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Abstract. Green seaweed *Caulerpa* sp is found in several coastal waters in Indonesia and is used as fresh vegetables by people in the growing habitat area. This study aimed to conduct a review of the potential of *Caulerpa* sp as functional food. The development of this paper is a literature review of relevant writings to determine the position of sea grapes *Caulerpa* sp as functional food. Data and relevant information are displayed in the form of figures and tables. *Caulerpa* seaweed grows naturally and is available throughout the year. *Caulerpa* contains crude fiber and secondary metabolites which positions *Caulerpa* as a functional food ingredient. The components of superior nutrition in *Caulerpa* are minerals, proteins, fats, and carbohydrates. The superiority of *Caulerpa* as a food ingredient is its processing which is very simple and brief and does not require food additives in the form of dyes and essences.

1. Introduction

Marine organisms in general, especially seaweed, have gained a good position in terms of consumption of the world community, either for food, industry, or medicine. Food originating from the sea has been believed to have a better level of security compared to cultivated land food. This is because the source of sea food is available naturally in the sea. Wide and clear seawater is classified as water that is still safe from pollution as seawater has the ability to clean itself.

Currently seaweed has become a favorite of the world community. *Caulerpa* sp is a type of seaweed from the Chlorophyta group known as sea grapes. In some waters, *Caulerpa* sea grapes grow naturally and are used by local people as vegetables [1] [2]. The global community knows *Caulerpa* by the name of sea grape. In some regions, *Caulerpa* is known by a different name, for example, in the Kei Islands it is known as *lat*, in Sulawesi known as *lawi-lawi*, *ar-arosep* or *latoh* in the Philippines, *umi budo* in Japan, *green caviar* in Europe, and also nama in *Fiji*.

For a long time, people in the coastal areas have consumed *Caulerpa* as fresh vegetables, especially during the lean season, especially when fish are hard to find. The people of the Kei Islands of Southeast Maluku consume *Caulerpa* as “fresh vegetables” with a traditional sauce, *colo-colo* or mixed with grated coconut and spices known as “urap” [3].

Sea grape is known by people in China, Korea and Japan as a beauty food. Several reports have shown that *Caulerpa* is very good to be processed into various processed products and has great potential as a functional food [1] [2] [3]. In Indonesia so far, sea grapes have not been processed into various processed products or it can be said that there has not been any touch of processing technology for the sea grapes *Caulerpa*. This is both a challenge and an opportunity to optimize its use (which has been observed by international markets) for the welfare of coastal communities.

Utilization of *Caulerpa* as fresh vegetables has actually given instructions that this sea grape can be turned into various types of processed products. Several studies have reported the physico-chemical composition of Caulerpa presenting its potential as a healthy functional food ingredient [2] [4]. Several other research results have also reported that *Caulerpa* contains good secondary metabolites, so it is appropriate to be developed as a healthy and safe functional food product [5] [6]. This paper is a review of relevant writings to determine the position of sea grape *Caulerpa* sp. as a functional food. Collecting data and information applied the literature studies. Data and relevant information are displayed in the form of figures and tables.

2. The Availability

Naturally, the sea grape *Caulerpa* sp. habitat is in shallow, clear waters with streams that tend to be calm. *Caulerpa* sea grapes grow naturally in the waters of the Maluku Kei Islands with a fairly dense population, and can be found throughout the year, known as *lat* [7] [8] [9]. The availability of sea grapes *Caulerpa* in the waters indicates good water quality with high enough light intensity which is the main parameter of biophysical conditions for *Caulerpa* habitat waters [2].

Sea grape *Caulerpa* sp. which belongs to the Sinophales has thalus, which is a reed that is not insulated (senositic), branched, and formed with a divider during breeding. The whole body of *Caulerpa* sp consists of one cell with a lower part that spreads like a stolon that has rhizoid as a sticking device on the substrate [10]. The color of thalus *Caulerpa* sp is green like leaf green so it is grouped into green algae (*Chlorophyceae*). This is because there are plastids in *Caulerpa* sp cells that contain chlorophyll a and b pigments as in the green leaves of higher plants.

There are 50 species of *Caulerpa* and 12 of which are found in Indonesia. Some of these *Caulerpa* species are *C. racemosa, C. lentillifera, C. sertularoides, C. serulata, C. taxifolia, C. elongata, C. brachypus, C. peltata* and others [10]. In Maluku there are three types of Caulerpa species that are dominant, among others *C. racemosa* and *C. lentillifera* which are edible and *C. peltata* which is not edible [3].

Along with the changing times, in the past decade, domestic and foreign market demand continues to increase. Increased demand for *Caulerpa* coincided with increased public awareness to consume functional food ingredients for their health. Previously, consumption of sea grape *Caulerpa* was only limited to the fishing community, which is during the lean season because fish are difficult to catch. This is caused by the lack of knowledge of a great number of people who do not know the benefits of *Caulerpa* for the body and the assumption that consuming *Caulerpa* is a characteristic of low economic society.

Figure 1. Morphology of *Caulerpa lentillifera* [3] [7]

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Currently sea grapes *Caulerpa* have been cultivated on a large scale in several countries such as the Philippines and Thailand [1]. In Indonesia, *Caulerpa* cultivation has been carried out in South Sulawesi and has been successfully exported every month to Japan with increasing demand. In Japan, the price of fresh "lat" sea grapes of the highest quality per kilogram is more expensive than the largest size vannamei prawn and reaches a price of 5000 Yen.

The speed of utilization that is not balanced with the time of regeneration can cause the extinction of an organism. Given the increasing demand for *Caulerpa*, cultivation efforts need to be made to ensure its availability all the time. The growth of marine organisms is based on the needs of the organism

against various factors in the aquatic environment. Although *Caulerpa* is naturally available in its habitat in several coastal waters in Indonesia, cultivation efforts need to be made to prevent the extinction of Caulerpa and ensure its availability.

The original natural habitat shows the composition of aquatic biophysical parameters in accordance with condition of sea grape *Caulerpa*. This illustrates that cultivation activities would be more appropriate if carried out in these natural habitats to support their growth and increase the percentage of successful conservation. The success of cultivation in habitats that are suitable to their growth needs will guarantee the availability of *Caulerpa* throughout the year.

3. Nutrient Content

Current market demand, both domestically and abroad, especially Japan, has indicated that the needs of the community for *Caulerpa* have increased along with the increased awareness to consume healthy and safe food for their health. *C. lentillifera* in fresh conditions is very easy to experience damage because the chemical composition of sea grapes (*Caulerpa* sp) is dominated by water. [11] reported that the proximate content of *C.racemosa* was 92.375% of water, 21.370% of protein, 8.681% of fat, 20.910% of ash, 48.679% of carbohydrate and 8.429 of crude fiber. Other studies on *C. racemosa* and *C. serulata* growing in the waters of Awur Jepara Bay showed a moisture content of 91.06%, ash content of 5.22%, protein content of 0.80%, fat content of 0.03% and carbohydrate of 2.89% [11].

Proximate composition and crude fiber of *C. lentillifera* from Kei Islands waters, both fresh and dry, can be seen in Table 1. Green seaweed has pigments in the form of chlorophyll a and b, beta, carotene gamma and santophyll. *C. racemosa* contains vitamin C, vitamin E, chlorophyll, carotenoids, xanthophyll and lutein [12].

Table 1. Chemical Composition *C. lentillifera*

Composition	Fresh [3]	Dried Directly [2]	dry wind [2]
Water content (%)	94,84	18,82	9,22
Ash content (%)	3,29	40,66	41,83
Protein (%)	1,29	5,63	7,55
Fat (%)	0,76	0,88	0,99
Carbohydrate (%)*	3,18	29,82	37,76
Crude fiber (%)	0,002	23,02	24,14

Remarks: (*) = *by different*

Nufus *et a*l [13] in their study reported that *C. lentillifera* from the Seribu Islands has higher ash and carbohydrate content than other proximate components. The mineral content of *C. lentillifera* was the highest macro mineral composition, Mg and followed by K, Ca and Na; while the highest micro minerals are Zn, Mn and Fe (Table 2). The mineral content of several types of *Caulerpa* can be seen in Table 3.

Table 2. The mineral content of dried *C. lentillifera* from Kei Islands [2]

Mineral Types	Composition (mg/100 g)	
	Dried Directly	Dry-Wind
Mg	387,5	426,7
Ca	47,392	53,536
K	446,0	453,0
Na	3,90	4,03
Zn	1,028	2,011
Mn	0,072	0,073
Fe	0,0016	0,0019

The superiority of minerals in *C. lentillifera* from the Kei Islands is Mg, K, and Zn [2]. The superiority of *C. lentillifera* from the Seribu Islands and the West Nusa Tenggara Sakotong are Ca (119.20 g/kg), Na (34.18 g/kg) and Fe (0.34 g/kg) [13]. The mineral content of several types of *Caulerpa* is presented in Table 3. Macro and micro minerals in food are needed to support the body's metabolic system. Some of the uses of minerals include: magnesium which prevents tooth decay, activates

enzymes, relaxes muscles, transmits nerves, and affects the digestive system and kidneys [14]; potassium optimizes structural and regulatory functions, controls membrane stimulation [15] also helps stabilize normal blood pressure and promote cell growth. Sodium plays a role in maintaining fluid, osmotic and acid-base balance [16]. Zinc is a cofactor of the enzyme system (cytochron C-oxidase), which stabilizes membranes, hormones and nucleic acids [13].

Table 3. The Mineral Content of Several Types of *Caulerpa*

Types	*C. lentillifera* (mg/100 g DW) [17]	*C. racemosa* (mg/10 g DW) [18]	*C. veravelensis* (mg/100 g DW) [18]	*C. scalpelliformi* (mg/100 g DW) [18]
Mg	630	161	-	-
Ca	780	476	-	-
K	970	503	-	-
Na	-	1064	-	-
Fe	9,3	2,97	14,79 ± 1,44	16,28 ± 2,11
Cu	2200 (µg)	0,06	0,41 ± 0,77	0,77 ± 0,55
Zn	2,6	0,68	5,42 ± 0,22	3,27 ± 0,28
Mn	7,9	-	2,00 ± 1,18	3,33 ± 0,36
Ni	-	-	0,20 ± 0,04	0,37 ± 0,55
As	-	-	0,21 ± 0,07	0,25 ± 0,09
Mo	-	-	0,13 ± 0,02	0,11 ± 0,01
Se	-	-	0,27 ± 0,04	0,15 ± 0,03
P	1030	-	-	-
I	1424 (µg)	-	-	-

3.1. Secondary Metabolites

Secondary metabolites are metabolites that are not essential for the growth of organisms but function to defend themselves from unfavorable environmental conditions, for example to overcome pests and diseases, attract pollinators, and as signaling molecules. Secondary metabolites are found in unique shapes or varied between species. Each organism usually produces secondary metabolites that are different, maybe even one type of secondary metabolite compounds is found only in one species in a kingdom [19]. Secondary metabolites produced by seaweed are in the form of chemicals as part of efforts to defend themselves from the danger of predators [20].

Secondary metabolites are currently being an important object to be explored regarding the content of biomass and unique bioactive compounds that are important. A review of the ability of seaweed as a biomedical and pharmaceutical resource has been reported among others, as the antibiotic, anticoagulant, antioxidant, antiproliferase, antitumor, anticomplementary, anti-inflammatory, antibacterial, antifungal, antiviral, antihelmintic, antiprotozoa, antiseptic, hypolipidemic, antiadhesive and antifouling [21]. Parsaeimehr and Chen [22] in their article showed the diversity of seaweed bioactive compounds as pathogenic antimicrobial agents.

Various natural bioactive ingredients contained in seaweed have been found such as amino acids, phenolic, carotenoids, terpenoids, indole, sterols, sulfated polysaccharides, alkaloids, peptides and proteins [23]. The discovery of bioactive compounds from the sea in particular and other living organisms in general has been rife lately and has become a new expectation for scientists and the public in response to the worries of synthetic materials with adverse effects that are not good for health. Bioactive substances are substances that are included as secondary metabolites that are biologically active and can be used for the food and pharmaceutical industries [24].

Caulerpa is one type of green algae (Chlorophyceae) that has not been widely used and is included in feather seaweed, which is edible seaweed and has bioactive substances such as antibacterial, anti-fungal, anti-tumor and can be used for high blood pressure and goiter [3]. Utilization of *Caulerpa* has been carried out to inhibit bacterial growth and maintain the freshness of fish during temporary storage with the application of fresh Caulerpa [7], dry *Caulerpa* [8] and as edible coating [9].

C. sertularioides has been investigated to have five compounds and has been isolated from n-hexane extracts namely caulerpin, O-sitosterol, palmitic acid and two other compounds that are suspected as

steroids and hydrocarbons. Ethyl acetate extract contains caulerpin and cyclotetra decane. From the methanol extract, caulerpin and a compound which is thought to be unsaturated hydrocarbons were isolated[25]. *C. racemosa* has antioxidant activity [26] and *C. sertulariodes* are antioxidants and methanol extracts containing three kinds of catechins (flavanols) namely gallo catechin, epicatechin and catechin gallate [6]. Catechin is the result of plant metabolites that belong to the group of flavonoid compounds and function as an antioxidant. [13] reported phytochemical compounds from *C. lentillifera* include flavonoids, steroids, triterpenoids, saponins, alkaloids and phenols as potential sources of antioxidants. Tapotubun *et al.* [27] reported phytochemical compounds from *C. lentillifera* fron Kei island include alkaloids, terpenoids, steroids, flavonoids.

Caulerpin is a non-toxic pigment and has a unique bis-indole structure [12]. Other content in *C. racemosa* is á-1-gliceryl-D-mannoside-4-ammonium which is used as an antihelmintic (worm-killing agent), as well as alkaloids which are used as to lower the blood pressure. While according to Fenical (1978) *in C. racemosa* contains metabolites from the diterpenoidacyclic group namely trifarin and the monocyclic diterpenoid compound namely caulerpol known as pro-vitamin A or retinol [28].

Tapotubun [2] reported that the method of drying under direct sunlight or indirect drying (dried) does not eliminate the content of alkaloids, terpenoids, steroids and flavonoids in *Caulerpa lentillifera*. This can give clues that the application of heat in the processing into various food products may not have a significant effect on the loss of active ingredients contained in *Caulerpa.*

3.2. *Functional Food*

At present the public's awareness is increasingly high for consuming healthy food products and can even pay more for functional and fresh foods that are free of harmful ingredients. In other words, modern society has a high awareness to maintain a healthy body by always consuming healthy and safe functional food products. Setha *et al*. [29] stated world market demand for seaweed is quite high at this time.

Seaweed is a group of marine plants that contribute to the process of photosynthesis in the sea and is generally used as traditional food. Seaweed contains primary metabolites in the form of important compounds such as vitamins, minerals, proteins, crude fiber, fatty acids and others and is generally used as traditional food. In addition, seaweed polysaccharide products that have economic value and have been used in the food and pharmaceutical industries are agar, alginate and carrageenan. Seaweed also contains secondary metabolites that have the potential to be developed into a source of new bioactive compounds that can be applied in various fields including food, pharmaceutical, cosmetics, fertilization, biofuel and others [3].

Green seaweed (*Caulerpa* sp) or sea grape is a type of seaweed that is eadible, especially in fresh condition. In Japan, Caulerpa is consumed as umi budo cuisine, in the Philippines it is consumed in fresh form while in Korea, besides being consumed fresh, it is also processed into soup. In Indonesia, Caulerpa is generally consumed fresh in the form of salads, besides seaweed can be processed into pickles and sweets and in Maluku, especially in the Kei Islands, Caulerpa is consumed fresh in the form of *urap* or eaten with colo-colo (traditional sauce) [3].

Currently Caulerpa has managed to get a pretty good position and has become a favorite menu for people in Maluku. Japanese, Chinese and Korean people always consume seaweed and believe it as a beauty food. Seaweed polysaccharide products that have economic value and have been used in the food and pharmaceutical industries include agar, alginate and carrageenan.

Caulerpa sea grapes have many benefits including antioxidants, diarrhea medicines, coughs, lowering blood pressure, and are believed to be beauty foods so they can be classified as economically valuable foodstuffs [1]. *Caulerpa sp* has been generally used as fresh food, but it can be used as a competitive food ingredient.

Caulerpa is a good source of fiber and contains fairly complete minerals and contains unique secondary metabolite components, especially as an antioxidant and is believed to be a beauty food [3]. Processing Caulerpa into a variety of healthy and attractive food products has excellent development prospects because the process is concise and has a distinctive taste and color.

C. lentillifera contained high amount of macro and micro minerals that could be added to food to increase its mineral content. The superiority of the mineral content in *C. lentillifera* from the Kei Islands is Mg, Ca and K [2].

Crude fiber is a carbohydrate that cannot be digested in human organs or non-ruminant animals, consisting of cellulose and lignin. Fiber is determined as an insoluble material in alkalis and dilute acids under specific conditions. Crude fiber is sourced from vegetables and fruits and is known as a non-nutritive substance but is needed by the body to facilitate the release of faces.

The crude fiber content of *C. lentillifera* with direct and indirect drying methods did not show a significant difference in the range of 23.02-24.24%. These results showed that the crude fiber content of *C. lentillifera* from the waters of Kei Islands, Maluku, is higher than that of *C. lentillifera* from the Amphor BanLam cultivation station which is 3.17% [18], *C.racemosa* from Jepara waters is 8.43% (Ma'aruf et al. 2013) and from Thai aquaculture ponds is 2.97% [30] and from Seribu Islands is 2,63±0,46 [13].

The high crude fiber content in *C. lentillifer* shows its level of efficiency as a functional food and can be used as a diet food [2]. Crude fiber is a dietary fiber and functional fiber consisting of cellulose, hemicellulose and lignin. Caulerpa seaweed is known as a source of crude fiber that can be used as a functional food and therapy for obese people [17] [31].

Protein is very important for the body because it functions as a builder, forms various new tissues, replaces damaged tissue, and reproduces. Protein plays a role in the formation of enzymes, as guardian hormones, and regulators of various metabolic processes in the body [32]. Protein can also utilize the carbon element contained therein as an energy source when energy needs are not met by carbohydrates and fats.

Organic compounds consisting of crude fiber and nitrogen free extract. Carbohydrates in simple form are generally more soluble in water than fat or protein. The content of carbohydrates in the form of crude fiber in a certain amount is needed to form clots of dirt making it easier to remove feces from the intestine.

Caulerpa sea grape has a very low fat content and is safe to consume in large quantities so that its utilization can be developed as one of the main constituent ingredients in low-fat diet foods. Ortiz *et al.* [33] stated that seaweed fat is generally composed of poly unsaturated fatty acids (PUFA) especially PUFA C18 which is an unsaturated fatty acid that is needed by the body.

The chemical component contained in *C. lentillifera* sea grapes shows that this seaweed has good nutrition and can be used as a good functional food (Tapotubun, 2018). *C. lentillifera* contains carbohydrates, high levels of ash and crude fiber and low fat so it is very good for daily consumption [17] [30] [34]. Besides being edible as fresh vegetables, Caulerpa sp has the potential to be processed into a variety of processed food functional products [3] and is a healthy food [35] [36].

As a species that grows naturally, sea grape population is quite abundant in the waters of its habitat but its use is still very limited to consumption as fresh vegetables. In terms of availability, sea grape *Caulerpa* has advantages compared to other seaweed, among others, provided directly by nature, always growing, and available all year [3] [27]. In terms of nutrition, *Caulerpa* has advantages in the composition of minerals and fiber as well as vitamin [2]. In terms of processing, sea grapes can be processed into various processed products that are in demand, have a distinctive taste and aroma with a natural green color, very simple processing, and do not require pre-processing so the processing time is very short. In addition, all parts are used so that it does not produce waste (zero waste) [3].

The nutritional content is quite good, either primary metabolites namely proximate composition, crude fiber and secondary metabolite content which position *Caulerpa* sp as functional foods that are very beneficial for public health. This position is supported by advantages in terms of ease of processing and short processing time. Besides that, another advantage is that *Caulerpa* does not need additives in the form of coloring or essence in its processing. Thus, seaweed *Caulerpa* sp is very feasible to be developed as food.

4. Conclusion

Caulerpa seaweed grows naturally and is available throughout the year. *Caulerpa* contains crude fiber and secondary metabolites so it positions *Caulerpa* as a functional food ingredient. The components of superior nutrition in *Caulerpa* are minerals, proteins, fats, and carbohydrates. The superiority of *Caulerpa* as a food ingredient is its processing which is very simple and brief and does not require food additives in the form of dyes and essences.

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