Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 12, pp.63103-63111, December, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

NUTRACEUTICAL AND PHARMACEUTICAL BIOLOGY OF GREEN SEAWEED *ULVA FASCIATA*

[1,*]Ananth, [2]Thangamathi, [1]Wilson, [2]Lavanya and [2]Gnanasoundari

[1]Department of Biotechnology, Bharathidasan University, Thiruchirapalli, 620024, India
[2]Department of Zoology, Kunthavai Naachiyar Government College for Women, (Autonomous), Thanjavur, 613001, India

ARTICLE INFO

Article History:
Received 19th September, 2017
Received in revised form
16th October, 2017
Accepted 24th November, 2017
Published online 31st December, 2017

Key words:
Ulva fasciata,
Nutraceuticals,
Pharmaceuticals,
Functional Food, Chlorophyta.

ABSTRACT

Seaweed are marine macroscopic algae which forms an important component of marine living ecosystem. Being a plant of unique structure and biochemical composition, seaweed could be exploited for its multi-functional properties in the form of food, energy, medicine and cosmetics. The review summarizes a literature review on the nutraceutical and pharmaceutical properties of chlorophyta, *Ulva fasciata*.

Citation: Ananth, Thangamathi, Wilson, Lavanya and Gnanasoundari, 2017. "Nutraceutical and pharmaceutical biology of green *seaweed Ulva fasciata*", *International Journal of Current Research*, 9, (12), 63103-63111.

INTRODUCTION

Seaweeds are referred as the large marine benthic macroalgae that are differentiated from other algae of microscopic size (Smith, 1994). The rocky beaches, mudflats, estuaries, coral reefs and lagoons provide suitable habitats for the growth of seaweeds. Based on the chemical composition, seaweeds are classified into *Rhodophyta* (Red algae), *Phaeophyta* (Brown algae), *Chlorophyta* (Green algae) and *Cyanophyceae* (blue-green algae) (Kolanjinathan *et al.*, 2004). Grown in marine environment, these seaweeds absorb the elements and minerals from the sea and accumulate in thalli (Kaur, 1997). The chemical composition of seaweeds largely depends on the geographical distributions, season, environmental factors such as water, temperature, salinity, light and availability of nutrients and minerals (Messyasz and Rybak, 2010). They contain maximum concentration of carbohydrates, proteins, vitamins, minerals, fat, fibre, ash and moisture content compared to cereals, pulses, fruits and vegetables (Narasimman and Murugaiyan, 2012) and is the only natural resource of agar, carrageenan and alignates. About 7.5 – 8 million tonnes of wet seaweeds are produced every year along the coastal regions worldwide (McHugh, 2003). In India, 271 genera and 1153 species of marine algae are enumerated (Anon, 2005).

Corresponding author: **Ananth,**
Department of Biotechnology, Bharathidasan University, Thiruchirapalli, 620024, India.

The green algae: *Ulva fasciata*

Ulva fasciata, are the predominantly found green algae in coastal regions of Tamilnadu both in inter-tidal and deep water (Selvin and Lipton, 2004). Generally known as sea lettuce they serve as source of food, feed, medicine and in agriculture (Bhosale *et al*., 1994). Though green seaweeds are the least producers of natural compounds compared to brown and red algae, about 300 natural compounds were produced by green seaweeds. Secondary metabolites produced from *Ulva fasciata* exhibits various biological activities such as antibacterial, anti-inflammatory, anti proliferative, anti viral (Shalaby, 2011), antifungal (Mohamed *et al*., 2012), anti neoplastic (Xu *et al*., 2004), anticancer, antiobesity, antidiabetic, antihypertensive, anti hyperlipedemic and antioxidant properties (Wijesekara *et al*., 2011). The chlorophyta contains sulphated polysaccharides in their cell wall known as *Ulvans*. Because of their unusual chemical composition and structure, these green algae possess various biological activities. The sulphated polysaccharides are also of potential interest in food, pharmaceuticals, agricultural applications (Stengel *et al*., 2011; Lahaye and Robic, 2007;

Costa *et al*., 2010), development of novel drugs, as a biomaterial in tissue engineering and regenerative medicine (Mohamed *et al*., 2012).

Biochemical composition and Nutraceutical properties

Seaweeds, consumed as traditional food is known to cure disease and maintain health. China and Indonesia were the two top producers of seaweeds by mariculture which estimated to about US $ 6.7 billion in 2013 (FAO, 2015) and 23.8 million tons of seaweeds (38% of global harvest) were consumed by humans during 2012 (FAO, 2014). The biomass of seaweeds greatly depends on the seasonal variations and chlorophyta had maximum biomass during autumn season (Dadolahi – Sohrab, *et al*., 2012). The presence of non-digestable polysaccharides in their cellwall makes them a good source of dietary fibre (Ruperez and Saura-Calixto, 2001). The bioactive component of seaweeds varies with species, season, locality and environmental factors. Polysaccharides, phenolics, phlorotannins, proteins, peptides, amino acids, terpenes, terpenoids, lipids and halogenated compounds are the main chemical constituents present in seaweeds (Black, 1994; FAO, 2004). The biochemical evaluation of seaweeds from Kanyakumari coast (Jayalakshmi *et al*., 2014) and Karachi coast (Kashif Ahmed *et al*., 2015) revealed that *U.fasciata* contains 14.98±0.9% of protein, 39.86±0.22% of carbohydrates, 0.21±.003% of lipid and 11.06g of protein, 21.27g of carbohydrates and 4.16g of lipid per 100g of dry weight respectively. The dietary fibre content was found to be 11.94g of dry weight. Suprana Roy and Anantharaman (Suparna Roy and Anantharaman, 2017) evaluated the biochemical composition of 33 seaweeds including *U.fasciata* collected from Rameshwaram, southeast coast of India.

Crude fibre, crude fat, crude protein, nitrogen free extracts and minerals such as sodium, potassium, phosphorus, magnesium, Zinc, Iron, Cadmium and lead from extracts of five seaweeds (*Hypnea musciforms, Sargassum oligocystum, Ulva fasciata, Eucheuma denticulatum, Laurencia intermedia*) collected from the Kenya Coast was studied by Muraguri *et al* (Eric *et al*., 2016). *U.fasciata* had high percentage of crude fat, crude protein and nitrogen free extract, potassium, zinc and iron among the tested seaweeds. Sodium, potassium, calcium and magnesium were also reported in *U.fasciata* (Manoj Kumar et al., 2011). Ismail, 2016 estimated the mineral and aminoacid content of *U.fasciata* and reported the presence of Ca, Na, K, Mg, Fe, Mn, Zn, Cu, Pd, Cd and amino acids such as glutamic acid, aspartic acid, alanine and leucine are responsible for the taste and flavour of *U.fasciata*. The study confirms the high content of proteins and low level of carbohydrates and lipids in *U.fasciata*. Similar findings were also reported by Chandraprabha *et al*., (2012) and Kokilam and Vasuki (2014), and Seenivasan *et al.,* (2012).

The lipid composition of *U.fasciata* contains unsaturated fatty acids, which were found to be MUFA – Mono Unsaturated Fatty Acids (17 – 33%), PUFA – Poly Unsaturated Fatty Acids (38.4%), Saturated Polysaccharides accounted for about 50% and long chain fatty acids contributed 82% of total fatty acids. Palmitic, Oleic and linolenic fatty acids were isolated from *U.fasciata* by Gas-liquid chromatography technique (Yaser *et al*., 2014). *U.fasciata* recorded a phospholipid content of 8.18%. Phosphatidyl serine, Phosphatidyl ethanol amine, Phosphatidic acid, Lysophosphatidyl choline, and Phosphatidyl glycerol are the main phospholipid composition (El Baky, 2014).

Antibacterial activity

Algal biomass has been reported to possess antimicrobial activity which mainly depends on the organic solvent used for extraction process. The antimicrobial compound isolated from algal biomass generally disturbs the cell membrane, electron transport system and nucleic acid synthesis of target organisms and coagulates proteins (Gupta *et al*., 2011). (Antimicrobial activity was reported) Guaiane sesquiterpene derivatives (guai-2-en-10a-ol and guai-2-en-10a-methanol), polyunsaturated fatty acids (stearidonic acid and α-linolenic acid), ulvanobiuronic acid 3-sulfate, bromophenolic and sphingosine-type compound were isolated from *U. fasciata* (Chakraborty *et al*., 2010; Paulert *et al*., 2009). It is reported that, *U. fasciata* extracts possess antibacterial and antiviral influences on *Micrococcus luteus, B. cereus, B. subtilis, E. coli, A. hydrophila , P. aeruginosa, V. fischeri, V. harveyi, Chlorella vulgaris, C. sorokiniana, and Scenedesmus subspicatus* and Human Metapneumo Virus (Selvin and Lipton, 2004; Mendes *et al*., 2010) . In this regard, labda- 14-ene 3 α, 8α -diol and labda -14ene-8α- hydroxy-3-one compounds isolated from *U. fasciata* showed inhibitory influences on the growth of *V. parahaemolyticus and V. alginolyticus*. Also, (E)-11- oxo-octadeca-12-enoic acid, (E) 11- hydroxy octadeca 12-enoic acids and 6-hydroxy-oct-7-enoic acid are novel fatty acids derived from *U. fasciata* which exposes antimicrobial activities (Chakraborty *et al*., 2010).

U. fasciata ethanolic, methanolic and acetone extracts inhibits both gram positive and gram negative bacteria (Seenivasan *et al*., 2010). Chellaram *et al* (2015), screened the antibacterial activity of acetone, petroleum ether and methanol extracts of *U.fasciata* against 10 human pathogenic bacteria. The acetone extract of *U.fasciata* showed marked antibacterial activity compared to methanol and petroleum ether extract. Osman *et al* (2013) reported that *Klebseilla pneumonia, Staphylococcus aureus* and *Bacillus substilis* were highly susceptible to acetone extract of *U.fasciata*. *E.coli, S.aureus, streptococci*, *Klebsiella aerogens, Aspergillus niger and candida albicans* were strongly inhibited by *U.fasciata* (Abirami and Kowsalya, 2011). Chandrasekaran *et al* (2016) reported that ethyl acetate extract of *U.fasciata* was most effective against *B.subtilis* compared to hexane, acetone, chloroform and methanol extracts. Toluene and ethanol extracts of *U.fasciata* was effective in inhibiting *Klebsiella pneumonia* and in particular these extracts shows strong inhibitory action against gram negative bacteria (Elnahas *et al*., 2017). Sivakumar *et al* (2014) proved that the *U.fasciata* extract reduces the phospholipase, proteolytic, lipolysis and thermonuclease activity of *Vibrio harveyi*. *Staphyloccoccus aureus* and *Pseudomonas aeruginosa,* the multi-drug resistant pathogens were inhibited by the methanolic extract of *U.fasciata* (Pramitha and Lipton, 2014).

The antimicrobial activity of algal sulfolipids was investigated by El Baz *et al* (2013). The sulfolipids showed high growth inhibition to *B.subtilis* and *E.coli* at concentration of 100µg/well. The *U.fasciata* sulfolipids recorded the growth inhibition of 16mm for *Bacillus subtilis* and 13mm against *E.coli*. Abdel – Khaliq *et al* (2014) examined the effectiveness of crude extract of *U.fasciata* against gram negative bacteria and gram positive bacteria and reported that *Salmonella typhimurium Serratia marcescens, E.coli, Neisseria meningitides, Haemophilus influenza, Klebsiella pneumonia, Staphylococccus aureus, Staphylococccus saprophyticus*

Bacillus subtilis, Streptococcus mutans, Streptococcus pyogens, Bacillus cereus and Staphylococcus epidermidis were effectively inhibited.

Parameswaran Kailas and Sukumuran Nair (2015) reported the antioxidant and antimicrobial activity of seaweeds including *U.fasciata* collected from the southwest coast of Tamilnadu. Gram negative bacterial strains, *E.coli* and *Salmonella abony* and gram positive bacterial strains, *Staphylococcus* and positive *Cocci* were highly inhibited by the seaweed extracts. The bioactive potential of methanolic extract of *U.fasciata* against *Vibrio parahaemolyticus*, *E.coli, S.aureus, P.aeruginosa, Salmonella enteric* and antibiotic resistant *Vibrios* was evaluated by Silva *et al* (2013) and was found effective against *V. Navarrensis*.

cause of morbidity and mortality (Gupta *et al*., 2012; Low and Rotstein, 2011). The treatment options for invasive fungal infections are limited since there are relatively few chemical classes and targets represented by existing antifungal drugs. Innate resistance in some fungal pathogens against the triazoles, viz., Fluconazole and Itraconazole is a concern in their use. Candidiasis is the most frequent infection by opportunistic fungi, where the species commonly associated with infections are *Candida albicans, Candida tropicalis, Candida parapsilosis, Candida glabrata and Candida krusei* (Cox *et al*., 2010). *U.fasciata* extracts (Ali *et al*., 2000, Anonymous, 2000) and natural products (Ali *et al*., 2000) isolated from this macroalgae are reported for their strong antifungal activity. *U.fasciata* showed strong antifungal activity against *Fusarium solani* (a plant pathogen), *Candida*

Table 1: Antibacterial and Antifungal properties of *Ulva fasciata* solvent extracts

Sl.No	Solvent Extract	Biological activity	Test Organism	Reference
1	Ethanol Methanol Acetone	Antibacterial	*Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumonia, Staphylococcus aureus*	Seenivasan *et al*., 2010
2	Acetone Petroleum ether Methanol	Antibacterial	*Escherichia coli, Shigella sonnei, Bacillus typhimurium, Staphylococcus aureus, Vibrio cholera, Enterobacter faecalis, Klebsiella pneumoniae, Strptococcus pyogenes, Micrococcus luteus*	Chellaram *et al*., 2015
3	Acetone	Antibacterial	*Klebsiella pneumonia, Staphylococcus aureus, Bacillus subtilis*	Osman et al., 2013
4	Methanol	Antibacterial Antifungal	*Escherichia coli, Staphylococcus aureus, Streptococci, Klebsiella aerogene, Proteus vulgaris,* *Aspergillus niger, Candida albicans*	Abirami, 2011
5	Ethyl acetate Hexane Acetone Chloroform Methanol	Antifungal Antibacterial	*Candida albicans, C. krusei, C. guilliermondi, C. parapsilosis, C. tropicalis, C. glabarata, Trichophyton rubrum, T. mentagrophytes, Microsporum gypseum and Epidermophyton flocossum.* *B. subtilis, S. pyogenes, E. coli, K. pneumoniae, P. aeruginosa, S. typhimurium, V. cholerae, Shigella flexneri, Proteus mirabilis and P. vulgaris*	Chandrasekaran *et al*., 2016
6	Toluene Ethanol	Antibacterial	*Staphylococcus aureus, Staphylococcus epidermidis and Pseudomonas aeruginosa, Klebsiella pneumoniae, Proteus mirabilis and Escherichia. coli, Acinetobacter sp. and Enterobacter sp.*	Elnahas *et al*., 2017
7	Crude extract	Antibacterial	*Vibrio harveyi*	Sivakumar *et al*., 2014
8	Methanol	Antibacterial	*Staphylococcus aureus, Pseudomonas aeruginosa, V.alginolyticus, A.hydrophila, B.subtilis*	Pramitha *et al*., 2014
9	Total Lipid	Antibacterial Antifungal Antiviral	*Bacillus subtilis, Escherichia coli,* *Aspergillus niger, Candida albicans* *Herps simplex virus type- 1 (HSV-1)*	El-Baz *et al*., 2013
10	Crude	Antibacterial Antifungal	*Salmonella typhimurium Serratia marcescens, E.coli, Neisseria meningitides, Haemophilus influenza, Klebsiella pneumonia, Staphylococccus aureus, Staphylococccus saprophyticus Bacillus subtilis, Streptococcus mutans, Streptococcus pyogens, Bacillus cereus and Staphylococcus epidermidis* *Fusarium solani, Candida albicans, Microsporum canis, Geotricum candidum, Candida albicans, Aspergillus clavatus, Aspergillus fumigates, Rhizopus oryzae, Mucor circinelloides and Pencillium marneffei*	Abdel-Khaliq, 2014
11	Aqueous	Antibacterial	*E.coli, Salmonella abony* , *Staphylococcus* and positive *Cocci*	Kailas *et al*., 2015
12	Methanol	Antibacterial	*Vibrio parahaemolyticus*, *E.coli, S.aureus, P.aeruginosa, Salmonella enteric*	Silva *et al*., 2013
13	Aqueous	Antibacterial	*E.coli* and *Salmonella abony* , *Staphylococcus* and positive *Cocci*	Kailas *et al*., 2015
14	Methanol	Antibacterial	*Vibrio parahaemolyticus*, *E.coli, S.aureus, P.aeruginosa, Salmonella enteric*	Silva *et al*., 2013
15	Ethyl acetate	Antifungal	*Fusarium solani, Fusarium oxysporum, Tricoderma hamatum, Aspergillus flavipes* and *candida albicans*.	Shobier *et al*., 2016
16	Methanol	Antifungal	*Aspergillus niger, Aspergillus flavus, Candida utilis, Fusarium solani, Pencillium sp.*	Ali, 2013
17	Methanol	Antifungal	*Nomuraea rileyi*	Kumari *et al*., 2017

Fungicidal activity

Fungi cause illnesses (mycoses) ranging from chronic to serious. The incidence of fungal infections has drastically increased over the past three decades and has become a major

albicans (a human pathogen) and *Microsporum canis* (an animal pathogen). The crude extract of *U.fasciata* produced high zone of inhibition against many pathogenic fungi such as *Geotricum candidum, Candida albicans, Aspergillus clavatus,*

Aspergillus fumigates, Rhizopus oryzae, Mucor circinelloides and Pencillium marneffei (Abdel – Khaliq *et al*., 2014).

Ethyl acetate and methanolic extracts of *U.fasciata* was effective against *Fusarium solani, Fusarium oxysporum, Tricoderma hamatum, Aspergillus flavipes* and *candida albicans*. Though the methanolic extract of *U.fasciata* was effective against all fungal pathogens, *A.flavipes* and *C.albicans* recorded a high MIC of 128µg/ml compared to 18µg for other pathogens. The antifungal property of methanolic extract was reported to the presence of palmitic acid, methylester, trichloromethyloxirane, linolenic acid, ethylster, 3, 7, 11, 15 tetramethyl-2- hexadecane-1-01, 11-Octadecenoic acid, methyl ester and 12, 15, Octadecadienoic acid (Shobier *et al*., 2016). Similarly the methanolic extract of *U.fasciata* inhibited *Aspergillus niger, Aspergillus flavus, Candida utilis, Fusarium solani, Pencillium sp.* (Ali, 2013). The antifungal activity of three seaweeds, *Caulerpa serrulata, Gracilaria edulis* and *U.fasciata* against silkworm fungal pathogen, *Nomuraea rileyi* was evaluated by Suguna kumara *et al*, (Kumari *et al*., 2017). The methanolic extract of both *G.edulis* and *U.fasciata* were effective against fungal pathogen producing 16mm zone of inhibition at 3mg/ml.

Antiviral activity

Natural products have been the source of most of the active ingredients of medicines (Clardy *et al*., 2006). Several screening studies have been carried out over few decades with the aim to discover new antibiotic or cytotoxic metabolites from green algae (Alejandro *et al*., 2004, 2007). A novel sphingosine derivative from *Ulva fasciata* has been found to have antiviral activity *in vivo* (63). Sulphated polysaccharide extracts collected by maceration and decoction from Green algae *Ulva fasciata* possessed 100% inhibitory activity against Human Meta Pneumo Virus (HMPV). Mendes *et al* (39) evaluated the antiviral activity of *U.fasciata* on the replication of Human Meta Pneumo Virus (HMPV). Similarly a previous work of Garg *et al* (1993), also reports the antiviral activity of *U.fasciata* and isolation of antiviral compound UF-131. Baky *et al* (2014) reported the antiviral, anticancer and antimicrobial activities of five marine macro algae, *Laurencia popillose, Galaxoura cylindrical, Ulva fasciata, Dilophs fasciola* and *Taonia atomaria*. Phospholipids are found to possess antiviral property, inhibiting simplex virus and antimicrobial property inhibiting bacteria, fungus and yeast. The study reported that the phospholipid fractions of *U.fasciata* in particular was highly effective against simplex virus, *E.coli* and *B.subtilis* but had no inhibitory effect on Fungus (*A.niger and C.albicans*). Antiviral activity of *U.fasciata* against Herpes Simplex Virus (HSV) was also evaluated by Soares *et al* (2012)**.** The highest activity (99.9%) of *U.fasciata* against HSV-1 may be due to the presence of triacyl glycerols and fatty acids. *Ulva fasciata* crude extracts [IC50 = 50 µg/ml] have been documented to exhibit strong activity against the promastigote form of *L. major in vitro* (Sabina *et al*., 2005).

Antioxidant activity and Anti cancer activity

The Reactive Oxygen Species (ROS) are an array of metabolites derived from molecular oxygen that causes damage in DNA, protein, lipids, altering biochemical compounds, corroding cell membranes and thereby play an important role in development of various diseases such as cancer, atherosclerosis and respiratory diseases. (Vijayabaskar and Vaseela, 2012). Cancer is one of the major health problems worldwide. The continuing increase in the incidence of cancer is due to changes in dietary patterns (Jemal *et al*., 2010). Preference of western style diets with large amount of animal fat leads to colon cancer (Yoon *et al*., 2007). The compounds from seaweeds are reported to induce apoptosis, inhibition of tumour invasions and hyaluronidase activity and anti-angiogenic activity (Suhaila *et al*., 2012). Shao *et al* (2013) compared the antioxidant activity of *U.fasciata*, *Gloiopeltis furcata and Sargassum henslouianum* and reported that *U.fasciata* showed excellent antioxidant property. The sulphate contents of polysaccharides had a significant role in scavenging the superoxide and hydroxyl radicals. The antioxidant mechanisms of sulphated polysaccharides might be due to strong hydrogen donating ability, a metal chelating ability, and their effectiveness as scavengers of superoxide and free radicals (Ghiselli *et al*., 1998). The chlorophyll pigments *a* and *b* are attributed to the antioxidant property of *U.fasciata* besides phenols and vitamins (Ismail, 2017). Premalatha *et al* (2011) confirmed the high antioxidant activity of *U.fasciata* to that of *Chaetomorpha antennina*. The dose dependent antioxidant activity of ethanolic extract (Radhika et al., 2013) and methanolic extract (Larangeira et al., 2016) of *U.fasciata* were reported. Vijavel and Martinez (2010) evaluated the antimicrobial and antioxidant potential of ethanolic extract of *U.fasciata* and *Gracilaria salicornia*. Kurup *et al* (2016) compared the DPPH and hydroxyl scavenging activity of *U.fasciata*, *S.swartzii* and *C.antennina*. *U.fasciata* was found to have excellent half maximal inhibitory effect on hydroxyl radical scavenging activity. All the three seaweeds showed DPPH radical, Hydroxy radical and Hydrogen peroxide radical scavenging property in the order *S.swartzi* < *U.fasciata* < *C.antennia*. Ryu *et al* (2013) reported that the *U.fasciata* extract was found to increase ROS level, which in term leads to apoptotic signals against human colon cancer HCT 116 cells. Shao *et al* (2013) reported the anti tumour activity of *U.fasciata* against MKN45 gastric cancer cells and the human intestinal cancer DLD cells. The cytotoxicity of sulphated polysaccharides of *U.fasciata* was confined to the presence of uronic acids. Human breast and liver cancer were inhibited by the phospholipid fractions of *U.fasciata* (El Baky *et al*., 2014). The antitumour and antioxidant potential of three sulphated polysaccharides (UFP_1, UFP_2, and UFP3) extracted from *U.fasciata* by hot water extraction was examined. The polysaccharide (UFP_2) with high sulphate and Uronic acid content showed better antioxidant activity and the partial desulfated polysaccharide ($DSUFP_3$) with low sulphate and high uronic acid exhibited antitumour activity against DLD cancer cells (Ping Shao *et al*., 2014). The water soluble polysaccharides extracts from *U.fasciata* showed antioxidant and antitumour potential and the *invitro* free radical scavenging activity was concentration dependent. (Shonima Govindan *et al*., 2012). The *in vitro* cytotoxic potential of methanolic extract of *U.fasciata* (MEUF) against human colon carcinoma (HT-29), human hepato carcinoma (Hep-G2) and human breast carcinoma (MCF-7) cell lines were evaluated using MTT assay and MEUF exhibited maximum cytotoxicity against Hep-G2 (Das et al., 2014)

Insecticidal and Larvicidal activity

WHO (1996), declared mosquitoes as targeted disease vectors. Human blood sucking mosquitoes belong to genera of *Aedes, Anopheles, Culex, Haemogogus, Mansonia, Sabethes and Psorophora* (Service, 1980). The mosquito control programmes uses synthetic insecticides which are harmful to

non-target organisms and environment. Hence there is a growing interest for the search of novel insecticides from natural sources as an alternative (Paeporn *et al*., 2003). The insecticidal activities of seaweeds have been reported early (Thangam and Kathiresan, 1991). *U.fasciata* exhibited larval mortality in *Meloidogyne javanica* L.after 72 hours of exposure (Rizvi and Shameel, 2012). Insecticidal activity of *U. fasciata* against *Trogoderma granarium* was reported by Valeem *et al* (2011). Nymphicidal and ovividal activity were exhibited by *U.fasciata* against red cotton bug *Dysdercus cingulatus* (Sahayaraj and Kalidas, 2011; Asha *et al*., 2012).

Male and female adult longevity, reduced fecundity, reduced hatchability and reduced body weight were reported by methanolic extract of *U.fasciata* against *D. Cingulatus* (Asha *et al*., 2012). Dichloromethane-Methanol extract of *U.fasciata* showed toxic effect on Brine shrimp, *Artemia salina* (Manilal *et al*., 2009). Similarly, Selvin and Lipton (2004) reported larvicidal activity of Dichloromethane-Methanol extract of *U.fasciata* against second instar larva of *Culex* species. The larvicidal activity of methanol, acetone and benzene extracts of *U.fasciata* was reported against *Anopheles stephensi* (Laali and Li, 2012a) *Culex quinquefasciatus* (Laali and Li, 2012b) and *Aedes aegypti* (Laali Nisha, 2013). Moderate inhibition of *Plasmodium falciparum* and larvicidal activity against *Anopheles stephensi* larvae by hexane and ethyl acetate extract of *U.fasciata* were reported by Sowmiya *et al* (2017). Khan Hira *et al* (2017) evaluated the larvicidal activity of ethanol extract of *U.fasciata* against *Aedes aegypti*. Dimethyl sulphoxide extract of *U.fasciata* showed antiplasmodic activity above 25µg/ml which is moderately low when compared to other seaweeds examined (Ravikumar *et al*., 2011).

Antidiabetic activity

U.fasciata could be used as an alternative for the nutrient and food requirement for controlling diabetes. *Sargassam weightii* and *U.fasciata* reduced diabetics and normalize lipid profile, body and organ weight in streptozotocin induced type 2 diabetic mice (Mohapatra *et al*., 2016). The aqueous extract of *U.fasciata* reduces blood glucose level and restores hepatic glycogen and hexokinase, glucokinase and glucose-6-phosphate (Abirami and Kowsalya, 2013).

Anti inflammatory activity

The anti-inflammatory pharmacology research had gained interest during 2009 – 2011 and several research reports were published on the molecular mechanism of action to target neutrophils and macrophages both *in vivo* and *in vitro* by marine natural products. Nitric oxide (NO) and Prostoglandin (PG) are involved in the pathogenesis of human inflammatory diseases. Ethylacetate extract of *U.fasciata* inhibited the synthesis of NO and PG and decreased the production of proinflammatory cytokines such as TNF – α, IL -1β and IL-6 in lipopolysaccharide stimulated macrophage cell (Kim *et al*., 2013).

Algicidal activity

The algicidal activity of *U.fasciata* was assessed by Mochammad Amin *Alamsjah et al* . The algicidal activity of fresh tissue, dry powder and methanol extracts of *Ulva fasciata* and *Ulva fasciata*. showed effective growth inhibition and lethal effects on *Heterosigma akashiwo*, *Alexandrium catenella* and *Chattonella marina* and moderate activity against *Fibrocapsa japonica* and *Karenia mikimotoi* cells (Mochammad Amin Alamsjah *et al*., 2006). Hexadeca-4,7,10,13-tetraenoic acid (HDTA) C16:4 n-3, C18:4 -linolenic acid (ALA) C18:3 n-3 and linoleic acid (LA) C18:2 n-6 as theαn-3 (ODTA) were the polyunsaturated fatty acids (PUFAs) that are found to be significantly active against several red tide phytoplankton at low concentrations and are promising for the chemical agents for HAB control (Mochammad Amin Alamsjah *et al*., 2009).The green alga *Ulva fasciata* (Ulvaceae, Chlorophyta) showed strongest algicidal activity among the seaweeds collected from the coast of Nagasaki Prefecture, Japan and tested against the red-tide phytoplankton *Heterosigma akashiwo*. Methanol extract of *U. fasciata* led to isolation of three algicidal compounds hexadeca- 4, 7, 10, 13-tetraenoic acid (HDTA), octadeca-6, 9, 12, 15- tetraenoic acid (ODTA), and linolenic acid on the basis of spectroscopic information. These polyunsaturated fatty acids (PUFAs) showed potent algicidal activity against *H. akashiwo* (Mochammad Amin Alamsjah *et al*., 2005). Linolenic acid and linoleic acid isolated from *Ulva fasciata* showed toxic effects on red tide phytoplankters in a concentration-dependent manner. *Raphidophycean flagellate Heterosigma akashiwo* was the most susceptible to these fatty acids, and 50% lethal concentrations (LC50) of linolenic acid and linoleic acid were estimated to be 0.58 and 1.91 g/ml respectively, whereas *dinoflagellate Gymnodinium impudicum* and *Heterocapsa circularisquama* were highly resistant and no significant toxic effects were observed up to 1,000g/ml. Both fatty acids were less toxic to fish (devil stinger), zooplankters (brine shrimp and rotifer), and mammalian cell lines (U937, HeLa, Vero, and CHO cells) than *H. akashiwo* (Mochammad Amin Alamsjah *et al*., 2007).

Conclusion

The present review highlights the pharmacological and neutraceutical properties of the green seaweed, *Ulva fasciata*. Southeast coast of India is a unique marine habitat and *Ulva fasciata* is one among the predominant species (105). The presence of non digestible polysaccharides, *Ulvan* in Chlorophyta makes them unique with different biological properties. Though the antibacterial, antifungal, antioxidant properties of *Ulva fasciata* had been addressed, the larvicidal, insecticidal, anti diabetic, anti inflammatory, anti coagulant, regulation of lipid and carbohydrate metabolism, antiobesity, antihypertensive property of *U.fasciata* has to be explored.

REFERENCES

Dadolahi-Sohrab, A., Garavand-Karimi, M., Riahi, H. and, H 2012. Seasonal variations in biomass and species composition of seaweeds along the northern coasts of Persian Gulf (Bushehr Province) J. Earth Syst. Sci. 121, No. 1, pp. 241–250

Ghiselli, A., Nardini, M., Baldi, A. C. 1998. Scaccini, Journal of Agricultural and Food Chemistry 46 361–367.

Abd El Baky, H. H., El Baz, F. K., El Baroty, G. S., Asker, M. M. S. and Ibrahim, E. A. 2014. Phospholipids of some marine microalgae: Identification, antivirus, anticancer and antimicrobial bioactivities. *Der Pharma Chemica*.

Abdel-Khaliq, A., Hassan, H. M., Rateb, M. E. and Hammouda, O. (n.d.). Antimicrobial Activity of Three Ulva Species Collected from Some Egyptian

Mediterranean Seashores. *International Journal of Engineering Research and General Science*, *2*(5).

Abirami and Kowsalya 2013. Antidiabetic activity of *Ulva fasciata* and its impact on carbohydrate metabolism enzymes in Alloxan induced diabetic rats. Int.J.Res. Phytochem.Parmacol.,3(3),136-141.

Abirami, R. G. and Kowsalya, S. 2011. Phytochemical screening , microbial load and antimicrobial activity of underexploited seaweeds. *International Research Journal of Microbiology*, *3*(October 2012), 328–332.

Alejandro M. S. Mayer and Mark T. Hamann 2004. Marine Pharmacology in 2000: Marine Compounds with Antibacterial, Anticoagulant, Antifungal, Anti-inflammatory, Antimalarial, Antiplatelet, Antituberculosis, and Antiviral Activities; Affecting the Cardiovascular, Immune, and Nervous Systems and Other Miscellaneous Mechanisms of Action. Mar Biotechnol (NY). 2004 Jan-Feb; 6(1): 37–52.

Alejandro M.S.Mayer, Abimael D.Rodríguez, Roberto G.S.Berlinck, Mark T.Hamann 2007. Marine compounds with anthelmintic antibacterial, anticoagulant, antifungal, anti-inflammatory, antimalarial, antiplatelet, antiprotozoal, antituberculosis, and antiviral activities; affecting the cardiovascular, immune and nervous systems, and other miscellaneous mechanisms of action. Volume 145, Issue 4, Pages 553-581

Ali MS, Mazhar F, Saleem M, Jahangir M, Pervez K, Usmanghani K & Ahmad VU 2000a. Chemistry and biology of algae from seacoasts of Karachi. In Ahmad VU (Ed): Proceeding of National ONR Symposium on Arabian Sea as a Resource of Biological Diversity. HEJ Res Chem, Karachi Univ Karachi p 33-44.

Ali, E. H. 2013. Antifungal activities of methanolic extracts of some marine algae (ulvaceae and dictyotaceae) of benghazi coasts , libya, *9*(1), 75–79.

Alves A, Sousa RA, Reis RL 2012. In Vitro Cytotoxicity Assessment of Ulvan a Polysaccharide Extracted from Green Algae. Phytother Res doi: 101002/ ptr4843 [Epub ahead of print].

Anon, 2005. Seaweeds: Wonder Plants of the Sea (ed. Krishnamurthy, V.), Aquaculture Foundation of India, Chennai, p. 30.

Anonymous 2000. The Wealth of India: Raw Materials, Vol. 1, A - Ci (Revised) NISC CSIR New Delhi p 38-41.

Asha A, Martin Rathi J, Patric Raja D, Sahayaraj K. 2012. Biocidal activity of twomarine green algal extracts against third instar nymph of Dysdercus cingulatus (Fab.) (Hemiptera: Pyrrhocoridae). J Biopest 5(Supplementary):129–134

Bhosale, S.H, Japtap, T.G, and Nair, C.G. 1999. Antifungal activity of some marine microorganisms from India, against food spoilage Aspergillus strains, Mycopathologia 147: 133-138

Black WAP 1954. Concentration gradients and their significance in Laminaria saccharina (L.) Lamour. J Mar Biol Assoc UK 33(1):49–60

Chakraborty K, Lipton AP, Paulraj R, Chakraborty RD. Guaiane sesquiterpenes from seaweed *Ulva fasciata* Delile and their antibacterial properties. European journal of medicinal chemistry. 2010; 45: 2237-2244.

Chandraprabha, M., Seenivasan, R., Indu, H. and Geetha, S. 2012. Biochemical and nanotechnological studies in selected seaweeds of chennai coast. Journal of Applied Pharmaceutical Science, 2(11), 100-107

Chellaram C et al. 2015. Medicinal Properties of Gren Seaweeds, *Ulva fasciata* (Delile, 1813) and U. reeticulate (Forsskal, 1777). Int. J. Res. Pharm. Sci., 6(1), 1-6.

Clardy J, FischbachMA,WalshCT(2006)Newantibiotics frombacterial natural products. Nat Biotechnol 24:1541–1550

Costa LS, Fidelis GP, Cordeiro SL, Oliveira RM, Sabry DA, et al. 2010. Biological activities of sulfated polysaccharides from tropical seaweeds. Biomed Pharmacother 64: 21-28.

Cox S, Abu-Ghannam N, Gupta S. 2010. An assessment of the antioxidant and antimicrobial activity of six species of edible Irish seaweeds. *Int Food Res J.*17:205-20.

Das, M. K., Sahu, P. K., Rao, G. S., Mukkanti, K. and Silpavathi, L. 2014. Application of response surface method to evaluate the cytotoxic potency of *Ulva fasciata* Delile, a marine macro alga. *Saudi Journal of Biological Sciences*, *21*(6), 539–546. https://doi.org/10.1016/j.sjbs.2014.02.003

El Baz, F. K., El Baroty, G. S., Abd El Baky, H. H., Abd El-Salam, O. I. and Ibrahim, E. A. (2013). Structural characterization and Biological Activity of Sulfolipids from selected Marine Algae. *Grasas Y Aceites*. https://doi.org/10.3989/gya.050213.

Elnahas, R. A., Salem, R., Dorgham, R., Elmorsy, A., Elwakil, B., Khattab, S. and Olama, Z. 2017. Algal Bioactive Metabolites against MDR Bacteria. *Int.J. Curr.Microbiol.App.Sci*,*6*(9),255– 279. https://doi.org/10.20546/ijcmas.2017.609.034.

Eric N. Muraguri, Joseph G. Wakibia, John N. Kinyuru 2016. Chemical Composition and Functional Properties of Selected Seaweeds from the Kenya Coast. Journal of Food Research; Vol. 5, No. 6

FAO (Food and Agriculture Organization of the United Nations) 2004. The state of world fisheries and aquaculture. Part 3. Highlights of special FAO studies. http://www.fao.org/docrep/007/y5600e/ y5600e00.htm. Accessed 24 Jan 2014

FAO 2014. The state of the world fisheries and aquaculture 2014. FAO, Rome, p 223

FAO 2015. FAO Global Aquaculture Production database updated to 2013 -Summary information. FAO, Rome

Ga, R., Chandrasekaran M, Jegan S, & Venkatesalu V. 2016. Phytochemical Analysis and Antifungal activity of Ulva Species from the Kanniyakumari Gulf of Mannar, South Coast India. *Nat Prod Ind J*, *12*(3).

Garg, H.S., 1993. Bioactive substances in marine algae, marine biotechnology, Plenum press, New York, pp: 1-8.

Gehan Ahmed ISMAIL 2017. Biochemical composition of some Egyptian seaweeds with potent nutritive and antioxidant properties. Food Sci. Technol, Campinas, 37(2): 294-302

Gupta P, Gautam P, Rai N. et al. 2012. An emerging hope to combat Candida albicans: plant based therapeutics. Biotechnol Int. 5:85-114.

Gupta, S., Cox, S., Rajauria, G., Jaiswal, A.K. and Abu-Ghannam, N. 2011. Food and Bioprocess Technology, 1.

Hira, K., Tariq, R. M., Sultana, V., Ara, J. and Ehteshamul-Haque, S. 2017. Effect of seaweeds occurring at Karachi coast on mosquito larvae and liver function in rats. *Pakistan Journal of Pharmaceutical Sciences*, *30*(2), 387–391.

ISMAIL, G. A. 2017. Biochemical composition of some Egyptian seaweeds with potent nutritive and antioxidant properties. *Food Science and Technology (Campinas)*. https://doi.org/10.1590/1678-457x.20316.

Jayalakshmi, J. Vasuki Subramanian and P. Anantharaman 2014. Evaluation of biochemical composition and in vitro antioxidant properties of selected seaweeds from Kanyakumari coast, Tamil Nadu, India. Advances in Applied Science Research, 2014, 5(4):74-81

Jemal A., Siegel R., Xu J., Ward E. 2010. Cancer statistics. **CA** *Cancer J. Clin.* 60: 277–300.

Kailas, A. P. and M, N. S. 2015. Comparison of nutrient compositions and calorific values of eight tropical seaweeds. *Phykos*, *45*(1), 62–74.

Kashif Ahmed, Seharish Munawar, Talat Mahmood And Iffat Mahmood 2015 Biochemical Analysis of Some Species of seaweeds from Karachi coastal area. FUUAST J. BIOL., 5(1): 43-45

Kaur, I. 1997. Potentials and future prospects. In: Vijayaraghavan MR, Kaur I, eds., Brown Algae. New Delhi, India, APH Publishing, pp. 277–294.

Kim, M.-J., Yang, K.W., Lee, W. J., Kim, S. S., Lee, N. H. and Hyun, C.-G. 2013. Inhibitory Effect of *Ulva fasciata* and Desmarestia viridis on the Production of Nitric Oxide, Prostaglandin E 2 , and Pro-inflammatory Cytokines in RAW 264.7 Cells ARTICLE INFO ABSTRACT. *Journal of Applied Pharmaceutical Science*, *3*(9), 1–7. https://doi.org/10.7324/JAPS.2013.3901

Kokilam, G. and Vasuki, S. 2014. Biochemical and phytochemical analysis on *Ulva fasciata* and Caulerpa taxifolia.International Journal of Pharmacy and Pharmaceutical Science Research, 4(1), 7-11.

Kolanjinathan K., Ganesh P. and Saranraj P. 2014. Pharmacological Importance of Seaweeds: A Review, World Journal of Fish and Marine Sciences, 6(1): 01-15

Kumari, S. S., Kumar, V. D. and Priyanka, B. 2017. Antifungal Efficacy of Seaweed Extracts Against Fungal Pathogen of Silkworm, Bombyx mori L. *International Journal of Agricultural Research*, *12*(3), 123–129. https://doi.org/10.3923/ijar.2017.123.129.

Kurup, M. and Jose, M. 2016. In Vitro Antioxidant Properties of Edible Marine Algae Sargassum swartzii, *Ulva fasciata* and Chaetomorpha antennina of Kerala Coast. *J Pharma Reports*, *1*(1).

Laali Nisha, J. L. 2013. www.currentsciencejournal.info Effect of two seaweeds *Ulva fasciata* and Grateloupia lithophila as larvicide against mosquito vector Aedes aegypti. *INT J CURR SCI*, *6*, 29–34.

Lahaye M, Robic A 2007. Structure and Functional Properties of Ulvan a Polysaccharide from Green Seaweeds. Biomacromolecules 8: 1765-1774.

Larangeira De Lima, R., Maria, K., Pires-Cavalcante, S., Barroso De Alencar, D., Arnaldo Viana, F., Sampaio, A. H. and Saker-Sampaio, S. (n.d.). In vitro evaluation of antioxidant activity of methanolic extracts obtained from seaweeds endemic to the coast of Ceará, Brazil. *Acta Scientiarum. Technology Maringá*, *38*(2), 247–255. https://doi.org/10.4025/actascitechnol.v28i2.27275.

Low CY, Rotstein C. 2011. Emerging fungal infections in immunocompromised patients. F1000 Med Rep. 3:14.

M. J. Ryu, A. D. Kim, K. A. Kang, 2013. "The green algae *Ulva fasciata*Delile extract induces apoptotic cell death in human colon cancer cells," In Vitro Cellular and Developmental Biology—Animal, vol.49, no.1, pp. 74–81.

Manilal, A., Sujith S, KiranGS, Selvin J, Shakir C, GandhimathiR, Panikkar MVN 2009. Biopotentials of seaweeds collected from southwest coast of India. J Mar Sci Technol 17(1):67–73.

Manoj Kumar, Puja Kumari, Nitin Trivedi, Mahendra K. Shukla, Vishal Gupta, C. R. K. Reddy 2011. Minerals, PUFAs and antioxidant properties of some tropical seaweeds from Saurashtra coast of India. Volume 23, Issue 5, pp 797–810

McHugh, D. J. 2003. A guide to the seaweed industry. FAO Fisheries Technical Paper, 441, p. 105.

Mendes GDS, Soares AR, Martins FO, Albuquerque MCMD, Costa SS, Yoneshigue-Valentin Y, Romanos MTV. 2010. Antiviral activity of the green marine alga *Ulva fasciata* on the replication of human metapneumovirus. Revista do Instituto de Medicina Tropical de São Paulo. 52: 03-10.

Messyasz B, Rybak A 2010. Abiotic factors affecting the development of Ulva sp. (Ulvophyceae, Chlorophyta) in freshwater ecosystems. *Aquat Ecol* 45: 75- 87.

Mochammad Amin Alamsjah , Shotaro Hirao , Fumito Ishibashi, Tatsuya Oda & Yuji Fujita 2009. Algicidal activity of polyunsaturated fatty acids derived from *Ulva fasciata* and U. pertusa (Ulvaceae, Chlorophyta) on phytoplankton. Journal of Applied Phycology, 20(5), pp.713-720.

Mochammad Amin Alamsjah, Keiko Ishibe, Daekyung Kim, Kenichi Yamaguchi, Fumito Ishibashi, Yuji Fujita and Tatsuya Oda 2007. Selective Toxic Effects of Polyunsaturated Fatty Acids Derived from *Ulva fasciata* on Red Tide Phyotoplankter Species. Biosci. Biotechnol. Biochem., 71 (1), 265–268.

Mochammad Amin Alamsjah, Fumito Ishibashi, Hitoshi Kitamura and Yuji Fujita The Effectiveness of *Ulva fasciata* and U. pertusa (Ulvales, Chiorophyta) as Algicidal Substances on Harmful Algal Bloom Species. Aquaculture Science 54(3), 325 - 334 (2006)

Mochammad Amin ALAMSJAH, Shotaro HIRAO, Fumito Ishibashi and Yuji Fujita 2005. Isolation and Structure Determination of Algicidal Compounds from *Ulva fasciata*. Biosci. Biotechnol. Biochem., 69 (11), 2186–2192.

Mohamed S, Hashim SN, Rahman AH 2012. Seaweeds: A sustainable functional food for complementary and alternative therapy. Trends Food Sci Tech 23: 83-96. 28.

Mohapatra, L., Bhattamishra, S. K., Panigrahy, R., Parida, S. and Pati, P. 2016. Antidiabetic Effect of Sargassum wightii and *Ulva fasciata* in High fat diet and Multi Low Dose Streptozotocin Induced Type 2 Diabetic Mice. *UK Journal of Pharmaceutical and Biosciences*, *4*(2), 13–23.

Narasimman S, Murugaiyan K 2012. Proximate composition of certain selected marine macro-algae from Mandapam coastal region (Gulf of Mannar), southeast coast of Tamil Nadu. Int J Pharm Biol Arch 3: 918–921

Osman, M. E. H., Aboshady, A. M. and Elshobary, M. E. 2013. African Journal of Biotechnology Production and characterization of antimicrobial active substance from some macroalgae collected from Abu - Qir bay (Alexandria) Egypt, *12*(49), 6847–6858. https://doi.org/ 10.5897/AJB10.2150.

Paeporn P, Komalamisra N, Deesin V, Rongsriyam Y, Eshita Y, Thongrungkiat S. 2003. Temephos resistance in two forms of Aedes aegypti and its significance for the resistance mechanism. Southeast Asian J TropMed Public Health 34(4):786–792

Paulert R, Talamini V, Cassolato JEF, Duarte MER, Noseda MD, Smania JA, Stadnik MJ. 2009. Effects of sulfated polysaccharide and alcoholic extracts from green seaweed *Ulva fasciata* on anthracnose severity and growth of

common bean (Phaseolus vulgaris L.). *Journal of Plant Diseases and Protection*. 6: 263-270.

Ping Shao, Yaping Pei, Zhongxian Fang and Peilong Sun 2014. Effects of partial desulfation on antioxidant and inhibition of DLD cancer cell of Ulva fasciata polysaccharide. International Journal of Biological Macromolecules. Volume 65, April 2014, Pages 307-313.

Pramitha, V. S. and Lipton, A. P. 2014. Antimicrobial effect of *Ulva fasciata* Delile, 1813 solvent extracts against multidrug resistant human pathogenic bacteria and fish pathogens. *Indian Journal of Geo-Marine Science*, *43*(12), 2244–2253.

Premalatha M, Dhasarathan P and Theriappan P. 2011. Phytochemical Characterization And Antimicrobial Efficiency Of Seaweed Samples, *Ulva fasciata* And Chaetomorpha antennina. *International Journal of Pharma And Bio Sciences.* Vol 2, Issue 1 B288-293.

Radhika, D., Veerabahu, C. and Priya, R. 2013. Invitro studies on antioxidant and haemagglutination activity of some selected seaweeds. *International Journal of Pharmacy and Pharmaceutical Sciences*.

Rizvi MA & Shameel M 2010. Econo-Medicinal Seaweeds of Pakistan. VDM Verlag Dr. Müller Saarbrücken Germany 336 pp.

Rizvi, M. A., Valeem, E. E. and Shameel, M. 2011. Bioactivity , Elementology and Fatty Acid Composition of Jolyna Laminarioides Guimarâes From a Rocky Ledge of Karachi , Pakistan, *7*(2), 153–162.

Rupérez, P. and Saura-Calixto, F. 2001. Dietary and physicochemical properties of edible Spanish seaweeds. *European Food Research and Technolog,* vol. 212, p. 349-354.

S Ravikumar , G Ramanathan , M Gnanadesigan , A Ramu, V. Vijayakumar 2011. In vitro antiplasmodial activity of methanolic extracts from seaweeds of South West Coast of India Asian Pacific Journal of Tropical Medicine 862-865

Sabina, H., Tasneem, S., Sambreen Kausar, Y., Choudhary, M.I., Aliya, R. 2005. Antileishmanial activity in the crude extract of various seaweed from the coast of Karachi, Pakistan. Pak. J. Bot. 37, 163-168.

Sahayaraj K, Kalidas S. 2011. Evaluation of nymphicidal and ovicidal effect of a seaweed, Padina pavonica (Linn.) (Phaeophyceae) on cotton pest, Dysdercus cingulatus (Fab.). Indian J Mar Sci 40(1): 125–129

Sathianeson Satheesh & Samuvel Godwin Wesley 2012. Diversity and distribution of seaweeds in Kudankulam coastal waters, South-Eastern coast of India.

Seenivasan, R., Indu, H., Archana, G. and Geetha, S. 2010. The Antibacterial Activity of Some Marine Algae from South East Coast of India. *& Environ. Sci*, *9*(5), 480–489.

Seenivasan, R., Rekha, M., Indu, H. and Geetha, S. 2012. Antibacterial activity and phytochemical analysis of selected seaweeds from Mandapam Coast, India. Journal of Applied Pharmaceutical Science., 2(10), 159-169.

Selvin J, Lipton AP 2004. Biopotentials of *Ulva fasciata* and Hypnea musciformis collected from the peninsular coast of India. J Mar Sci Technol 12(1):1–6

Selvin J, Lipton AP. 2004. Biopotentials of *Ulva fasciata* and Hypnea musciformis collected from the peninsular coast of India. *Journal of Marine Science and Technology.* 12:1-6.

Selvin, J., Lipton, A.P. 2004. Journal of Marine Science and Technology 12 1-6

Service, MW. 1980. A guide to medical entomology Macmillan tropical and sub-tropical medical texts. Macmillan, London

Shalaby EA 2011. Algae as promising organisms for environment and health. Plant Signal Behav 6: 1338-1350.

Shao, P., Chen, M., Pei, Y. and Sun, P. 2013. In intro antioxidant activities of different sulfated polysaccharides from chlorophytan seaweeds *Ulva fasciata*. *International Journal of Biological Macromolecules*, *59*, 295–300. https://doi.org/10.1016/j.ijbiomac.2013.04.048.

Shobier, A. H., Abdel Ghani, S. A. and Barakat, K. M. 2016. GC/MS spectroscopic approach and antifungal potential of bioactive extracts produced by marine macroalgae. *Egyptian Journal of Aquatic Research*. https://doi.org/10.1016/j.ejar.2016.07.003.

Shonima Govindan, M., Thomas, J. and Muraleedhara Kurup, G. 2012. In vitro antioxidant and antitumor activity of polysaccharide isolated from *Ulva fasciata*. *International Journal of Pharma and Bio Sciences*.

Silva, G. C., Albuquerque-Costa, R., Oliveira-Peixoto, J. R., Pessoa-Nascimento, F. E., De Macedo-Carneiro, P. B. and Silva Dos Fernandes-Vieira, R. H. 2013. Antibacterial activity of macroalgae Tropical Atlantic marine macroalgae with bioactivity against virulent and antibiotic resistant Vibrio. *J. Aquat. Res*, *41*(1), 183–188.

Sivakumar, K., Kannappan, S., Dineshkumar, M. and Patil, P. K. 2014. African Journal of Microbiology Research Evaluation of marine macro alga, *Ulva fasciata* against bio-luminescent causing Vibrio harveyi during Penaeus monodon larviculture, *8*(8), 803–813. https://doi.org/10.5897/AJMR2013.6233.

Smith, G. M. 1944. Marine Algae of the Monterey Peninsula, Stanford Univ., California, 2nd edn.

Soares, A. R., Robaina, M. C. S., Mendes, G. S., Silva, T. S. L., Gestinari, L. M. S., Pamplona, O. S., Romanos, V. (n.d.). Antiviral activity of extracts from Brazilian seaweeds against herpes simplex virus. *Revista Brasileira de Farmacognosia Brazilian Journal of Pharmacognosy*, *22*(4), 714–723. https://doi.org/10.1590/S0102

Sowmiya, R., Balasubramani, G., Deepak, P., Aiswarya, D., Ravikumar, S., Prasannakumar, S. and Perumal, P. 2017. Characterization and screening of in vitro antimalarial and larvicidal activities of selected seaweeds from southeast coast of India against Plasmodium falciparum and Anopheles stephensi. *Journal of Coastal Life Medicine*, *5*(56), 2017–7. https://doi.org/ 10.12980/jclm.5.2017J7-35

Stengel DB, Connan S, Popper ZA 2011. Algal chemodiversity and bioactivity: Sources of natural variability and implications for commercial application. Biotechnol Adv 29: 483-501.

Suhaila Mohamed, Siti Nadia Hashim, Hafeedza Abdul Rahman., 2012. Seaweeds: A sustainable functional food for complementary and alternative therapy, Trends in food science & technology, 23 (2) 83–96.

Suparna Roy, P. Anantharaman 2017 Heavy Metals Accumulation of Different Parts of Turbinaria spp. along the Olaikuda Coast, Rameshwaram, Tamilnadu, India. International Advanced Research Journal in Science, Engineering and Technology. Vol. 4, Issue 3, March 20: 99-102.

Thangam TS, Kathiresan K. 1991b. Mosquito larvicidal effect of sea- weed extracts. BotMar 34:433–435

Tv, P., Laali, J. and Ll, N. 2012. Larvicidal activity of two seaweeds, *Ulva fasciata* and Grateloupia lithophila against mosquito vector, Anopheles stephensi. *INT J CURR SCI*, *4*, 67–71.

Tv, P., Laali, J. and Ll, N. 2012. Larvicidal activity of two seaweeds, *Ulva fasciata* and Grateloupia lithophila against

mosquito vector, Culex quinquefasciatus. *INT J CURR SCI*, 163–168.

Vijayabaskar P, Vaseela N. 2012. In vitro antioxidant properties of sulfated polysaccharide from brown marine algae Sargassum tenerrimum. Asian Pac J Trop Dis 2: S890-S896

Vijayavel, K., Martinez, J.A. 2010. *In vitro* antioxidant and antimicrobial activities of two Hawaiian marine *limu*: *Ulva fasciata* (Chlorophyta) and *Gracilaria salicornia* (Rhodophyta). *J. Med. Food., 13*, 1494–1499.

Wijesekara I, Pangestuti R, Kim SK 2011. Biological activities and potential health benefits of sulfated polysaccharides derived from marine algae. Carbohyd Polym 84: 14-21.

World Health Organization 1996 Evaluation on the testing of insecti- cides—report of the WHO informal consultation, 7–11 October 1996, Geneva. Ref: CTD/WHOPES/IC/96.1. http://www.who.int/whopes/resources/resources_1996/en/. Accessed 11May 2014.

Xu N, Fan X, Yan X, Tseng CK. 2004. Screening marine algae from China for their antitumor activities. *J Appl Phycol.,* 16: 451-456.

Yasser T. A. Moustafa and Ahmed Moustafa M. Batran 2014. Lipid chemistry of green macroalgae Ulva sp. a potential resource for biotechnological applications in the Southern Mediterranean Sea Coast, Alexandria shore, Egypt. Egypt. J. Aquat. Biol. & Fish., Vol. 18, No. 4: 9 – 20 (2014) ISSN 1110 – 6131.

Yoon Y. S., Yu C. S., Jung S. H., Choi P. W., Han K. R., Kim H. C., Kim J. C. Characteristics of colorectal cancer detected at the health promotion center. *J. Korean Soc. Coloproctol.* 23: 321–326; 2007.

****