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Review article

Current trends in seaweeds as a functional food: Nutritional health perspective

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ABSTRACT

The world's need for food grains obtained from non-traditional sources among the various food sources available in the world is increasing day by day. Accordingly, in countries with geographical and climatic diversity, awareness about food grains and the nutrients, medicinal components, etc. obtained from them is also increasing in recent times. In this context; Seaweeds have emerged as a prominent functional food due to their diverse nutritional composition and potential health benefits. Rich in essential nutrients like proteins, dietary fibers, vitamins, and minerals, as well as bioactive compounds such as polyphenols, carotenoids, and polysaccharides, seaweeds offer significant contributions to human health. The present article reviews current trends in consumable and therapeutic seaweeds which highlight their role in preventing chronic diseases, including cardiovascular disorders, diabetes, obesity, and certain cancers. The unique bioactive properties of seaweeds, particularly their antioxidant, anti-inflammatory, and antimicrobial activities, are being explored for improving gut health, immune modulation, and metabolic regulation. As consumer interest in plant-based and sustainable foods grows, seaweeds are increasingly incorporated into various food products, ranging from snacks to nutritional supplements. Overall, seaweeds present a promising avenue for developing nutritionally rich, health-promoting functional foods in the global market. The present review article deals with the various avenues of utilizing seaweeds as a functional human food putting a step ahead towards sustainable goals.

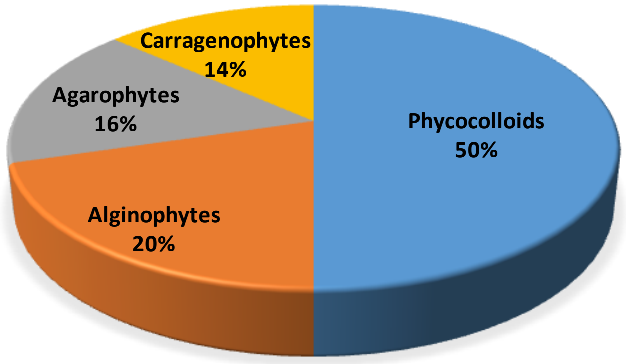
INTRODUCTION

Macroalgae, or seaweeds, are large, diverse colonies of algae that grow in both freshwater and marine environments worldwide. Seaweeds first appeared on Earth over 1.2 billion years ago (Butterfield, 2000). They vary widely in size, shape, and color, and are primarily classified into three groups based on the pigments used in photosynthesis: green (Chlorophyta), red (Rhodophyta), and brown (Phaeophyta) (Kumar et al., 2019). These groups are distinguished by characteristics such as pigmentation, the composition of photosynthetic storage products, the arrangement of photosynthetic membranes, and other physical traits.

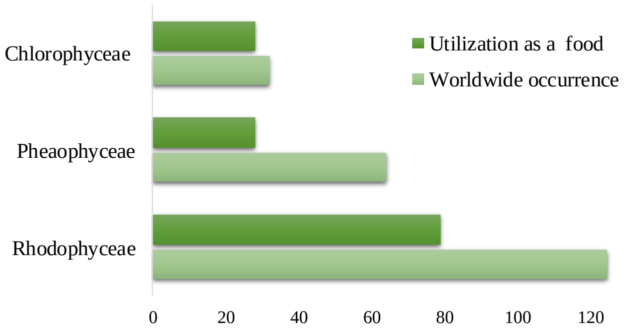
Traditionally, seaweeds have been classified into four groups, based on color, since the mid-1900s: green algae (phylum: Chlorophyta, including classes like Bryopsidophyceae and Chlorophyceae, with around 1200 species), brown algae (phylum: Ochrophyta, class: Phaeophyceae, with about 1750 species), blue-green algae (phylum: Cyanophyta, with up to 1500 species), and red algae (phylum: Rhodophyta, with about 6000 species). All these groups have microscopic forms at some stage in their life cycle (Kılınç et al., 2013).

Seaweeds play a vital role as primary producers in aquatic food webs, especially in marine environments. They are rich in minerals, trace elements, and raw materials that are valuable to industries like cosmetics and pharmaceuticals (Chapman, 2012). In 2000, approximately 10 million tons of seaweed, both wild and farmed, were produced globally. The leading producers include China, France, the United Kingdom, Japan, Chile, the Philippines, Korea, Indonesia, Norway, the United States, Canada, and Ireland. While wild seaweed collection has remained relatively stable, aquaculture, including integrated mariculture, has been steadily growing over the past twelve years (Guiry, 2011; Alga-Net, 2010).

Seaweeds are used in various industries, including fertilizers, human food, cosmetics, and industrial gums and chemicals. They provide both short- and long-chain chemicals for industrial and health-related uses (Guiry, 2011). Out of the 221 species of seaweeds distributed globally, over 145 species are used directly as food, and around 202 species are utilized in the algal industry. Additionally, approximately 12 species are used in traditional medicine, while 25 species are employed in agriculture, animal feed, and fertilizers (Zemke-White and Ohno, 1999; Pereira, 2011) (Fig. 1 (1A and 1B)).



1A. Seaweeds: Industrial utilization



1B. Number of seaweed species utilized as food

Fig. 1. Seaweeds share of worldwide occurrence and utilization

SEAWEED RESOURCES

Since ancient times, seaweed has been a staple in the diets of China, Japan, and Korea. In 600 BC, SzeTeu mentioned in Chinese literature that "some algae are a delicacy fit for the most honored guests, even for the King himself." In Japan, around 21 species of seaweed—six of which have been used since the eighth century—are commonly incorporated into everyday cooking. Until recently, seaweed (known as Kaiso) accounted for over 10% of the Japanese diet. In 1973, seaweed consumption averaged 3.5 kg per family, a 20% increase in just a decade (Nisizawa, 2002). While seaweed has not historically been a part of Western cuisine, there has been a recent resurgence of interest in using seaweed as a vegetable in Western countries (Hotchkiss et al., 2007).

Seaweeds are increasingly recognized for their role in functional foods, which offer physiological benefits in addition to basic nutrition, such as anti-inflammatory, antioxidant, and antihypertensive properties (Goldberg, 1994). A food is considered functional if it enhances one or more physiological processes, promotes wellbeing, or reduces the risk of disease. Functional foods emphasize prevention over treatment. Recently, nutraceuticals, which are food-derived products marketed in tablet or pill form, have gained popularity. These items, sold as dietary supplements, provide significant health benefits. Functional foods are often derived from traditional dishes that have been enhanced with ingredients that support human health (Pereira, 2011).

Brown seaweeds lack true starch and instead contain alginic acid, a long-chain heteropolysaccharide found in their cell walls. For example, over 26,000 tonnes of brown kelp (*Macrocystis pyrifera*) are harvested annually off the coasts of California, Mexico, and Chile for alginic acid extraction (David, 2002). There are over 2,200 species of brown algae, most of which thrive in cold marine environments. Common brown seaweeds include *Sargassum*, *Porphyra*, *Undaria*, *Hizikia*, and *Fucus*. Red algae, which contain the pigments phycocyanin and phycoerythrin, appear red and have cell walls composed of carrageenan and cellulose agar. There are approximately 6,500 species of red algae, with common varieties like *Gracilaria*, *Gelidium*, *Euchema*, *Porphyra*, *Acanthophora*, and *Palmaria* (Kumar, 2008).

The majority of seaweed species are aquatic, living in both freshwater and marine environments. Some species are terrestrial, found on rocks, trees, or soil. Notable types of green seaweed include *Ulva*, *Enteromorpha*, *Monostroma*, and *Caulerpa* (Kumar, 2008) (Table 1).

Table 1. Seaweeds authorized for human consumption

Class	Name
Phaeophyceae (Brown seaweeds)	*Ascophyllum nodosum* *Fucus vesiculosus* *Fucus serratus* *Himanthalia elongata* *Undaria pinnatifida*
Rhodophyceae (Red seaweeds)	*Porphyra umbilicalis* *Palmaria palmata* *Gracilaria verrucosa* *Chondrus crispus*
Chlorophyceae (Green seaweeds)	*Ulva spp.* *Enteromorpha spp.*
Microalgae	*Spirulina sp.* *Odontella aurita*

NUTRITIONAL POTENTIAL OF SEAWEEDS

Polysaccharides and dietary fibers

Seaweeds are rich in polysaccharides, particularly in the structural polysaccharides found in their cell walls, which are extracted by the hydrocolloid industry. Red seaweeds contain agar, carrageenan, and carginate, while brown seaweeds provide alginate. Other minor polysaccharides in seaweed cell walls include ulvans in green seaweeds, fucoidans in brown seaweeds, and xylans in some red and green species. Seaweeds also store polysaccharides like floridean starch (a glucan similar to amylopectin) in red seaweeds and laminarin (a β-1,3-glucan) in brown seaweeds. Most of these polysaccharides, such as agar, carrageenans, ulvans, and fucoidans, are not metabolized by humans and are classified as dietary fibers (Lahaye and Thibault, 1990). Water-soluble and insoluble fibers have different physiological effects. Water-insoluble polysaccharides like cellulose are primarily linked to faster digestion, while viscous soluble polysaccharides such as pectins and guar gum are associated with lowering cholesterol and blood sugar levels (Southgate, 1990). Fucoidans, in particular, have attracted attention due to their biological activities, including anti-thrombotic, anti-coagulant, anti-cancer, anti-inflammatory, and anti-viral effects, making them potential therapeutic agents. Xylans and laminarins are broken down by gut bacteria, while alginates are only partially metabolized, producing significant amounts of short-chain fatty acids (Burtin, 2003).

Minerals

Seaweeds extract a remarkable array of minerals, macro-elements, and trace elements from the ocean, with some seaweeds containing up to 36% minerals by dry weight. Historically, brown seaweeds have been used to treat thyroid goitre (Suzuki et al., 1965), a connection later linked to iodine. Seaweeds such as *Fucus vesiculosus* are still included in the European Pharmacopoeia for their high iodine content, though they are no longer widely used as a primary source of iodine except in China. Laminaria species, with iodine concentrations ranging from 1500 to 8000 ppm, are now the main source of iodine, while other seaweeds like *Fucus* provide iodine in the range of 500-1000 ppm. Seaweeds are also significant sources of calcium, with macroalgae containing up to 7% calcium by dry weight. The chalky seaweed *Lithothamnion* can have calcium concentrations as high as 25-34%, making seaweed an important source of calcium for populations such as the elderly, adolescents, and pregnant women (Burtin, 2003).

Proteins and amino acids

Brown seaweeds typically have low protein content, averaging 5-15% of dry weight, while green and red seaweeds contain higher protein levels, ranging from 10-30%. Some red seaweeds, like *Porphyra tenera* (nori) and *Palmaria palmata* (dulse), can contain up to 35% and 47% protein, respectively, which is comparable to high-protein crops like soybeans. Green seaweeds like *Ulva* species have protein contents between 15-20%. While brown seaweeds like *Laminaria digitata* and *Ascophyllum nodosum* have lower protein levels, *Undaria pinnatifida* is an exception with 11-24% protein content. While proteins from brown and green seaweeds show similar effects, their phenolic content may reduce protein availability in vivo, unlike green and red seaweeds with lower phenol levels. Phycobiliproteins found in red and blue algae (e.g., phycoerythrin in red algae and phycocyanin in *Spirulina*) have antioxidant properties that may help prevent or treat oxidative stress-related neurodegenerative disorders (Burtin, 2003).

Lipids and fatty acids

Lipids in seaweeds make up 1-5% of dry matter, and they contain polyunsaturated fatty acids, especially omega-3 and omega-6 fatty acids, which are linked to reduced risks of diabetes, osteoarthritis, and cardiovascular disease. Green algae are rich in alpha-linolenic acid (ω3 C18:3), while red and brown algae are abundant in fatty acids with 20 carbon atoms, such as arachidonic acid (ω6 C20:4) and eicosapentaenoic acid (EPA, ω3 C20:5). *Spirulina* contains gamma-linolenic acid (GLA), which makes up 20-25% of its lipid fraction and serves as a precursor to prostaglandins, leukotrienes, and thromboxanes that regulate inflammatory, immunological, and cardiovascular responses. In addition to fatty acids, seaweeds contain unsaponifiable compounds such as tocopherols, sterols (e.g., fucosterol in brown seaweeds), terpenoids, and carotenoids (e.g., β-carotene, lutein, and violaxanthin in red and green seaweeds, and fucoxanthin in brown seaweeds). Seaweed lipid extracts have demonstrated antioxidant activity and synergistic effects with tocopherols (Burtin, 2003; Sánchez-Machado et al., 2004) (Fig. 2).

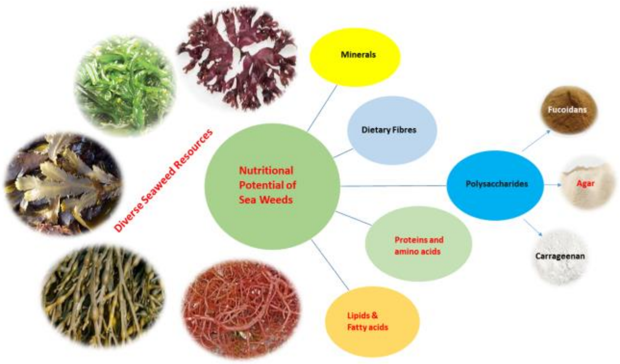


Fig. 2. Seaweeds and their nutritional role due to presence of bioactive compounds

Seaweeds as therapeutics

A dietary intervention study conducted in Quito, Ecuador, with 27 participants showing at least one symptom of metabolic syndrome, found that consuming 4-6 grams of dried whole seaweed or *Undaria pinnatifida* daily significantly reduced blood pressure and improved symptoms of metabolic syndrome (Brown et al., 2014). In another study, 12 healthy overweight and obese males were given seaweed-enriched bread (4% *Ascophyllum nodosum*) as part of a single breakfast meal. The results showed that calorie intake at a subsequent lunch, 4 hours later, and total energy consumed over the next 24 hours were significantly reduced by 506 kcal. The potential role of alginate, a marine fiber derived from brown seaweed cell walls, in weight control has also been explored. A four-week study demonstrated that drinking an alginate-based beverage significantly reduced energy intake in both healthy individuals and those who were obese or overweight, compared to a high-fiber control drink (Paxman et al., 2008). Many animal studies on *Undaria* species in the context of diabetes have shown positive results, including improved lipid profiles, reduced inflammation, less weight gain, and better blood glucose regulation (Murata et al., 1999). Additionally, a single dose of dried seaweed extract from *Fucus vesiculosus* and *Ascophyllum nodosum* enhanced insulin sensitivity and insulin levels following a carbohydrate-rich meal in healthy individuals, though it had no effect on postprandial glucose levels (Paradis et al., 2011) (Fig. 3).

Bioactive substances

Seaweeds are rich in biologically active compounds such as polysaccharides, proteins, lipids, minerals, and polyphenols (Fig. 2). The overall composition of various seaweeds is summarized in Table 2 (Chowdhury et al., 2021). For this review, several substances found in seaweeds are categorized by their roles, such as lipid-related compounds, carotenoids, and unique fatty acids like conjugated fatty acids. The following sections briefly describe the bioactive compounds in seaweeds and their potential health benefits (Kumar, 2008).

Antioxidant activities

Seaweeds possess strong antioxidant properties, which are essential in combating various diseases such as cancer, chronic inflammation, atherosclerosis, cardiovascular disease, and the aging process (Pooja, 2014). These antioxidants help to slow the growth of cancer cells, offering potential protective effects (Richardson, 1993).

Antimicrobial and antifungal activity

Crude methanol extracts of *Gracilaria corticata* have been shown to exhibit significant antibacterial and antifungal properties. Among various solvent extracts (methanol, acetone, chloroform, and hexane-ethyl acetate), methanol demonstrated the strongest antibacterial activity against pathogens like *Enterobacter aerogenes*, *Klebsiella pneumoniae*, *Bacillus cereus*, *Bacillus subtilis*, and *Streptococcus pyogenes* (Kolanjinathan and Stella, 2011).

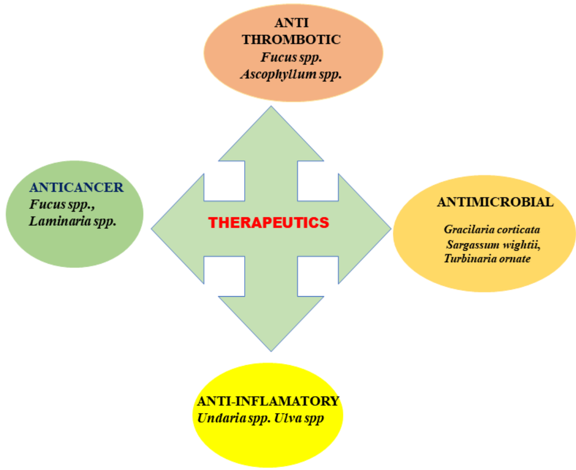


Fig. 3. Potential seaweeds and their application in therapeutics

Table 2. Proximate composition analysis (Mean ± SD) of wild seaweed species

Class	species	Moisture (%)	Ash (%)	Lipid	Crude Fibre	Protein	Carbohydrate
Rhodophyceae	*Hypnea sp.*	15.43±0.85	7.05±0.27	1.46±0.30	5.72±1.17	23.64±1.44	46.71±0.54
Chlorohyceae	*Enteromorpha sp.*	15.79±0.66	32.40±1.75	0.59±0.06	0.23±0.01	18.35±1.51	32.65±3.88
	Sargassum sp.	20.29±1.25	19.44±0.74	0.39±0.07	7.78±0.42	13.36±0.15	38.75±1.01
	H. clathratus	17.79±1.29	61.98±0.54	0.15±0.06	2.19±0.23	7.20±0.31	10.70±0.16
	P. pavonica	12.09±2.92	54.51±8.07	0.23±0.08	0.83±0.02	7.64±1.29	24.72±6.54
Phaeophyceae	*C. sinuosa*	12.74±1.36	57.21±1.91	0.20±0.03	5.68±0.29	7.15±0.52	17.04±2.44
	P. fascia	17.80±0.07	18.51±2.42	2.75±0.14	10.08±0.07	7.24±0.45	43.63±2.72
	D. ciliolata	29.65±1.92	44.49±2.40	1.68±0.06	1.76±0.06	7.69±1.02	14.74±3.31

Other notable sources of antibacterial agents include *Sargassum wightii*, *Turbinaria ornata*, and *Gracilaria corticata* (Vijayabaskar and Shiyamala, 2011). When comparing ethanol and methanol extracts, ethanol was found to have stronger antibacterial effects against *Staphylococcus* species, *Proteus* species, and *Escherichia coli* (Karthikaidevi et al., 2009).

Seaweeds as anticancer agents

Numerous studies have demonstrated that seaweed extracts can either completely eliminate or significantly reduce the efficacy of cancer cells. Incorporating seaweed into the diet has also been linked to a potential protective effect against the development of breast cancer (Teas, 1981). Research on brown algae species such as *Fucus spp.* has shown efficacy against colorectal and breast cancers. Historically, *Laminaria* species were used in Chinese medicine to treat cancer, and ancient Ayurvedic texts also mention their use. A seaweed-rich diet is associated with a reduced risk of breast cancer and other malignancies through mechanisms like lowering blood pressure, binding biliary hormones, providing antioxidative effects, binding harmful substances, inhibiting cell adhesion, inducing apoptosis, and supplementing essential trace minerals (Pati et al., 2016).

Seaweed recipes

Incorporating fresh seaweed into recipes is a fantastic way to start the day with a nutritious, plant-based meal. Seaweed-based recipes are highly versatile, can be prepared in advance, are rich in vitamins, and are incredibly flavorful (https://lofotenseaweed.no/seaweed-recipes) (Table 3). These nutritious dishes offer valuable novel compounds that are well-suited for human consumption (Fig. 4).

Fig. 4. Various seaweed recipes and nutritious preparations serving as novel source of therapeutically rich biomolecules

Table 3. Examples of popular Seaweed recipes, seaweed resources used and method of their preparation of food product

Seaweed Recipes	Seaweed resource used/ ingredients	Method of preparation
Seaweed Soup & Soup powder	*Sargassum tenerrimum*	The method for preparing seaweed soup powder involves washing and soaking fresh *Sargassum tenerrimum* seaweed, followed by boiling for 15 minutes. The seaweed is then ground into a paste, to which starch, garlic paste, and ginger paste are added. The mixture is dried in the sun and pulverized to create the final powder, which is packaged in 10g pouches. To prepare the soup, 5g of the powder is mixed with lukewarm water to form a paste, then added to 200ml of boiling water. Soy sauce and chili sauce are added to taste, and the soup is served hot. For standardization, different starch types (corn flour, tapioca, and maizena) and concentrations (7%, 7.5%, and 8%) are tested to find the most suitable starch. Similarly, varying quantities of garlic paste (5%, 6%, and 7%) are tested to determine the optimal amount for the soup powder mixture (Yadav et al., 2010).
Choux pastry	Seaweed (Nori) High protein wheat flour 110 g, Milk 125 ml, Water 125 ml, Spinach 100 g, Salt 1 g, Butter 58 g, 3 eggs, Salmon 200 g, Carrot 100 g, Potato 100 g, Celery 20 g, Garlic 20 g, Onion 100 g, Pepper 2 g, Coriander 2 g, Salt (To taste), Sugar (To taste), Oyster sauce 15 mL, Wheat flour 30 g Seaweed (nori) 12.5 g, Mayonnaise 100 g.	The cube potatoes are fried until half-cooked. The onions are sautéed until fragrant, then pepper, coriander, and garlic are added and cooked. Next, the chopped salmon is added to the stirred onions. Carrots and milk are added after the salmon changes color to pale. Salt, sugar, and oyster sauce are added to taste, and water is added if necessary. Finally, the flour is added, stirred, and cooked until all of the flour is mixed. To make the choux dough, the spinach is cut and blended with an additional 100 ml of water. Spinach extract is obtained after filtering the mixture of spinach and water. The seaweed (nori) is cut and blended until it becomes powder. Next, 125 ml of spinach extract is mixed with milk, butter, and salt, then boiled. After the dough is boiled, the heat is turned off and the flour is added. The dough is stirred quickly with a wooden spoon to prevent it from sticking to the pan. If necessary, the dough is heated for 1-2 minutes to reduce the water content. After the dough is heated and the temperature is reduced, the eggs are added one by one to create a shiny, thick, and smooth dough with a pipeable consistency. The soft dough is put into the piping bag with a nozzle and piped into a rectangular shape onto the greased baking tray. Ragout, nori powder, and mayonnaise are added to the top of the dough and covered with choux dough. The choux dough is baked at 185-200°C for 40 minutes to create a light, airy, puffy, and crisp pastry, which is sliced after cooling (Ana et al., 2022).
Seaweed snack	*Ulva rigida*	The seaweed is washed five times with tap water at a ratio of 1:8 (w/v), then blanched in boiling water for 15 seconds and immediately cooled in iced water. After cooling, the seaweed is weighed and mixed with water at a ratio of 1:10 (w/v), then ground for 40, 60, or 90 seconds using a blender. The mixture is filtered through muslin cloth to collect the residue for drying. Seaweed polysaccharides dissolved in water at concentrations of 0.125%, 0.25%, and 0.5% (w/v) are added to the filtered seaweed at a ratio of 2:3 (w/w). The mixture is spread as a thin layer on heat-resistant Teflon film to form seaweed sheets (2 mm thickness). The seaweed is dried at 150°C in a hot air oven for 5 to 45 minutes. Afterward, the sheets are coated with a seasoning mixture of soy sauce, sugar, and flavoring, then dried at 130°C for 8 minutes to obtain the finished seaweed snack (Thunyawanichnondh et al., 2020).
Seaweed based Jam	*Ulva Spp.* and fruits like wood apple, orange and mango, and sugar, citric acid and sodium benzoate.	Seaweed samples are washed, cleaned, and epiphytes are removed. The cleaned seaweeds are dried at 45°C in an electrical oven for 1-2 days. The dehydrated seaweed is powdered, stored in airtight containers at 4°C, and used in jam formulations within one month. The dried and ground seaweed powder of *Gracilaria verucosa* (agrophyta) and *Kappaphycus alvarezii* (carrageenophyta) are used to extract agar-agar and carrageenan. The powder of *Ulva* species is used to prepare a jam recipe. Four types of jam are prepared using wood apple, orange, mango, and *Ulva* species powder. Each jam is made with fruits, sugar, additives (citric acid and sodium benzoate), and different levels of agar-agar or carrageenan. The jams are evaluated for sensory quality, including color, aroma, taste, and consistency, by trained panelists. Each jam sample is filled into 250g glass

		jars and tightly capped. Shelf life studies for the different fruit jams and *Ulva* jam are carried out over six months (Jayasinghe et al., 2015).
Seaweed Bread	Sugar kelp (*Saccharina latissima*) *Beta vulgaris*, 2 g dry instant yeast (*Malteserkors tørgær*)	Sugar kelp (*Saccharina latissima*) is freeze-dried, containing 150 mg of NaCl per gram (dry weight). The kelp liquid is prepared in batches by blending the dried kelp flakes into a powder. The dough formulation is based on a 60% hydration dough, with sugar added to aid yeast gas production. The dough consists of 200 g flour, kelp liquid (with concentrations stated above), 8 g sugar (Dan Sukker, Beta Vulgaris), 2 g dry instant yeast (Malteserkors tørgær), and varying amounts of salt (Maldon Sea salt) at 0%, 0.5%, or 1% of the total dough weight. The bread contains a maximum of 1% added salt, which aligns with the highest potential salt content from the seaweed extract. All ingredients are mixed in a mixer for 8 minutes at speed 2. Two batches of dough, each weighing 330 g, are prepared, one for baking and one for dough development and gas measurements. The dough for baking is shaped into buns of matching sizes. Texture analyzer measurements are taken using a 33 g dough sample. The dough is placed in an oven to rise for 35 minutes at 30°C. After proving, the dough is transferred to another oven and baked at 200°C for 15 minutes (Aabel et al., 2024).
Seaweed Almond Brittle	Seaweed, Hard Sugar candy, embedded with nuts (typically peanuts, almonds, pistachios and sesame seeds).	Put the Seaweed, sugar, butter and water into a non-stick frying pan and heat gently. Continue to stir until the sugar dissolves. Then increase the heat and boil for 4-5 mins and wait for a light golden brown colour. Add the nuts and stir once before tipping onto a greased baking sheet. Scatter over the smoked seaweed salt. Leave to cool. Snap into pieces to serve (https://lofotenseaweed.no/seaweed-recipes/)
Toasted Seaweed Chips	1 packet yakinori sheets. 1 tbsp tamari (or liquid or coconut aminos), 1 tbsp sesame oil. Optional toppings sesame seeds, nutritional yeast	Pre-heat a fan forced oven to 150°C/ 300°F. Mix tamari and sesame oil together in a small bowl. Brush the shiny side of the nori sheet with the oil/tamari mix (right to the edges), sprinkle with optional toppings and place another sheet, rough side down on top. Repeat with two -three more sheets (to make a stack of three to four sheets). Place on a baking tray lined with baking paper and place another piece of baking paper on top. Bake for 10-15 minutes until crisp at the edges. Cut with a large sharp knife (you can pry into single sheets or leave as a stack) and enjoy immediately. It can be stored in an airtight container (https://lofotenseaweed.no/seaweed-recipes/).
Seaweed & Urad Dal Pakoras	1/4 cup urad dal (split black gram), soaked for 2 hours (makes 20 small pakoras) 5 small seaweed sheets, 1 small onion, chopped.1-2 green chilies, chopped, 1 piece ginger, grated, 2 tbsp. mint-coriander leaves, chopped to taste salt, 1/4 tsp. turmeric powder. 1 tbsp. roasted chickpea flour, as required oil to deep fry, 1 tsp. flaxseed (opt), 1/2 tsp. garam masala powder.	Coarsely grind the soaked dal with very less water. Mix along with the remaining ingredients (except oil) and keep aside for 10-15 minutes. Make small equal sized balls. Heat oil in a pan & deep fry them in batches till light golden in colour. Drain on a kitchen towel. Serve with any chutney as an appetizer or as a tea time snack (https://lofotenseaweed.no/seaweed-recipes/).
Seaweed Smoothie	Seaweed Spp., 15g Flax seeds,70ml Orange juice, 10g Arctic Ocean Green, 30g Kale, 300ml Oat milk, 1 Banana, 1 tbsp honey.	Mix orange juice with flax seeds and Seaweed and leave it to soak for 10 minutes. Place all the other ingredients in a blender, then add the orange juice mixture. Blend until smooth. Top with berries, pumpkin seeds, granola, yoghurt, an extra sprinkle of Arctic Ocean Greens, or whatever your favourite smoothie topping is (https://lofotenseaweed.no/seaweed-recipes/)
Seaweed Hummus	2x400g cans chickpeas, 2 cloves garlic, minced, 4 tsp tahini, 3 tsp cumin 1 tsp paprika, 3 tsp Arctic Ocean Greens, 1½ lemons, Salt and pepper to taste.	Drain chickpeas over a bowl, reserving the water (Aquafaba) from the Can. Using a food processor, blend the chickpeas to a paste. While the food processor is blending on a low setting, add the aquafaba and lemon juice until you reach your desired consistency. Add the garlic, tahini, cumin, paprika, salt, pepper and Arctic Ocean Greens. Make sure to taste as you go. Keep blending, tasting and adjusting until you are happy. Serve with crackers or sliced vegetables and pickles (https://lofotenseaweed.no/seaweed-recipes/).

CONCLUSION

This article reviews current trends in consumable and therapeutic seaweeds, emphasizing their potential in preventing chronic diseases such as cardiovascular disorders, diabetes, obesity, and certain cancers. While seaweeds are ecologically significant, they also offer unique and valuable nutritional benefits. They are particularly known for their high content of soluble dietary fiber, essential minerals (including calcium and iodine), vitamin B12, and bioactive compounds like fucoxanthin, fucosterol, and phlorotannin. However, the commercial use of seaweeds faces challenges, including the need for standardization, regulatory frameworks, and further research on the long-term effects of consumption.

Seaweeds have the potential to be an underutilized source of health-promoting compounds for the food processing and nutraceutical industries. Additional research is needed to evaluate the nutritional value of other marine algae species, such as *Grateloupia spp.*, *Bonnemaisonia spp.*, and *Delesseria spp*. As nutraceuticals or dietary supplements, seaweeds can contribute to the development of condition-specific antioxidant solutions. In conclusion, seaweeds are promising natural agents for creating and delivering effective health solutions.

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CONFLICTS OF INTEREST

The author(s) declare(s) no conflicts of interest.

DECLARATION

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