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Physicochemical & Mechanical Investigation of Algal Species

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Abstract
Natural materials and plants have a long history of medical applications due to their broad range of favourable biological functions including biocompatibility, anti-bacterial, anti-oxidant and anti-inflammatory properties. Main objective of this study will be phytochemical investigation and develop of alginate fibres from freshwater algal species which is used in engineering material.
This review study conducted investigate the phytochemical study of freshwater algal species and comparing their inhibition activities. This review may help in order to make a library of isolated volatile and nonvolatile chemical constituents of different algal species of water sources. This article can help future scientist to discover new drugs.This article also provide details about mechanical properties of alginate fibers and their comparison on the basis of previous literature. Alginate fibres is lightweight reinforce material and can be used in formation of lightweightcomposite materials, algae-based textile products, bio medical application, lightweight aircraft and marine industries etc.

Keywords: *Phytochemical Investigation, inhibitory activities, alginate fiber, mechanical properties*

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I. Introduction

Algae are being extensively used for deriving components that are widely used in pharmaceutical industries, medical industries and food industries. The bioactive components derived from algae are used for various purposes. Microalgae can be utilized in the production of nutritional supplements, antioxidants, cosmetics, natural dyes and poly unsaturated fatty acids. Brown, red and green algae are rich in molecules with antiviral, antioxidant, antifungal and antimicrobial activities because of its great nutritional value, S. platensis is being used since olden times as a resource of food. It is prospered in nutrients like minerals, protein, carbohydrates, vitamins and (γ)-linolenic acid. Algae contain variety of components like secondary metabolites including phenols and flavonoids. Phenols, sometimes called phenolics, are one of the main secondary metabolites present in the plant kingdom. [1]

Recent reports indicate that there is an inverse relationship between the dietary intake of antioxidant-rich foods and the incidence of human diseases. As a result, many researchers have focused on natural antioxidants as numerous crude extracts and pure natural compounds have previously been reported to exhibit/possess antioxidant properties in the plant kingdom [2]. Recently, aquatic habitats have increasingly been shown to provide a rich source of natural bioactive compounds with hypocholesterolemia, antinflammatory, antiviral, antineoplastic, antimicrobial and hypertensive properties. According to their chemical structure, most isolated compounds belong to sulfated polysaccharides, phenolics, terpenoids, lactons, sterol and fatty acids. [3-5]

Some seaweed contains high amounts of essential proteins, vitamins, and minerals. [6] Velichko and Shevchenko (1998)[7] have reported that seaweeds as a dietary supplement are found to be good for the prophylaxis of coronary atherosclerosis. Its antioxidant activity is one of the most important and active in marine bioactive substances and lots of algal and algae-derived compounds such as carotenoids, phenolics, terpenoids and sulphated polysaccharides exhibit potent antioxidant activities. The antioxidant activities of these compounds are mainly attributed to scavenging activity against superoxide and hydroxyl radicals, chelating ability, quenching singlet and triplet oxygen and reducing power [8-9].

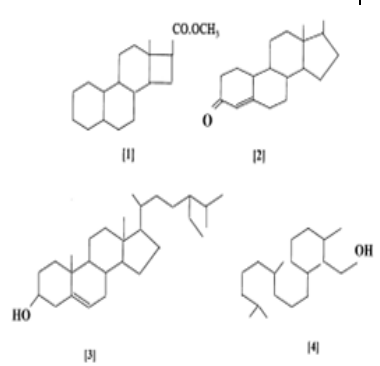
Marine algae, also called seaweeds, are abundantly present in the coastal area of Iran, especially in Persian Gulf. One of the products easily obtainable from Ulvales seaweeds is a polysaccharide, a phycocolloid[10] commonly known as ulvan. Studying the saccharidic composition of ulvan, Percival and Worldshowed that by this name is indicated a family of water-soluble anionic polysaccharides structurally

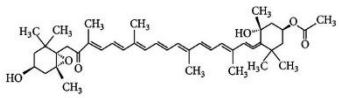
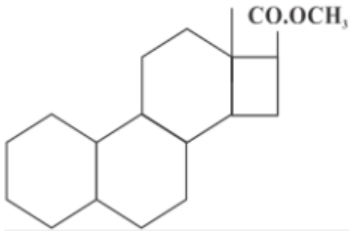
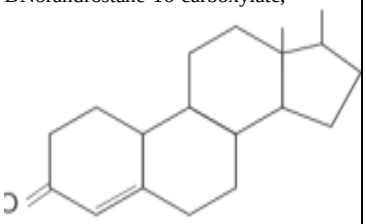
heterogeneous containing galactose, xylose, rhamnose, glucuronic acid and iduronic acid arranged in an essentially linear fashion [11]. The composition and extent of these structural motifs, called aldobiuronic A3S and B3S sequences, can vary depending on the sources and on the year/period of collection of the algal material. Algal polysaccharides have been demonstrated to play an important role as free-radical scavengers in vitro and antioxidants in the prevention of oxidative damage in living organisms. [12] Furthermore, many polysaccharides found in seaweeds have diverse biological activities, including effects on the immune system and cancer. [13]

Altogether, this review may help in order to make a library of isolated volatile and nonvolatile chemical constituents of different algal species. This article can help future scientist to discover new drugs. This article may also help to identify comparative studies of previous isolated algal fibers which are using different medical, automobile, civil, space etc. application.

A. Phytochemical investigation

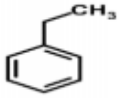
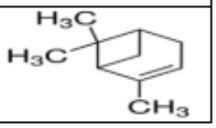
The phytochemical analysis of fresh water algal species are presented in Table 1.

Sr. No.	Algal species	Sources	Isolated compounds	Extract	Activities	Ref.
1.	Eleven green algae belonging to the phyla Volvocophyta Chlorophyta, and Charophyta	freshwater habitats of Sindh (Pakistan)	D-norandrostane-16-carboxylic acid (1), β-sitosterol (2), 17β-hydroxyandrost-4-en-3-one (testosterone) (3) and trans-phytol (4)  [1] [2] [3] [4]	methanol extracts	antifungal activity, phytotoxic activity, insecticidal, and antitumor activities	[14]
2.	zooplankton(*Moinamicrura*)		phytosterol, tannin, alkaloids, and saponin	aqueous algal extract	antibacterial activities	[15]
3.	green algae *Chlorella vulgaris*	Unkal Lake in Dharwad District, Karnataka, India	alkaloids, flavonoids, glycosides, carotenoids, phenols, lignins, saponins, sterols, tannins, reducing sugars, volatile oil, fats, amino acids and carbohydrates	Polarity based different solvent extracts	Antimicrobial activity Against Human pathogens such as Staphylococcus aureus, Corynebacterium, Bacillus subtilis, Streptococcus, Escherichia coli, Salmonella Paratyphi B, Klebsiellapneumoniae, Aerobacteraerogenes, Candida albicans and Aspergillusniger	[16]
4.	marine red *alga Champiaparvula*	Mandapam coast of Tamil Nadu, India	Sterols, glycosides, anthroquinones, phenols, alkaloids, triterpenoids, tannins, saponins, flavonoids, steroids. Flavonoid: rutin, quercetin, kamferol Phenol compounds: gallic acid and cinnamic acid. fatty acids: palmitic acid, margaric acid, stearic acid, oleic acid, linolenic acid, alpha linolenic acid, moroctic acid Among the phytochemical contents the triterpenoids and glycosides are present in high. Among the seven fatty acid,	methanol	Flavonoids are proved to have antitumour and antioxidant properties, Glycosides are known to lower the blood pressure, Tannin containing remedies are in	[17]

			stearic acid (6.03 ± 0.012%) and moroctic acid (5.58 ± 0.004%) were identified.		use as antihelmintic, antioxidant, antimicrobial and antiviral and for cancer treatment,terpenoids have antioxidant activity, Alkaloids are commonly found to have antimicrobial,cytotoxicand antiplasmodicproperties.	
5.	marine algae *Chlorococcumhumicola*	Rameshwaram sea shore, Tamil Nadu	Alkaloids (Mayer's test Wagner's test), Flavonoids (Lead acetate test H2SO4 test), Steroids (Liebermann Burchard test), Saponin, Carbohydrates, Oil And Resin **GCMS analysis (Table-2)**	ethanol, ethyl acetate and hexane extracts	antioxidant activity	[18]
6.	red algae Porphyravietnamensis,	Ratnagiri coast, Maharashtra, India	Evaluation of pharmacognostical, phytochemical and anti-microbial properties of Porphyravietnamensis			
7.	Brown algae (Sargassumilicifolium)	west coast of Maharashtra, India	Fucoxanthin 	Methanol extract	utilized for bio-efficacy and bioactivity	[19]
8.	algae Chara [Green algae]	pond of Chitradurga fort	 DNorandrostane-16-carboxylate,  17B-hydroxyandrost-4-en-3-one	methanol extract (GCMS/ NMR)	antibacterial activity	[20]
9.	green macroalgae, Spirogyra sp. and Chara sp.	BeastanSwr Spring Water in Sulaimani-Kurdistan Region of Iraq	Fatty acid: Palmatic,Stearic, Oleic,Linoleic,Linoleic,Arachidic,Eruci c acid, Docosadienoic acid	Hydro-distillation extraction (Oil extract) by FLC	-	[21]
10.	Kappaphycus sp.	sea coast of Rameswaram, India	**Fatty acid**-Caproic acid, Caprylic acid, Methyl heptanonaite, Butanoic acid, Ethanoic acid, Octadecic acid, Octadecatrienoic acid, 4-Methylo atanonaite **Sterols**-Camposterol, Cholesterol, Stigmasterol, E-Sistosterol, Methylenechole sterol E-Carotene	Methanol extract	Results of this study suggest the utility of Kappaphycus sp. for various nutritional products for use as health food or nutraceutical supplement.	[22]
11	marine algae (red algae), Halymeniadila	coastal area of Mandapam, Tamil Nadu,	Photochemical constituents of the algae and the analysis revealed the presence of seventeen phytocomponents.	GC-MS analysis of the methanol	Most of the identified compounds	[23]

	tata	India	Majority of the identified compounds were found to be from the fatty acid group and others were from alkane, acetate, amide, alkenyl, alcohol and steroid group. The major constituents of the extract includes Hexadecanoic acid, methyl ester, n-Hexadecanoic acid, 6,10,14-Trimethylpentadecan-2- one, 9-Octadecenoicacid (Z)-methyl ester and 2-Dodecen-1-yl(-)succinic anhydride. (**Details of GCMS Analysis including table-3& 4**)	extract	were reported to possess antimicrobial, antioxidant, anti-inflammatory, antitumor and antifouling properties.	
12	Marine red algae, Botryocladiale ptopoda	inter-tidal rocky shore of the Mandapam, Gulf of Mannar, South East coast of Tamil Nadu, India	Steroids, anthroquinones, alkaloids, triterpenoids, saponins, glycosides, flavonoids, phenols and tannins. triterpenoids and glycosides are available in higher amounts.	methanol extract	to use remedies of natural source for therapeutic illness as these claimed to produce less side effects	[24]
13	Chlorella vulgaris Beijerinck (Chlorellaceae)	Cultured in Bold Basal medium (BBM) and incubated for 15 days at 24 ± 1 ºC in a thermostatically controlled room and illuminated with cool inflorescence lamps (2000 lux in a 12: 12 h L/D) regime.	Alkaloid, flavonoid, phenol, tannin, terpenoids, saponin and glycosides. Acetone and ethanol extracts were potential antimicrobial agent when compared to chloroform and aqueous extracts.	chloroform, acetone, ethanol and aqueous extracts	Antimicrobial activity, Daily supplementation of food with C. vulgaris Beijerinck will not only nourish in the body growth but it will also serve as immense source to defend against bacterial infection.	[25]

Table 2: GCMS activity in ethanol extract of *Chlorococcumhumicola*

S.NO.	RT	Compound name	M.F.	M.W.	Peak Area	Nature of Compound	Stucture
1.	1.83	Ethylbenzene	C_8H_{10}	106	3.27	-	
2.	7.08	Octanoic acid, ethyl ester	$C_{10}H_{20}O_2$	172	0.26	Ester	
3.	8.27	α-Pinene	$C_{10}H_{16}$	136.23	4.7	Terpene	

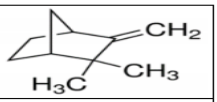
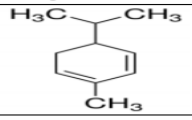
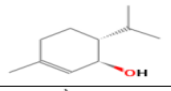
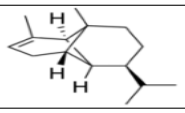
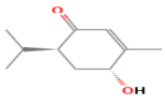
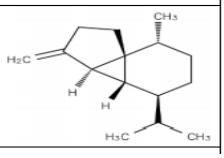
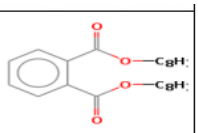
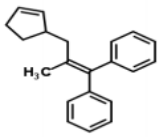
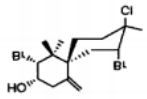
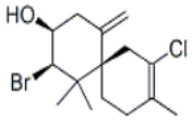
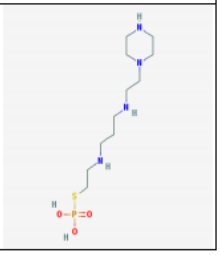
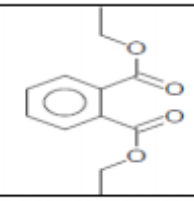
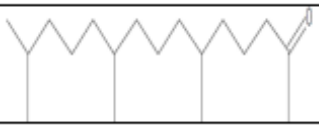
4.	8.23	Camphene	$C_{10}H_{16}$	136.24	0.4	bicyclic monoterpene	
5.	11.88	β-Phellandrene	$C_{10}H_{16}$	136.24	12.5	monoterpenes	
6.	16.68	trans-3-Methyl-6-(1-methylethyl)-2-cyclohexen-1-ol	$C_{10}H_{18}O$	154.24	0.3	Terpenoids	
7.	20.82	Ylangene	$C_{15}H_{24}$	204.35	0.2	Hydrocarbon compounds like oil	
8.	22.00	trans-4-Hydroxy-3-methyl-6-(1-methylethyl)-2-cyclohexen-1-one	$C_{10}H_{16}O_2$	168.23	0.2	terpene	
9.	22.17	β-Cubebene	$C_{15}H_{24}$	204.35	0.1	Terpene	
10.	24.00	1,2-Benzene dicarboxylic acid, diisooctyl ester	$C_{24}H_{38}O_4$	390.23	0.54	ester	
11.	27.75	1-Propene, 3-(2-cyclopentenyl)-2-methyl-1,1-diphenyl-	$C_{21}H_{22}$	274.399	4.8	-	
12.	32.24	cartilagineol	$C_{15}H_{23}Br_2ClO$	414.60	0.52	Halogenated compounds	
13.	35.52	elatol	$C_{15}H_{22}BrClO$	333.69	2.5	Halogenated compounds	
14.	40.23	N-[2- [1-Piperazyl]ethyl]-N'- [2-thiophosphatoethyl]-1,3-propanamine	$C_{11}H_{27}N_4O_3PS$	326.39	3.1	-	

Table-3 Active compounds identified in the methanol extract of Halymeniadilatata (red algae)

S.No	Name of the compound	RT	Peak Area (%)	Mol.wt g/mol	Mol. Formula	Structure
1	Diethyl Phthalate	5.89	3.05	222.24	$C_{12}H_{14}O_4$	
2	1-Hexadecanol	6.36	4.02	242.44	$C_{16}H_{34}O$	
3	6,10,14-Trimethylpentadecan-2-one	7.53	7.56	268.49	$C_{18}H_{36}O$	
4	9-Hexadecenoic acid, methyl ester, (Z)-	7.99	6.06	268.44	$C_{17}H_{32}O_2$	
5	Hexadecanoic acid, methyl ester	8.17	11.87	270.46	$C_{19}H_{34}O_2$	
6	n-Hexadecanoic acid	8.46	9.11	256.43	$C_{16}H_{32}O_2$	

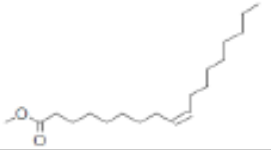
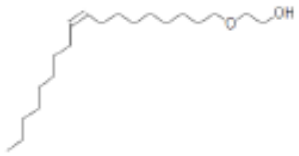
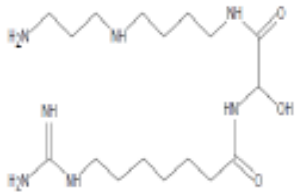
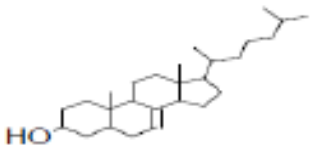
7	Oleic Acid	8.84	2.97	326.57	$C_{18}H_{34}O_2$	
8	8,11-Octadecadienoic acid, methyl ester	9.53	4.57	294.47	$C_{18}H_{34}O_2$	
9	9-Octadecenoic acid (Z)-, methyl ester	9.59	7.2	296.50	$C_{19}H_{36}O_2$	
10	Ethanol, 2-(9-octadecenyloxy)-, (Z)-	9.71	5.05	312.54	$C_{20}H_{40}O_2$	
11	Deoxyspergualin	10.214	3.29	423.99	$C_{17}H_{37}O_3$	
12	11,13-Dimethyl-12-tetradecen-1-ol acetate	10.914	5.4	254.41	$C_{18}H_{34}O_2$	
13	Heptacosane	12.874	2.61	380.75	$C_{27}H_{56}$	
14	Hexacosane	13.655	2.6	366.72	$C_{26}H_{54}$	
15	Z)-9-Hexadecenoic acid (Z)-9-octadecenyl ester	16.979	2.62	504.87	$C_{34}H_{64}O_2$	
16	2-Dodecen-1 -yl(-)succinic anhydride	17.646	7.3	266.38	$C_{16}H_{26}O_3$	
17	Lathosterol	17.783	4.25	386.66	$C_{27}H_{46}O$	

Table 4: Chemical nature and biological activity of phyto-components identified in the methanol extract of *Halymeniadilatata*

S.No	Name of the compound	Chemical nature	Biological Activity
1	Diethyl Phthalate	Phthalic acid ester	Antimicrobial
2	1-Hexadecanol	Palmityl alcohol	Antimicrobial
3	6,10,14-Trimethylpentadecan-2-one	Alcoholic compound	Flavoring Agent, antimicrobial
4	9-Hexadecenoic acid, methyl ester, (Z)-	Palmitic acid ester	Antioxidant, nematicide, pesticide, antiandrogenic, flavor
5	Hexadecanoic acid, methyl ester	Palmitic acid ester	Antioxidant, nematicide, pesticide, antiandrogenic, flavor
6	n-Hexadecanoic acid	Palmitic acid	Antioxidant, nematicide, pesticide, antiandrogenic, antifouling
7	Oleic Acid	Oleic Acid	Anti-inflammatory
8	8,11-Octadecadienoic acid, methyl ester	Linoleic acid ester	Anti-inflammatory, Cancer preventive.
9	9-Octadecenoic acid (Z)-, methyl ester	Oleic acid ester	Anti-inflammatory, Antiandrogenic, Cancer preventive
10	Ethanol, 2-(9-octadecenyloxy)-, (Z)-	Alcoholic compound	Antimicrobial
11	Deoxyspergualin	Amide	Antitumor, cytoprotection, immunomodulation
12	11,13-Dimethyl-12-tetradecen-1-ol acetate	Acetate compound	Not reported
13	Heptacosane	Alkanes	Antioxidant
14	Hexacosane	Alkanes	Antioxidant
15	Z)-9-Hexadecenoic acid (Z)-9-octadecenyl ester	Fatty acid	Not reported
16	2-Dodecen-1-yl(-)succinic anhydride	Alkenyl	Antineoplastic agents, Antioxidants, Antimicrobial
17	Lathosterol	Steroid	Steroidal activity

B. **Phytochemical screening:**

Acetone, methanol, ethanol and chloroform extracts prepared from all the five differentmicroalgae were used to screen various phytochemicals such as tannins, flavonoids, terpenoids, steroids, saponins, glycosidesand alkaloids as described by Sanjeet et al.,(2010).[26-27]

i. **Test for Tannins:** Algal extracts of 700 µl were mixed with 50 ml of distilled water and 1 % of ferric chloride was addeddrop by drop. Formation of a dark green solution indicated the presence of tannins.

ii. **Test for Flavonoids:** Algal extract of 500 µl was dissolved in 1ml of 10 % NaOH and a few drops of concentrated HClwere added. The presence of flavonoids was indicated by the disappearance of yellow color.

iii. **Test for Terpenoids:** To 1 ml of algal extract was taken and 400 µl of chloroform was added and mixed. A few drops ofconcentrated sulfuric acid were added. A reddish brown interface was formed and this indicated the presence of terpenoids.

iv. **Test for Steroids:** To 100 µl of algal extracts was taken and 400 µl of acetic anhydride and a few drops of concentratedsulfuric acid were added. The formation of a brown ring indicated the presence of steroids.

v. **Test for Saponins:** To 1 ml of algal extracts, few drops of 1 % ferric chloride were added. Frothing or appearance of acreamy mass of small bubbles showed the presence of saponins.

vi. **Test for Glycosides:** To 1 ml of algal extracts, 1 ml of pyridine and a few drops of freshly prepared sodium nitroprussidesolution were added. Appearance of pink to red color indicated the presence of glycosides.

vii. **Test for Alkaloids:** To the algal extract, few drops of Wagner's reagent (solution of iodine in potassium iodide) wereadded. Appearance of reddish brown precipitate indicated the presence of alkaloids.

C. Mechanical behaviors of algal fibers

Algae as a raw material for paper making are an innovative solution to Global environmental issues dealing with deforestation and global warming. Algae contain cellulose and hemi-cellulose but no lignin. The algae filler composites were fabricated and tested for finding out the mechanical propertiessuch as tensile, flexural, impact strength.The potential of the seaweed fibers has attracted competitors. Early sales of algae-based textile products have gained a positive customer acceptance since there is a broad awareness of the capacity of algae extracts to regenerate and maintain a healthy skin. The potential output of renewable alginate fibers from China based on available resources in the country could reach 1.9 million tons annually. This turns algae fibers from nowhere into the third most important natural fiber on the market. This implies that China (and the world) could further reduce its dependency on pesticide dependent and water intensive cotton without the need of land space for farming.

The textile applications for algae-fibers already evolved from bandages and specialty wear to fashionable products.Marine algae to concrete showed an increase in strength properties.

The best replacement of asbestos fire can be algal fiber .as asbestoses is bed to health and cause lung cancer. On the contrary algal is used for manufacturing anti cancer drug.

Algal fiber has anti inflammatory properties it can be use for coating very high temperature producing part so that the possibility of fire can be avoid.Anti-corrosion properties of algal fiber make it [28-31].

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