



## Seaweed as novel food for prevention and therapy for life style related disease

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### Introduction

Seaweed has long been known and consumed as a functional food and folk medicine, especially in people who live in coastal areas. Research on seaweed has recently increased with the surge need for alternative sources of functional food to deal with health problems related to lifestyle, such as obesity, diabetes, hypertension and cardiovascular disease. Epidemiology studies have found that population consumed seaweed is on a regular basis have significantly less diet-related diseases.<sup>1,2</sup> Even the largest population of old age is in Japan, which consumes the most seaweed in the world.<sup>1,3</sup> In countries such as Japan, China, and Korea, approximately 66% of algae species have been used as a daily ingredient in their dishes for many years.<sup>4</sup>

Seaweed are autotrophic organism with unicellular morphology without roots, stems, leaves and flowers and is called a thallus, smooth, has many branches both long and short, the colors are usually red, brown or green. Seaweeds are commonly classified into three taxonomic groups Rhodophyta

(red seaweed), Phaeophyta (brown seaweed) and Chlorophyta (green seaweed). The nutrient content in seaweed is very dependent on the type of marine biota, location and environment where the seaweed grows, so it is more varied than land plants.<sup>5,6</sup> Seaweeds are abundant source of nutrient protein, dietary fiber, vitamin and minerals as a result of stressful situations on seaweed tissues, exposure to ultraviolet radiation, changes in temperature and salinity, or environmental pollutants.<sup>7</sup> Seaweed is rich in: essential amino acids, dietary fiber,  $\omega$ -3 fatty acids, mineral and vitamins A, B, C, and E compared to the terrestrial plants and animal-based foods.<sup>8,9</sup>

### Protein

Seaweeds protein content depends on the type of seaweed and varies widely, protein contents was higher in red and green seaweeds (10–47% of dry weight) than those found in brown seaweeds (5–24% dry weight)<sup>9</sup>. Most seaweeds have a higher protein score than all plant-based proteins, with the exception of soy, which has a score of 1.0.<sup>10,11</sup> However, the high polyphenolic content of seaweeds can reduce the digestibility of seaweed proteins, giving a slightly lower score on the protein digestibility-corrected amino acid scale.<sup>12</sup> Seaweed proteins are rich in glycine, arginine, alanine, and

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glutamic acid. Their limiting amino acids are lysine and cystine<sup>9,13</sup>

Bioactive proteins that can be extracted from seaweed are phycobiliproteins and lectins.

Some studies have shown that phycobiliproteins extracted from red algae (phycoerythrin) could be beneficial in the prevention or treatment of neurodegenerative diseases caused by oxidative stress (Alzheimer and Parkinson's) due to their antioxidant effects.<sup>9,14</sup> Lectins can recognise and bind to specific carbohydrate structures and take part in many biological processes like intercellular communication and those isolated to date have highly novel amino acid sequences.<sup>15</sup> The lectins found in *Bryothamnion* spp. (Rhodophyta) show an inhibitory effect on the growth of strains of *Streptococcus* spp.; therefore, they can be used as bactericidal compounds.<sup>9,16</sup> Seaweed also contains peptides which have angiotensin converting enzyme inhibitor (ACE-I) activity.<sup>17,18</sup>

Protein digestibility is limited by the non-protein fraction, which accounts for 10–20% of the nitrogen content. The isolation of protein from algae is difficult due to viscous polysaccharides; the use of buffers and detergents for effective cell lysis and removal of polysaccharide was proposed.<sup>19</sup>

## Carbohydrate

Seaweeds contain carbohydrate as polysaccharides that has been studied for their physiological and biological potential. Physiological potential of seaweed polysaccharides as sources of fiber. Insoluble fiber: cellulose is an indigestible, non-nutritive polysaccharide as structure of cell walls of seaweeds and constitutes from 2% to 10% of total polysaccharides.<sup>10</sup> Soluble fiber is characterized by its ability to form viscous gels, in contact with water, in the intestinal tract. Soluble fiber is fermented in high proportion, and its main properties are related to the decrease of cholesterol and glucose in blood and the development of intestinal microbiota.<sup>9</sup> Meanwhile, insoluble fiber or cellulose will decrease gastrointestinal transit time and prevent constipation.<sup>9,20</sup>

Seaweed cell walls are enriched with sulfated polysaccharides, that progressively investigated for their potential value in food and pharmaceutical applications.<sup>21</sup> Sulfated polysaccharides in seaweed:

laminarans and fucoidans in the *Phaeophyta*, carrageenans in the *Rhodophyta*, and ulvans in the *Chlorophyta*.<sup>22</sup> One of the most vital properties linked with sulfated polysaccharides is their anticoagulant characteristics. Sulfated polysaccharide of green seaweeds from *Ulva* and *Enteromorpha*, are called ulvans, and their oligosaccharides, have demonstrated strong antitumor and immune-modulating activities, antihyperlipidemic activities and anticoagulant activities.<sup>23</sup>

The main products of fiber fermentation are short chain fatty acids (SCFA), mainly acetic, propionic, and butyric, which lead to a drop in pH and even to the stimulation of the growth of certain microorganisms, modifying the bacterial metabolism in the colon, known as the prebiotic effect.<sup>6</sup> In addition, SCFA may have a beneficial effect on cholesterol metabolism.<sup>9,24</sup> In animal studies fed with red seaweed extract, the number of prebiotics *bifidobacterium* and *lactobacillus* increased.<sup>25</sup> Al-Sheraji, et al., concluded that prebiotics increase absorption of Ca and Mg, can affect blood sugar levels and improve blood fat levels.<sup>26</sup> In experiments with mice, those who were hypertensive and then given a diet containing 10% fiber powder from brown seaweed showed a significant reduction in blood pressure and a reduced incidence of stroke (0 versus 100% in the control group on day 30 of the experiment). In this study, it is suspected that alginic acid from seaweed fibers inhibits the absorption of Na in the digestive tract and has the effect of preventing an increase in blood pressure.<sup>27</sup>

## Fat

The fat content of seaweed is low, about 1-5% of dry weight with a composition of polyunsaturated fatty acids such as omega 3 and omega 6. Omega 3 is mostly contained in green seaweed, while red and brown seaweed contains lots of fatty acids with 20 carbon atoms such as eicosapentanoic acid and arachidonic acid.<sup>5,28</sup> The ratio between *n*-6 and *n*-3 fatty acid is considered an index for evaluating the nutritional value of a dietary lipid source.<sup>29,30</sup> An imbalance between *n*-6 and *n*-3 FAs in biological tissues is known to cause inflammatory processes in the body.<sup>30</sup> since in western diets, the ratio has risen to around 15–20:1,<sup>31</sup> this far beyond the ideal

ratio, (<5:1).<sup>29</sup> Since the *n-6/n-3* ratio of the seaweed was within the recommended range of <5:1, they have the potential to enhance the nutritional quality of food products, e.g. by regulating low-density lipoprotein and cholesterol levels, and help to prevent inflammatory, cardiovascular diseases and nervous system disorders.<sup>10,29</sup>

Fatty acid composition also varies between different geographic regions; for example in warm water *chlorophyta* contain higher saturated fatty acid and oleic acid, but in cold water it will have higher polyunsaturated fatty acids levels.<sup>14,32,33</sup> Polyunsaturated fatty acids (PUFA) are useful in regulating blood clotting, blood pressure, helping the function of the brain and nervous system. PUFA produce mediators called eicosanoids to regulate inflammatory reactions.<sup>5</sup> Long chain PUFAs (LC-PUFAs) play key roles in cellular and tissue metabolism, including the regulation of membrane fluidity, electron and oxygen transport, as well as thermal adaptation.<sup>14</sup>

### Vitamin and mineral

Seaweeds contain both water- and fat-soluble vitamins.<sup>6,28</sup> Seaweed foods offer one of the few vegetarian alternatives for cobalamin (vitamin B<sub>12</sub>) in the diet. Ortiz in 2006 reported that 100 grams of seaweed can meet the daily needs of vitamins A, B<sub>2</sub>, B<sub>12</sub> and two-thirds of vitamin C.<sup>34</sup> The content of red seaweed vitamins includes vitamin B<sub>12</sub>, vitamins C, vitamin E and carotene. Vitamin C levels can reach 100-800 mg / kg in red seaweed. Vitamin E which acts as an antioxidant is also contained in seaweed. The availability of vitamin E in brown seaweed is higher than green and red seaweed. This is because brown seaweed contains  $\alpha$ ,  $\beta$ , and  $\gamma$ -tocopherol, while green and red seaweed only contains  $\alpha$ -tocopherol.<sup>28,35</sup> This vitamin is beneficial to health as an antioxidant, strengthens the immune system and is anti-aging.<sup>5,35</sup>

Seaweed also contains minerals more than 36% dry weight with the content: calcium, magnesium and iodine as the main minerals.<sup>28</sup> The sodium content in seaweed is generally low around 2-3%, while the levels of potassium is around 5-6%, so the sodium / potassium ratio of seaweed is around 0.3. Composition of Na and K in seaweed is thought to be useful as an antihypertensive in mild

hypertension.<sup>36</sup> Seaweed also contains high levels of magnesium and calcium compared to land plants such as vegetables.<sup>20</sup> Seaweed calcium can reach 7% of dry weight.<sup>28</sup>

### Limitation

Seaweed bioactive consistency is a challenge for commercial application, since bioactive substance of seaweed is greatly vary and influenced by many factors, such as natural variability: type of species, time and location of harvest.<sup>32</sup> Other limitation are accumulation of undesirable elements, heavy metals and other pollutants, such as: cadmium, mercury, plumbum and arsenic.<sup>29</sup> Cadmium level was relatively low in green seaweed compared with red and brown seaweed. The concentrations of mercury were relatively low in all species.<sup>29,37</sup> Lead was found to be low in red and brown seaweed compare with in green seaweed.<sup>29,38</sup> Arsenic in biological matrices exists either in organic forms or as inorganic arsenic form, organo arsenic forms are considered to be non-toxic or of low toxicity. Total arsenic were found in brown algae higher than other taxonomic groups with gradation as brown seaweed > red seaweed > green seaweed.<sup>37,38,38</sup>

### Conclusion

Seaweed has long been consumed as a functional food and folk medicine for people who live in coastal areas. Seaweed contains elements of protein, carbohydrates including fiber, vitamins and minerals with a composition that can play a role in the prevention and therapy of diseases associated with modern life patterns. There are limitations of seaweed that can be applied commercially, namely the consistency of bioactive levels and the presence of unwanted substances such as heavy metals and other pollutants.

### Conflict of Interest

Authors declared no conflict of interest regarding this article.

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