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SARGASSUM – A RESOURCE OF NECESSITY

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Abstract

Sargassum is large, edible, invasive brown seaweed which acts as a shelter for most marine organisms. It contains many essential compounds like proteins, carbohydrates, minerals, vitamins and fatty acid and also has many value added natural products for pharmaceutical and cosmetic industry. As for as now the commercial cultivation of Sargassum was used mainly for the production of alginate. This seaweed is proved to aid as an anti-cancer, anti-diabetics and anti-obesity properties and antimicrobial activity against many human pathogens. The Sargassum sp. can efficiently absorb variety of heavy metals to protect sea environment. The emerging application of this seaweed is generation of bio fuel which will be a future fuel. Here we discussed the enormous applications of the marine macroalgae Sargassum elaborately.

Keywords: *Antioxidant, Alginate, Biofuel, Biofertilizer, Heavy metal absorbant and anti tumor activity.*

Introduction

Macroalgae or seaweeds are plant like organisms that grows in water usually attached to rocks while some are found floating. Generally seaweeds are classified into three major groups based on their colour: Phaeophyta (brown algae), Rhodophyta (red algae) and Chlorophyta (green algae). Seaweeds are used as food in many countries because of its high nutritional value and Brown algae yield a substance called algin and red algae produce substances called agar and carrageenan. These substances are used as additives in food products and drugs to give them a smooth texture and help them to retain moisture. They are also used in lipsticks, soaps, film, paint, varnish and buttons. Seaweeds are extremely important for the industrial development of pharmaceuticals, cosmetic and nutritional supplements for its unique secondary metabolites. More than 600 secondary metabolites were isolated from marine algae, such as polysaccharides, proteins, lipids, vitamins, carotenoids, antibiotics and enzymes (Hu *et al.*, 2016). *Sargassum*, invasive seaweed, comprises of 400 species abundantly present in warm and temperate waters, especially in the Indo-west Pacific region and Australia (Tseng *et al.*, 1985). *Sargassum* is large brown algae and a free floating and edible seaweed. It can form large floating mats or long windrows of weed. *Sargassum* provides a home, food source and shelter to marine organisms like shrimp, crab, fish, turtle and whale (Sfriso *et al.*, 2013). Marine organisms which feed on the *Sargassum* have elevated level of poly unsaturated fatty acids in their blood (Turner & Rooker, 2006). *Sargassum* can disperse throughout the world's ocean by wind, storm and spiralling currents. Even though it is considered as weed, it is used as a feed for sheep and cattle in tropical and sub tropical regions (Alejandro *et al.*, 2005) and also has many applications. *Sargassum* grows

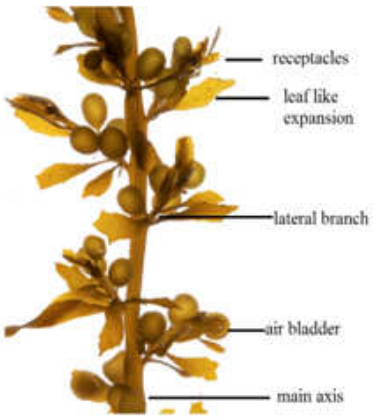

Fig I: *Sargassum* spp

abundantly both in east and west coasts of India, Australia and Ceylon. In India Sargassum is represented by about 16 species. Some common Indian species are namely *S. carpophyllu S. christifolium, S. cinereum, S. duplicatum, S. ilicifolium, S. myriocystwn, S. plagiophyllum* and *S. wightii* (Bhattathiri, 1992).

The main axis or 'stem' is erect, elongated, cylindrical or flat. The main axis bears large number of primary laterals or branches. Primary laterals are arranged on two sides of the main axis. The branching is always monopodial. The main axis and primary laterals bear flat leaf like branches known as secondary laterals or "leaves". The leaves like laterals are flat and simple with blade, veins and petiole like structure. It has small ball like structures called airbladder, which is used to float o the surface of ocean.

Origin of *Sargassum* in India

Seaweeds are the main ingredients used in Chinese medicine and food from several hundred years back but in India it is not more than two decades (Rao *et al.,* 2006). The utilization of seaweed led us understanding that the superior and valuable retrived compound from those was not lesser than compared with same on land. Agar, Carrageenan and Alginates are the compounds produced from variety of chemicals synthesized by seaweeds. All over the world approximately 8 million tons of wet seaweed produced per year (Thivy, 1960). During Second World War, India started to utilize renewable sources from the sea to produce Agar. Central Salt & Marine Chemicals Research Institute (CSMCRI) has been doing many R&D works on seaweed for many decades. With the help of this institute many small scale industries started to manufacture agar and alginate in coastal area of India. CSMCRI started to cultivate *Sargassum* for the production of alginate and liquid seaweed fertilizer. This seaweed is culturing can be taken place in three different stages follows:

- Acclimatization
- Laboratory culture
- Raft method or novel bag technology in sea, respectively.

This type of culture is first performed in coast of Gujarat and in Mandapam, Tamilnadu. Different government financial agencies are providing financial support to small scale industries to encourage seaweed cultivation. In India, *Turbunaria and Sargassum are used to produce alginate. Sargassum is mostly preferred, because the quality and the quantity of alginate produced is high.*

Drawbacks of *Sargassum*

In Gulf of Mexico and western Atlantic, a large area of sea is troubled by *Sargassum* dispersion (Jim *et al.,* 2015). Western Atlantic Ocean is characterized by mass of free floating *Sargassum natans* and *S. fluitans. So the seaweed is named after the sea as Sargasso Sea. In Caribbean Sea, massive amount of Sargassum is washed ashore which is a major problem for beach tourism. Sargassum muticum, The Asian seaweed is invasive in many areas outside its native range.*

Biofuel from *Sargassum* spp

Seaweeds are the potential candidate for the production of biofuels worldwide (Obata *et al.,* 2016). Especially brown algae can grow rapidly and contain low amount of lignin coupled with sizeable amount of polysaccharides (Hughes *et al.,* 2012). Currently petroleum is used as a transport fuel emits lethal concentration of carbon dioxide. So many researchers were trying hard to found replacement and alternative for petroleum with renewable energy to minimize the environmental pollution and finally Researchers concluded that biodiesel and bioethanol could be an effective alternative (Lee, J. Y *et al.,* 2013, Agarwal *et al.,* 2007 and Aresta *et al.,* 2005). Bioethanol is produce by fermentation process using microorganisms (Obata *et al.,* 2016). Enzyme

saccharification and fermentation of *Sargassum* spp. by yeast cells results in bioethanol production (Myra *et al.,* 2013, Jelynne *et al.,* 2014) Caldicellulosiruptor saccharolyticus can ferment *Sargassum* spp. and produces biohythae-a future fuel (José *et al.,* 2015).

Sargassum spp. in Heavy Metal Removal

Compared to the conventional methods, biosorption is very effective in removal of heavy metals and particularly important for removal of industrial effluents (Ping *et al.,* 2007).*Sargassum* spp. proved to have the capacity to absorb heavy metal even contaminants present in trace amounts.(Table I)

Table I Use of _Sargassum_ in heavy metal removal

Sargassum spp.	Nature	Heavy metal	Reference
Sargassum spp.	dead Sargassum spp.	Cadmium, lead	Claudio et al., 2004 Bruno et al., 2006
Sargassum thunbergii and Sargassum oligocystum,	Raw Sargassum spp.	cadmium	Thomas et al., 2004
Sargassum filipendula	Sargassum filipendula treated with hydrochloric acid	Copper and Nickel	Sirle et al., 2010
Sargassum spp.	Residual biomass of Sargassum spp.	copper and zinc	Valdman et al, 2010
Sargassum spp	raw and formaldehyde-modified Sargassum spp.	lead , copper , alkaline earth metal.	Paul et al.,2006
Sargassum spp	In combination with Ascophyllum and Fucus	Lead	Senthilkumar et al., 2007.
Sargassum spp	Sargassum spp. encapsulated with epichlorohydrin (ECH) and cross-linked chitosan (CS)	nickel	Fan Yang et al., 2011

Therapeutic Applications

Marine macroalgae *Sargassum* spp. contains several essential secondary metabolites like meroterpenoids, phlorotanins and fucoidan which can induce the invitro and invivo pharmacological activity and these compounds can acts as a immunomodulators (Lei *et al.,* 2012). Scientists identified antipyretic, analgesic, and anti-inflammatory activities of ethanol and dichloromethane extracts of *Sargassum fulvellum* and *Sargassum thunbergii* in mice (J.Y. Kang *et al.,* 2007).

Anti-cancer activity

Cancer is characterized by excessive and abnormal proliferation of cells (Zandi *et al.,* 2010). Currently used anticancer drugs in chemotherapy are prone to cause several side effects. To overcome this scientist were in thirst of searching new natural compounds from plants and seaweeds to treat cancer (Purker *et al.,* 2009). Polysaccharides extracted using supercritical fluid extraction from *Sargassum pallidum* showed antitumor activity against the HepG2 cells, A549 cells and MGC-803 cells and also has fibrinolytic activity (Hong *et al.,* 2008 and Wenhui *et al.,* 2009). Fucoidans from *Sargassum mcclurei* can be used as potential anticancer agent hence it inhibit the growth of colon cancer DLD-1 cells (Pham *et al.,* 2013). Water: ethanol and water: chloroform extracts of *Sargassum vulgare* exhibited cytotoxic effect against Jurkar cancer cell line (Mona *et al.,* 2016). *Sargassum oligocystum* showed antitumor activity against K562 and Daudi cell lines (Zandi *et al.,* 2010). Recently researchers investigated the anticancer activity of gold nano particles which is synthesized by using water extracts of *Sargassum glaucescens*. These nano particles can be further developed into a new chemotherapeutic drug especially to treat cervical cancer (Zahra *et al.,* 2016).

Anti-Diabetic Activity

A diabetic is the endocrine disorder, caused due to the defect in metabolism of carbohydrate, protein and lipid and also by inefficiency of insulin to transport glucose in to the cells from blood (Kopelman, 2000). Sargaquinoic acid (SQA) and sargahydroquinoic acid (SHQA) are the compounds extracted from *Sargassum yezoense* significantly improve glucose and lipid impairment in diabetic mice model (Su-Nam Kim *et al.,* 2012). Oral intake of ethanolic extract of *Sargassum polycystum* results in reduction in liver, kidney damage in diabetic rats and also increase the restorative effect of pancrease (Mahsa *et al.,* 2014). Fucoxantin extracted from *Sargassum* spp. can be used to reduce insulin resistance in cells (Nicolantonio *et al.,* 2012).

Anti-Obesity Activity

Obesity is a common condition leads to several disease found all over the world. The main reason for obesity is high accumulation of fat in tissues. People using synthetic drugs to reduce the obesity turned interest to take natural medicines and natural product due to the side effects of synthetics (Ahmed *et al.,* 2012). Raw and ethanolic extract of *Sargassum confusum Sargassum muticum, Sargassum subrepandum* and *Sargassum polycystum* has resulted in reducing obesity related factors in serum and attenuates weight gain in mice (Ahmed *et al.,* 2012, *Jang, Y.J., et a.,* 2013, Eun-Kyung *et al.,* 2013 and Afzan *et al.,* 2014).

Anti-Microbial Activity

Microorganisms are very important causative agents for many human diseases and also a key factor for human mortality rate (Megna N *et al.,* 2014). Earlier researches proved that extract of *Sargassum* spp. have antibacterial, antifungal and antiviral activity. Hexane, Petroleum ether, Ethyl acetate, Methanol and Ethanol extract of *Sargassum* spp shown inhibition against several human pathogens like *E.coli, Bacillus cereus, Bacillus subtilis, Klebsiella Pneumoniae, Staphylococcus aureus, Streptococcus pyrogens, salmonella typhimuricum* and *Proteus vulgaris* (Raman R *et al.,* 2014, J K Patra *et al.,* 2008 and Vengadesan P *et al.,* 2013) Spectroscopic aid the scientists to identify that dioctyl phthalate, a compound present in extracts of *Sargassum* spp. responsible for antibacterial activity (Sastry *et al.,* 1995). Chloroform, methanol and cyclohexane extracts of *Sargassum vulgare* and *Sargassum muticum* proved to have antifungal activity against fungal species like *Colletotrichum lagenarium, Aspergillus flavus, Aspergillus Niger, Aspergillus ochraceus, Cladosporium cladosporioides, Epicoccum nigrum and Penicillium citrinum (*Julio *et al.,* 2012 and Khallil *et al.,* 2015*).*

Cosmetic applications of Sargassum

Now a days many researches are going on to replace synthetic products by agro-industrial products in cosmetics to avoid side effects of chemicals and to reduce the production cost (Mitali et al., 2011). Properties of seaweeds grab the attention of scientists to use extracts of marine macroalgae in cosmetics for its antiaging, antiedema and antiwrinkle properties (Drums et al., 2014). Variety of metabolites have been identified in Sargassum spp. which are used by cosmetic industries to treat skin diseases like aging, tanning and pigmentation disorders (Hui-Min *et al.,*2014). *Those metabolites are: sulfated polysaccharides, chromenens, plastoquinines, chromanols and phenolics* (Ayyad *et al.,* 2011, E Bernarsha *et al.,* 2012). Recently researchers tested the antioxidant activity of *Sargassum muticum* ethanol extract (SmEE) and hydrothermal fraction (SmAE) on skin cells to increase antiaging and to enhance the appearance of skin (Elena *et al.,* 2014).

Anti-oxidant activity

Oxidation is a series of reaction produces free radicals which can induce damage to cells. To defeat that several antioxidant drugs are commercially available. Several plants and

macroalgae have natural compounds which has antioxidant property. Studies shown that brown macroalgae has highest antioxidant property compared to green and red macroalgae (Indu & Srinivasan, 2013). Poly phenol, sulphated polysaccharides, vitamins from *Sargassum* spp. that includes *S. cinereum, S. ilicifolium* and *S. tenerrimum, S. polycystum* and *S. wightii shown antioxidant activity* (Lynn M *et al.,* 2010, Anggadiredja J *et al.,* 1997 and Raman R *et al.,*2014). Scientists suggest that it is better to eat raw seaweeds instead of taking chemical drugs as antioxidants (Megna N *et al.,* 2014).

Sargassum spp. as Biofertilizer

Agroindustrial waste materials are successesfully used as biofertilizers instead of chemical fertilizers. They are ecofriendly and very effective. They enhance the texture and nutritive value of the soil. *Sargassum* spp. which can be used as liquid fertilizer to improve the plant growth and soil nutrition were listed in table II.

Table II Use of Sargassum as biofertilizer

Sargassum spp.	Used as	Plant	Uses	Reference
Sargassum crassifolium	Liquid fertilizer	Lycopersicon esculentum	Increase shoot and root dry weight and increase fruit number	Sutharsan et al., 2014,
Sargassum wightii	Liquid fertilizer	Abelmoschus esculentus (L.) Medikus	promote the shoot length, root length, , protein, amino acid, reducing sugar, total sugar, α-amylase and ß-amylase activity	N. Jothinayagi et al., 2009.
Sargassum wightii grev	Liquid fertilizer	Vigna radiata (L.) R. wilczek	Speed up germination	Ashok Kumar et al., 2012
Sargassum myriocystum	Liquid fertilizer	Vigna mungo (L.) Hepper	Stimulate seedling	C. Kalaivanan and V. Venkatesalu,2012
sargassum wightii	Liquid fertilizer	cyamopsis tetragonoloba (L)	enhance the total chlorophyll content	Thambiraj J et al., 2012.
Sargassum johnstonii	conditioner and fertilizer	Lycopersicon Esculentum	Increase productivity	Kumari, R et al., 2013.
Sargassum fluitans and Sargassum natans	Fertilizer	Panicum Amarum	Increase growth	Amy Williams et al., 2010.
Sargassum polycystum	Liquid fertilizer	Cajanus cajan	Enhance seed germination	V. Erulan et al., 2009.

Conclusion

Even though this seaweed is considered as a weed it has many promising applications. *Sargassum* influxes can be managed by both regional co-ordination and local action by the government. Lots of researches have been done on this abundant and invasive seaweed already. Though several novel and effective drugs strongly reported successfully, so far were taken for the clinical trials and commercialized were very minimum. This valuable drug from cheap sources has to encourage in fast mode for clinical trials and commercialization to benefit peoples. This transformation of invaluable *Sargassum* junks to a precious drugs need special consideration on the parts of quality improvement, large scale production and purification of the novel formulates

through more research and parallel applications. This will solve the people's necessity as are source in future.

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