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Biochemical composition, alginic acid yield and antioxidant activity of brown seaweeds from Mandapam region, Gulf of Mannar

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ABSTRACT

In this present study, four brown seaweeds viz Sargassum wightii Greville, Padina tetrastromatica Hauck, Chnoospora minima, Hormophysa triquetra (C. Ag.) Kutz, collected from Mandapam region of Gulf of Mannar were analyzed for its bioactive potentials. High protein content was observed in Hormophysa triquetra (15.34±0.01%) and carbohydrate (59.30±0.66%); lipid (0.55±0.002%) were recorded in Padina tetrastromatica. Total phenolic content (20±3.46 mg GAE /g) was found to be high in Sargassum wightii, whereas antioxidant activity (34.66±5.77 mg AAE /g) in Padina tetrastromatica. Flavonoid content (66.3±1.43 mg QE /g), DPPH radical scavenging activity (85.08±1.17%) and alginic acid yield (26.70%) was found to be high in Hormophysa triquetra. The viscosity of sodium alginate was found to be high in 5 hours of extraction period in all the seaweeds.

INTRODUCTION

The marine environment in which seaweed exist possess great taxonomic diversity and synthesise metabolites with varied structure with interesting biological activities for food material and medical applications (Batista *et al.,* 2009). Antioxidant, dietary fibre, essential fatty acids, vitamins and minerals are rich source of bioactive compounds obtained from seaweeds (Draw - Vrillon, 1983; Chandini *et al.,* 2008). Extraction of seaweeds shows strong antioxidant activity (Barrow & Shahidi, 2008; Gamal- Eldeen *et al.,* 2009).The Phaeophyta (brown seaweeds) shows comparatively higher antioxidant activity than green and red algae (Al-Amoudi, 2012). Seaweeds contain different variety of inorganic and organic substances which can be used for human health for examples polyphenols, carotenoids and tocopherols, terpenes, ascorbic acid, alkoloid (Chanda *et al.,* 2010). This addition of compounds have demonstrated antioxidant activity in a variety of *in vitro* studies (Heo *et al.,* 2009).

Free radicals are produced as a part of normal metabolic processes. Reactive oxygen species (ROS) include free radical for example, hydroxyl radical($OH^{\cdot}$), superoxide anion (O_2) and non free radical species such as hydrogen peroxide (H_2O_2), nitric oxide (NO) are various forms of activated oxygen and are destructive to various physiologically important molecules including protein, lipids, cell membrane, DNA and other cellular constituents (Wijeratne *et al.,* 2005). It induces different types of serious human diseases such as atherosclerosis, rheumatoid arthritis muscular dystrophy, cataracts, some neurological disorders and some type of cancer as well as aging (Kovatcheva *et al.,* 2001). Sodium benzoate, sodium nitrite are synthetic antimicrobials and butylated hydroxyanisole, butylated hydroxytoluene, tert-butyl hydroxyquinone are synthetic antioxidant. It is commonly used in food industry for preserving food and its quality but those have been suspected of toxic and exerting carcinogenic effect (Gupta & Abu-Ghannam, 2011).

Alginate forms a major structural polysaccharide of many marine brown algae comprising up to 40% of the dry matter (Haug, 1964). It is a family of linear (1→4)-linked α-L-gulurono β-D-mannuronans of widely varying composition and sequential structure (Painter, 1983). Seaweeds are used as food in many countries like China, Japan and Taiwan. In India, their use as food is very limited (Thinakaran & Sivakumar, 2012). Alginate is widely used in textile printing, paper coating and other relatively low margin industrial applications. The only other derivative of alginic acid that is used in the food industry is propylene glycol

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alginate or PGA (Bixler & Porse, 2010). There is a large potentials for alginate in biotechnological applications. Alginate is widely used in industry because of its ability to retain water, and its gelling, viscosifying and stabilising properties (Haug, 1964). So the aim of the present study is to analyze the bioactive compounds from four algin yielding seaweeds *viz, Sargassum wightii Greville, Padina tetrastromatica Hauck, Chnoospora minima,* and *Hormophysa triquetra* (C.Ag.) Kutz, collected from Mandapam region of Gulf of Mannar.

MATERIALS AND METHODS

Sample collection and preparation

Sargassum wightii Greville, *Padina tetrastromatica* Hauck, *Chnoospora minima,* and *Hormophysa triquetra* (C. Ag.) Kutz, plants were collected from Mandapam region of Gulf of Mannar. The algae were washed with tap water to remove dirt, sand and then the same was shade dried until constant weight is obtained and ground in an electric mixer. The powdered samples were then stored in refrigerator for future use.

Extraction procedure

0.5 g of seaweed powder was extracted with 10 ml of 80% methanol at 35^{o}C in a shaking water bath. After 24 h the samples were cooled down to the room temperature and centrifuged at 4000 rpm for 10 min. The supernatant was recovered for the antioxidant activity (Cai *et al.,* 2004).

Biochemical composition

Protein estimation

The total protein was estimated using the Lowry method (1951). The protein was calculated by using BSA as a standard and expressed in percentage.

Carbohydrate estimation

The total carbohydrate was estimated by following the phenol-sulphuric acid method of Dubois *et al.,* (1956). The carbohydrate content was calculated by referring to a standard D-glucose and the results are expressed in percentage .

Lipid estimation

The extraction of lipid was done by the chloroform-methanol mixture by using Folch *et al*.,(1956) and it is expressed in percentage.

Total phenolic content

The amount of total phenolics in methanol extract was determined with Folin– Ciocalteu reagent according to the method of Singleton and Rossi (1965) with Gallic acid as the standard. Briefly standard stock solution of 10 mg/10 ml of gallic acid was prepared in distilled water. From this, various concentrations ranging from 200-1000 µg/ml were prepared. To this 1 ml Folin and Ciacalteau reagents (1:2 with water) was added and kept at room temperature for 5 min and then 1 ml of 7% sodium carbonate solution was added to the reaction mixture and incubated at room temperature for 90 minutes. The colour developed was read at 750 nm. A 100 µl of methanol extract of sample was mixed with the same reagents. Gallic acid was used as the reference standard and the results are expressed as milligram gallic acid equivalent (mg / g dry weight of seaweed material. All samples were analysed in triplicate.

Total antioxidant activity

Total antioxidant activity of seaweed extracts was determined according to the method of Prieto *et al.,* (1999). Briefly 0.3 ml of sample was mixed with 3 ml of reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). Then reaction mixture was incubated at 95° C for 90 min. Absorbance of all the sample was measured at 695 nm. Total antioxidant activity is expressed as the number of equivalence of ascorbic acid in milligram per gram of extract.

Total flavonoid content

Aluminium chloride colorimetric technique was used for flavonoids estimation (Chang *et al.,* 2002). 0.5 ml of sample, 0.1 ml of 10% aluminium chloride, 0.1 ml of 1 M potassium acetate, 2.8 ml of distilled water were taken and mixed in the given order. It was left at room temperature for 30 minutes after which the absorbance of the reaction mixture was measured at 415 nm. The calibration curve was prepared using Quercetin solution (20-100µg) in methanol.

DPPH radical - scavenging activity

The scavenging effects of samples for DPPH radical were monitored according to the method of Yen and Chen (1995) Briefly, 2.0 ml of aliquot of test sample was added to 2.0 ml of 0.16 mM DPPH methanolic solution . The mixture was vortexes for 1 minutes and then left to stand at room temperature for 30 minutes in the dark, and its absorbance was read at 517 nm .The percentage of scavenge the DPPH radical was calculated using the following equation. Gallic acid was used as positive controls.

DPPH scavenging activity (%) = [(Ac-As) /Ac]×100

where Ac is the absorbance of the control (100µL of ethanol with 100µL of the DPPH solution) and As is the absorbance of the sample.

Extraction of alginic acid

The Suzuki method (1955) was adopted to extract alginic acid. The extraction was monitored for 1hr and 5hr at 80^{o} C. The precipitate obtained was dried under ambient conditions. The crude alginic acid extracted was converted into sodium alginate by adding 5% sodium carbonate solution. The viscosity of 1% alginate samples was determined using Ostwald's viscometer. The values were expressed in mPa.

Table. 1: Yield and viscosity of alginic acid (1 hour & 5 hours) in brown seaweeds.

Sl.No	Name of the brown seaweeds	Extraction time			
		1 hour		5 hour	
		Yield of alginic acid(%)	Viscosity (mPa)	Yield of alginic acid(%)	Viscosity (mPa)
1	*Sargassum wightii*	14.21%	12.82 mPa	21.71%	14.32 mPa
2	*Padina tetrastromatica*	12.40%	12.64 mPa	19.70%	14.14 mPa
3	*Chnoospora minima*	12.70%	11.99 mPa	20.20%	13.49 mPa
4	*Hormophysa triquetra*	19.20%	13.59 mpa	26.70%	15.09 mPa

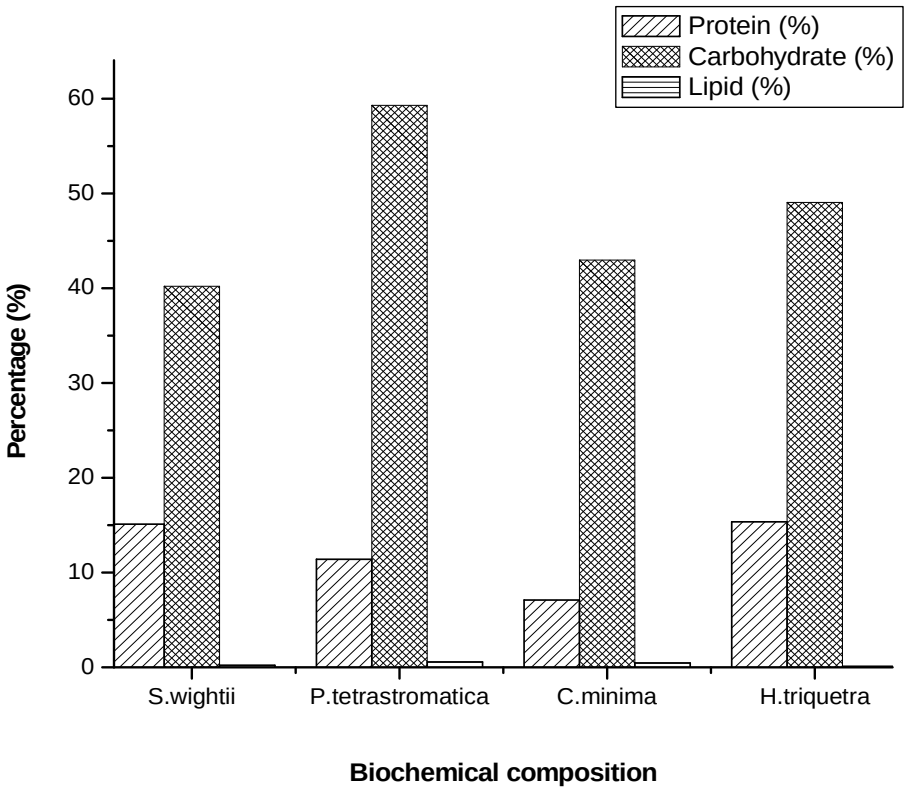

Fig. 1: Biochemical composition of brown seaweeds collected from Mandapam region of Gulf of Mannar**.**

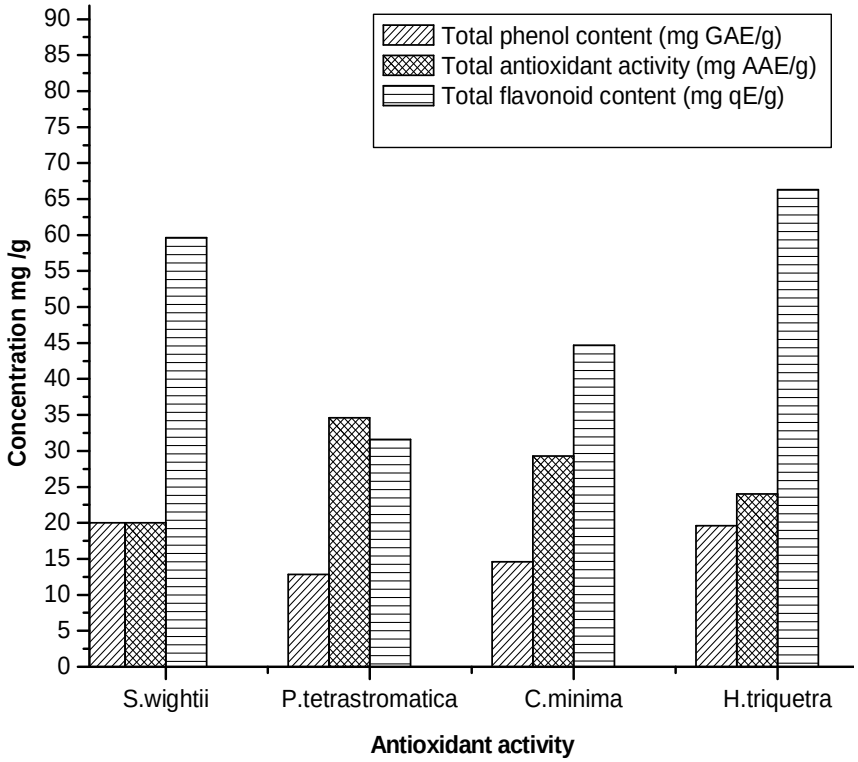

Fig. 2: Antioxidant activity of brown seaweeds collected from Mandapam region of Gulf of Mannar.

RESULTS

Biochemical composition

In the present investigation total protein content varied from 7.11±0.01 to 15.34±0.01%. The high protein content was recorded in *Hormophysa triquetra* (15.34±0.01%) followed by *Sargassum wightii* (15.10±0.08%), *Padina tetrastromatica* (11.39±0.02%), while low protein content was observed in *Chnoospora minima* (7.11±0.01%).

The protein values are significantly different between the four seaweeds ($P < 0.05$). The maximum carbohydrate was recorded in *Padina tetrastromatica* (59.30±0.66%) followed by *Hormophysa triquetra* (49.06±1.02%), *Chnoospora minima* (42.98±1.12%) while minimum carbohydrate content was observed in *Sargassum wightii* (40.21±0.66%).

The carbohydrate values are significantly different between the four seaweeds ($P < 0.05$). The lipid content varied from (0.55±0.002% to 0.11±0.001%). High lipid content was recorded in *Padina tetrastromatica* (0.55±0.002%), followed by *Chnoospora minima*,(0.45±0.002%), *Sargassum wightii*,(0.21±0.001%) , while low lipid content was observed in *Hormophysa triquetra* (0.11±0.001%). The lipid values are significantly different between the four seaweeds ($P < 0.05$). Figure.1

Total phenol content

The maximum phenol content was observed in *Sargassum wightii* (20±3.46 mg /g) followed by *Hormophysa triquetra* (19.6±1.52 mg /g), *Chnoospora minima* (14.66±1.15mg /g), while the minimum phenol content was observed in *Padina tetrastromatica* (12.83±1.04 mg /g). The total phenol content of methanolic extracts are significantly different between the four seaweeds ($P < 0.05$). Figure.2

Total antioxidant activity

The total antioxidant activity of methanol extract of four different brown seaweeds are presented in Fig 2. *Padina tetrastromatica* showed highest total antioxidant activity (34.66±5.77 mg ascorbic acid equivalent/g) followed by *Chnoospora minima* (29.3±9.86 mg /g), *Hormophysa triquetra* (24.0±3.05 mg /g) and *Sargassum wightii* showed lowest antioxidant activity (20.0±2 mg /g). The total antioxidant activity of methanolic extracts are significantly different between the four seaweeds ($P < 0.05$).

Total Flavonoid content

Hormophysa triquetra was found to contain maximum flavonoid (66.3±1.43 mg quercetin equvalent/g) followed by *Sargassum wightii* (59.66±1.52mg /g), *Chnoospora minima* (44.7±1.25mg /g) and minimum content was observed in *Padina tetrastromatica* (31.60±4.04 mg /g). The total flavonoid content of methanolic extracts are significantly different between the four seaweeds ($P < 0.05$). Fig 2

DPPH free radical scavenging activity

The free radical scavenging activity of methanolic extract of seaweeds was studied. The maximum activity was found in *Hormophysa triquetra* (85.08±1.17%), followed by *Sargassum wightii* (69.31±0.70%), *Padina tetrastromatica* (61.04±0.93%) and minimum free radical scavenging activity was observed in *Chnoospora minima* (46.91±1.32%). The DPPH free radical scavenging activity of methanolic extracts are significantly different between the four seaweeds ($P < 0.05$).

Alginic acid yield and viscosity

The total alginate yield obtained from *Sargassum wightii* , *Padina tetrastromatica*, *Chnoospora minima* and *Hormophysa triquetra* are shown in Table .1 .The maximum alginic acid yield was obtained from *Hormophysa triquetra* (26.70%) and lowest yield was obtained from *Padina tetrastromatica* (19.70%). The alginic acid yield are significantly different between the four seaweeds ($P < 0.05$). High viscosity was observed in *Hormophysa triquetra* (15.09 mPa) and minimum was observed in *Chnoospora minima* (13.49 mPa) after 5 hours of extraction period.

DISCUSSION

Studies on the chemical composition of seaweeds have shown that these are good sources of proteins, lipids carbohydrates minerals and trace elements. The protein content in brown seaweeds are generally lower ranging from 5 to 15% of dry weight of seaweed (Burtin, 2003; Chakraborty & Santra, 2008; Manivannan *et al.,* 2008, 2009; Rohani-Ghadikolaei *et al.,* 2011).In the present study all the four species of brown algae showed more or less similar values for protein. It has been observed that the protein content of seaweed is dependent on season and environmental growth conditions (Dawczynski *et al.,* 2007). Besides the low protein content, it has been shown that these seaweeds are rich in essential amino acids (Joel Fleurence, 1999).

Carbohydrate is one of the important components for metabolism and it supplies the energy needed for respiration and other most important processes. The typical carbohydrates in brown seaweeds are fucoidan, laminaran, cellulose and alginates (Dawczynski *et al.,* 2007). According to the study done by Marinho-Soriano *et al* (2006) the synthesis of carbohydrates seemed to be favoured by both, intensity of light and temperature while decreasing the proteins and lipids content. Similarly in the present study also the carbohydrate content was high when compared to other species (Chennubhotia *et al.,* 1987; Rameshkumar *et al.,* 2012; Murugaiyan & Narasimman, 2012; Anantharaman *et al.,* 2013; Goecke *et al.,* 2012).

Although macroalgae have been reported to have low lipid contents (Mabeau & Fleurence, 1993), their polyunsaturated fatty acid (PUFA) composition is superior to those of terrestrial vegetables in regard to the human diet (Kumari *et al.,* 2010). The lipid content of seaweeds reported from Mandapam region varied from 3.15% to 5.30% (Anantharaman *et al.,* 2013).The levels of

lipids detected in the present study were lower than previously reported for other brown seaweed species (Seenivasan *et al.,* 2012). Different types of antioxidants in brown seaweeds have been reported (Chandini *et al.,* 2008; Yan *et al.,* 1996; Yan *et al.,* 1999; Ngo *et al.,* 2011; Gupta and Abu-Ghannam, 2011). Phenolics play a primary role as structural components of cell walls and may have secondary roles in signalling, defence (Amsler & Fairhead, 2006)or in responses to environmental stress. In the present study the total flavonoid content and total antioxidant activity and DPPH assay of methanolic extract of *S.wightii* was found higher than earlier reported by Meenakshi *et al*.,(2009). The DPPH radical scavenging activity of *Hormophysa* extract showed significantly higher activity followed by *Sargassum wightii* (69.31%) P. *tetrastomatica* (61.04%) and *Choonospora* (46.91%) than earlier reports (Chandini *et al.,* 2008; Ganesan, Kumar, & Bhaskar, 2008). The present results indicates that all the four species could be an important source of antioxidant molecules.

The alginates are widely utilized as gelling agents in pharmaceutical and food applications. The role of alginate in human health has broadened with the recognition that they have a number of potentially beneficial physiological effects in the gastrointestinal tract. The role of appropriately designed alginate formulations in the management of overweight and obesity was reported recently (Dettmar *et al.,* 2011).Yield and viscosity of the alginates extracted in the present study showed lesser value for same species collected from other regions of Gulf of Mannar (Thomas & Subbaramaiah, 1991; Umamaheswara Rao, 1969). But it was more less similar to other species reported from the same region (Kalimuthu *et al.,* 1991).

Viscosity of alginate is important for its biological property. (Torres *et al.,* 2007) investigated the in vivo anti-tumor activity of two alginates with different viscosity extracted from brown seaweed *Sargassum vulgare* C Agardh, against Sarcoma 180cells transplanted in mice. However, only SVLV led to acute tubular necrosis suggesting that the observed anti-tumor activity could be related to alginates immunomodulatory properties. In the present study the seaweeds analyzed showed low viscosity when compared to other seaweeds (Gupta & Abu-Ghannam, 2011; Rengasamy *et al.,* 2003; Jothi saraswathi *et al.,* 2006). Increase in the yield was observed at 5 hours of extraction period whereas only a slight increase in viscosity was observed in the present study. Similar effect of extraction time and temperature on specific viscosity was reported by Torres *et al* (2007). This was probably due to dissolution of high molar mass macromolecules that result in high solution of viscosity.

CONCLUSION

It can be concluded that seaweeds selected in the present study can be utilized as a source of natural antioxidant compounds as their crude extracts exhibits good antioxidant activity. Bioactive compounds found in seaweeds await a major breakthrough for a variety of food/medical applications (alginate/phenolics) as they have the potential for application as natural antioxidants in different food/ pharmaceuticals products.

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REFERENCE

Al-Amoudi OA., Mutawie HH., Patel AV., Blunden G. Chemical composition and antioxidant activities of Jeddah corniche algae. Saudi Journal of Biological Sciences. 2009; 16: 23–29.

Amsler CD., Fairhead VA. Defensive and sensory chemical ecology of brown algae. Adv. Bot Res. 2006; 43:1–91.

Anantharaman P., Parthiban C., Saranya C., Girija K., Hemalatha A., Suresh M. Biochemical composition of some selected seaweeds from Tuticorin coast. Advances in Appl. Sci. Res. 2013; 4(3):362-366.

Barrow C., Shahidi F. 2008. Marine nutraceuticals and functional foods, New York, CRC Press.

Batista Gonzalez AE., Charles MB., Mancini-Filho J., Vidal Novoa A. Seaweeds as sources of antioxidant phytomedicines. Revista Cubana de Plantas Medicinales. 2009; 14:1–18.

Bixler HJ., Porse H. A decade of change in the seaweed hydrocolloids industry. Journal of Applied Phycology. 2012; 23:321-335.

Burtin P. Nutritional value of seaweeds. Electronic Journal of Environmental. Agricultural and Food Chemistry. 2003; 2: 498-503.

Chanda S., Dave R., Kaneria M., Nagani K. Seaweeds: a novel, untapped source of drugs from sea to combat infectious diseases. Current Research, Technology and Education Topics in Applied Microbial Biotechnology. 2010; 473-480.

Cai YZ., Luo Q., Sun M., Corke H. Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer. Life Sci. 2004; 74:2157-2184.

Chang CC., Yang MH., Ucen HM., Chern JC. Estimation of total flavonoid content in propolis by complementary colorimetric method. Journals of food and drug analysis. 2002; 10:178-182.

Chandini SK., Ganesan P., Bhaskar N. In vitro antioxidant activities of three selected brown seaweeds of India. Food Chem. 2008;107: 707-713.

Chakraborty S., Santra SC. Biochemical composition of eight benthic algae collected from Sunderban. Indian J Mar Sci. 2008; 37:329–332.

Chennubhovla VSK., Najmuedin M., Ramalingam JR., Kaliaperumal N. 1987. Biochemical composition of some marine algae of Mandapam cost (South India). *Symposium on Research and Development in Marine Fisheries*. Mandapam camp.

Darcy-Vrillon B. Nutritional aspect of the developing use of marine macro algae for the human food industry. Int. J. food sci. Nutr. 1993; 44: S23-S35.

Dawezynski C., Schubert R., Jahreis G. Amino acids, fatty acids and dietary fibre in edible seaweed products. Food Chemistry. 2007; 103: 891–899.

Dettmar PW., Strugala V., Craig Richardson J. The key role alginates play in health . Food Hydrocolloids. 2011; 25:263-266.

Dubois M., Giles KA., Hamilton JK., Reborsand PA., Smith F. Calorimetric method for determination of sugars and related substances. Analytical Chemistry.1956; 28:350-356.

Folch J., Lees M., Solane Stanley GH A. simple method for the isolation and purification of total lipids from animal tissues. Journal Biological Chemistry. 1956; 26: 497-509.

Gamal-Eldeen AM., Ahmed EF, Abo-Zeid MA. In vitro cancer chemopreventive properties of polysaccharide extract from the brown alga, *Sargassum latifolium*. Food and Chemical Toxicology. 2009; 47:1378–1384.

Ganesan P., Kumar CS., Bhaskar N. Antioxidant properties of methanol extract and its solvent fractions obtained from selected Indian red seaweeds. Bioresource Technol. 2008; 99: 2717-2723.

Goecke F., Escobar M., Collantes G. Chemical composition of *Padina fernandeziana* (Phaeophyceae, Dictyotales) from Juan Fernandez Archipelago, Chile. Rev Latinoam Biotecnol Amb Algal. 2012; 3(2):95-104.

Gupta S., Abu-Ghannam N. Recent developments in the application of seaweeds or seawedd extracts as a means for enhancing the safety and quality attributes of foods. Innovative Food Science and Emerging Technologies. 2011; 12:600-609.

Haug A (1964). Composition and properties of alginate. Thesis , Norwegian Institute of Technology Trondheim.

Heo SJ., Ko SC., Cha SH., Kang DH., Park HS., Choi YU. Effect of phlorotannins isolated from Ecklonia cava on melanogenesis and their protective effect against photo-oxidative stress induced by UV-B radiation. Toxicology in Vitro. 2009; 23:1123–1130.

Joel Fleurence. Seaweedproteins:biochemical,nutritional aspects and potential uses. Trends in Food Science & Technology. 1999; 10: 25±28.

Jothi saraswathi S., Babu B., Rengasamy R. Seasonal studies on alginate and its composition II: *Turbinaria conoides* (J.Ag.) K¨ utz. (Fucales, Phaeophyceae). J. Appl. Phycol. 2006; 18: 161-166.

Kaladharan p., kaliaperumal M. seaweed industry in India. ICLARM (NAGA).1999; 22:11-14.

Kalimuthu S., Kaliaperumal N., Ramaligam JR. Standing crop, algin and mannitol of some alginophytes of Mandapam coast. J. mar. biol. Ass. India. 1991; 33(1&2) :170-174.

Kovatcheva EG., Koleva II., Ilieva M., Pavlov A., Mincheva M., Konushlieva M .Antioxidant activity of extracts from *Lavandula vera* MM cell culture. Food Chemistry. 2001; 7:1069–1077.

Kumari P., Kumar M., Gupta V., Reddy CRK., Jha B. Tropical marine macroalgae as potential sources of nutritionally important PUFAs. Food Chemistry. 2010; 120: 749–757.

Lowry OH., Rosebrough NJ., Farr AL., Randall RJ. Protein measurement with the phenol regent. Journal of Biological Chemistry.1951; 193: 265-275.

Manivannan K., Thirumaran G., Karthikai Devi G., Hemalatha A., Anantharaman P. Biochemical composition of seaweeds from Mandapam coastal regions along southeast coast of India. American - Eurasian Journal of Botany.2008; 1(2): 32-37.

Manivannan K., Thirumaran G., Karthikai Devi G., Anantharaman P., Balasubramanian T. Proximate Composition of Different Group of Seaweeds from Vedalai Coastal Waters (Gulf of Mannar) Southeast Coast of India. Middle-East journal of Scientific Research. 2009; 4 (2): 72-77.

Marinho-Soriano E., Fonseca PC., Carneiro MAA., Moreira WSC. Seasonal variation in the chemical composition of two tropical seaweeds. Bioresour Technol.2006; 97:2402-2406.

Mabeau S., Fleurence J. Seaweed in food products: bio-chemical and nutritional aspects.Trends in Food Science and Technology.1993; 4: 103±107.

Meenakshi S., Gnanambigai DM., Tamil mozhi S., Arumugam M., Balasubramanian T. Total flavonoid and in-vitro antioxidant activity of two seaweeds of Rameshwaram Coast. Global Journal of Pharmacology. 2009; 3(2):59-62.

Murugaiyan K., Narasimman S., Anatharaman P. Proximate composition of marine macro algae from Seeniappa Dharka, Gulf of Mannar region, Tamil Nadu. International Journal of Research in Marine Sciences. 2012; 1(1): 1-3.

Ngo DH., Wijesekara I., Vo TS., Van Ta Q., Kim SK. Marine food-derived functional ingredients as potential antioxidants in the food industry: An overview Food Research International. 2011; 44: 523–529.

Painter T. 1983. In The Polysaccharides; Aspinall, G, O., Ed.; Academic Press : New York . p.2.

Prieto P., Pineda M., Aguilar MM. Spectrophotometric quantification of antioxidant capacity through the formation of a phoshomolybdenum complex; specific application to the determination of vitamin E. Analytical Biochemistry. 1999; 269: 337-341.

Rohani-Ghadikolaei K., Abdulalianand E., Ng WK. Evaluation of the proximate, fatty acid and mineral composition of representative green, brown and red seaweeds from the Persian Gulf of Iran as potential food and feed resources. J Food Sci Technol 2011DOI 10.1007/s13197-010-0220-0.

Rameshkumar S.,Ramakritinan CM., Eswaran K., Yokeshbabu M. Proximate composition of some selected seaweeds from Palk bay and Gulf of Mannar, Tamil Nadu, India. Asian Journal of Biomedical and Pharmaceutical Sciences.2012; 3(16):1-5.

Rengasamy R., JothiSaraswathi S., Babu B. Seasonal studies on the alginate and its biochemical composition I:*Sargassum polycystum* (Fucales), Phaeophyceae. Phycological Research. 2003; 51(4): 240-243.

Seenivasan R., Rekha M., Indu H., Geetha S. Antibacterial activity and phytochemical analysis of selected seaweeds from Mandapam cost, India. J.of.Appl.Pharm.Sci. 2012; 2(10):159-169.

Singleton VL., Rossi JA. Colorimetry of total phenolics with phosphomolybdic- phosphotungstic acid reagents. American Journal of Enology Viticulture. 1965; 6: 144-158.

Suzuki N. Studies on the manufacture of algin from brown algae. Memoirs of the Faculty of Fisheries. Hokkaido University. 1965; 3: 93-158.

Thinakaran T.,Sivakumar K. Seasonal variation and biochemical studies on cert in seaweeds from Pamban coast, Gulf of Mannar biosphere reserve. International Journal of Research in Biological Sciences. 2012; 2249–9687**.**

Thomas PC., Subbaramaiah K. Seasonal variations in growth, reproduction, alginic acid, mannitol, iodine and ash contents of brown alga *Sargassum wightii*. Ind J Mar Sci .1991; 20:169–175.

Torres MR., Sousa APA., Silva Filho EAT., Melo DF., Feitosa JPA., De Paula RCM., Lima MGS. Extraction and physicochemical characterization of *Sargassum vulgare* alginate from Brazil. Carbohydrate research. 2007; 342: 2067-2074.

Umamaheswara Rao M. 1969. Seasonal variations in growth, alginic acid and mannitol contents of *Sargassum wightii* and *Turbinaria conoides* from the Gulf of Mannar, India. *Proceedings of the Sixth International Seaweed Symposium*; Santiago de Compostela, Spain. pp. 579–84.

Wijeratne SSK., Cuppett SL., Schlegel V. Hydrogen peroxide induced oxidative stress damage and antioxidant enzyme response in Caco-2 human colon cells. J. of. Agri and Food Chem. 2005; 53: 8768–8774.

Yan XJ., Li XC., Zhou CX., Fan X. Prevention of fish oil rancidity by phlorotannins from *Sargassum kjellmanianum*. J. of Appl. Phyco.1996; 8:201–203.

Yan XJ., Chuda Y., Suzuki M., Nagata T. Fucoxanthin as a major antioxidant in *Hijikia fusiformis*, a common edible seaweed. Bioscience, Biotechnology and Biochemistry . 1999; 63:605-607.

Yen GH., Chen HY. Antioxidant activity various tea extract in relation to their antimutagenicity. J. of Agri and Food Chem.1955; 43:27-32.

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