Review Article

International Journal of Research in Pharmaceutical Sciences

Published by JK Welfare & Pharmascope Foundation Journal Home Page: www.pharmascope.org/ijrps

A review on medicinal and commercial use of Marine Algae

Navaith Ahmed S, Usharani B*

Department of Biochemistry, Vels Institute of Science, Technology and Advanced Studies, Pallavaram, Chennai– 600117, Tamil Nadu, India

Article History:

Received on: 30 Mar 2021
Revised on: 28 Apr 2021
Accepted on: 03 May 2021

Keywords:

Antibacterial,
Antiobesity,
Antioxidant,
Antiviral,
Seagrass,
Types of algae

Abstract

Algae are a various group of autotrophic organisms that varies from unicellular to multicellular forms and found in saltwater as well as freshwater. They are key producers with a great source of nutrients and vitamins. In the last few decades' discovery of biological activity from marine algae has increased significantly. Seaweed offers wide range of therapeutic possibilities both externally and internally as they are good source of neutraceuticals and potent drug. Seaweed is widely distributed along temperate and tropical coastlines of the world and they found to depths of 50-60 meters. Our focus is on the potential applications of the medical field. It is used as medicine, food and supplement for ages and also found in rudimentary applications in the cosmetics and industrial industry. The potential uses of algae in the medical field are based on properties like antioxidant, anticancer, antiviral, antimicrobial, antihypertensive, anti-inflammatory, antieczemic etc., The nutrient value in the algae envisages it as a potential supplement for vitamins. Algae is accepted as complete food as it is well balanced with carbohydrates, proteins, essential amino acids, minerals and vitamins and they are commonly named superfoods. Medicinal properties of different algae species attract the attention of scientists worldwide for the synthesis of pharmaceutical products that promote good health. Algae are also widely used in Obesity management which is one of the great challenges of the century.

*Corresponding Author

Name: Usharani B
Phone:
Email: usharani.sls@velsuniv.ac.in

ISSN: 0975-7538

DOI: https://doi.org/10.26452/ijrps.v12i3.4777

Production and Hosted by

Pharmascope.org

INTRODUCTION

Algae are one of the plants that contain chlorophyll in plant cells that does photosynthesis. Algae are divided broadly into two, namely macro (macroscopic) and micro (microscopic) algae (Singh *et al.*, 2005). Algae are rich in proteins, minerals, vitamins and fatty acids etc., considered well balanced food for the living system (Pulz and Gross, 2004). The study of algae should be focussed more to get detailed knowledge on the significance of them in many more areas as their uses are many more (Babić *et al.*, 2014).Marine algae were used as healthy food and essential medicine for centuries. Different species of algae useful in different fields like dairy, food, pharmaceutical and cosmetic industry and they studied individually in each type. Algae are also one of the important sources of Bioethanol, Biobutanol, Biodiesel and Hydrogen gases (Rengasamy *et al.*, 2013) and also plays a vital role as antibiotics, antioxidants and antiviral agents and used widely in Pharmaceuticals. Food items prepared from algae could have positive, negative, or disputable effects on the living system. Accordingly, higher toxic contents (e.g., cadmium) or fucotoxins in algal food products are to be avoided as they will is harmful to

the system. The digestibility, bioactive compounds and fibre content in algae are measured analytically and used in the evaluation of algal food quality. Study on digestibility is based on nitrogen usage by algae during digestion, which is analysed enzymatically by pepsin under in vitro conditions (Mabeau and Fleurence, 1993). There are a bunch of analytical methods are available in the field to study biologically active compounds in algae (Mišurcová *et al.*, 2010) which used to explore more active compounds in algae.

Types of Algae

The algae that form the seafloor are nonflowering organisms, very diverse and vary in size, shape and colour, they are typically termed seaweeds. Seaweeds occur on any shore where a solid bottom or other patterns of stable ground are present. They are mainly divided based on colour into three groups, namely green, red and brown algae. Other than the colour, they differ by photosynthetic property, composition, cell walls composition, presence/absence of flagella ultrastructure of mitosis, the structure of the choroplasts and many other properties. The red and green algae are coming under plants, while brown algae come under a different kingdom named Chromista (Brodie *et al.*, 2007). This classification is based on the development of these groups. All eukaryotic algae are originated through the endosymbiosis process, in which a unicellular organism was captured and united by another type of unicellular organism.

Green Algae

The green algae is present in seawater as well as in freshwater habitats. The classification of green algae is revised based on a DNA data bank. Based on the current revision, green algae are part of a larger group called Viridiplante, in which the land plants are also included (Lewis and McCourt, 2004). However, all marine green algae are classified in a common class called Ulyophyeae. The Ulyophyceae are a very diverse group that include about 920 species and distributed all around the world.

Green seaweeds have a variety of forms but with simple morphology of with or without branched thin filaments. Cladophora and Chaetomorpha are a better example of these types. Ulva is the best example of sheets formed by two layers of cells. They termed sea lettuce due to their appearance. These algae have the maximum capacity to absorb nutrients from seawater and grow rapidly.

Red Algae

The species of red algae are believed to be the oldest algae type. (Bangiomorpha pubssens). These are the only seaweeds without flagells (Cavalier-Smith, 2007). The colour of algae ranges from pink to bright red, purple or rarely dark brown due to phycobilin pigments.

Brown Algae

Brown algae are classified under Fucophyceae class of the phylum Ochrophyta (Brodie *et al.*, 2007). There are about 1780 species of brown algae in total. Brown seaweeds live mixed with green seaweeds on rocky shores and look similar macroscopically, but they are of the different kingdom of chromsita. The brown seaweeds are distributed all around the world, but the most abundant in cold seas, especially the largest-sized brown algae, are found in the polar region and cold-water countries, examples are Laminariales and Desmaresiales etc., Species like Sargassum and Turbinaria are found in the tropical ocean.

Giant pacific kelp Macrocystis pyrifera is the largest brown seaweeds which is categorised under Laminariales and called as kelps. It grows up to 60 meters and forms like dense forests on the pacific shores of the U.S.A and Canada. Species like Echlonia, Eisenia Laminaria and Lessonia forms the same submerged forests.

Antioxidant Property of Marine Algae

Antioxidants play a vital role in acting against cancer in its later stages. Polyphenols, phycobiliproteins are the most important water-soluble antioxidants found in algae (Plaza *et al.*, 2008). Oxidative processes develop carcinogenesis, antioxidant inhibits oxidation and reverse the cancer development. A number of algal species prevented oxidative damage by scavenging the process of free radicals and active oxygen and prevents cancer cell formation (Richardson, 1993), these antioxidants not only work against cancer but also chronic inflammation, atherosclerosis, the ageing process and cardiovascular diseases (Kohen and Nyska, 2002). Polyphenols present in brown seeds act as antioxidants, they are called phlorotannins and formed by the polymerization of phlorogucinol (1,3,5 – trihydroxybenzene). Biochemical scientists use different methodologies to extract biologically active compounds from algae (Athukorala *et al.*, 2006).

Anticancer Property of Marine Algae

Marine macro-algae are the most valuable algae group due to their biological activities like microbial (Bouhlal *et al.*, 2011), antiviral (Kim *et al.*, 2011), antifungal (de Felício *et al.*, 2010), antiallergic (Na *et al.*, 2005), anticoagulant (Shi *et al.*, 2008), anticancer (Kim *et al.*, 2011), antifouling and antioxidant activities (Devi *et al.*, 2011). Marine algae have protection by chemically active metabo-

lite from other growing organisms (Bhadury and Wright, 2004). There are many marine algae that produce substances with antibacterial, antiviral, antifungal properties and against other infections. The individual alga's antibiotic property is based on species, season, environmental conditions etc., (Centeno and Ballantine, 1998). Preliminary studies done on algae provide that some antioxidants like β-carotene is a vital part of the treatment of premalignant conditions like oral leukoplakia (Boopathy and Kathiresan, 2010). The practical difficulty of collecting marine floral samples is the primary cause of slowness in the development of marine algae as medicine. Pharmaceutical companies and academic institutions are making maximum effort to isolate and identify new marine-derivatives. The marine floras are not found to be explored to the next level for promoting further research in this field (James, 2011).

Antiviral Properties of Marine Algae

Vaccination is most effective against many viral diseases, but some diseases are not controllable by immunisation. Antiviral made against active herpetic infections synthetically were not effective (Naesens and Clercq, 2001). Severe allergic, side effects and some resistance mutation reported for this vaccine, especially for the long-term treatment. Some plant extracts and algae extracts were tested for their antiviral effects on different viruses, including herpes (Serkedjieva, 2004). In a notable number of these studies on different species of brown algae found that these algae certainly have antiviral property. Antiviral agent should have important qualities like eradicate the virus completely, not be immunosuppressive and there should be no compromise of the normal immune system (Munro *et al.*, 1987). The study of interferon in the cellular antiviral system has led to renewed interest in antiviral therapy.

Hormones in Seaweeds

Melatonin

Melatonin hormone present in many seaweeds 1000 folds than land plants. Calming effects by seaweeds consumption is due to melatonin presence. Night time harvested seaweed are richer in melatonin than daytime harvested ones. These studies revealed the opportunities to obtain melatonin from seaweeds.

Thyroid Hormones in Seaweeds

Thyroid hormones required to be given to thyroid disorder patients, usually they are produced from an animal source. Brown seaweeds found to be the only non-animal source for thyroid hormones. The organically bound iodine in brown seaweeds as thyroid hormones could explore the benefits of brown algae towards thyroid therapy.

DI-Iodothyronin

Fucus species of brown seaweeds are in use for thyroid disorders since the olden time. The thyroid hormone found in the Fucus species is Di-iodothyronine (DIT); it is weekly active as a thyroid hormone in the human system. Two molecules of DIT are combined in an esterification process to produce tetraiodothyronine (T4, Thyroxine). The organically bound iodine in Fucus may enhance T4 production by furnish some readymade portions of T4. Fucus-sourced DIT not studied so far in detail with regards to the thyroid. The therapeutic effect of Fucus in powder form, 3-5 grams daily, gives the better medicinal effects of thyroxine drugs. Fucus sourced DIT is effective in cases like shrinking of goitres, determination of symptomatic non-autimmune hypothyroidism, weight loss, return of energy with enthusiasm, decrease in psychiatric disturbances and resolution of the eczemas. This is proven to be effective for women undergoing post-delivery physiological depression caused by being pregnant for many years and nursing one too many children. Thyroxine and Tri-iodothyronine, which is proved as the main organically bound iodine present in some brown seaweeds, mainly Laminaria and Sargassum species. It is present in more amount in Sargassum species; it is rapidly expanding in all temperate coast; which is certainly useful news for thyroid patients (Felfoldi, 2006).

Algal Metabolites in Food

In recent years people are more concerned towards diet for many reasons like health conscious and nutritional value etc., The diet with high calorie value joined with the latest cooking style results in health issues, such as obesity, cardiac diseases, diabetes mellitus, etc., Therefore food items need to be focussed more on a diet with vitamins, minerals, etc., and of natural forms of ingredients instead of artificial ones. Algae are used as food for centuries, with many benefits for the living system. The studies have suggested that there is considerable improvement in the state of health not only because of algal proteins but also in the therapeutic use (Sousa *et al.*, 2008). In coastal areas all over the world, sea-weeds are used for human and animal nutritional use, and they are cultivated by algal farming. Species such as Porhyra sp., Chondus Crispus, Himanthalia elongate, an Undaria pinnatifida are examples of algae used as food and observed by the food industry because of their lower calorie and higher in vitamin contents, mineral and dietetic fibre (Plaza *et al.*, 2008). Micro-

algal biomass is available in different forms such as powder, tablets, capsules and liquid. It can also be incorporated into different food material and used for nutritional use. Spirulina and Chlorella genera are the best examples of nutritional usage.

Bioactive compounds are essential to produce new drugs and healthy foods. Edible algae contain dietary fibre, proteins and minerals (Kuda *et al.*, 2002). Marine algae also contain antioxidants in high amount (Nagai and Yukimoto, 2003). Examples of antioxidant from brown algae are phylophoephytin in Eisenia bicyclis (arame) (Cahyana *et al.*, 1992) and fucoxantine in (Yan *et al.*, 1999). The seaweeds are boiled, steamed followed by drying for future usage. The dry powder is then added with 20 to 40 times of water consumption (Jiménez-Escrig *et al.*, 2001). Agar gelatin, extracted from red seaweeds such as Gracilaria, are used in the food manufacturing industry and microbiological laboratory as culture media. Carrageenans is additive extracted from red sea algae such as Cjhondrus, Gymnogongrus, and Eucheuma, are used as gel products. There is plenty of microalgae fusion with other foods available worldwide (Raja *et al.*, 2013).

Anti-Obesity Activity

Obesity defined as an over bodyweight and having an unhealthy body mass index (Kong *et al.*, 2009). Obesity is considered one of the significant public health challenges since the last century. A number of research studies indicated that obesity is directly associated with Type 2 diabetes mellitus, selected cancer types, cardiovascular disease and sleep and breath disorders (Kopelman, 2000). Furthermore, obesity continues to increase in all age group in developing countries, which is a challenge to the world (Kelishadi, 2007). Consequently, the need of discovering the alternative source of anti-obesity has emerged with demand for anti-obesity drugs with less or no side effects.

Since the growth of adipose tissue in excessive amount in obesity results from adipocyte hypertrophy and the synthesis of new adipose tissues from its precursor cells, known as adipogenesis, controlling the adipogenesis is considered as the best method for obesity treatment. Evodiamine improves diet - induced obesity in uncoupling protein-1-independent manner: Involvement of antiadipogenic mechanism & extracellularly regulated kinase/mitogen activated protein kinase signaling. Fucoxanthin extrated from U. pinnatifida and fucoxanthinol species found to inhibit the differentiation of 3T3-L1 pre adipocytes into adipocytes (Hayato *et al.*, 2006).The effectiveness of fucoxanthin and fucoxanhinol on adipocyte regulation is based on inhibitory obesity treatment (Okada *et al.*, 2008). Studies proved that oral intake of fucoxanthin reduced considerably the abdominal adipose tissue with the mice model. In the study, KKAy female mice and normal mice were fed with a high-fat diet (Maeda *et al.*, 2005). In addition, there is no change on normal mice noted, normal mice is given with a normal diet. The results obtained suggest that fucoxanthin especially control adipose tissue in obese mice. The mechanisms of action for the anti-obesity effect of fucoxanthin were mainly measured by protein1 in abdominal white adipose tissue (Woo *et al.*, 2009). In humans, most of the body fat is stored in white adipose tissue, which is the major type of adipose tissue in the human system, which is commonly called "fat" in mammals. As nutrigenomic study proved that fucoxanthin will be an vital and appealing agent for manufacturing anti-obesity drugs.

Nevertheless, further studies to verify the molecular mechanisms also need to be explored to gain a better knowledge of the underlying UCP1 trigger by fucoxanthin. Clinical studies proved that the anti-obesity effect of xanthigen, an anti-obesity supplement with fucoxanthin and pomegranate seeds oil. In the study, it is proved that xanthigen is very effective in weight management, reduce body fat and improve liver function in obese non-diabetic women (Abidov *et al.*, 2010). Natural pigments have the potential to be used in obesity and weight management as they have strong anti-obesity activity. There are many advantages of natural pigments derived from seaweeds to be used as food and in the pharma industry, with comparatively low production costs, low cytotoxicity, safe to use and wider acceptability.

CONCLUSIONS

The marine algae are categorically varied, high-yielding, bioactive, and chemically distinctive leads a great hope for discovering new anticancer drugs. The seaweeds contain polyphenols and sulphated polysaccharides are rich in the clinically effective chemical component. Since algae proved to be the important source of vitamins, minerals, antioxidants and natural colorants, the combination of the whole biomass in food and feed could be used to provide colour, enhance nutritional value and increase texture or resistance to the oxidation process. While a combination of various species of seaweeds or incorporation with other traditional food opens up many possibilities. The farming of algae colonies with plenty of medicinal values needs to be explored and improved by the latest technology.

ACKNOWLEDGEMENT

I am thankful to the Department of Biochemistry, School of Life Sciences (VISTAS) for providing me with an opportunity to publish my research paper.

Funding Support

The authors declare that they have no funding support for this study.

Conflict of Interest

The authors declare that they have no conflict of interest for this study.

REFERENCES

Abidov, M., Ramazanov, Z., Seifulla, R., Grachev, S. 2010. The effects of Xanthigenâ¢in the weight management of obese premenopausal women with non-alcoholic fatty liver disease and normal liver fat. *Diabetes, Obesity and Metabolism*, 12(1):72–81. ISSN: 1462-8902, 1463-1326.

Athukorala, Y., Kim, K.-N., Jeon, Y.-J. 2006. Antiproliferative and antioxidant properties of an enzymatic hydrolysate from brown alga, Ecklonia cava. *Food and Chemical Toxicology*, 44(7):1065–1074. ISSN: 0278-6915.

Babić, B., Đukić, A., Stanić, M. 2014. Managing water pressure for water savings in developing countries. *Water SA*, 40:221–221. ISSN: 0378-4738.

Bhadury, P., Wright, P. 2004. Exploitation of marine algae: biogenic compounds for potential antifouling applications. *Planta*, 219(4):561–578. ISSN: 0032-0935, 1432-2048.

Boopathy, N. S., Kathiresan, K. 2010. Anticancer Drugs from Marine Flora: An Overview. *Journal of Oncology*, 2010:1–18. ISSN: 1687-8450, 1687-8469.

Bouhlal, R., Haslin, C., Chermann, J.-C., Colliec-Jouault, S., Sinquin, C., Simon, G., Cerantola, S., Riadi, H., Bourgougnon, N. 2011. Antiviral Activities of Sulfated Polysaccharides Isolated from Sphaerococcus coronopifolius (Rhodophytha, Gigartinales) and Boergeseniella thuyoides (Rhodophyta, Ceramiales). *Marine Drugs*, 9:1187–1209. ISSN: 1660-3397.

Brodie, J., Lewis, J., Reviers, B. D., F, R., Draisma, S. G. A. 2007. Classification of the Phaeophyceae from past to present and current challenges. pages 267–284, Boca Raton, London & New York. CRC Press.

Cahyana, A. H., Shuto, Y., Kinoshita, Y. 1992. Pyropheophytinaas an Antioxidative Substance from the Marine Alga, Arame (Eisenia bicyclis). *Bioscience, Biotechnology, and Biochemistry*, 56(10):1533–1535. ISSN: 0916-8451, 1347-6947.

Cavalier-Smith, T. 2007. Evolution and relationships of algae: major branches of the tree of life. pages 21–55.

Centeno, P. O. R., Ballantine, D. L. 1998. Effects of culture conditions on production of antibiotically active metabolites by the marine alga Spyridia filamentosa (Ceramiaceae, Rhodophyta). I. Light. *Journal of applied phycology*, 10(5):453–453.

de Felício, R., de Albuquerque, S., Young, M. C. M., Yokoya, N. S., Debonsi, H. M. 2010. Trypanocidal, leishmanicidal and antifungal potential from marine red alga Bostrychia tenella J. Agardh (Rhodomelaceae, Ceramiales). *Journal of Pharmaceutical and Biomedical Analysis*, 52(5):763–769.

Devi, G. K., Manivannan, K., Thirumaran, G., Rajathi, F. A. A., Anantharaman, P. 2011. In vitro antioxidant activities of selected seaweeds from Southeast coast of India. *Asian Pacific Journal of Tropical Medicine*, 4(3):205–211. ISSN: 1995-7645.

Felfoldi, G. 2006. The Healing Powers of Seaweed & Algae - 2006. page 34.

Hayato, M., Masashi, Tokutake, Nobuyuki, Teruo 2006. M Kasuo - Fucoxanthin & its metabolite Fucanthinol, suppress adipocyte differentiation in 3T3-L1 cells. *International journal of Molecular Medicine*, 18:147–152.

James, K. 2011. The therapeutic properties of Edible Algae for the promotion of health and support of disease: A combined western and Eastern perspective. pages 1–18.

Jiménez-Escrig, A., Jiménez-Jiménez, I., Pulido, R., Saura-Calixto, F. 2001. Antioxidant activity of fresh and processed edible seaweeds. *Journal of the Science of Food and Agriculture*, 81(5):530–534. ISSN: 0022-5142.

Kelishadi, R. 2007. Childhood Overweight, Obesity, and the Metabolic Syndrome in Developing Countries. *Epidemiologic Reviews*, 29(1):62–76. ISSN: 0193-936X, 1478-6729.

Kim, S. K., Thomas, N. V., Li, X. 2011. Anticancer Compounds from Marine Macroalgae and Their Application as Medicinal Foods. *Advances in Food and Nutrition Research*, pages 213–224.

Kohen, R., Nyska, A. 2002. Invited Review: Oxidation of Biological Systems: Oxidative Stress Phenomena, Antioxidants, Redox Reactions, and Methods for Their Quantification. *Toxicologic Pathology*, 30(6):620–650. ISSN:0192-6233, 1533-1601.

Kong, C. S., Kim, J. A., Kim, S. K. 2009. Anti-obesity effect of sulfated glucosamine by AMPK signal pathway in 3T3-L1 adipocytes. *Food and chemical*

toxicology, 47(10):2401–2406.

Kopelman, P. G. 2000. Obesity as a medical problem. *Nature*, 404(6778):635–643. ISSN: 0028-0836, 1476-4687.

Kuda, T., Taniguchi, E., Nishizawa, M., Araki, Y. 2002. Fate of Water-Soluble Polysaccharides in Dried Chorda filum a Brown Alga During Water Washing. *Journal of Food Composition and Analysis*, 15(1):3–9. ISSN: 0889-1575.

Lewis, L. A., McCourt, R. M. 2004. Green algae and the origin of land plants. *American Journal of Botany*, 91(10):1535–1556. ISSN: 0002-9122.

Mabeau, S., Fleurence, J. 1993. Seaweed in food products: biochemical and nutritional aspects. *Trends in Food Science & Technology*, 4(4):103–107. ISSN: 0924-2244.

Maeda, H., Hosokawa, M., Sashima, T., Funayama, K., Miyashita, K. 2005. Fucoxanthin from edible seaweed, Undaria pinnatifida, shows antiobesity effect through UCP1 expression in white adipose tissues. *Biochemical and Biophysical Research Communications*, 332(2):392–397. ISSN: 0006-291X.

Mišurcová, L., Kráčmar, S., Klejdus, B., Vacek, J. 2010. Nitrogen content, dietary fiber, and digestibility in algal food products. *Czech Journal of Food Sciences*, 28(No. 1):27–35. ISSN: 1212-1800, 1805-9317.

Munro, M. H., Luibrand, R. T., Blunt, J. W. 1987. The search for antiviral and anticancer compounds from marine organisms. *Bioorganic marine chemistry*, pages 93–176.

Na, H. J., Moon, P. D., Lee, H. J., Kim, H. R., Chae, H. J., Shin, T., Kim, H. M. 2005. Regulatory effect of atopic allergic reaction by Carpopeltis affinis. *Journal of Ethnopharmacology*, 101(1-3):43–48.

Naesens, L., Clercq, E. D. 2001. Recent developments in herpesvirus therapy. *Herpes: the journal of the IHMF*, 8(1):12–16.

Nagai, T., Yukimoto, T. 2003. Preparation and functional properties of beverages made from sea algae. *Food Chemistry*, 81(3):327–332. ISSN: 0308-8146.

Okada, T., Nakai, M., Maeda, H., Hosokawa, M., Sashima, T., Miyashita, K. 2008. Suppressive Effect of Neoxanthin on the Differentiation of 3T3-L1 Adipose Cells. *Journal of Oleo Science*, 57(6):345–351. ISSN: 1345-8957, 1347-3352.

Plaza, M., Cifuentes, A., Ibanez, E. 2008. In the search of new functional food ingredients from algae. *Trends in Food Science & Technology*, 19(1):31–39. ISSN: 0924-2244.

Pulz, O., Gross, W. 2004. Valuable products from biotechnology of microalgae. *Applied Microbiology and Biotechnology*, 65(6):635–648. ISSN: 0175-7598, 1432-0614.

Raja, A., Vipin, C., Aiyappan, A. 2013. Biological importance of marine algae-an overview. *Int. J. Curr. Microbiol. Appl. Sci*, 2:222–227.

Rengasamy, R. R. K., Radjassegarin, A., Perumal, A. 2013. Seagrasses as potential source of medicinal food ingredients: Nutritional analysis and multivariate approach. *Biomedicine & Preventive Nutrition*, 3(4):375–380. ISSN: 2210-5239.

Richardson, J. S. 1993. Free radicals in the genesis of Alzheimer's disease a. *Annals of the New York Academy of Sciences*, 695(1):73–76.

Serkedjieva, J. 2004. Antiviral activity of the red marine algaCeramium rubrum. *Phytotherapy Research*, 18(6):480–483. ISSN: 0951-418X, 1099-1573.

Shi, D., Li, J., Guo, S., Han, L. 2008. Antithrombotic effect of bromophenol, the alga-derived thrombin inhibitor. *Journal of Biotechnology*, 136:S579–S579. ISSN: 0168-1656.

Singh, S., Kate, B. N., Banerjee, U. C. 2005. Bioactive Compounds from Cyanobacteria and Microalgae: An Overview. *Critical Reviews in Biotechnology*, 25(3):73–95. ISSN: 0738-8551, 1549-7801.

Sousa, I., Gouveia, L., Batista, A. P., Raymundo, A., Bandarra, N. M. 2008. Microalgae in novel food products. *Food chemistry research developments*, pages 75–112.

Woo, M. N., Jeon, Y. C. S. M., Shin, M. K., Lee, M. A., Kang, M. S., Choi 2009. Anti-obese property of fucoxanthin - adipose tissue in mice. *Molecular Nutrition and Food Res*, 53:1603–1611.

Yan, X., Chuda, Y., Suzuki, M., Nagata, T. 1999. Fucoxanthin as the Major Antioxidant inHijikia fusiformis, a Common Edible Seaweed. *Bioscience, Biotechnology, and Biochemistry*, 63(3):605–607. ISSN: 0916-8451, 1347-6947.

