Eman, K.A.R., Rosi, F., 2020. First report on molecular identification of *Caulerpa* Green algae from Mandangin Island Indonesia using partial 18SrRNA genes. *Journal of Aquaculture and Fish Health*, 9(3).

Darmawati, P., Ode, I., Setyono, D.H.B., Laheng, S., Mujtahidah, T., Sari, P.Y., Putri, W.I., Abidin, Z., Sukendar, W., Sulthoniyah, T.M.S., Marda, B.A., Yusuf, M.A., Suci, N.N.A., Abdullah, A., & Setyaka, S., 2023. *Kiat agribinis rumput laut.* Tohar Media (Vol. 1).

Gazali, M., 2018. The potency study of *Padina australis* (Hauck 1887) extracts as tyrosinase inhibitor from simeulue islands. *Journal of Aceh Aquatic Science*, 2(1): 37–47.

Gazali, M., Husni, A., Majid, F.A.A., Zuriat, S.R., Wahyuni, S., Hidayat, D., 2023. The evaluation of antioxidant action of green seaweed *Boergesenia forbesii* extracts. *Marbiouticom*, 1137(1).

Halimah, N., Harlina, H., Kasnir, M., 2021. *Laju pertumbuhan dan produksi rumput laut (Kappaphycus alvarezii) dengan metode budidaya yang berbeda di pesisir pantai Kecamatan Mare Kabupaten Bone.* Seminar Ilmiah Nasional Fakultas Perikanan dan Ilmu Kelautan Universitas Muslim Indonesia, 61–75.

Hardan, H., Warsidah, W., Ierwan, S., 2020. Laju pertumbuhan rumput laut *Kappaphycus alvarezii* dengan metode penanaman yang berbeda di Perairan Laut Desa Sepempang Kabupaten Natuna. *Jurnal Laut Khatulistiwa*, 3(1).

Haryani, T.S., Uswatun, H., Oom, K., Intan, L., Dina, A., 2022. Potensi ekstrak *Codium*, *Halimeda*, *Dictyota*, *Chondrus*, *Glacillaria* sebagai sumber pigmen dan antioksidan alami. *Ekologia: Jurnal Ilmiah Ilmu Dasar dan Lingkungan Hidup*, 22(1): 9-17

Hidayati, J.R., Ridlo, A., Pramesti, R., 2017. Aktivitas antioksidan ekstrak rumput laut *Padina* sp. dari Perairan Bandengan Jepara dengan metode transfer elektron. *Buletin Oseanografi Marina*, 6(1): 46–52.

Indahyani, D.E., Praharani, D., Barid, I., Tri, A., Handayani, W., 2019. Antioxidant activity and total polysaccharide of red, green, and brown seaweed from Jangkar Situbondo Coastal. *Stomatognatic* (J.K.G Unej), 16(2): 64–69.

Lestari, F.P., Juliono, F., Ramadhani, H., Hafidz, M., 2023. Inventarisasi jenis - jenis makroalga di Perairan Pantai Pulau Pelapis Kabupaten Kayong Utara. *Jurnal Laut Khatulistiwa*, 6(2): 99–107.

Linthin, D., Pong-Masak, P.R., 2023. Seaweed cultivation technology *Gelidium* sp. with different substrates in the pond. *Jurnal Perikanan*, 13(3): 736–743.

Liu, J., Hafting, J., Critchley, A.T., Banskota, A.H., Prithiviraj, B., 2013. Components of the cultivated red seaweed *Chondrus crispus* enhance the immune response of *Caenorhabditis elegans* to *Pseudomonas aeruginosa* through the pmk-1, daf-2/daf-16, and skn-1 pathways. *Applied and Environmental Microbiology*, 79(23): 7343–7350.

Loho, R.E.M., Tiho, M., Assa, Y.A., 2021. Kandungan dan aktivitas antioksidan pada rumput laut merah. *Medical Scope Journal*, 3(1):113.

Malkab, I., Hadijah., Mulyani, S., 2021. Analisis pengembangan budidaya rumput laut *Gracillaria* sp di Kecamatan Sinjai Timur Kabupaten Sinjai. *Journal of Aquaculture Environment*, 3(2): 30–33.

Maradhy, E., Nazriel, R.S., Sutjahjo, S.H., Rusli, M.S., Widiatmaka., Sondita, M.F.A., 2021. Evaluation of water suitability for sustainable seaweed (*Kappaphycus alvarezii*) cultivation to support science technopark in North Kalimantan. *Journal of Natural Resources and Environmental Management*, 11(3): 490–503.

Meiyasa, F., Tarigan, N., 2021. Keanekaragaman jenis makroalga yang ditemukan di Perairan Wula-Waijelu Kabupaten Sumba Timur. *Quagga: Jurnal Pendidikan dan Biologi*, 13(2): 60–67.

Mendoza-Becerril, M.A., Pedroche, F.F., Estrada-González, M.C., Serviere-Zaragoza, E., 2023. Records of the non-native alga *Acanthophora spicifera* (Rhodophyta) and their colonial epibionts in La Paz Bay, Gulf of California. *Biodiversity Data Journal*, 11.

Mohebbi, F., Zarezadeh, S., 2023. a Review of *Ulva intestinalis*, the only macroscopic alga of Urmia Lake. *Iranian Journal of Botany*, 29(1): 83–88.

Mulyadi, M., 2023. Kajian kualitas air terhadap pertumbuhan rumput laut *Eucheuma cottonii*; Studi Kasus di Desa Tapi-Tapi Kec. Marobo Sulawesi Tenggara. *Jurnal Perikanan*, 3(13): 682-689

Nyunt, T., See-Htun, U., 2008. Studies on the morphology and distribution of *Galaxaura arborea* Kjellman (Nemaliales, Rhodophyta) from Myanmar. *Universitas Research Journal*, 1(4).

Prasedya, E.S., Frediansyah, A., Martyasari, N.W.R., Ilhami, B.K., Abidin, A.S., Padmi, H., Sunarwidhi,

A.L., 2021. Effect of particle size on phytochemical composition and antioxidant properties of *Sargassum cristaefolium* ethanol extract. *Scientific Reports*, 11(1): 17876.

Ramdan, M.R., Nuraeni, E., 2021. Identifikasi Morfologi *Ulva intestinalis* dan *Acanthophora spicifera* di Kawasan Pantai Tanjung Layar, Sawarna, Bayah, Kabupaten Lebak, Banten. *Tropical Bioscience: Journal of Biological Science*, 1(1): 1–10.

Rukka, A.H., Masyahoro, A., Samsul, Y., 2022. Analisis pertumbuhan rumput laut (*Euchema cottonii*) pada bobot awal dan jarak tanam berbeda yang dibudidayakan di lepas dasar Perairan Pulau Lingayan. *Jurnal Ilmiah Samudra Akuatika*, 6(2): 58–67

Sami, F.J., Nur, S., 2022. Isolation, identification and biochemical studies of gallic acid from *Turbinaria decurrens Bory*. *Current Research on Biosciences and Biotechnology*, 4(1), 238–241.

Sarita, I.D.A.A.D.S., Subrata, I.M., Sumaryani, N.P., Rai, I.G.A., 2021. Identifikasi jenis rumput laut yang terdapat pada ekosistem alami Perairan Nusa Penida. *Jurnal Edukasi Matematika dan Sains*, 10(1): 141–154.

Shobir, H., Triastinurmiatiningsih, T., Ismanto, I., 2019. Kenekaragaman Jenis makroalga yang berpotensi sebagai bahan obat di Perairan Pantai Cidatu Kabupaten Pandeglang. *Ekologia: Jurnal Ilmiah Ilmu Dasar dan Lingkungan Hidup*, 19(2): 89–98.

Widyastuti, H., Kasim, M., Ketjulan, R., 2022. Pola sebaran klorofil-a kaitannya dengan kepadatan daerah budidaya rumput laut di Perairan Pantai Bone-Bone. *Seminar Ilmiah Nasional Fakultas Perikanan dan Ilmu Kelautan Universitas Muslim Indonesia, 2, 20-36*.

Wiyoto, W., Effendi, I., 2020. Analisis kualitas air untuk marikultur di Moro, Karimun, Kepulauan Riau dengan analisis komponen utama. *Journal of Aquaculture and Fish Health*, 9(2): 143–154.

Wizemann, A., Meyer, F.W., Hofmann, L.C., Wild, C., Westphal, H., 2015. Ocean acidification alters the calcareous microstructure of the green macro-alga *Halimeda opuntia*. *Coral Reefs*, 34(3): 941–954.

Yahya, M.A., Nurrosyidah, I.H., 2020. Antioxidant activity ethanol extract of gotu kola (*Centella asiatica* (L.) Urban) with DPPH method (2,2-Diphenyl-1-Pikrilhidrazil). *Journal of Halal Product and Research*, 3(2), 106–112.

Zunnuraini, Z., Cokrowati, N., & Diniarti, N., 2023. Profil klorofil selada laut *Ulva* sp. dengan umur panen yang berbeda pada budidaya terkontrol. *E-Journal Budidaya Perairan*, 11(1): 68–78.