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Antibacterial and Antioxidant Activity of Sulphated Polysaccharides from selected Seaweeds of Vadinar Coast

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Abstract

In the present study the antibacterial and antioxidant activity of sulfated polysaccharide from selected seaweed (*U. lactuca, S. tenerrimum, S. cinctum, S. myriostum, P. Boergesenii* and *G.edulis)* has been carried out. The elemental analysis was done showed a high sodium concentration (825 ± 4.25 ppm) in *G. edulis* followed by *U. lactuca* (815 ± 5.66 ppm). Potassium was obtained higher percentage in *P. boergesnii* (21436 ± 5.66 ppm) followed by *U. lactuca* (16263.5 ± 4.95 ppm). The maximum concentration of calcium was recorded in *S. cinctum* (6527 ± 5.67 ppm). The physico chemical parameters like carbohydrate and sulphate was obtained maximum concentration in *U.lactuca* (0.955 ± 0.035 mg; 2.422 ± 0.086). FT- IR analysis of the different six (*U. lactuca, S. tenerrimum, S. cinctum, S. myriostum, P. boergesenii, G.edulis)* seaweed sample was done and functional group associated were determined. *U. lactuca* shows effective peaks in 3174 cm^{-1}, 3458cm^{-1}, which belongs to amide group and O-H group respectively. *S. tenerrimum* exhibited peak value in 1150-1070cm^{-1} and 3000-2500 cm^{-1}, which belongs to C-O, O-H functional group respectively.

Keywords: ***Antioxidant activity; U. lactuca***

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Introduction

Seaweeds are the macroscopic marine algae attached to the bottom, relatively in shallow coastal waters. They grow in the intertidal, shallow and deep sea areas up to 180 meter depth and also in estuaries and backwaters on the solid substrate such as rocks, dead corals and pebbles. Seaweed zone is one of the conspicuous and wide-spread biotope in the shallow marine environment. The seaweeds are entirely different from higher plants as they neither have true leaves, stems and roots or vascular systems nor specialized sex organs [1]. Seaweeds are living and renewable resources of sea which are used as food by human, feed for animals and fertilizer for agriculture in many parts of the world. Seaweeds contain more than 60 trace elements, minerals, vitamins, protein, iodine, bromine, carbohydrate, lipid and several bioactive compounds. More than 20,000 species of seaweeds were recorded globally. Based on their morphology, pigent and anatomical characters the

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seaweeds belonging three different following categories such as green algae (*Chlorophyceae*), red algae (*Rhodophyceae*) and brown (*Phaeophyceae*).

Seaweeds are considered as a rich source of antioxidants [2]. Antioxidant substances in seaweeds are found to be following endogenous defence mechanism as protection against oxidative stress due to extreme environmental condition [3]. Seaweeds are contains antioxidant properties which have multiple function in biological system such as defence against oxidative damage and participation in the pathway of cells [4]. One of the most important actions of antioxidant is to prevent damage caused by the action of reactive oxygen species. Oxidative stress and reactive oxygen species have been associated with the chronic disease in human [5].

Seaweeds are exposed to combination of light and oxygen that leads to the formation of free radicals and other strong oxidizing agents [6], but absent of the oxidative damage in the structural component (polyunsaturated fatty acid) of seaweeds [7] and their stability to oxidation during strong [8] suggest that their cells have protective antioxidant defence system [9]. Due to the increase in bacterial resistance against commercial antibiotics there is a growing need, for new antibacterial compounds that are active against pathogenic bacteria. In addition, most of the existing antibiotics are occasionally associated with adverse effects to the host, including hypersensitivity, immune suppression and allergic reactions. These developments demand that a renewed effort be made to seek antibacterial agents effective against pathogenic bacteria resistant to current antibiotics. Extracts of seaweeds were reported to exhibit antibacterial activity.

Reactive oxygen species such as hydroxyl, superoxide and peroxyl radicals are formed in human cells by endogenous factors and exogenously result in extensive oxidative damage that in turn leads to geriatric degenerative conditions, cancer and a wide range of other human diseases. More recent reports revealed seaweeds to be a rich source of antioxidant compounds. Having the advantages of low cost raw material, high amounts of secondary metabolites, and no secondary pollution, seaweed may be used to be a natural source of antibacterial and antioxidant agents.

Thus the objective of the present study was to analyze the chemical composition of the sulfated polysaccharides of six different seaweeds such as *Ulva lactuca*, *Sargassum tenerrimum*, *Sargassum cinctum*, *Padina boergesenii* and *Gracilaria edulis*, which were collected from Vadinar, Jamnagar coast of Gujarat and to determine the elemental composition of seaweeds by using digital flame photo-meter followed by investigation of the antibacterial and antioxidant activities of the ethanol and diethyl ether extracts and characterization using GC/MS and FT-IR.

Study Area Description

Study area of seaweed is located north side of Jamnagar district near Vadinar, situated in western side of Gujarat state (**FIG 1**). The coordinate of sampling location is 22° 26’59.42”N and 69° 40’ 22.50”E.

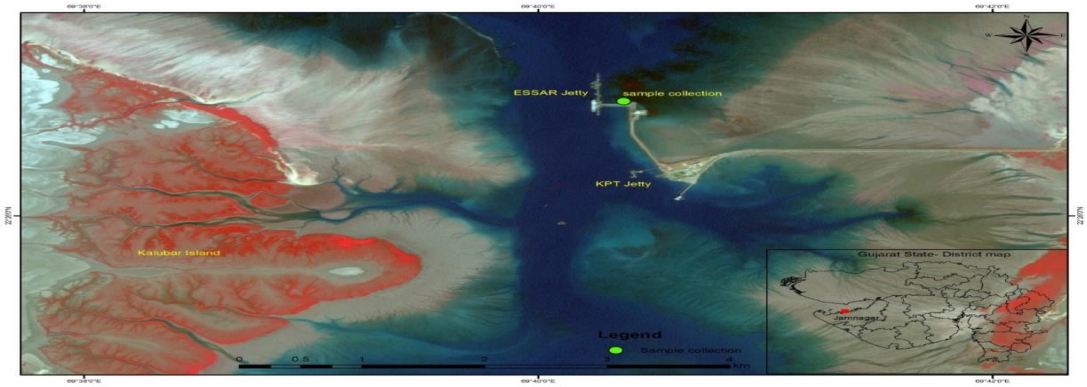

FIG. 1. **Location of Vadinar Coast (Jamnagar).**

Materials and Methods

Sample collection and preparation

The seaweeds were collected from Vadinar, Jamnagar coastal regions of Gujarat, India. Seaweed sample was picked with hand and immediately washed with seawater to remove the foreign particles, sand particles and epiphytes. Then it was kept in an ice box containing slush ice and immediately shifted to the laboratory and washed thoroughly using tap water to remove the salt on the surface of the sample. Subsequently seaweed species were segregated on the basis of different groups such as Chlorophyceae (*Ulva lactuca*), Phaeophyceae (*Sargassum tenerrimum*, *Sargassum cinctum*, *Sargassum myriocystum*, *Padina boergesenii*) and Rhodophyceae (*Gracilaria edulis*). Then the seaweeds were spread on blotting paper to remove excess of water in room temperature for one week. Afterwards the dried seaweed samples were ground in an electric mixture and stored in a cool place for further analysis.

Extraction of sulphated polysaccharides

Sulphated polysaccharides from the seaweeds were extracted by using standard method. One hundred gram of dried seaweed powder of 6 different species was extracted with three volumes of water at 90-95°C at 16 h. Then different coloured syrup (green, brown and red) was filtered through whatman-3 filter paper, concentrated to ¼th of its original volume, cooled, and precipitated with three volumes of ethanol and diethyl ether. The precipitate was collected by centrifugation and dehydrated with diethyl ether to afford different colour crude extract for further analysis.

Physico - chemical analysis

In present study physico-chemical parameters such as pH, carbohydrate and sulphate was analyzed by following methods. pH was measured by pH pen (Elico).

Carbohydrate

The total carbohydrate content of the crude extract was estimated by the phenol sulphuric acid method. 100 mg of the sample hydrolyzed with 5 ml of 2.5N- HCL then neutralized with sodium carbonate. Make up 100 ml (pipette out 0.2, 0.4, 0.6, 0.8, and 1.0 ml of working standard series). Set a blank with 1ml of water and add 1ml of phenol solution and 5ml of 96% phenol with sulphuric acid. After 10 minutes, shake the content and place in a water bath at 25-30ºC for 20 minutes. The absorbance was read at 490 nm and calculated the amount of total carbohydrate present in the sample solution by using standard graph.

Sulphate

The sulphate content was determined by the barium chloride gelatine method. Seaweeds sample (10 ml) was taken, 2.5ml of conditioning reagent (75 g sodium chloride, 30 ml conc. HCL, 100 ml isopropyl, 50 ml glycerol, finally content made up to 500 ml) and pinch of barium chloride added in the sample. The sample was mixed well, after 10 minutes absorbance was read at 420 nm in spectrophotometer.

Element analysis of seaweed

The element composition of seaweed such as sodium, potassium and calcium was analyzed by using Flame Photometer. One gram of seaweed powder was taken and added a 25 ml of ammonium acetate. Shake the sample for 5 minutes and filter through filter paper. The sample reading was taken in a flame photometer by using different standard solution.

Antibacterial activity

Bacterial strain used the pathogenic bacterial strains such as *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Klebsiella pneumonia* used for the present study were received from Adani General Hospital, Bhuj-Kachchh, Gujarat.

Preparation of bacterial culture

Nutrient broth was prepared and sterilized in an autoclave at 15 lbs pressure. The pathogens were inoculated in the nutrient broth and incubated at 28°C for 24 hrs.

Well diffusion method

Antibacterial activity was analyzed using agar well diffusion test technique. Muller Hinton Agar medium (MHA) plates were prepared and the pH was maintained at. A sterile cotton swab was used for spreading the test microorganism from the 24 hours inoculated broth evenly on the plates. Similarly swabbing was done separately for each test microorganism on the plates and left for few minutes to allow complete absorption of the inoculum. In each of these plates two wells of 5 mm diameter were made using an appropriate size sterilized cork borer. The crude extract (ethanol and diethyl ether) from 100 µg seaweed (*U. lactuca*, *S. tenerrimum*, *S. cinctum*, *S. myriostum*, *P. Boergesenii* and *G. edulis*) was dissolved in 100 µl of sterile distilled water and from that 10 µl of the sample was injected into the well. The control well was filled with 10 µl of ampicillin (10 µg/100 µl). The plates were then incubated at 37ºC for 24 hour. After incubation, in case of positive antibacterial activity, the zone of inhabitation was measure and expressed in millimetres.

Analysis of antioxidant activity

Determination of Total Antioxidant Capacity (TAC): Total antioxidant activity of seaweed extract was determined according to the method of Mitsuda. 7.45 ml of sulphuric acid (0.6 mol.L^{-1}), 0.99 g of sodium sulphate (28 mol.L^{-1}) and 1.23 g of ammonium molybdate (4 mol. L^{-1}) were mixed together in 250 ml with distilled water and labelled as total antioxidant capacity (TAC); 0.1 ml of the seaweed extract (50, 100, 250, 500 and 1000 µg) was dissolved in 1 ml of TAC and the absorbance was read at 695 nm after 15 minutes. In this experiment Ascorbic acid was used as a standard agent.

Determination of reducing power: Reducing power of the extract was determined by the method of Yamanguchi. A sample (0.75 ml) of extract at various concentration (200, 400, 600, 800 and 1000 µg) was mixed with 0.75 ml phosphate buffer (pH 6.6) and 0.75 ml of 1% potassium ferricyanide was added. The mixture was incubated at 50ºC for 20 minutes. 0.75 ml of 10% trichloroacetic acid was added to the mixture and centrifuged at 3000 rpm for 10 minutes. A sample (1.5 ml) of the supernatant was mixed with 1.5 ml of distilled water and 0.1 ml of 0.1% ferric chloride. The absorbance was read at 700 nm after 10 minutes of the incubation.

Hydrogen peroxide scavenging assay: The free radical scavenging activity of the extract was determined by the hydrogen peroxide assay. Hydrogen peroxide (10 $mol.L^{-1}$) solution was prepared in phosphate buffered saline (0.1 $mol.L^{-1}$, pH 7.4). One ml of the extract (50, 100, 250, 500, and 1000 µg) was rapidly mixed with 2 ml of the hydrogen peroxide solution. The absorbance was measured at 230 nm in the UV spectrophotometer after 10 min of incubation at 37ºC against a blank (without hydrogen peroxide was calculated using the formula,

% of scavenging = $[(A_0 – A_1/ A_0] \times 100$

Where A_0 is the absorbance of control and A_1 is the absorbance of sample.

Characterization of seaweed

FT-IR spectrophotometer analysis: Infrared spectra (IR) were also used to identify the sulphated polysaccharide compounds. Seaweed extract along with the standard galic acid were tested using SHIMANDZU FT-IR instrument. One milligram of dry seaweed sample was mixed with 100 mg of dry potassium bromide (KBr) and then compressed to prepare salt-disc (3 mm diameter). These discs were analysed under Fourier transform IR- spectrophotometer. The absorbance was read in the range 400-4000 cm^{-1}.

GC–MS analysis: The polysaccharide was hydrolysed to monomeric units and transformed to the corresponding alditol acetates. A sample (0.1g) of crude product was mixed with 1.25 ml of 72% sulphuric acid and incubated for 60 min. at 30ºC. The mixture was diluted with 13.5 ml of distilled water and incubated in boiling water bath for 4 hour. After incubation, the mixture was cooled and 3.1 ml of 32% of NaOH (*w/V*) was added. At the end of hydrolysis, a 0.2 ml of sample was taken separately and 2 ml of 2% Borohydride in dimethyl sulfoxide was added. The mixture was then shaken well at 40ºC for 90 minute after which 0.2 ml of galic acid was added to decompose the excess sodium borohydride. After cooling 4 ml of acetic anhydride and 0.4 ml of 1- Methyl imidazole were added to the solution. The mixtures were the incubated for 10 minutes at room temperature, and then 20 ml of distilled water was added to decompose excess acetic anhydride. After cooling, 8 ml of dichloromethane was added and the mixture was shaken vigorously to achieve total alditol acetate extraction. The upper layer was removed and lower phase was washed three times with 20 ml of distilled water. The dichloromethane was evaporated at 40ºC under vacuum and the final alditol acetate residue were 1 ml of dichloromethane and stored below 20ºC. Alditol acetates were separated on a 30 m × 0.25 mm ID × 0.25 µm film thickness column DB 5 ms (Agilent technologies) attached to the GC–2010 (GCM-QP 2010) shimadzu chromatography equipped with a flame-ionization detector and a split injector. High purity hydrogen was used as the carrier gas at a flow rate of 1.40 $ml.min^{-1}$, the column temperatures were maintained at 200ºC and 240ºC respectively, and a 1 µl of sample in dichloromethane was injected through a glass-lined splitter, set at 1/90 ration. The absorption was read between m/z 40 and 800.

Results and Discussion

An attempt was made to study the presence of physico-chemical parameters, elemental composition, chemical constituents, antioxidant properties and antibacterial activity of sulphated polysaccharide from the following seaweeds such as *Ulva lactuca*, *Sargassum tenerrimum*, *Sargassum cinctum*, *Sargassum myriostum*, *Padina boergesenii* and *Gracilaria edulis*. In physico-chemical analysis, carbohydrate content in the *U. lactuca* (0.955 ± 0.035 mg) shows higher concentarion followed by *G. edulis (*0.922 ± 0.033 mg) and *S. tenerrimum* (0.910 ± 0.102 mg). During the present study sulphate content was found to be maximum in *U. lactuca* (2.24 ± 0.086 mg/ml) followed by *P. boergesenii* (2.188 ± 0.099 mg/ml). The maximum pH was recorded *U. lactuca* (8.6 ± 0.0) and minimum in *S. tenerrimum* (7.15 ± 0.070) (**FIG. 2**).

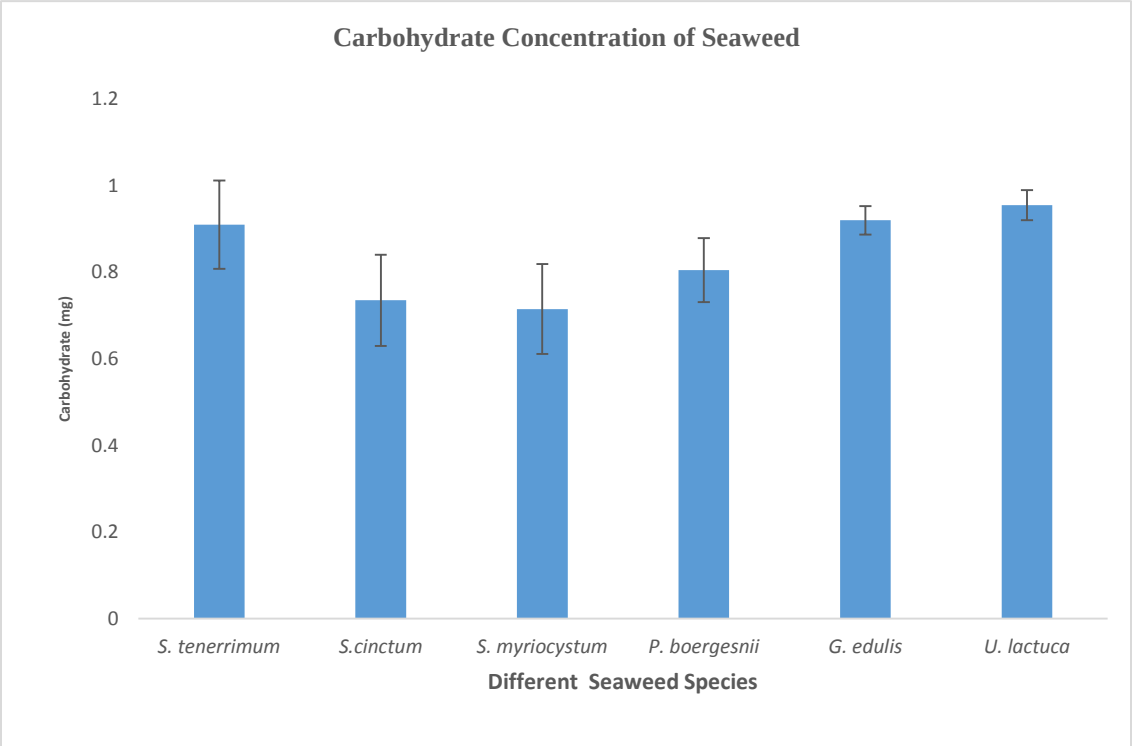

FIG. 2. **Total carbohydrate content of the different seaweeds.**

Elemental analysis was done in the present study, showed high concentration of sodium in *G. edulis* (822 ± 4.24 ppm) followed by *U. lactuca* (819 ± 5.66 ppm) (Fig. 2). Potassium concentration was obtained maximum in *P. boergesenii* (21436 ± 5.66 ppm) and minimum in *S. cinctum* (256.5 ± 4.95 ppm). The calcium of the present study shows higher concentration in *S. cinctum* (6527 ± 5.66 ppm) followed by *S. myriostum* (3824.5 ± 4.95 ppm).

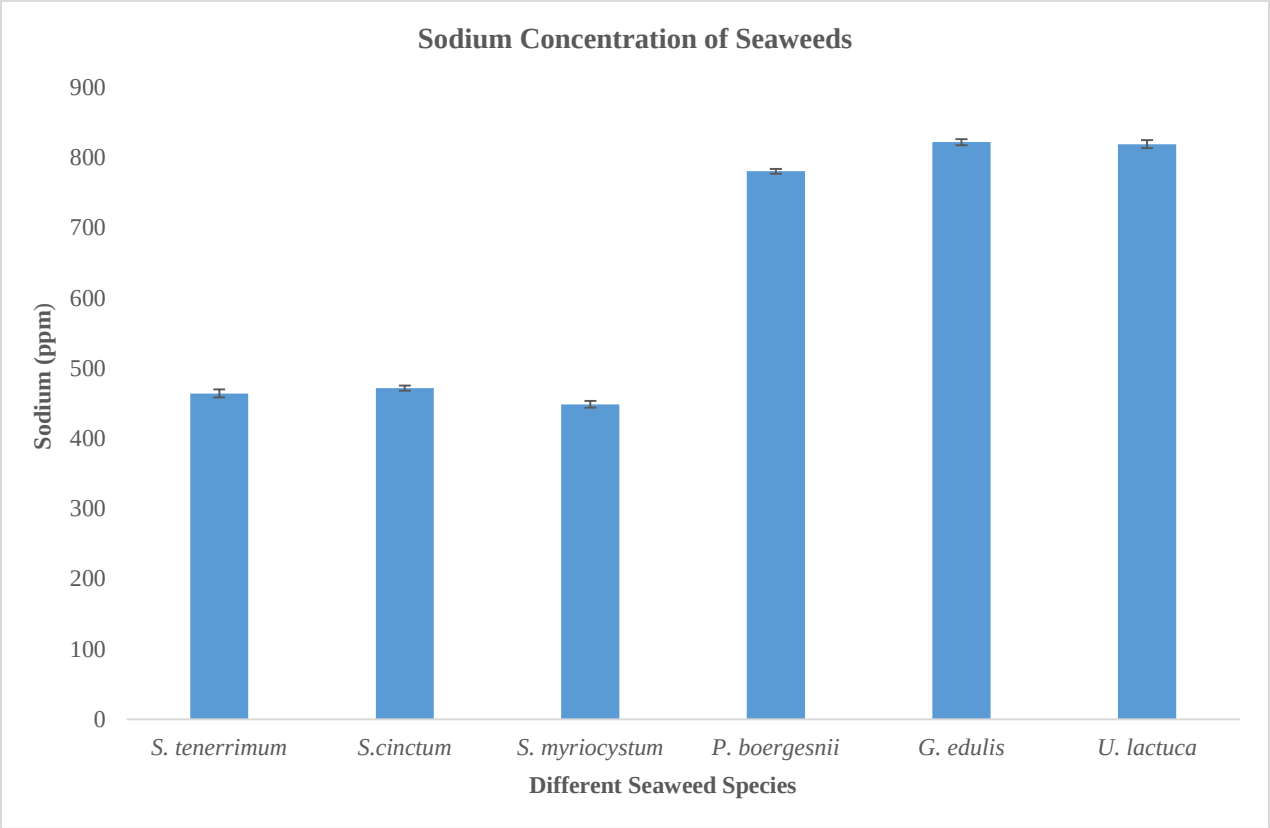

FIG. 3. **Sodium of concentration of different seaweeds species.**

The total antioxidant capacity of selected seaweeds (*U. lactuca, S. tenerrimum S. cinctum, S. myriostum P. boergesenii and G. edulis)* was measured by using ammonium molybdenum method. The total antioxidant activities were increased with increasing concentration of the sample. The diethyl ether extract at a concentration of 1000 µg/ml shows higher result in *S. tenerrimum* (41.15 ± 2.13%) than other five seaweeds such as *U. lactuca, S. cinctum, S. myriostum P. boergesenii* and *G. edulis* (**FIG. 3**).

In ethanol extract shows maximum total antioxidant activities in *S. cinctum* (32.54 ± 0.56%) than other five seaweeds like *U. lactuca, S. myriostum P. boergesenii* and *G. edulis*. During the present study, the reducing power of the sulphated polysaccharide was exhibited better result increased with increasing concentration in diethyl ether of *G. edulis* (38.67 ± 5.99%) followed by *P. boergesnii* (33.25 ± 1.06%). The reducing power of the sulphated polysaccharides by ethanol extract shows maximum activity in *S. myriocystum* (26.51 ± 0.44%).

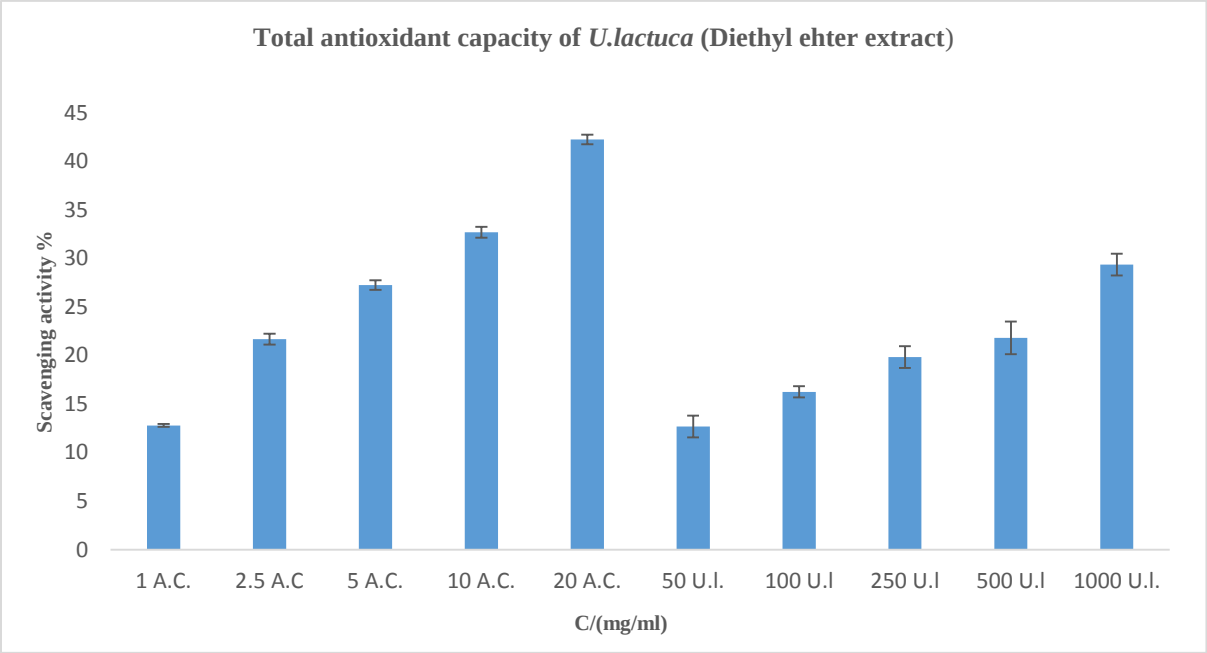

FIG. 4. **Total antioxidant capacity of sulphated polysaccharide of *U. lactuca* of diethyl ether extract (different concentration) compared with ascorbic acid standard**.

The inhibitive effect of the diethyl ether extract was subjected to a hydrogen peroxide scavenging assay was found to be maximum in *P. boergesnii* (31.14 ± 2.47%) than other seaweeds (**FIG. 4).** The ethanol extract of *U. lactuca* show better hydrogen peroxide scavenging (33.1 ± 1.11%) than other five seaweeds such as *S. tenerrimum*, *S. cinctum*, *S. myriocystum*, *P. boergesnii* and *G. edulis.*

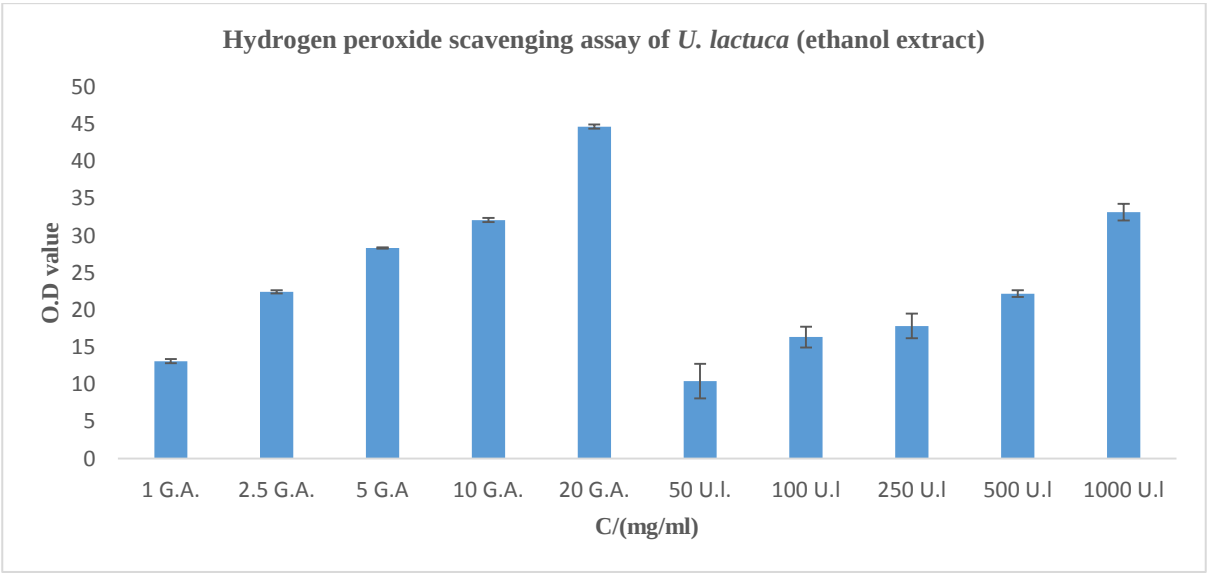

FIG.5. **Hydrogen peroxide radical scavenging activities of ethanol extract of seaweed *U. lactuca* compared with standard galic acid.**

In the present study the antibacterial activity was done by using six seaweeds (*U. lactuca, S. tenerrimum, S. cinctum, S. myriostum P. boergesenii* and *G. edulis*) with two different two solvent like ethanol and diethyl against four bacterial pathogenic strains (*Escherichia coli, Staphylococcus aureus, Pseudomonas aeroginosa, Klebsiella pneumonia)*. The ethanol extract inhibition zone was ranged from 2 mm to 15 mm. The maximum antibacterial activity of ethanol extract (15 ± 0.21 mm) was recorded in *Sargassum cinctum* against *Staphylococcus aureus* and minimum activity (2 ± 0.07 mm) obtained in *Padina boergesenii* against *Klebsiella pneumonia* (**FIG. 5**). The diethyl ether extract inhibition zone was varied from 3 to 12 mm. The maximum antibacterial activity (12 ± 0.35 mm) was obtained in *Padina boergesenii* against *Klebsiella pneumonia* and minimum activity and lowest activity (3 ± 0.07 mm) recorded in *Ulva lactuca* against *Pseudomonas aeruginosa.*

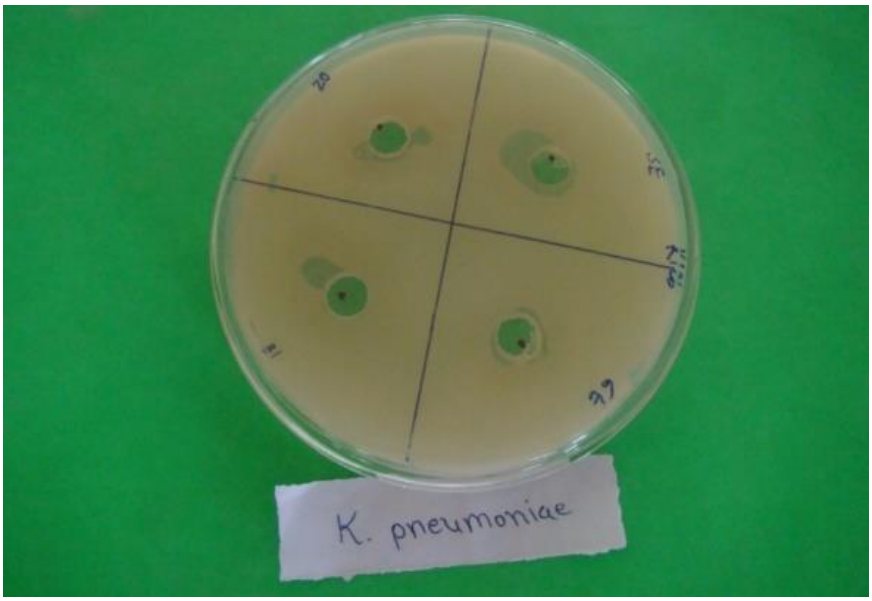

FIG. 6. **Antibacterial activity of diethyl ether extract of S. cinctum against *S. aureus*.**

Antibacterial activity of six different seaweeds (*U. lactuca, S. tenerrimum, S. cinctum, S. myriostum P. boergesenii* and *G. edulis*) against four different human pathogens (*Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumonia)* of ethanol extract in **TABLE 1.**

TABLE 1. **Antibacterial activity of ethanol extract of six different seaweeds against four human pathogens.**

	E.coli	***P. aeroginosa***	***S. aureus***	***K. pneumoniae***
U. lactuca	7 ± 0.09 mm	6 ± 0.17 mm	4 ± 0.10 mm	4 ± 0.08 mm
S. tenerrimum	6 ± 0.07 mm	8 ± 0.07 mm	3 ± 0.14 mm	4 ± 0.07 mm
S. cinctum	2 ± 0.07 mm	0	5 ± 0.07 mm	15 ± 0.21 mm
S. myriostum	6 ± 0.07 mm	0	2 ± 0.07 mm	0
P. boergesenii	5 ± 0.10 mm	0	2 ± 0.07 mm	0
G. edulis	10 ± 0.007 mm	5 ± 0.10 mm	10 ± 0.05 mm	11± 0.15 mm

Antibacterial activity of six different seaweed (*U. lactuca, S. tenerrimum, S. cinctum, S. myriostum P. boergesenii* and *G. edulis*) against four different human pathogens (*Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumonia)* of diethyl ether extract in **TABLE 2.**

TABLE. 2. **Antibacterial activity of ethanol extract of six different seaweeds against four human pathogens.**

	E.coli	***P. aeroginosa***	***S. aureus***	***K. pneumoniae***
U. lactuca	0	3 ± 0.07 mm	0	0
S. tenerrimum	0	7.0 ± 0.07 mm	8 ± 0.07 mm	0
S. cinctum	0	0	9 ± 0.07 mm	0
S. myriostum	4 ± 0.07 mm	4 ± 0.11 mm	0	5 ± 0.03 mm
P. boergesenii	0	3 ± 0.06 mm	12 ± 0.35 mm	8 ± 0.13 mm
G. edulis	0	0	6 ± 0.07 mm	9 ± 0.67 mm

In the FT- IR analysis of the six different seaweed sample (*U. lactuca, S. tenerrimum, S. cinctum, S. myriostum, P. boergesenii* and *G.edulis)* was done and functional group determined. The all six species give some effective peaks. *U. Lactuca* (**FIG. 7)** gives effective peaks 3174 cm^{-1} corresponding to amide group and sharp peaks at 3458 cm^{-1}, 3772 cm^{-1} belongs to the O-H functional group which is not hydrogen bonded in nature. *S. tenerrimum* shows peaks in the following ranges 1150-1070 cm^{-1} and 3000-2500 cm^{-1}, which belongs to the functional groups of C-O str and O-H str (ether and carboxylic acid) respectively. *S.cinctum* and *S. myriostum* were given two effective peaks 1070-1150 cm^{-1}, 3200-3400 cm^{-1}, which belongs to the category of C-O str (carboxyl) and O-H str (hydroxyl) functional groups. *P.boergesenii* gives good peaks in the range of 3200-3400 cm^{-1} its effective peaks O-H str functional groups present. *G. edulis* show the peak value near 1665-1680 in range which belongs to C=O (carboxyl) and second peaks 1450 C=C (aromatic) group.

In the present study two species of seaweeds (*S. tenerrimum* and *G. edulis*) were reported to have two compounds which identified by using a combination of a mass-spectral database and retention data. *S. tenerrimum* shows the following compounds of 1-chlorobenzene -4-(-2- hydroxybenzylidenamino (28.77%). In analytical data of GC-MS for *G. edulis* shows a chemical Octadecanoic acid (21.81%) and pentadecanoic acid (18.74%).

Seaweeds are considered to be a rich source of biologically active substance like antioxidant, anti-viral, anti-inflammatory, and anticoagulant agents. There is some evidence that seaweeds contain compounds with a relatively high antioxidant and anti-proliferative activity. Seaweeds are low in fats, but contain vitamins and bioactive compounds, like terpenoids and sulfated polysaccharides, the latter being a potential natural antioxidant not found in land plant. Sulfated polysaccharides from marine algae are known to exhibit many biological and physiological activities, including anticoagulant, anti hyperlipidemic, antiviral, anti-tumorand antioxidant activities [10,11] .

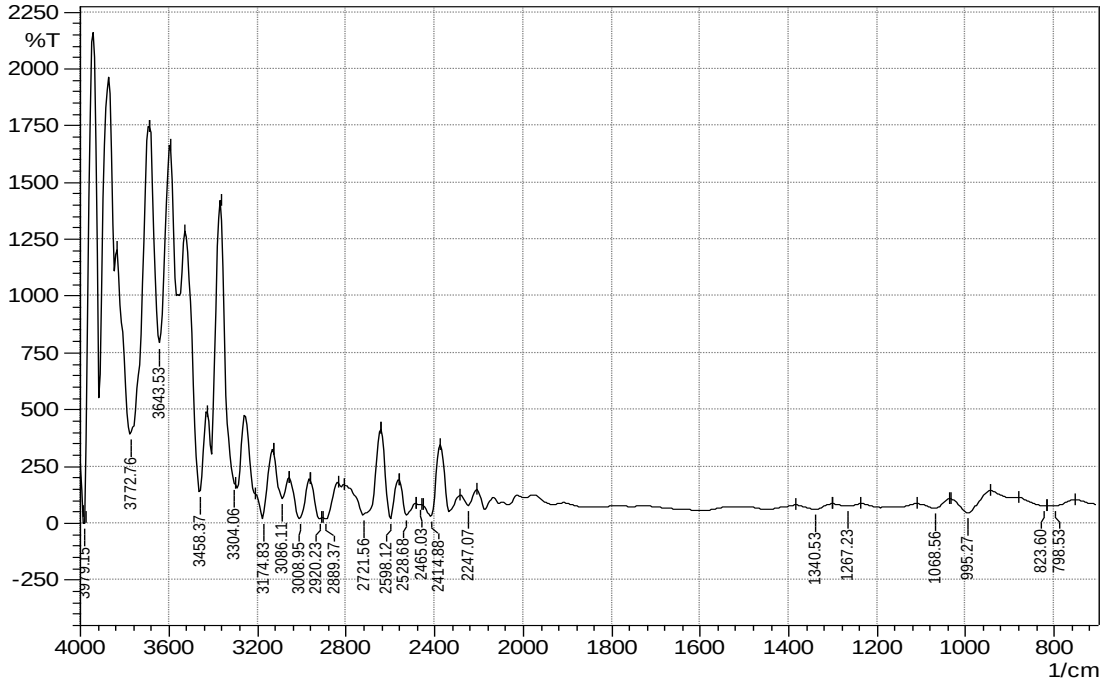

FIG.7. **FT-IR analysis of sulphated polysaccharide of *U. lactuca.***

Previous studies have been indicated that the polysaccharide bioactivities depend on the degree of sulfation [12]. The above mentioned investigations were similar to present study; here the sulphated polysaccharides from six different seaweeds (*Ulva lactuca*, *Sargassum tenerrimum*, *Sargassum cinctum*, *Padina boergesenii* and *Gracilaria edulis*) exhibited excellent bioactivities such as antibacterial and antioxidant activity. The previous studies of crude extracts of the green algae *Ulva lactuca* showed higher activity against certain human pathogens. The same phenomenon was also observed in another species of *Ulva fasciata* against oral pathogens [13]. Priyadharshini have been studied antibacterial activity of some selected green seaweeds against fish pathogens. Most of the marine algae showed moderate to high level activity against *Staphylococcus aureus* [14]. The earlier investigations are contrast to the present study; here ethanol of *S. cinctum* (brown algae) shows superior antibacterial activity against *Klebsiella pneumonia* followed by diethyl ether extract of brown algae *P. Boergesenii* against *Staphylococcus aureus*. Whereas extract of brown algae *Stocheospermum marginatum* exhibited higher level of activity against *Klebsiella pneumonia* [15] elongate showed maximum activity against *Listeria monocytogenes* [4]. The previous investigations [4,15] indicated that brown algae exhibited maximum antibacterial activity against *Klebsiella pneumonia*, present study similar to earlier investigation, here brown algae of *S. cinctum* shows good result against the same pathogen (*Klebsiella pneumonia*).

In the reducing power assay, antioxidants in the sample reduce ferric (III) to ferrous (II) in a redox linked colorimetric reaction that involves single electron transfer, the reducing power indicates that the antioxidant compounds are electron donors and reduce the oxidized intermediate of the lipid peroxidation process, so that they can act as primary and secondary antioxidants. Concentration dependency of antioxidant activity was investigated as a function of reducing power as this gave a general view of reductions present in the sample. Reducing power increased with increasing concentrations in all the samples. In the present study also reducing power increased with increasing concentration, maximum reducing power value

was observed in 1 ml concentration of *G. edulis* (38.67 ± 5.99). The present results are in agreed with Matsukawa [7] who found that the antioxidant activity of brown algae was superior to that of red or green groups.

There are some reports in the literature of antioxidant capacity seaweeds. Alcoholic and aqueous extracts of seaweeds have been evaluated for antioxidant activity by lipoxygenase inhibition, DPPH assay, and deoxyribose assays [9,16]. Recently, several marine alginate derivatives, sulfated fucoidans from the brown seaweed *Laminaria japonica,* agar-like sulfated galactans from *Fucus vesiculosus* have been reported to have antioxidant activity [17].

Synthetic drug are notably more hazardous, and their continuous use has affected the ecosystem to a considerable extent, due to their high persistency and constant accumulation in the biological system. To overcome this considerable effect, investigation is being carried out to develop safer source of disease control agents from algal sources. Caccames recorded that the family phaeophyceae showed the highest antibacterial activity. The present study similar to the above mentioned statement, study exhibited superior antibacterial activity from ethanol extract Phaeophyceae members (*S. cinctum* and *P. boergesnii*). The crude sulphated polysaccharide from several algae were reported to inhibit only gram positive bacteria, e.g. *P. gymnospora* and *Dictyotadichotoma* extract, while *Hypneamusciformis* extract showed activity against *salmonella typhae* para-A [18]. The antibacterial activity result similar to that the Helloi who found that *S. muticum* extracts inhibited both of gram positive and gram negative bacteria. In the present study this is similar to earlier investigations, *S. cinctum* shows good antibacterial activity both result gram positive and gram negative bacteria. Total antioxidant activity of *T. ornata* phosphor molybdenum method. The results showed that *T. ornata* have the antioxidant activity of (88.17 ± 1.39)%. Oxidative damage within the cellular systems is a multi-step process involving free radical chain initiation and propagation steps. This is similar in the present study from *P. Boergesenii* extract. One of the mechanisms by which antioxidants bring about their action is by scavenging free radicals. Hence it is important to assess the scavenging ability of the brown seaweed extract. Hydrogen peroxide is a weak oxidizing agent and can inactivate a few enzymes directly, usually by oxidation of essential thiol (SH) groups. H_2O_2 can cross cell membranes rapidly and once inside the cell it can react with Fe^{2+} and possibly Cu^{2+} to form hydroxyl radicals and this may be the origin of many of toxic effects. It is therefore, advantageous for cells to control the amount of hydrogen peroxide that is allowed to accumulate. In the present study, a strong anti- H_2O_2 activity was observed from *U.lactuca* (33.17 ± 1.1%) when compared with other the species like *S. tenerrimum* (29.53 ± 0.52%), *S. cinctum* (29.27 ± 0.99%), *S. myriostum* (22.92 ± 0.62%), *P. boergesenii* (31.14 ± 2.47), and *G. edulis* (26.87 ± 0.37).

Conclusions

Seaweeds have several active chemicals such as antioxidant and antibacterial compounds. In this research, the antioxidant and antibacterial activity of selected seaweeds (*U. lactuca, S. tenerrimum, S. cinctum S. myriostum and P. boergesenii, and G. edulis*) from the Vadinar coast (Jamnagar, Gujarat) was investigated. The seaweeds are currently undergoing detailed investigations with the objective of isolating biologically active molecules along with the search for new compounds. Moreover, it indicated that the Vadinar coast is a potential area of a variety of biologically active seaweeds and it is hope that the present results will provide a starting point for investigations aimed at exploiting new natural antioxidant and antibacterial substances present in the extracts of seaweed collected from Vadinar coast.

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