CHAPTER 5

Sea Lettuces: Culinary Uses and Nutritional Value

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Contents

Abstract

In many countries, sea lettuces are commonly consumed as food by human since the beginning of times. Sea lettuces contain significant amount of nutrients which are essential for human body. Moreover, several studies have provided insight into biological activities and health promoting effects of sea lettuces. Despite having so much health beneficial effects, sea lettuces are still identified as an underexploited plant resources for food purposes. Hence, sea lettuces have a great potential for further development as products in foods and pharmaceutical areas. Further, potential applications of polysaccharides, protein and amino acid, lipid and fatty

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acid, mineral and vitamin contents may increase the sea lettuces value. This contributions presents information on the currently culinary use of sea lettuces worldwide and nutritional aspects of sea lettuces.

I. INTRODUCTION

The ancient tradition and everyday habits of seaweeds consumption have made possible large numbers of epidemiological studies showing the health benefits linked to seaweeds consumption. When considering in combination with international diet-related chronic disease incidences, a significant environmental factors including dietary difference between populations varying in seaweeds consumption have revealed. For example, several epidemiologic studies showed that seaweeds consumption correlates with low breast cancer rates in Japan and China compared with North America and Europe (Pisani *et al*., 2002; Yuan and Walsh, 2006). Further, Jorm and Jolley reported that neurodegenerative cases in East Asian countries were lower than that of Europe ($p < 0.0004$; Jorm and Jolley, 1998). Studies showed that low cancer and neurodegenerative disease cases in Eastern hemisphere are associated with high amount of seaweeds consumption. In Asian culture, seaweeds have always been of particular interest as food sources (Khan *et al*., 2010; Pangestuti and Kim, 2011). Edible marine algae accounted for more than 10% of Japanese diet with average consumption reaching an average of 1.4 kg per person per year (Burtin, 2003).

Seaweeds represent one of the most nutritious plant foods, and general utilization of seaweeds in food products has grown steadily since the early 1980s (Besada *et al*., 2009). In recent years, consumers in developed countries are turning to more natural and nutritional products such as seaweeds (Van Netten *et al*., 2000). Seaweeds have recently been approved in France for human consumption, thus opening for the food and fisheries industries. During 2003, it was estimated that about 1 million tons of seaweeds were harvested in 35 countries mainly as food sources (Garcia-Casal *et al*., 2009).

Several seaweed species are consumed by human directly after only minor preprocessing such as drying. *Porphyra* sp. which is commercially known as nori or lavers are the most widely consumed among edible red seaweeds worldwide (Watanabe *et al*., 1999). Among green seaweeds, sea lettuces are the most common, ubiquitous, and environmentally important genera (Tan *et al*., 1999). Sea lettuces comprise the genus *Ulva*, a group of edible green seaweeds which is widely distributed along the coasts of the world's oceans and often found in the mid and upper tidal zones. Sea lettuces or sometimes termed as green laver are found in tidal and near tidal seawater worldwide, generally anchored to rocks or other algae. They are easily identified by its paper-thin, semitranslucent, and vibrant green color. Most sea lettuces are gathered wild as it grows prolifically wherever there are sufficient nutrients, but some is farmed. Many species of sea lettuces are reported to be tolerant of organic and metal pollution; hence, if we consume, we need to make sure that they are collected far from any potential sources of pollution.

There are a number of reviews available on the pharmaceuticals and medicinal bioactive compounds derived from marine algae. This chapter focuses specifically on the culinary use, nutritional value of sea lettuces, and emphasizing their associated health promoting effects. Further, it is important to acknowledge that there are gaps in our knowledge of local names for sea lettuces, which some also lack common names in English. Hence, in this chapter, we present several local names for sea lettuces in several countries.

II. CULINARY USES OF SEA LETTUCES

Sea lettuces are eaten by a number of different sea animals, including manatees or sometimes referred as sea cows and the sea slugs known as sea hares (Carefoot, 1979). Not only consumed by marine fauna, many species of sea lettuces are consumed by humans in Scandinavia, Great Britain, Ireland, China, Korea, and Japan. As a food for humans, sea lettuces are eaten raw in salads, dried, toasted, cooked in soups, as a garnish, etc. Sea lettuces taste better when harvested early in the spring growing season (Misheer *et al*., 2006).

In Japan, sea lettuces are known as *aosa nori* (Murata and Nakazoe, 2001). The texture of these sea lettuces closely resembles *nori* (*Porphyra* sp.); sea lettuces, however, have milder in flavor and less expensive. It is used in dried form for flavoring some of Japanese foods. Sea lettuces used in Japan in the same way as parsley and lettuces are often employed by American as a garnishment for foods. Commonly, they are used by sprinkling the sea lettuces powder on the hot food to obtain specific aroma. Sea lettuces are widely used as a savory seasoning in processed Japanese foods like fried noodle (*Yakisoba* or *yakiudon*), *okonomiyaki* (Japanese pancake), *takoyaki* (octopus dumpling ball), potato chips, rice cracker, etc. Japan and Korea use sea lettuces as side dishes (known as *banchan*) which help to compliment Korean dishes, by adding special flavors to the meal (Kwak *et al*., 2005).

Hawaiian name for sea lettuces is *pālahalaha* which means spread out. Hawaiians commonly eat fresh sea lettuces after chopping and sometimes mix with other seaweeds (Novaczek, 2002). In Cuba, sea lettuces were boiled and then drunk as a juice to kill intestinal worms. Sea lettuces have also been used as worm medicine and folk remedy for gout treatment in Pacific (Novaczek, 2002). Local name for sea lettuces in Philippines is *gam gamet-Ilokano;* which is the most popular and highly prized sea vegetables in the Ilocandia, Philippines (Novaczek, 2002). In Philippines, the most common food preparation of sea lettuces is salad. Sea lettuces collected from the sea were washed and then added to prepare salad or soup. The translucent, slightly bitter leaves make these seaweeds perfect as salad ingredients. After washing and blanching with lukewarm water, the sea lettuces are mixed with crushed ripe tomatoes, sliced green mango, and sliced onion, complemented with native fermented fish to taste. Similar in Philippines, the most common food preparation of sea lettuces in Indonesia is salad (Istini *et al.*, 1998).

In British Isles, sea lettuces are commonly toasted (Kenicer *et al.*, 2000). To prepare toasted sea lettuces, salt and sesame oil were mixed and rubbed on the sea lettuces. Around six leaves were laid on top of one another and each leaf was cooked separately in a hot pan over low heat until crisp. Laverbread are the most common sea lettuces preparation in Wales (Fitton, 2003). To make laverbread, the sea lettuces are boiled for several hours and then minced or grinded into puree. Laverbread are traditionally eaten fried with bacon and cockles for breakfast. It can also be used to make a sauce to accompany lamb, crab, monkfish, etc. Further, in Scotland, sea lettuces have been eaten for hundreds of years and also particularly popular food (Kenicer *et al.*, 2000; Misheer *et al.*, 2006).

The Japanese, Koreans, Chinese, British, Scottish, Philippines, Indonesians, and Hawaiians consider sea lettuces as valuable source for human food and great delicacy. Further, sea lettuces are also known for their richness in nutrition such as polysaccharides, minerals, vitamins, protein, amino acids, lipids, and fatty acids. This gives sea lettuces great potential as functional and medicinal foods.

III. NUTRITIONAL VALUE OF SEA LETTUCES

A. Polysaccharides

Sea lettuces contain large amount of polysaccharides which constitute around 38–54% of the dry matter. These include four polysaccharide family in sea lettuces; two major ones, the water soluble ulvan and insoluble cellulose, and two minor ones, xyloglucan and glucuronan (Lahaye and Robic, 2007). When faced with the human intestinal bacteria, most of these polysaccharides are not digested by human and hence can be regarded as dietary fiber. Water soluble and insoluble fibers have been associated with different biological activities and health-promoting effects. Soluble polysaccharides are primarily associated with hypocholesterolemic and hypoglycemic effects (Panlasigui *et al.*, 2003). Further, insoluble fiber such as cellulose are associated with excretion of bile acids, increase fecal bulk, and decrease intestinal transit time (Burtin, 2003; Moore *et al.*, 1998).

Among polysaccharides isolated from sea lettuces, ulvan has attracted greater attention as they display several physiochemical and biological features. The name ulvan actually derived from the terms ulvin and ulvacin which refers to different fractions of *Ulva lactuca* water soluble polysaccharides. Presently, it is being used to refer to polysaccharides from the members of the Ulvales, mainly sea lettuces. Researchers have revealed that ulvan (Fig. 5.1) exhibited various biological activities such as anticoagulant, antiviral, antioxidant, antiallergic, anticancer, anti-inflammatory, antihyperlipidemia, etc. For example, Qi *et al.* (2005) have prepared different molecular weight ulvans from *Ulva pertusa* by sulfur trioxide/*N*,*N*-dimethylformamide (SO_3–DMF) in formamide and their antioxidant activities were investigated. The results showed that low molecular weight ulvans had a strong antioxidant activity. The rationale for this is low molecular weight of ulvan may incorporate into the cells more efficiently and donate proton effectively compared to high molecular weight one (Qi *et al.*, 2005). Ulvan may also modulate lipid metabolism in rats and mice. A decrease of serum high-density lipoprotein cholesterol (HDL-cholesterol) and an increase of low-density lipoprotein cholesterol (LDL-cholesterol) and triglyceride are considered to be significant risk factors in cardiovascular diseases. Ulvan or ulvan derived oligosaccharides significantly lowered the level of serum total cholesterol, LDL-cholesterol, and reduced triglyceride, while they increased the levels of serum HDL-cholesterol (Pengzhan *et al.*, 2003). In addition, Mao *et al.* (2006) found that the anticoagulant activity of ulvan from *Ulva conglobata* mainly consisted of rhamnose with variable contents of glucose and fucose, fucose, trace amounts of xylose, glactose, and mannose. Anticoagulant activity of ulvan has also been reported from *Ulva lactuca* (AhdEl-Baky *et al.*, 2009). In comparison, *Ulva neumatoidea* extracts have higher anticoagulant activity compared to other seaweed species such as *Egregia menziesii*, *Silvetia compressa*, and *Codium fragile* (Guerra-Rivas *et al.*, 2010).

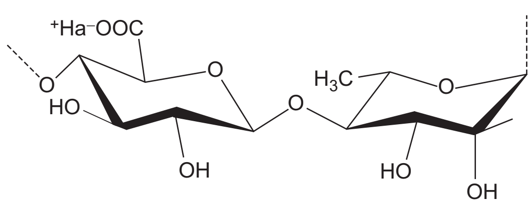

FIGURE 5.1 Chemical structure of the main repeating disaccharides in Ulvan.

These ulvan biological properties open up a wide field of potential applications; food, pharmaceuticals, agricultural, cosmetic, and chemical industry. Some of those potential applications are already the subject of patents.

B. Protein and amino acids

The protein content of sea lettuces varies with the species but generally present in high amounts. For example, protein content in *Ulva reticulata* is 21.06% of the dry weight, whereas higher protein contents are recorded in *Ulva lactuca* 27.2% of the dry weight (Ortiz *et al*., 2006; Ratana-arporn and Chirapart, 2006). These level are comparable to those found in high-protein terrestrial vegetables such as soybeans, in which protein make up 40% of the dry mass (Murata and Nakazoe, 2001).

The general levels of some amino acids in sea lettuces proteins are higher than those found in terrestrial plants. Eight essential amino acids (cysteine, isoleucine, leucine, lysine, methionine, phenylalanine, tyrosine, and valine) which cannot be synthesized by our body are present in a high level in sea lettuces. The amino acid compositions of sea lettuces are presented in Table 5.1. Several sea lettuces species such as *Ulva lactuca*, *Ulva pertusa,* and *Ulva armoricana* are rich in leucine. Leucine is one of the building blocks for protein, and recent studies reported that a diet rich in the amino acid leucine might help prevent the muscle loss that typically comes with aging (Anthony *et al*., 2000). French researchers found that a leucine supplemented diet restored a more youthful pattern of muscle-protein breakdown and synthesis to elderly rats. In addition to leucine, other amino acids which found in a high amount in sea lettuces are threonine, arginine, alanine, aspartic acid, and glutamic acid (Fleurence *et al*., 1999; Fujiwara-Arasaki *et al*., 1984; Mai *et al*., 1994; Ratana-arporn and Chirapart, 2006; Wong and Cheung, 2000). The proteins from *Ulva reticulata* and *Ulva armoricana* exhibit an amino acid composition close to that of soybean protein (Fleurence *et al*., 1999; Ratana-arporn and Chirapart, 2006). Further, *Ulva reticulata* proteins are of high quality since the essential amino acids represented almost 40% of total amino acids (Ratana-arporn and Chirapart, 2006).

Bioactive lectins are found in sea lettuces (Sampaio *et al*., 1998; Wang *et al*., 2004). However, lectins derived from sea lettuces are relatively recent ones compared to other seaweeds. In human body, lectins are involved in numerous biological processes such as cell–cell communication, induction of apoptosis, host–pathogen interaction, cancer metastasis and differentiation, recognizing and binding carbohydrates, increase the agglutination of blood cells (erythrocytes), detection of disease related alterations of glycan synthesis, including infectious agents such as viruses, etc. (Holdt and Kraan, 2011).

TABLE 5.1 Comparison of amino acid composition of some sea lettuces species (g/100 g dry basis)

Amino acids	*Ulva alactuca*[a]	*Ulva reticulata*[b]	*Ulva pertusa*[c]	*Ulva armoricana*[d]
Histidine	1.8	0.23	4.00	2.10
Isoleucine	6.1	0.90	3.50	2.99
Leucine	9.2	1.68	6.90	5.92
Methionine	1.8	–	1.60	2.58
Phenylalanine	6.3	1.12	3.90	7.10
Threonine	4.6	1.15	3.10	6.88
Tryptophan	–	–	0.30	–
Valine	7.7	1.34	4.90	5.01
Lysine	6.3	1.28	4.50	4.01
Alanine	8.5	1.72	6.10	7.05
Arginine	5.1	1.84	14.9	6.28
Aspartic acid	9.2	2.66	6.50	6.09
Cysteine	2.2	–	–	–
Glycine	7	1.38	5.20	6.34
Glutamic acid	10	2.76	6.90	18.24
Proline	5.2	1.08	4.90	6.92
Hydroxyproline	–	–	–	1.89
Serine	4	1.36	3.0	5.92
Tyrosine	–	0.77	1.40	4.76

Adapted from: [a]Mai *et al.* (1994), [b]Ratana-arporn and Chirapart (2006), [c]Fujiwara-Arasaki *et al.* (1984), [d]Fleurence *et al.* (1999).

C. Lipids and fatty acids

Lipids are a broad group of naturally occurring molecules which includes fat, waxes, sterols, fat-soluble vitamins, mono-, di-, and tryacylglycerol, diglycerides, phospholipids, etc. The literature has been established that, in general, the lipid content in sea lettuces is less than 4% (Ortiz *et al.*, 2006). Total lipid contents in *Ulva lactuca*, *Ulva reticulata*, *Ulva fasciata* were 1.64, 0.75, 3.6 g/100 g, respectively (McDermid and Stuercke, 2003; Ratana-arporn and Chirapart, 2006; Wong and Cheung, 2000).

Further, sea lettuces show an interesting polyunsaturated fatty acid (PUFA) composition (Table 5.2). There are two major families of dietary PUFA, the (ω6) and (ω3) families. The ω6 PUFA are derived from the parent compound linoleic acid [LA; 18:2(ω6)]. They contain at least two double bonds where the first double bond is located at sixth carbons from the methyl end of the molecule (Whelan and McEntee, 2004). Meanwhile, the ω3 PUFA has the first double bond at the third carbon from the methyl

TABLE 5.2 Fatty acid profiles of some sea lettuces species

Fatty acids	*Ulva lactuca*[a]	*Ulva reticulata*[b]	*Ulva fasciata*[c]	*Ulva pertusa*[c]	*Ulva arasakii*[c]	*Ulva conglobata*[c]
C10:0 (decanoic acid)	–	–	0.78	0.96	0.29	0.55
C12:0 (lauric acid)	0.14	–	–	–	–	–
C14:0 (myristic acid)	1.14	–	0.70	0.68	0.44	1.03
C14:1 (myristoleic acid)	–	–	1.81	2.07	0.87	3.35
C15:0 (pentadecanoic acid)	0.2	–	–	–	–	–
C16:0 (palmitic acid)	14	1.43	29.32	27.36	25.43	34.16
C16:1 (palmitoleic acid)	0.69	0.32	–	–	–	–
C18:0 (stearic acid)	8.39	0.92	0.91	1.03	–	2.39
C18:1ω9 (oleic acid)	0.37	0.13	5.12	5.15	7.4	6.31
C18:2ω6 (linoleic acid)	8.31	0.14	7.87	8.09	21	6.81
C18:3ω3 (linolenic acid)	4.38	0.19	17.25	17.96	22.98	14.37
C18:4ω3 (stearidonic acid)	0.41	–	–	–	–	–
C20:0 (arachidate)	0.19	0.11	–	–	–	–
C20:1 (eicosanoate)	4.21	0.06	1.98	1.35	0.42	1.77
C20:4ω6 (arachidonic acid)	0.34	0.04	–	–	–	–
C20:5ω3 (eicosapentanoic acid)	1.01	0.03	–	–	–	–
C22:0 (Behanate)	0.27	0.03	0.80	0.65	2.87	2.5
C22:1 (erucate)	0.79	0.003	2.46	2.88	1.42	2.57
C22:6ω3 (docosahexaenoic acid)	0.8	0.04	–	–	–	–

Adapted from: [a]Ortiz *et al*. (2006), [b]Ratana-arporn and Chirapart (2006)), [c]Alamsjah *et al*. (2008).

terminus and contain up to six double bonds. Sea lettuces are particularly rich in ω3 fatty acids (Ortiz *et al*., 2006). Eicosapentanoic acid (EPA; 20:5) and docosahexanoic acid (DHA; 22:6) are the two important fatty acids of sea lettuces, along with the precursor α-linolenic acid (ALA; 18:3). Both EPA and DHA are basically derived from ALA through elongation and desaturation (Alamsjah *et al*., 2008; Ortiz *et al*., 2006; Ratana-arporn and Chirapart, 2006). The ω3 fatty acids have been demonstrated to play significant role in human body. In human body, the beneficial effect of ω3 fatty acids can be classified into two main areas. First, these fatty acids sustain normal healthy life through the reduction of blood pressure, plasma triglycerides, and cholesterol, together with increased blood coagulation time. Both EPA and DHA are important for maintenance of normal blood flow as they lower fibrinogen levels and also prevent platelet from sticking each other. Second, they alleviate certain diseases such as blood vessel disorders and inflammatory conditions. Deficiency of ω3 fatty acids causes several disorders such as restrictive growth, abnormality of the skin and hair, damage of reproductive system, and abnormal composition of serum and tissue fatty acids. The human body cannot synthesize ω3 fatty acids *de novo*; hence to obtain their potential health promoting effects, ω3 fatty acids should be introduced in human diet. One of the potential sources of EPA, DHA, and ALA is sea lettuces. In addition, sea lettuces also contain significant quantities of C18:4ω3 (stearidonic acid) which recently has been demonstrated to possess several biological activities similar to EPA (Whelan, 2009). *Ulva lactuca* are the best source of EPA and DHA among several sea lettuces species tested in several studies. Meanwhile, *Ulva arasakii* are a better source of palmitic acid. Sea lettuces are therefore a good source of ω3 fatty acids and also an important source of supply of ω3 fatty acids for the homeotasis and promoting human health.

D. Vitamins

Sea lettuces contain considerable amount of vitamins. These include both water- and fat-soluble vitamin such as vitamin A, B, D, and E (Table 5.3).

1. Vitamin B complex

Sea lettuces are a source of vitamins from group B (MacArtain *et al*., 2007; McDermid and Stuercke, 2003). For instances, *Ulva lactuca* contain high amount of cobalamin or vitamin B12. Vitamin B12 plays a key role in homeostasis of the brain and nervous system, and for the formation of blood (Scalabrino, 2009). Daily ingestion of 1.4 g/day of *Ulva lactuca* will be enough to meet the daily requirements of vitamin B12 (MacArtain *et al*., 2007). One of the most important vitamins B occurring in *Ulva reticulata* is riboflavin (vitamin B2). Vitamin B2 deficiency is often endemic in human

TABLE 5.3 Vitamin contents of some sea lettuces species (mg/100 g edible portion *except for vitamin A and D in IU)

Vitamins	*Ulva lactuca*[a,b]	*Ulva reticulata*[c]	*Ulva fasciata*[d]
A*	6050	–	–
B1	0.42	10	–
B2	0.03	13	0.1
B3	8	–	6.6
B9	0.01	–	–
B12	6.3	–	–
C	10	–	22
D*	848	–	–
E	13.7	–	–

Adapted from: [a]Briand and Morand (1997), [b]MacArtain *et al.* (2007), [c]Ratana-arporn and Chirapart (2006), [d]McDermid and Stuercke (2003).

populations that subsist on diets poor in dairy products and meat. Vitamin B2 cannot be synthesized by mammals, and there is only limited, short-term storage capacity for this vitamin in the liver. Humans are vulnerable to develop a vitamin B2 deficiency during periods of dietary deprivation or stress, and this may lead to a variety of clinical abnormalities, such as growth retardation, anemia, skin lesions, and degenerative changes in the nervous system. Therefore, this water-soluble vitamin should be present in the diet on a daily basis (Van Herwaarden *et al.*, 2007).

2. Vitamin C

Water-soluble vitamins such as vitamin C are present in large amount in sea lettuces. The levels of vitamin C in sea lettuces average from 500 to 3000 mg/kg of dry matter. These levels of vitamin C are comparable with that of parsley, blackcurrant, and peppers. In sea lettuces, the highest level of vitamin C were found in *Ulva fasciata* (22 mg/100 g) (McDermid and Stuercke, 2003). Vitamin C is of interest for many reasons. First, it strengthens the immune defense system, activates the intestinal absorption of iron, as a reversible reductant and antioxidant in the aqueous fluid and tissue compartments. Further, this vitamin is specifically required for the activity of eight human enzymes involved in collagen, hormone, amino acid, and carnitine synthesis or metabolism (Jacob and Sotoudeh, 2002).

3. Vitamin E

Burtin (2003) reported that green seaweeds contain low amount of vitamin E (Burtin, 2003). In contrast, Ortiz *et al.* (2006) demonstrated that *Ulva lactuca* showed high level of vitamin E. Daily ingestion of 109.5 g/day of

Ulva lactuca consumption will be enough to meet the daily requirements of vitamin E (Briand and Morand, 1997). The determined levels of vitamin E show a good nutritional complement that confirms the importance of sea lettuces in normal diets for human.

E. Minerals

Minerals are inorganic elements that retain their chemical identity in foods. It can be classified into two groups; macro- (calcium, phosphorous, potassium, sulfur, sodium, chloride, and magnesium) and trace minerals.

Sea lettuces which draw from the sea contain wealth of mineral elements (Table 5.4). Calcium, one of the most important minerals essential for human body, is accumulated in sea lettuces at a higher level compared with milk, brown rice, spinach, peanuts, and lentils (MacArtain *et al.*, 2007). Calcium contents in *Ulva lactuca*, *Ulva reticulata*, *Ulva fasciata* were 32.5, 147, and 0.47 mg/100 g edible portion, respectively. Moreover, potassium and sodium are known as electrolytes because their ability to dissociate into positively and negatively charged ions when dissolved in water. Potassium is the major cation of intracellular fluid. Together with sodium, it maintains normal water balance. In addition, potassium also promotes cellular growth and maintains normal blood pressure. Potential source of potassium is *Ulva reticulata*, which contains 1540 mg potassium per 100 g edible portion (Ratana-arporn and Chirapart, 2006).

TABLE 5.4 Mineral contents of some sea lettuces species (mg/100 g edible portion)

Minerals	*Ulva lactuca*[a]	*Ulva reticulata*[b]	*Ulva fasciata*[c]
Ca	32.5	140	0.47
K	24.5	1540	2.87
Mg	46.5	140	2.19
Na	34	–	–
Cu	0.03	0.6	5
Fe	1.53	174.8	86
I	0.16	1.124	–
Zn	0.09	3.3	9
N	–	–	3.62
P	–	180	0.22
S	–		5.24
B	–	–	77
Mn	–	48.1	12

Adapted from: [a]MacArtain *et al.* (2007), [b]Ratana-arporn and Chirapart (2006), [c]McDermid and Stuercke (2003).

Iodine is an important mineral in metabolic regulation and growth patterns. The recommended daily intake of iodine for adults is 150 μg per day. During pregnancy and lactation, an additional dose of 25 and 50 μg per day are recommended. Notably, the iodine deficiency is prevalent worldwide, which may correspond to the worldwide phenomena of brain damage and mental retardation. During pregnancy, infancy and childhood may lead to endemic and irreversible cretinism in infants or children. *Ulva reticulate* and *Ulva lactuca* have been described as a good source of iodine. Hence, considering the high mineral contents, sea lettuces could be used as a food supplement to meet the daily intake of essential minerals.

IV. CONCLUSIONS

Sea lettuces are rich in nutrients with medicinal and health-promoting effect. From a nutritional standpoint, the main properties of sea lettuces are their richness in polysaccharides, protein and amino acids, fatty acids, minerals, and vitamins. Therefore, their nutritional value makes them valuable food supplements. Further, sea lettuces may be used to fortify processed foods. Food preparations from sea lettuces worldwide may be studied to increase sea lettuce utilization. Moreover, recognition of sea lettuces as sources of diverse bioactive principles may open medicinal potential of sea lettuces and there is a great potential to be used in pharmaceuticals. Therefore, combination between culinary use and research on bioactive compounds may revitalize the use of sea lettuces in the newly health conscious consumers. Sea lettuce products could be used for food fortification, enrichment, and multipurpose applications.

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