

## Review

# History, Nutrition, and Advantages of Seaweed for Human Body

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**Abstract** Seaweed has been consumed especially in the Asia since centuries ago as a vegetable (Matsukawa, 1997; Burtin, 2000; Raghavendran 2003). Seaweed has many valuable nutrients i.e. as a mineral resources, vitamin, and non-caloric fiber, also has potential antioxidant resources. Such of nutrition consists in the Seaweed is Chlorophyll, Carotene, Fucoxantine, Lutein and Zeaxantine, Polysaccharide and Diet Fiber, Mineral, Protein and Amino Acid, Fat and Fatty Acid, Vitamin, Polifenol, also Methanol. The benefits of some nutrition content on seaweed are as an antioxidant, slimmer agent, anti-diabetes, healthy for heart, eyes health, Iodium source, and some kind of vitamins functions. As a conclusion, developing research about seaweed we believe it would be a part of medicine material and food processing, also cosmetic industrial.

**Key words :** seaweed, antioxidant, nutrition, diabetes, slimmer

## Introduction

One of important natural resources asset and potential to be developed in Indonesia are marine resources (Resosudarmo, 2002). That was based on condition which almost 75 % of Indonesia territory consists of coastal water and open water territory (Bengen and Adrianto, 1998). Second, with the widest coastal water territory, there are many natural resources, that are not explored, optimized and yet, untouchable by human (Resosudarmo, *et al.*, 2000). Third, rare and limited inland resources force people to look for alternate resources such as marine resources.

According to *United Nation Convention on the Law of the Sea* (UNCLOS) 1982, Indonesian water territory has 8.6% seaweed of seawater resources (Dahuri, 1998). Van Bosse (Siboga marine expedition, 1899-1900) also reported that Indonesia has 555 of 8642 seaweed species in the world, 6.42 % total seaweed biodiversity in the world (Surono, *et al.*, 2004).

On the marine ecosystem, seaweed has important bio-

logical and chemical also ecosystem functions because these organisms serve as nutrition, spawning ground and habitat for the other living organism in the seawater (Wahber, 1997; Fleurence 1999; Fleurence *et. al.*, 1999; Wilson 2002). Seaweed becomes important substance on holding the ecosystem stabilization with those various function (Dere *et al.*, 2003). Seaweed does not only play the role on the seawater ecosystem, but also for human being. Since long time ago, seaweed has consumed by human as a food also used for medication. It is because seaweed had many beneficiaries contained on it.

## History of discovering the seaweed

Seaweed has been consumed especially in the Asia since centuries ago as a vegetable (Matsukawa, 1997; Burtin, 2000; Raghavendran 2003). Sze Tsu report from China in 600 BC state that seaweed is the best served for the special guest event, it was Caesar. They used

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**Fig. 1.** (a.) dulse in the origin habit; (b.) rolls sushi of nori; (c.) Arame salad; (d.) Thin layer of Nori; (e.) Miso soup (Source: Microsoft Encarta, 2007).

karengo (kind of Nori) for - seasoning soup or salad. Indians in North America often walk into the pacific shore just for harvesting seaweed (alaria) annually. Old Hawaiian's King also likes seaweeds (limu). Long time ago at the northern-west of Europe, Scandinavian or Vikings chewed the dulse (kind of seaweed) as long as their trip in the sea, even at present we still found dulse at traditional arcade in Scotland and Ireland. Wild natural Nori as known for laver also still exists at the traditional market in north Wales (Razamanov, 2000). Fig. 1 are various products from seaweed.

Roll Sushi of Nori, Arame salad, miso and nori soup that is shown in the Fig. 1 are Japanese product. Japan is the most innovative country on exploring and utilizing seaweed until at present. Almost every japanese food seasoned with various kind of seaweed. Total consumption of seaweed of Japanese people is around one, 4 kg/people/year. In the few decades later, there were many publications reporting the advantages of costuming to consume seaweed. (Hiqashi *et al.*, 1999; Funahashi *et al.*, 1999). Seaweed has many valuable nutrients i.e. as a mineral resources, vitamin, and non-caloric fiber, also has potential antioxidant resources (Yan *et al.*, 1999).

### Nutrition value consists in the Seaweed.

Exploration of alternative medicine from various plants is very popular now (Lee, *et al.*, 2003). Exploration not only limited on the terrestrial plant, but also into the marine plant especially seaweed in case for discovering the chemicals material to construct a new medicine. (Faulkner, 1993; Raghavendran, 2004). Until at present seaweed is believed to contain many

secondary metabolic matter and vitamins, which can be used as a chemo preventive agent. Down here, we will figure out some example of material compound, vitamin, also primer metabolic on seaweed.

### CHLOROPHYLL

Chlorophyll was important material in the photosynthesis, and it would not be happen without chlorophyll. Chlorophyll is a green pigments that spread out in the photosynthesis organism, ex: plant, seaweed, bacteria, etc. Scheer (1991) report that chlorophyll was divided into chlorophyll *a*, *b*, *c*, *d*, *protochlorophyll* also *bacteriochlorophyll a*, *b*, *c*, *d*, *e*, and *g*. The following table shows the chlorophyll distribution on the high-level organism and seaweed.

**Table 1.** The chlorophyll distribution on the high-level organism and seaweed

Organism	Pigment				
	Chlorophyll				
	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>
high-level organism	+	+	-	-	-
Seaweed					
1. Chlorophyceae	+	+	-	-	-
2. Phaeophytceae	+	-	+	-	-
3. Rhodophytceae	+	-	-	+	-

(Gross, 2001)

Chlorophyll *a* founded in every photosynthetic plan that uses oxygen, event the photosynthesis happens on the nucleus of reaction or in the light responder agent (Svec, 1978). Chlorophyll *a* is the primary pigment for holding of photosynthesis, and the other is the secondary pigments that support photosynthesis, i.e. chlorophyll *a*, *b*, *c*, *d* and *e*. On the previous table, seaweed

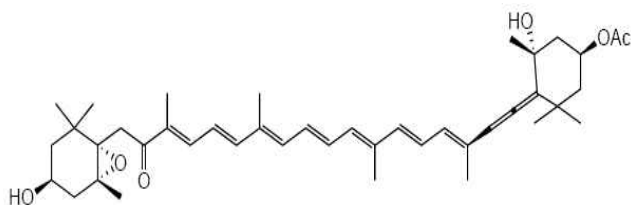
has a special pigment that cannot be found in the other plant (terrestrial plant) i.e. chlorophyll *c* in the brown algae, also chlorophyll *d* in the red algae.

## CAROTENE

Discovering of anticancer activity from beta-carotene and Vitamin A, encourage many researcher to do research on carotene content in seaweed. (Matsuno, 2001). This Following will present a few example of specific carotene content on seaweed.

### Fucoxantine

Fucoxantine are a blue pigment that has ability to absorb the blue-green color energy and through over it into the chlorophyll to do photosynthesis, that activity where monitored on the absorption of 400-540 nm. (Haxo and Blinks, 1950; Nishio, 2000; Mori, 2004). Fucoxantine was included on primary and specific carotene in the brown seaweed belongs to non-provitamin A carotene. (Haugan *et al.*, 1992; Asai *et al.*, 2004). Schemas of fucoxantine are shown on figure 2.



**Fig. 2.** Molecule Structure of Fucoxantine Source: Mori *et al.*, 2004.

### Luteen and Zeaxantine

Another example of pro-vitamin A carotene on the seaweed is luteen and zeaxantine. Luteen and zeaxantine has pro-vitamin A activity that finally would be changed into trans-retinol acid form. (Murakami, 2001). Retinol form will underwent etherification, transported into lymph and stored in the liver. (Bauernfeind, 1972)

### Polysaccharide and Diet Fiber

Polysaccharide is a primary component on the cell rilm bane or on the intercellular tissue of seaweed (Khotimchenko and Khotimchenko, 2004). Polysaccharide

**Table 2.** Diet Fiber content on the various plant

	Fiber (% Dry Wight)		
	Solution	Insolubility	Total
<b>Phaeophyceae</b>			
Wakame ( <i>Undaria pinnatifida</i> )	30	5.3	35.3
Sea-Spaghetti ( <i>Himanthalia elongate</i> )	25.7	7.0	32.7
Kombu ( <i>Laminaria digitata</i> )	32.6	4.7	37.3
<b>Chlorophyceae</b>			
Sea Salad( <i>Ulva lactuca</i> )	21.3	16.8	38.1
Ao nori ( <i>Enteromorpha spp</i> )	17.2	16.2	33.4
<b>Rhodophyceae</b>			
Nori ( <i>Porphyra tenera</i> )	17.9	6.8	34.7
<b>Terrestrial Plant</b>			
apple	5.9	8.3	14.2
Cabbage	16.8	17.5	34.3
Rice flour	8.0	77.0	85.0

(Source: Burtin, 2000)

was found in the seaweed in enormous number. Polysaccharide usually founded in the form of alginate (brown algae), carrageen and gelatin (red algae). Another Polysaccharide was founded in the small number are: fucoidan (brown seaweed), xylem (Red & Green seaweed) (Rosemary. 2000). Several diet fibers were present in the table 2.

In the table 2, we can see that fiber content of seaweed is higher than terrestrial plant. This statement shows that seaweed is a potential fiber resource. Other ways, Polysaccharide has been used especially for food, industry, and formation. (Pilnic and Roumbouts, 1985; Skjak-Brak, 1992).

### Mineral

Seaweed consists of many mineral, micro or macro elements. Mineral water content of seaweed is up to 36% from dry weight.

### Protein and Amino Acid

Protein content of brown seaweed is relatively less (in average of 5 - 15% in dry weight) than red and green seaweed (in average of 10 - 30 % in dry weight). Some red seaweed; i.e. *Palmaria palmata* (dulse) and *Porphyra tenera* (nori) has protein content up to 35-47% in dry weight. Proteins content level on the seaweed and soybean are relatively equal (35% in

the dry weight). Protein content in seaweed is influenced by ficobiliprotein compound. This compound is formed from bilin molecule that related with protein chain on covalent. The latest research shows that ficobiliprotein has an antioxidant activity. (Funahashi, 1999; Burtin, 2000).

### Fat and Fatty Acid

There is only 1 - 5% Fats content of seaweed the dry weight. In spite of that, seaweed also has unsaturated fatty acids; they are omega 3 and omega 6, both have function to prevent heart disease, diabetes, also osteoarthritis. Green algae contain *alfa linoleat acid* ( $\omega 3$  (omega3) C18:3), Red and Brown Algae also have a lot of fatty acid with 20 molecule of carbon, they are eicosapentanoat acid (EPA,  $\omega 3$  (omega3) C20:5) and arasidonat acid (AA,  $\omega 6$  (omega6) C20:4). Seaweed also contain carotenoid (ex;  $\beta$ -carotene, lutein and violaxanthin on red and green algae, fucosanthin on brown algae) and terpenoid. The rest of seaweed extraction had shown an antioxidant activity. (Burtin, 2000).

### Micronutrient

#### Vitamin

Some of vitamin content on seaweed is vitamin B<sub>12</sub>, C and E. Human body in very small number synthesizes those kinds of vitamin, therefore it is not sufficient to body requirement. Some of vitamin content and composition of various seaweeds are shown in the following table;

#### Vitamin B

**Table 3.** The vitamin B content marine algae

Material Tested	Where Obtained	Grams Fed Per Day For A Gain In Weight Of 3 Gm. Per Week	Units (Sherman) Of Vitamin B (B <sub>1</sub> ) Per Gram
Phaeophyceae:			
Alaria valida	Upper sub-littoral zone	0.4	2.5
Laminaria sp.	Dredge from a depth of 5 to 10 fathoms	0.5	2.0
Rhodophyceae:			
Porphyra nereocystis	Surface	0.18	5.5
Porphyra perforate	Littoral zone	0.2	5.0
Rhodomenia pertusa	Dredge from a depth of 5 to 10 fathoms	0.45	2.2
Chlorophyceae:			
Enteromorpha sp.	Littoral zone	.....	Trace only
Ulva lactuca	Surface	0.25	4.0
Dried brewers yeast	.....	0.075	13.3

#### Vitamin C

**Table 4.** The vitamin C content marine algae

Name of Algae	Vitamin C milligram per gram wet weight	
	1934	1935
Phaeophyceae (brown algae)		
From the surface, littoral and upper sub littoral zones:		
Alaria valida	0.53	
Egregia menziesii	0.04	
Fucus evanescens	0.24	0.36
Hedophyllum sessile	0.21	
Macrocystis pyrifera	0.19	
Postelsia palmaeformis	0.09	
Dredged from a depth of 5 to 10 fathoms:		
Agarum fimbriatum	0.02	
Costaria costata	0.02	
Desmarestia munda	0.01	0.01
Laminaria bullata	0.02	0.01
Chlorophyceae (Green Algae)		
From the surface, littoral and upper sub littoral zones:		
Enteromorpha sp.	0.15	0.11
Ulva lactuca	0.46	0.38
Rhodophyceae (Red Algae):		
From the surface, littoral and upper sub littoral zones:		
Gigartina papillata	0.41	0.25
Grateloupia Cutleriae	Less than 0.01	
Halosaccion glandiforme	0.13	
Iridaea sp.	0.26	
Porphyra naiadum	0.36	
Porphyra nereocystis	0.53	
Porphyra perforata	0.60	
Prionitis Lyallii	0.03	
Turnerella pacifica		0.09
Dredged from a depth of 5 to 10 fathoms:		
Agardhiella tenera	Less than 0.01	
Anatheca furcata	Less than 0.01	
Callophyllis sp.		Less than 0.01
Dasyopsis plumose	Less than 0.01	
Hymenena sp.	Less than 0.01	
Opuntia californica	Less than 0.01	
Polyneura latissima	Less than 0.01	Less than 0.01
Rhodomenia pertusa	Less than 0.01	Less than 0.01

Source: Earl, R. Norris; Mary K, Simeon and Hal B, Williams. 1936

#### Polifenol

Polifenol that come from seaweed called plorotanin. This one is different with polyfenol that extracted from terrestrial plan that form galic acid and egalic acid. Seaweed polyfenol are produced from ploroglusinol unit (1,3,5-trihydrobenzyne). Plorotanin are heterogeneous molecules (polymerase structure and degree). The highest plorotanin and polyfenol content are found on the brown algae, where there is an average 5-15% plorotanin content. Antioxidant activities of brown and red algae extract was checked by in vitro test. The research shows that polyfenol and plorotanin from seaweed are more effective than plorotanin from terrestrial plan to

prevent the disease that related with oxidative stress. (Anggardiredja et. al., 1997; Burtin, 2000)

## Methanol

Extract of methanol from sargassum show strong antioxidant activity. This extract is greater than standard Ampicillin on controlling antimicrobial activity in order to prevent the gram-positive bacteria and gram-negative bacteria. That kind of statement are also represent latest research that methanol extract from sargassum was a good source of antioxidant, moreover it has potential to be developed for supplement food or antimicrobial agent on pharmacology industrial field. (J. K. Patra, S. K. Rath, K. Jena, V. K. Rathod, H. Thatoi. 2007)

## The Benefit of Some Nutrition Content on Seaweed

### Function and Benefit of Chlorophyll

Chlorophyll is a leaf green-particle that functioned as a light detention on photosynthesis circle (Gross, 1991). Development and exploration of chlorophyll as therapeutic agent is based on the similarity of chemical structure also its bioactivity within hemin (red blood cell composer). In the medicine field, antioxidant and phototoxic compound are having benefit as preventing cancer, heart disease, asthma and diabetes, event chlorophyll also effective to determinate some inflammation such us acne, laryngitis, gingivitis and gastritis. Because of its ability on determinate those many infections, it is well known as a thousand-medicine. (Limantara, 2004).

Research result shown that chlorophyll and its derivation have special mechanism to neutralize carcinogenic compound and prohibit carcinogenic process. (Singh, dkk., 1996, Cho, dkk., 2000, Ferruzzi, dkk., 2005). Other than that, chlorophyll also a natural detoxification agent because of its ability on spur on detoxification processes. Chlorophyll are become important energy resources for human body because of its ability to synthesis oxygen and carbohydrate. Chlorophyll has also stimulates production of phagocyte, so that it can increase body immune system and determine micro-

organism attack causing disease. (Limantara, 2004).

### Function and Benefit of Fucoxantine

Fucoxantine has various functions such as:

#### 1. Antioxidant

Antioxidant was defined as a material that in low concentration could be a prohibitive compound for some oxidation molecule. That kind of material can stop the chain reaction of free radical agent formation. (Lim, 2002; Chang. *et. all*, 2002). Free radical agent are harmful for human body, it can destruct body tissue, cause degenerative disease such as cancer, heart attack, cataract, early aging process, and other. (Buratti *et al.*, 2001; Rao, 2003; Shivashankara *et al.*, 2004).

Many of the latest research show that extract of seaweed have very active function as antioxidant agent (Jimenez and Goni, 1999). Existence of unknown free radical may stimulate many disease to occur, and reactive-oxygen also known as accelerating agent for that many diseases such as cancer, carotid structure, and decline in neural function. In this case, natural antioxidants that come from seaweed was believed as preventative agent for unknown free radical that act as transfer medium for disease. In some paper, antioxidant activity of seaweed extract has a relation with their carotene content amount, (ex: fucoxantine) (Rivero, *et al.* 2006). Activity of fucoxantine antioxidant was showed by its unique molecular structure, which is fucoxantine having double bond allenic carbon (the position is on C-7) that was not commonly found in the other carotene, and other than that fucoxantine has two group of hydroxyl (Nomura et. al., 1997; Yan et. al., 1999).

#### 2. Anti Obesity

Some researches are proving that fucoxantine has ability as slimming agent. Miyashita (2003) has reported that consuming 2 % of carotene from fucoxantine continuously would reduce the body weight around 5-10%. That mechanism can be explained as follow; fucoxantine promote construction of UCP-1 (Uncoupling protein 1). UCP-1 usually expressed on brown adipose tissue. UCP-1 is the important agent that responsible on fat oxidation and energy conversion. UCP-1 dysfunction can cause obesity. An adult person

has smaller brown adipose tissue therefore; most of their fats are deposit into white adipose tissue. In line with continuously consuming fucoxanthine, UCP-1 will be synthesized on white adipose tissue (Maeda, 2005).

### 3. Antidiabetes

Fucoxanthine has anti-diabetes type II activity. Depletion of fat accumulation on white adipose tissue will affect existence of disease such as diabetes type II. Direct digestion of fat by oxidation in white adipose tissue would reduce the risk of diabetes to human. (Maeda, 2005).

### 4. Healthy for heart

The latest epidemiology study about carotenoid has also shown its role as preventive agent for heart disease. Fucoxanthine activity will be propulsive for DHA syntheses (Fatty Acid  $\omega - 3$ ) in the heart. In line with increase of DHA, it will reduce "Harmfully Fat" (LDL) that was known to be primary cause of heart disease. The function of fucoxanthine here are slightly similar with "Cod" (Fish Oil) in the same mechanism, however fucoxanthine has some advantages such as no fishy smell and relatively cheap (Maeda, 2005).

## The Function and Advantages of *Lutein and Zeaxanthine*

### 1. Eyes Health

Macula in the human eyes contain two carotenoid, lutein and zeaxanthin, although present, we do not know why should both carotenoid contained in our eyes especially in the macula. The same thing is also found in the other animal such as mammalian, avers, reptile, fish, and amphibian. Latest hypotheses reporting that lutein and zeaxanthin can protect the macula from light penetration, corrosion and determinate free radical that it was form in the photoreceptor.

*The NIH Eye Disease Case Control Study* has also studying about the effect of consuming several carotein to the macular degeneration (AMD). Statistic proved that increasing carotenoid has effect to reduce risks of the disease. In this case increasing dissolved of carotene, lutein, and zeaxanthine are the most active on reducing the risk of macular degeneration (AMD) (Fraser, 2000; Lawrence, 2001). The risk of cataract disease can

be eliminated by continuously consume lutein and zeaxanthine, because carotene can produce substance that have pro-vitamin A activity. Vitamin A is the vitamin that very helpful on eyesight mechanism, the growth of bone and tooth, reproduction, also able to reduce the risk of cancer. (Wills *et al.*, 1988; Lee *et al.*, 1989; Matthew-Roth, 1991; Bonnie and Choo, 2000; Murakami, 2002). Other than that, vitamin A is also known as important agent on reproduction and cell differentiation process (Piacentini *et al.*, 1992; Chicca *et al.*, 1988). Vitamin A are also playing role on cell immunity related with differentiation of nervous system that was activate by acetyl Colin (Ross *et a.l.*, 1992; Yang *et al.*, 1993; Malik *et al.*, 2000).

Deficiency of Vitamin A would be potential for suffering exophthalmia. That kind of disease can be eliminate by consuming carotenoid that function as provitamin A. Eye disease that caused by aging such as cataract and AMD were globally found and affect olds people. Since now many research are doing experiment for this phenomenon.

In-vitro study that was done with human lens epithelial cell (HLEC) show that adding lycopene to the cultured cell can inhibite vacuole forming on HLEC. Data collection for 8 years shows that consuming lateen and zeaxanthine continuously can reduce 19% risk of cataract attack. Luteins found on the class of RED and GREEN algae, while zeaxanthine found on almost all class of seaweed. In the other case, research done by American physician for 12 years, show that continuously consumption of zeaxanthine and lateen are able to reduce the risk of cataract attack on smoker.

### 2. MINERAL

Brown seaweed was use as mumps medicine since long time ago. It was because those kinds of seaweed contain high Iodium, therefore until now brown seaweed was list on the European medicines book (*pharmacopoeia*) as one of iodium resources. Other than that, Calcium are also one of mineral that contained on seaweed, so consume much seaweed are helpful for pregnant womens, adult person, also olds people that having risk for calcium deficiency. (Burtin, 2000).

### 3. MICRONUTRIENT

#### Vitamin

##### Vitamin B<sub>12</sub>

Seaweed is one of potential Vitamin B resources; mostly found in highly dissolved is vitamin B<sub>12</sub>. Vitamin B<sub>12</sub> commonly role in the aging process, anemia, etc, because the primary function of vitamin B<sub>12</sub> are forming red blood cell. (Dr. Made Wardhana at Bulletin Info Vegetarian, 2007)

##### Vitamin C

Vitamin C content on the seaweed is mathematically enough to supply human body needs of vitamin C. Vitamin C content on the red and green seaweed are about 500 - 3000 mg/kg dry weight (this number was relatively same with vitamin C content on peterseli, pepper, *blackcurrant*), while on the red seaweed content of vitamin C around 100 - 800 mg/kg dry weight. Vitamin C are very important because it has many function on the human body, such as increasing body immune, Fe absorption activation in the digestion system, also having role on trapping free radical. Dr. Made Wardhana at Bulletin Info Vegetarian (2007), report that vitamin C can be an antioxidant, detoxification for carcinogenic agent, accelerate wound healing, and can renew vitamin E.

##### Vitamin E

Vitamin E was preventing human body oxidation from *low density*-lipoprotein or "harmful fat" based on its antioxidant activity. Vitamin E also plays an important role in the arakidonat acid chain to prevent the formation of prostaglandin and thrombosis. Brown seaweed contains more vitamin E than red and green seaweed. Brown seaweed contains alpha, beta and gamma tocopherol, while the red and green seaweed only contain alpha tokoferol. Gamma and alpha tokoferol increase production and activities of nitrate oxidation (cNOS) and plays an important role in preventing heart disease (Burtin, 2000).

### Conclusions

Seaweed proves to have many advantages, as it is contain useful nutrition. Some part of content are polysaccharide and diet fiber, mineral, fat and fatty acid,

even the benefit of that pigment are quite special. By developing research about seaweed, we believe seaweed would be a part of medicine material also food processing, and cosmetic.

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