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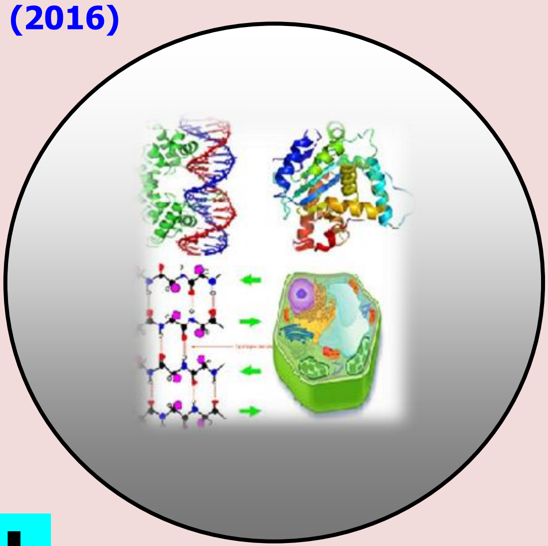

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RESEARCH PAPER

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Macroalgae of the Red Sea from Jizan, Saudi Arabia

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ABSTRACT

Red sea stretches along the border of the Jizan province of Saudi Arabia and is a habitation of diverse groups of marine macroalgae. These algae are economically important not only as feed, fodder, but are also medicinally, industrially and pharmaceutically important .This is the first study to collect and identify the diverse groups of macroalgae inhabiting the red sea coast of Jizan province, Saudi Arabia. The algal samples were collected from five different places i.e. Jizan, Al Shuqaiq, Al Huraidha, Al Qahma and Al Birk of the province during January to April 2018. The collected samples were preserved in formaldehyde solution in plastic containers and also as dry herbarium specimens. The algae were identified by morphological characters like the pigment, structure of the vegetative thallus along with reproductive and other characters using identification manuals and key's to identification. The macroalgae collected during this study belong to three major classes Chlorophyta, Phaeophyta and Rhodophyta. A total of sixteen genera were studied. The Chlorophyta included three genera namely Cladophora, Derbesia and Ulva. The Phaeophyta was represented by seven genera namely Fucus, Hormophysa, Laminaria, Macrocystis, Padina, Sargassum and Turbinaria. Rhodophyta was represented by six genera namely Acanthophora, Galaxaura, Hypnea, Laurentia, Gelidium and Microcladia. Phaeophyta was the predominant class with the highest number of genera. Sargassum was the most predominant and frequently occurring genera with ten species collected during this study. All the macro algae collected during this study are economically important. They are used medicinally, industrially and pharmaceutically. Hence these algae can be collected and then utilized in various ways to get the maximum benefits with low cost thereby helping in the improvement of the health and economic position of the country.
Key words: Macroalgae, Red Sea, Jizan and Saudi Arabia.

INTRODUCTION

Jizan including many regions of the province are located at the Rea sea coast which is a rich reservoir of diverse groups of flora of macroalgae. This study is aimed at exploring the biodiversity of the marine macroalgae of the red sea bordering the red sea coast of Jizan, Al Shuqaiq, Al Huraidha, Al Qahma and Al Birk during January to April 2018. There has been no study of macroalgae from the province. The Red Sea (also the Erythraean Sea) is a seawater inlet of the Indian Ocean, lying between Africa and Asia. The Red Sea has a surface area of roughly 438,000 km^2 (169,100 mi^2), is about 2250 km (1398 mi) long and, at its widest point, 355 km (220.6 mi) wide. It is the world's northernmost tropical sea.

Red sea borders the major cities of southern and western Saudi Arabia extending with the Southern tip at Jizan province. The long coastline provides an extensive sea shore harbouring a large number of algal flora.

Algal collections were obtained from 6 localities along the eastern coast of the Arabian Gulf of Saudi Arabia (Map 1) namely: Ras Tanura, Safwah, Al Qatif, Sayhat, Ad Dammam and Al Aziziyah. Specimens were collected in different seasons during the years 2003- 2006. The collected samples were processed as herbarium specimens on the same day of collection; others were preserved in 5% formalin in sea water.(Mohamed S.M. Abdel-Kareem, 2009).

The first to collect marine algae from the Saudi Arabian Red Sea Coast, was the Danish botanist and explorer Pehr Forsskal (1775) who, in the month of November 1762, made a collection of seaweeds from the Sea of Jeddah to Egypt and Arabia (A. A. Aleem, 1978).

Macroalgae (or seaweeds) are multicellular plants growing in salt or fresh water. They are often fast growing and can reach sizes of up to 60 m in length [34]. Macroalgal species primarily occur in near-shore marine coastal waters, where they grow attached to rocks or suitable substrates. In these conditions, some species can form stable, multi-layered and perennial vegetation. These organisms have been recognized as essential components for preserving the biodiversity of marine ecosystems [23, 35]. 9 In addition, macroalgae can be found in the open ocean, sea and freshwater habitats as floating forms. Asian countries (75% of global production occurs in China) mainly to produce food and hydrocolloids for the food, pharmaceutical and chemical industries. Almost all (99%) of cultivated species belong to the red and brown groups, as they can be used in different industries. Reproduction is authorized provided the source is acknowledged (Stefania Rocca; Alessandro Agostini; Jacopo Giuntoli; Luisa Marelli; 2015).

Very few papers, based on taxonomic source, were published dealing with the marine algal flora of the Arabian (Persian) Gulf (Mohamed S.M. Abdel-Kareem, 2009).This study is an attempt to collect and preserve the major economically important macroalgae from five regions of Jizan Province . The samples were collected from the Sea shores of Jizan , Al Shuqaiq, Al Huraidha , Al Qahma and Al Birk.The macroalgae collected during this study from the various places during this study are economically important in various ways .These algae are economically important not only as feed , fodder , but are also industrially and pharmaceutically important .This is the first study to collect and identify the diverse groups of macroalgae inhabiting the red sea coast of Jizan province , Saudi Arabia.

The macroalgae collected and identified during the study belonged to the three major classes of algae Chlorophyceae, Phaeophyceae and Rhodophyceae. The marine algal flora of the Arabian (Persian) Gulf received little attention than other marine wate rbodies. In this paper a total of 26 species are reported for the first time as occurring in the Arabian Gulf coastof Saudi Arabia, including 13 species as new records for the Gulf. These species related to Chlorophyceae (8), Bacillariophyceae (6), Phaeophyceae (4) and Rhodophyceae (8). Description of these newly reported species were provided in the text (Mohamed S.M. Abdel-Kareem, 2009). Seaweeds have been one of the richest and most promising sources of bioactive primary and secondary metabolites and their discovery has significantly expanded in the past three decades. The algae synthesize a variety of compounds such as carotenoids, terpenoids, xanthophylls, chlorophyll, vitamins, saturated and polyunsaturated fatty acids, amino acids, acetogenins, antioxidants such as polyphenols, alkaloids, halogenated compounds and polysaccharides such as agar, carrageenan, proteoglycans, alginate, laminaran, rhamnan sulfate, galactosyl glycerol and fucoidan (Cynthia Layse F. de Almeida, 2011). These compounds probably have diverse simultaneous functions for the seaweeds and can act as allelopathic, antimicrobial, antifouling, and herbivore deterrents, or as ultraviolet-screening agents. They are also used by the pharmaceutical industry in drug development to treat diseases like cancer, acquired immune-deficiency syndrome (AIDS), inflammation, pain, arthritis, infection for virus, bacteria and fungus (Cynthia Layse F. de Almeida, 2011). Seaweeds are rich in soluble dietary fibers, proteins, minerals, vitamins, antioxidants, phytochemicals, and polyunsaturated fatty acids, with low caloric value. They are an excellent source of vitamins A, B_l, B_2, B_3, B_{12}, C, D., E. Their amino acid content is well-balanced and contains all or most of the essential amino acids needed for life and health. Moreover, biologically active compounds isolated from marine macroalgae exhibit various biological activities such as antioxidant, anti-viral, anti-allergic , anti-inflammatory ,anti-cancer ,anti-coagulant (Subhash R. Yende, Uday N. Harle and Bhupal B. Chaugule, 2014).

Seaweeds have come up step by step starting with using them as food, later as raw material for industrial, medicinal, pharmaceutical and cosmetic purposes associated with their high contents of protein, polysaccharides, minerals, essential fatty acids, carotenoids and vitamins which are related to several environmental factors . Marine algae contain more than 60 trace elements in a concentration, which are much higher than that in terrestrial plants and have various pharmacological activities.

The Red Sea is a rich and diverse ecosystem. The rich diversity is in part due to the 2 000 km of coral reef extending along its coastline. Over 500 species of seaweeds have been recorded in the Red Sea. *T. ornata* and its associated seaweeds were collected, identified and their abundances were estimated.. This alga is a perennial brown alga native to coral reef ecosystems in tropical areas of the Pacific and Indian Ocean. Biochemical composition of *T. ornata* reveals their suitability to be a good source for human consumption. Brown algae are economically valuable (Mohamed Ali Deyab, Fatma Mohamed Elnabawy Ward, 2016).

Commercial production and exploitation of specific compounds with interesting biotechnological importance from marine macroalgae including microbicides, nematicides, insecticides, biofertilizers, biostimulators and soil conditioners are highlighted and discussed in detail. Bioactive compounds like fatty acids (in particular polyunsaturated fatty acids (PUFAs), proteins (amino acids), bioflavonoids, sulfated polysaccharides, carotenoids, polyphenols and carbohydrates are considered to have bactericidal, antiviral and fungicidal effects against some plant-infecting pathogens. These biocontrol agents provide multiple benefits and act as useful pointers for improving cultivation practices in diverse habitats. Marine macroalgae can be generally considered as promising multifunctional bioinoculants and ecofriendly environmental tools in recent trends of organic farming .Recent investigation of de Corato et al., (2017) also demonstrated that high contents of fatty acids in marine macroalgae (e.g. *Laminaria digitata, Undaria pinnatifida* and *Porphyra umbilicalis)* may have a role in fungal treatment For example*, Gelidium serrulatum, Sargassum filipendula* and *Ulva lactuca* extracts showed induced jasmonate signaling defense systems (Ramkissoon et al., 2017) (Seham M. Hamed, Amal A. Abd El-Rhman, Neveen Abdel-Raouf, Ibraheem B.M. Ibraheem, 2018).

Marine-based bioactive compounds can be derived from a vast array of sources, including marine plants, macro- and microalgae, microorganisms, and sponges, all of which contain their own unique set of biomolecules. Macroalgae, known also as seaweeds, produce many biologically active phytochemicals, which include among others, carotenoids, terpenoids, xanthophylls, chlorophylls, phycobilins, polyunsaturated fatty acids, polysaccharides, vitamins, sterols, tocopherol and phycocyanins. They are used as food, fodder, feed and fertilizer and many of the bioactive compounds produced by the macroalgae are known to have potential beneficial use in healthcare (Matteo Francavilla, Massimo Franchi, Massimo Monteleone, and Carmela Caroppo, 2011).

Different species of collected algae were cleaned with seawater to remove impurities. The seaweeds were transported to the laboratory in sterile polythene bags (Shimaa M. El Shafay, Samh S. Ali, Mostafa M. El-Sheekh, 2016).

The city of Algal samples were handpicked, washed thoroughly with seawater to remove all the impurities, sand particles and epiphytes. They were transported in an icebox to the microbiology laboratory, KSU, Riyadh, identified .Samples were washed thoroughly using tap water and then with sterile distilled water to be air dried at room temperature (Nadine M.S. Moubayed , Hadeel Jawad Al Houri, Manal M. Al Khulaifi, Dunia A. Al Farraj, 2017).

The algae were identified by morphological characters like the pigment, structure of the vegetative thallus along with reproductive and other characters using identification manuals and key's to identification.

Marine algae were reported to produce a wide variety of bioactive secondary metabolites as antimicrobial, antifeedant, antihelmintic and cytotoxic agents and the bioactive substances included alkaloids, polyketides, cyclic peptide, polysaccharide, phlorotannins, diterpenoids, sterols, quinones, lipids and glycerols (Cabrita et al., 2010)and marine macro-algae are considered as the actual producers of some bioactive compounds with high activity (Shimizu,1996). The antibacterial activities of four important seaweeds namely *Ulva lactuca, Padina gymnospora, Sargassum wightii* and *Gracilaria edulis* were screened against human bacterial pathogen (Vallinayagamet al., 2009). Extracts from algae from Indian waters Dictyota dichotoma, and Padina gymnosora were reported to be effective against *Bacillus megatherium* and *S. aureus* (Rao et al., 1977) (Sarah Saleh Abdu-llah Al-Saif, Nevein Abdel-Raouf, Hend A. El-Wazanani, Ibrahim A. Aref , 2014).

Due to increased interest in bio-fuels and food supplements of algal origin, in the recent times, there is widening scope for industries to exploit the availability of other algal products, mainly dyes, fodder and bio-plastics (http://www.clarku.edu/faculty/robertson/Laboratory%20Methods/Pigments.html).

Fucus is an important source of alginates and iodine .These algae provide food and shelter for unique communities of marine animals and microbes and lead to rates of primary productivity in the open oceans far higher than would be possible if the phaeophytes were absent (Kingdoms and Domains (Fourth Edition), 2009).

Iodine is also accumulated in the ocean by brown algae, mostly the *Laminaria* genus, red algae, *Rhodophyta,* and some sponges (Ethan M. Cox, Yuji Arai, 2014). *Laminaria* is a sea weed rich in iodine, iron and potassium. It is medicinally important in thyroid hormone regulation, weight loss, blood pressure, laxative and also in the treatment of cancer.

Sodium laminarin sulphate and fucoidin, were used as blood coagulants.Marine algae represent an important source of novel natural products. While their bioactive potentialhas been studied to some extent, limited information is available on marine algae from the Red Sea.Marine organisms have proven to be a rich source of novel and promising bioactive molecules for awide range of applications, including new therapeutics, cosmetics, and biotechnology .Marine algae havebeen shown to harbor a plethora of activities, including anti-neoplastic, anti-viral, anti-biotic, antioxidant, and anti-inflammatory effects, and in addition have multiple applications in nutrition and cosmetics . Natural products in general are a major source of compounds for the treatment of cancer with more than 75% of anti-cancer drugs in clinical trials being either derived or at least inspired by nature. In this respect, marine algae play a special role as they are an increasingly important dietary constituent in large parts of the world and are discussed as potential medicinal foods in the management of cancer (Stephan Kremb, Constanze Müller, Philippe Schmitt-Kopplin, and Christian R. Voolstra, Sylvia Urban, 2017). It is widely recognized that certain species of algae can be used in human therapeutics .for example sodium laminarin sulfate and fucoidin, were used as blood coagulants. Few papers were published regarding the distribution of the algal species along the Red Sea. (A.N. Khalil, B.A.H.El Tawil, 1982).

Brown alga *Hormophysa cuneiformis* collected from south coast of Arabian Gulf (Ad Dammam seashore), has been shown to possess a specific antimicrobial and anti-hyperlipidemic activities (Neveen Abdel-Raouf, Nouf Mohammad Al-Enazi, Ibraheem B.M. Ibraheem, Reem Mohammad Al-Harbie, 2015). Giant kelp *(Macrocystis pyrifera*) is the fastest growing organism on the planet. In ideal conditions, Macrocystis can grow up to 2 feet in a single Giant kelp is widely used in cosmetic and food industries as a thickening agent in products like toothpaste, ice cream, and makeup. Giant kelp is also being targeted as a possible bio-converter into ethanol as a fuel source for cars and boats (CIMI BLOG, 2017). Some species of *Sargassum* and probably *Turbinaria* and *Hormophysa* are used as fertilizers and additives in poultry and cattle feed.*Laminaria* is a type of seaweed that is native to Japan. It contains iodine, an element that the body needs to make thyroid hormones. It is also a rich source of iron and potassium. The *Phaeophyta* is represented by many species of *Sargassum*. It is the most commonly growing alga found floating and growing near the seashores. *Sargassum* species are found throughout tropical and subtropical areas of the world and are reported to produce metabolites of structural classes such as terpenoids, polysaccharides, polyphenols, sargaquinoic acids, sargachromenol, plastoquinones, steroids, glycerides etc., which possesses several therapeutic activities (Subhash R. Yende, Uday N. Harle, and Bhupal B. Chaugule, 2014). The effect of extracts of the brown algae *Cystoseira myriophylloides*, *Laminaria digitata*, and *Fucus spiralis* against the tomato pathogens *Verticillium dahliae* and *Agrobacterium tumefaciens* was evaluated in vitro and in the greenhouse(Siham Esserti, Amal Smaili, Lalla Aicha Rifai, Tayeb Koussa, Kacem Makroum, Malika Belfaiza, El Mostafa Kabil, Lydia Faize , 2017).

In addition, Basson [15] provided a checklist of the marine algae of the Arabian Gulf in which he reported a total of 207 taxa. . A total of sixteen genera were studied. The *Chlorophyta* included three genera namely *Cladophora , Derbesia and Ulva .The Phaeophyta* was represented by seven genera namely *Fucus, Hormophysa, Laminaria , Macrocystis , Padina , Sargassum* and *Turbinaria . Rhodophyta was* represented by six genera namely *Acanthophora , Galaxaura, Hypnea , Laurentia, Gelidium* and *Microcladia .Phaeophyta* was the predominant class with the highest number of genera. Four macroalgae (*Dictyota* sp., *Sarcodiotheca furcata*, *Cystoseira myrica* and *Sargassum ramifolium*) were tested for their antimicrobial activities. Algal extracts were more effective against Gram negative bacteria than Gram positive bacteria and fungi (Mostafa M. El-Sheekh1, Mohamed M. Gharieb, Sabha M. El-Sabbagh, Walaa T. Hamza, 2014). *Sargassum* was the most predominant and frequently occurring genera with ten species collected during this study. In a previous work, the author reported 12 *Sargassum* species for the first time as occurring in the Arabian Gulf coast of Saudi Arabia, including 7 species as new records for the Gulf (Mohamed S.M. Abdel-Kareem, 2009). The present study demonstrates the antibacterial activity of selected brown and green marine algae collected from Saudi Arabia Red Sea and Arabian Gulf. Both brown seaweed species *Sargassum latifolium B* and *Sargassum platycarpum* A methanolic extracts were found to be active against gram positive than gram negative; however, *S. latifolium* acetone extract gave the highest inhibitory activity against *Salmonella sp*. (Nadine M.S. Moubayed , Hadeel Jawad Al Houri, Manal M. Al Khulaifi, Dunia A. Al Farraj, 2017).

This study evaluates the antibacterial activity of diethyl ether, methanol, ethanol and chloroform extracts of red algae *Ceramium rubrum (Rhodophyta), Sargassum vulgare, Sargassum fusiforme* and *Padina pavonia (Phaeophyta)* collected from Red sea, Egypt. The algal extracts were tested for their antibacterial activity against ten multidrug resistant clinical isolates of Gram positive and Gram negative bacteria (Shimaa M. El Shafay, Samh S. Ali, Mostafa M. El-Sheekh, 2016).In the present study, marine algae were collected from the southern coast of Jeddah, Saudi Arabia during summer and autumn 2009. The antibacterial activities of petroleum ether, diethyl ether, ethyl acetate and methanol extracts of marine algae belonging to the *Chlorophyta, Phaeophyta* and *Rhodophyta* were studied. The maximum inhibition activities were shown for extracts of *Padina pavonica* and *Turbinaria triquetra*. The growth inhibitions of bacteria by S*argassum portieriatum* extracts were higher in samples collected during autumn than that investigated in summer. The maximum inhibitory effect of *Gracilaria multipartita* was observed in the petroleum ether extract against *B. subtilis* and *E. coli.* The ethyl acetate and petroleum ether extract of *Enteromorpha prolifera* and *Ulva reticulata* showed strong activity against the tested bacteria. (H. H. Omar1, H. M. Shiekh, N. M. Gumgumjee, M. M. El-Kazan and A. M. El-Gendy, 2012)

Dictyota dichotoma, D. divaricata, Dilophus fasciola and *Gelidium atifolium* were found to have considerably higher levels of iodine indicating that these species, rather than the others are potentially a better source of iodine. Iodine was accumulated selectively by various organs of *Sargassum salicifolium* and *S. subrepandum*. Generally speaking, the leaves of two species of *Sargassum* had higher content of iodine that did the stipes. In contrast, *Turbinaria triquetra* exhibited no well marked differences in iodine levels between leaves and stipes(M.E.E. EL-NAGGAR , 1995).

Moreover, with the growing use of *Padina* species for heavy metal biosorption in the case of P. pavonica (Linnaeus) Thivy (Raize 2003) and for environmental remediation like P. boergesenii Allender and Kraft (Dulymamode et al. 2001), it is becoming very important to study its taxonomy as different species may have different physico-chemical composition that will in turn affect their physiological performance (Paul John L. Geraldino, Lawrence M. Liao and Sung Min Boo, 2005).

Biochemical composition of *T. ornata* reveals their suitability to be a good source for human consumption [10]. Brown algae are economically valuable seaweeds as a source of raw material for the extraction of polysaccharides (e.g. alginate, laminaran, cellulose and fucoidan)(Mohamed Ali Deyab, Fatma Mohamed Elnabawy Ward ,2016).

Macrocystis is commercially important seaweed. *M.pyrifera* has been utilized for many years as a food source;[18][19] it also contains many compounds such as iodine, potassium, other minerals vitamins and carbohydrates and thus has also used as a dietary supplement (http://eol.org)

*Turbinaria ornata*has high contents of protein, alginates, agar carotenoids, vitamins, minerals and heavy metals .Marine macroalgae are plant-like organisms with simple internal structures that generally live in coastal areas. They mainly include different communities of red, brown and green macroalgae. Marine macroalgae commonly occupy intertidal and sublittoral-to-littoral zones on rocks and other hard substrata. They are considered to be an excellent natural biosource in different aspects of agricultural fields. They have great proficiency in improving soil physical and chemical properties. Marine macroalgae are also characterized by producing a large array of biologically active biocidal substances against plant-infecting pathogens(Seham M. Hamed , Amal A. Abd El-Rhman, Neveen Abdel-Raouf , Ibraheem B.M. Ibraheem, 2018).

A. spicifera is eaten as a vegetable in parts of the Pacific including Fiji (South, 1993) and Vanuatu (Dixon and Kraft, 2007). In India, culture and utilization of *A. spicifera* has been explored (Ninwe, 1997), including culture as a source of additional income for local fishermen during the monsoon (Mohammed, 2000).

A. spicifera is one of a number of marine macroalgae studied to show that they could be utilized as a source of natural antioxidant compounds on the basis of crude extracts and fractions exhibiting antioxidant activity (Ganesan et al., 2008). This species has also been used in anti-cancer research/drug development https://www.cabi.org/2018).

Mustafa and Nakagawa (1995) investigated the importance of algae as ingredients in fish feed. For aquafeeds, numerous studies determined the inclusion level of various seaweed species: *Ulva* (Wassef et al., 2001), *Sargassum spp.* (Casas-Valdez et al., 2006), *Gracilaria bursa-pastoris*, *Gracilaria cornea* and *Ulva rigida* (Valente et al., 2006), and *Padina arborescens*, *Sargassum siliquastrum* (Ma et al., 2005). Most of these investigations summarized encouraging results for the use of seaweed as a partial substitution of fishmeal in aqua feeds (Nasser A. Al-Asgah, El-Sayed M. Younis,Abdel-Wahab A. Abdel-Warith, and Faozi S. Shamlol).

The aim of the present study was to test integrated aquaculture of seaweed and marine fish *(Oreochromisspilurus*) for the first time in Saudi Arabia and to determine the seaweeds, *Ulva lactuca* and *Gracilariaarcuata*. Both seaweeds are suitable for integrated aquaculture and bioremediation, (Yousef S. Al-Hafedh, Aftab Alam , Alejandro H. Buschmann and Kevin M. Fitzsimmons, 2012).

Tank-based integrated technique for bio-remediation of effluents using the red alga, *Gracilaria arcuata*, and the green alga, *Ulva lactuca*, both of which are available in the Red Sea off the Jeddah coast of Saudi Arabia. Aquaculture entrepreneurs in Saudi Arabia may consider a possible reduction of feed concentrations in seawater effluent and a chance to diversify the materials of production in changing market status as offering the possibility for additional sources of income. This work is highly relevant to a developing aquaculture industry in Saudi Arabia (FAO, 2010) and to reducing the environmental dangers to an oligotrophic sea that has a high level of biodiversity (Khalil and Abdel-Rahman, 1997, Baars et al., 1998). Mustafa and Nakagawa (1995) investigated the importance of algae as ingredients in fish feed. For aquafeeds, numerous studies determined the inclusion level of various seaweed species: *Ulva rigida* (Valente et al., 2006), and *Padina arborescens*, *Sargassum siliquastrum* (Ma et al., 2005). Most of these investigations summarized encouraging results for the use of seaweed as a partial substitution of fishmeal in aqua feeds (Nasser A. Al-Asgah,a El-Sayed M. Younis,a, Abdel-Wahab A. Abdel-Warith, a, b and Faozi S. Shamlola, 2016).

The world's first source of agar, from the middle of the seventeenth century, was *Gelidium* from Japan, but by the beginning of the twentieth century demand for the phycocolloid exceeded of the supply of this alga. This does not show the synergistic reaction with locust bean gum apparent with *Gelidium* agar (Armisen, R. J Appl Phycol, 1995)

"*H. musciformis* is an important carrageenan resource of Brazil used in the industry of phycocolloid gelling agent" (Bravin and Yoneshigue-Valentin, 2002).*H. musciformis* is reported to be present in, Egypt (Red Sea), Jordan, Saudi Arabia, Yemen. (Guiry & Dhonncha, 2005). Since its introduction, *H. musciformis* has become a staple food source for the green sea turtle (see *Chelonia mydas* in IUCN Red List of Threatened Species Salimabi (1980) found that, "Pharmacological studies on K-carrageenan extracted from *H. musciformis* have shown that it antagonizes histamine-induced spasm in guinea pig ielum and possesses anti-inflammatory activity against rat hind paw oedema induced by commercial carrageenan (Bravin and Yoneshigue-Valentin, 2002), (Masuda *et al.*1997 in Reis & Yoneshigue-Valentin, 2000) (Marit Ruge Bjaerke).

Gelidium J.V. Lamouroux is the largest genus of the order *Gelidiales (Rhodophyta)* with 123 species (Kim *et al.* 2011a; Guiry & Guiry 2011) including *G. corneum* (Hudson) J.V. Lamouroux, which was designated the type by Schmitz (1889). The diverse uses of this genus as food, agar, biofuel and paper pulp have increased interests in its member species (Jeon *et al.* 2005; Seo *et al.* 2010). *Gelidium* is distributed globally in tropical, subtropical, temperate and even some polar regions (Freshwater & Rueness 1994; Millar & Freshwater 2005).

Since its introduction, *H. musciformis* has become a staple food source for the green sea turtle SuriaLink (2003) The University of Hawai'i (UNDATED) states that, "*H. musciformis* is often found as an epiphyte on reef algae such as *Sargassum echinocarpum*, *Sargassum polyphyllum*, and *Acanthophora spicifera*." "*H. musciformis* is an important carrageenan resource of Brazil used in the industry of phycocolloid gelling agent" (Bravin and Yoneshigue-Valentin, 2002) (National Biological Information Infrastructure (NBII & IUCN/SSC).

To investigate some selected metabolic constituents of *Hypnea valentiae* (Turner) Montagne collected from the Red Sea coast of Sudan to evaluate the economic potential of the alga. The protein, lipid, and carrageenan constituted (9.30 ± 0.70) %, (6.50 ± 0.34) %, and (33.70 ± 0.01) %, respectively of the alga dry matter. Phytochemically the alga contained alkaloids, flavonoids and tannins. The major saturated fatty acids was the heptadecanoic acid. This alga may represent a promising source of functional food and therapeutic metabolites. (Nahid Abdel Rahim Osman ,Mona Mohamed Alhassan ,Braa Karar Abas, 2016).

The seaweed samples were enriched in essential amino acids, ω3 and ω6. The results exposed that these seaweed species contain high nutritive value and are promising in the field of pharmaceuticals and industry (Hanan Omar ,Molouk Mohamed El-Kazan , Adel El-Gendy, 2013).Red algae genus *Laurencia* is an interesting alga with the ability to produce halogenated secondary metabolites that exhibits ecological and pharmaceutical potential (K Palaniveloo - 2014). Three new laurene-type sesquiterpenes, 12-hydroxy isolaurene (1), 8, 11-dihydro-12-hydroxy isolaurene (2) and isolauraldehyde (3) were isolated from the organic extract of the red alga *Laurencia obtusa*. The newly isolated compounds were tested for their antimicrobial and antitumor activities. (Walied M. Alarif a,Sultan S. Al-Lihaibi a, Seif-Eldin N. Ayyad b, Mohamed H. Abdel-Rhman c, Farid A. Badria d , 2012) .

All the macro algae collected during this study are economically important. They are used medicinally as antibiotics, anti cancer, anti coagulants and anti oxidants etc. Industrially they are used as biofuels, bioplastics, biofertilizers, bioremediation for preparation of agar, dyes, paints and as cosmetics etc. They are also pharmaceutically important due to the presence of medicinally important phytochemicals like flavonoids, terpenoids , alkaloids ,pigments along with iodine , laminarin etc. and hence can be manipulated in further research to extract maximum benefits in the herbal drug industry. Hence these algae can be collected and then utilized in various ways to get the maximum benefit with low cost thereby helping in the improvement of the health and also economic position of the country.

MATERIALS AND METHODS

Sample Collection

The Red sea is very rich in Algal flora. The macroalgae are found in the deep and shallow layers either floating on the surface and or are carried by the waves and hence can be collected easily by handpicking. Some of the algae collected are attached to rocks, stones or corals in the sea. The microalgae were also collected by handpicking and also by deep swimming. The collected samples were stored in containers and polythene bags. They were then temporarily stored in the refrigerator and then brought to the laboratory in iced condition and washed thoroughly under tap water and then rinsed three times in distilled water to remove sand, salt and other impurities. The collected algal samples were stored in plastic bags and transported to the laboratory under iced conditions. The samples were initially washed thoroughly with sea water to remove sand and any adhering substance and then washed thoroughly with fresh water to remove salts, and stored at _20 _C until compound extraction (Sarah Saleh Abdu-llah Al-Saif, Nevein Abdel-Raouf, Hend A. El-Wazanani, Ibrahim A. Aref, 2014).

The specimens were gathered by SCUBA diving as well as by shore-collecting, both attached in shallow water and as drift material. Approximately 50 erect specimens were examined in this study. Most of the collections were processed as herbarium specimens the same day; smaller amounts were preserved in 5% formalin in seawater. Additional pressed specimens were deposited in other herbaria as cited (Michael J. Wynne, 2002).

Herbarium Preparation: The Algal samples from the sea were collected and washed thoroughly in tap water and then in distilled water .The algae were placed on tissue papers to dry. Then the samples were spread on white paper and dried under shade for two days and then pasted with a cellotape. The algae with thicker plant body were spread on paper and covered with paper and pressed for iron drying before applying cellotape for long term preservation. The papers were placed in plastic covers and arranged in a file with serial numbers along with the date, place of collection along with the name of the collector. Information on the name of the algal genera with its classification were also provided .The collected algal samples were identified and saved in the Botany laboratory of the College of Science and Arts at Ad Darb , Jizan University. The marine red and brown algae were collected from the red sea coast to study their bioactivity. Specimens of all species tested (*Dictyota* sp., *Sarcodiotheca furcata*, *Cystoseira myrica* and *Sargassumramifolium*) are deposited in the herbarium of the Laboratory of Phycology. The collected algae were rinsed with sterile water to remove any associated debris and were kept under sunshade for 7 days (Mostafa M. El-Sheekh, Mohamed M. Gharieb, Sabha M. El-Sabbagh, Walaa T. Hamza, 2014). Some of these samples were preserved in the form of herbarium sheets and given series numbers with the date of collection (H. Arraj, H. Mayhoob and A. Abbas, 2016).

Sample Preservation: Plastic bottles with air tight caps were used to store the samples in 5 % formaldehyde solution. The bottles were labeled with the name of alga .The collected algal samples were identified and saved in the Botany laboratory of the College of Science and Arts at Ad Darb , Jizan University. The samples were washed thoroughly and preserved in a 4 % formalin-seawater solution for further investigation. (H. Arraj, H. Mayhoob and A. Abbas, 2016).

Macroscopic observation: Identification was carried out by using standard manuals and keys to the identification. Morphological characters of the macroalgae were used to identify and classify them into different classes. The morphological characters studied were the habit, sexual and asexual reproductive structures, the shapes, arrangement and structures of specialized identification features along with the colour. The shape and size of the plant body.

The shapes of the leaf, its apex, margin, petiole and mid rib characters are used to classify the species of *Sargassum*. The shape, size, length, breadth of the vesicle and its pedicel were used to identify .The main axis shape and size were also studied during the identification process by using the keys to identification.

The algae identified are macroscopic, multicellular marine sea weeds belonging to the three classes of algae namely. They are classified based on the pigments, structure, ecology, uses etc. Brown algae *(Phaeophyta*), Green algae (*Chlorophyta*), and Red algae (*Rhodophyta*). Brown seaweeds are predominantly brown due to the presence of the carotenoid fucoxanthin, and the primary polysaccharides present include alginates, laminarins, fucans, and cellulose. Green seaweeds are dominated by chlorophyll a and b, with ulvan being the major polysaccharide component. While in Red seaweeds, principal pigments are phycoerythrin and phycocyanin and the primary polysaccharides are agars and carrageenans (Subhash R. Yende, Uday N. Harle, and Bhupal B. Chaugule, 2014).

Sampling sites from Jizan province

Figure 1. Map of Jizan , Al Shuqaiq, Al Huraidha , Al Qahma and Al Birk along the Red Sea Coast.

Figure 2. Pictures of Macroalgae growing naturally at the Red Sea Shore of Jizan Province.

Pictures of the algae growing in the natural marine habitat (Fig.2) were taken and also the photographs of each algae is also shown.

Algae are found in large quantities in Saudi Arabian sea shores of the red sea. The marine waters of Jizan including the red sea coasts of Jizan, Al Shuqaiq, Al Huraidha, Al Qahma and Al Birk regions were five sampling sites of this study (Fig.1). A survey of the red sea coast was carried out to collect the different algal species during the January 2018 - April 2018. Jizan has hot humid climate where the inshore shallow water temperature ranged between 24 °C- 34 °C during the sampling months.

RESULTS AND DISCUSSION

This is the first study to collect and identify the diverse groups of macroalgae inhabiting the red sea coast of Jizan province, Saudi Arabia. The algal samples were collected from five different places i.e. Jizan, Jizan , Al Shuqaiq, Al Huraidha , Al Qahma and Al Birk of the province . The collected samples were preserved in formaldehyde solution in plastic containers as well as dried specimens were preserved as Herbarium.

The herbarium sheets were placed in plastic covers and arranged in a file with serial numbers along with the date, place of collection, name of the collector. Information on the name of the algal genera with its classification are also provided (Figs.3).The collected algal samples were identified and saved as “Herbarium of Macroalgae from the Red Sea Shore of Jizan” in the Botany laboratory of the College of Science and Arts at Ad Darb , Jizan University Fig. Plastic bottles with air tight caps were used to store the samples in formaldehyde solution. The bottles were labeled with name of alga .The collected algal samples were identified and saved in the Botany laboratory of the College of Science and Arts at Ad Darb , Jizan University (Fig. 4). The algae were identified by morphological characters like the pigment, structure of the vegetative thallus along with reproductive and other characters .The macroalgae collected during this study belong to three major classes *Chlorophyta, Phaeophyta* and *Rhodophyta*. A total of sixteen genera were studied. The *Chlorophyta* included three genera namely *Cladophora, Derbesia and Ulva* (Fig.5a.-5c.). *The Phaeophyta* is represented by seven genera namely *Fucus, Hormophysa, Laminaria, Macrocystis, Padina, Turbinaria* (Fig.6a.-6j.) and *Sargassum* (Fig.7a.-7n.). *Rhodophyta* is represented by six genera namely *Acanthophora, Galaxaura, Hypnea, Laurentia, Gelidium* and *Microcladia* (Fig.8a.-8i.) *. Sargassum* was the most predominant and frequently occurring genera with more than ten species collected during this study .All the macroalgae collected and identified during the study are very important economically. Seaweed specimens can easily be collected and preserved. Such specimens are valuable for further research and confirmation. Well preserved specimens can be kept for two or three hundred years. Specimens prepared in this manner should then be labelled, usually on the bottom right-hand corner with the name of the species, the collector, the determinor, the date, the site where collected and details of the shore as recorded. Algae (http://www.thierrykarsenti.ca/sitesweb/)

Many of the algae are reported from different places of the red sea coasts in Saudi Arabia. A total of 19 species are reported for the first time as occurring in the Umluj coast of Saudi Arabia. These species related to *Chlorophyta (1), Phaeophyceae (6) and Rhodophyceae (12*) (Ibraheem Borie Mohammad Ibraheem, 2014).

During the study, 4 species of seaweeds were recorded in *Phaeophyceae* which were *Laminaria sp., Padina fraseri, Sargassum muticum* and *Turbinaria ornata*. (Al-Harbi SM (2017). The green alga *Derbesia* and the red alga *Microcladia* are the uncommon and rare genera collected during this study.

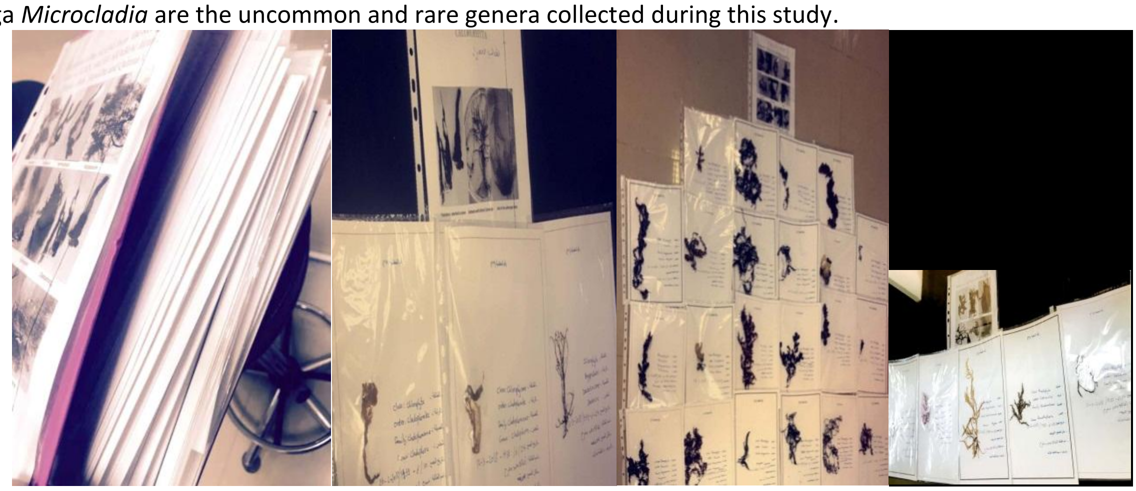


Fig. 3 Pictures of Herbarium of Macroalgae from the Red Sea Shore of Jizan Province.

Fig.4. Pictures of the Preserved Algal Samples in Plastic Containers from Jizan Province.

Pictures of Macroalgae of the Red Sea Coast of Jizan

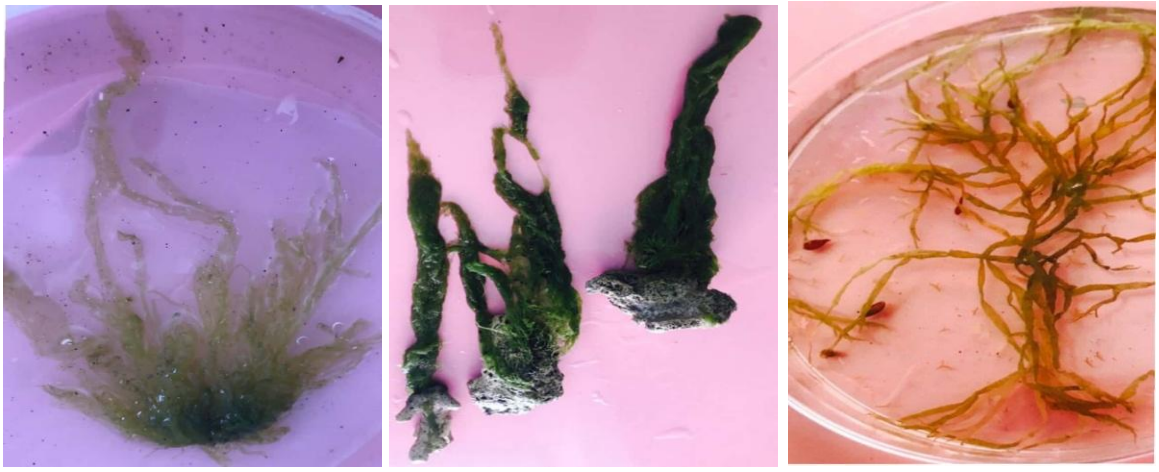


Figure 5. CHLOROPHYTA
5 a*. Cladophora attached* to stone 5 b. *Derbesia* with distinct Sporangia 5c. *Ulva* in the submerged state

Figure 6 .PHAEOPHYTA
6 a. *Fucus serratus* 6 b. *Fucus serratus* -close up 6 c.*Hormophysa* 6d. *Hormophysa*

6 e.*Laminaria*

6 f.*Macrocystis*

6 g. *Padina*

6 h.*Turbinaria*

6 i. *Turbinaria*

6 j. *Turbinaria* with holdfast

Different Species of *Sargassum* – The most predominant genera collected during the study

7 a. *Sargassum latifolium*

7 b. *Sargassum augustifolium*

7 c. *Sargassum* sp.

7 d. *Sargassum sp.*



7 e. *Sargassum filipendula* 7 f. *Sargassum crassifolium* 7 g. *Sargassum platycarpum*



7 h.*Sargassum vulgare* 7 i.*Sargassum natans* 7 j.*Sargassum muticum*




7 k. *Sargassum* 7 l. *Sargassum palmeri* 7m.*Sargassum* 7 n. *Sargassum denticulatum*

Indexed, Abstracted and Cited in Indexed Copernicus International and 20 other databases of National and International repute

RHODOPHYTA

8 a. *Acanthophora*

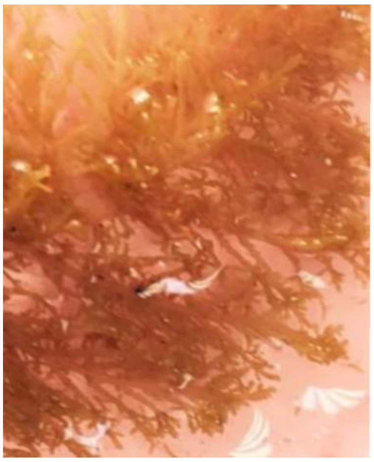
8 b. *Acanthophora*

8 c. *Galaxaura*

8 d. *Hypnea*

8 e. *Hypnea*

8 f. *Laurencia*



8 g. *Laurencia*

8 h. *Gelidium*

8 i. *Microcladia*

Morphological features and Taxonomic status of the different Algal Genera collected and identified during the study

Chlorophyta

Cladophora*:* It is a green alga belonging to *Chlorophyta,* order *Cladophorales* and family *Cladophoraceae. Cladophora* is a cosmopolitan alga and can be found in huge masses of a variety of marine and fresh waters, which provide habitat as well as food for numerous organisms (Dodds and Gudder, 1992). Many species of *Cladophora* are also present as an epiphyte on other seaweeds or is host to many other algae. *Cladophora* also causes mass algal blooms (Bach and Josselyn, 1978). The plant body of *Cladophora* is usually yellowish green and often rough to the touch. This alga can grow up to a few meters and the thallus is usually pseudodichotomously branched. However, some members are highly branched (*P. Bawej, 2016).*

Derbesia*:* It is a green alga belonging to *Chlorophyta ,* order *Cladophorales* and family *Derbesiaceae* . It has fine, much-branched, non-septate filaments 3 - 5 cm tall .These filaments develop and later produce the adult, clavate, branches which bear sporangia., It grows in the marine waters of the red sea. The branches are brush like and siphonous arising from rhizoidal siphons.

Ulva: It is a green alga belonging to *Chlorophyta ,* order *Ulvales* and family *Ulvaceae.* It is green flat leaf like alga with ruffled margin without a stipe. It has discoid holdfast which helps in attaching to rocks and other substrata. It's length ranges from 18-30 cm.

Phaeophyta

Fucus*:* It is a brown alga belonging to*Phaeophyta,* order *Fucales* and family *Fucaceae.Fucus*, rockweed, is very common on temperate rocky seacoasts. As in other members of the order *Fucales,* the thallus is flattened; it branches in one. Although most frequently found along seashores, some brown algae, such as the well-known *Sargassum* found in the Sargasso Sea, form immense floating masses far offshore. (Kingdoms and Domains (Fourth Edition), 2009).

Hormophysa :It is red alga belonging to the class *Phaeophyta ,* order *Fucales ,* family *Sargassaceae*. Thallus 20-50 cm high, erect, stiff; branching irregular, pinnate or in verticils; basis perennial, small; annual branches single or numerous on a small stipe, three-winged, more or less segmented and with markedly dentate margins; aerocysts intercalary, developed in the medulla, giving an articulated appearance to the axes because the axes are constricted between two aerocysts and the wing-like structures are interrupted; orangy brown. (F. Krupp, A.H. Abuzinada & LA. Nader, 1996).

Laminaria*:* It is a brown alga belonging to *Phaeophyta,* order *Laminariales and* family *Laminariaceae.* The plant body of Laminaria is diploid and attains a length of 2 to 12 metre or more in length. The sporophytic plant body is differentiated into holdfast, stipe and blade (lamina) .Holdfast is an organ of attachment in variable forms. It may be like a solid disc or a cluster of profusely branched cylindrical root-like organs, also called haptera. Stipe is an unbranched and cylindrical or slightly flattened stalk-like structure, developed on the holdfast and bears terminal blade (s).Blade may be simple (L saccharina) or a cluster of vertically divided segments (L. cloustoni, L. digitata) (Fig. 3.123A, B). Blades are flat, long, ribbon-shaped with wavy or smooth margin and tough and leathery in texture (Neelesh T.).

Macrocystis: It is a brown alga belonging to *Phaeophyta ,* order *Laminariales and* family *Laminariaceae*It is a giant tall kelp with many blades . At the base of the blades there are air bladders filled with air. Kelps are edible and are used in the preparation of nutritious soups and salads. They are also industrially useful in the preparation of toothpaste, shampoo and ice cream etc. They also act as shelters or food for the fish and other marine animals. *Macrocystis pyrifera* plants consist of a holdfast, which anchors the plant to the substrate, bundles of fronds analogous to the branches and leaves of a land plant, and reproductive structures called sporophylls located just above the holdfast (http://eol.org/pages/906815/details).

Padina*:* It is a brown alga belonging to *Phaeophyta,* order *Dictyotales* and family *Dictyotaceae*. It has rhizoids with which it is fixed to the substratum and also found abundantly floating on the surface and is carried by waves in the seas. The thalli are composed of fan-shaped lobes with in rolled margins. These lobes are attached to each other at the base by a short stem (Arraj et al., 2016). Thallus composed of several supple, flabellate to funnel-shaped lobes, only slightly calcified on both sides, up to 15 cm wide; attachment by a small pluricellular disc, covered by rhizoids; (F. Krupp, A.H. Abuzinada and L.A. Nader, 1996).

The peacock's tail, *Padina pavonica*, is a brown macroalga found throughout the Indian River Lagoon (see "IRL Distribution" below).The thallus, or body, of the alga is brown to tan, forming fan-shaped clusters. Each blade is calcified, more heavily above and lightly below, and curls inward near the edges. Both the upper and lower blade surfaces bear minute surface hairs arranged in a series of bands approximately 1.5 to 6 mm apart (Taylor 1979; Littler & Littler 2000; Littler *et al.* 2008). The blades attach to the substratum via a holdfast, which is often matted (LH Sweat, 2010).

The "ear-like" blades have a circinnately inrolled apical margin (Womersley 1987; Lee and Kamura 1991; Huisman 2000), where a row of meristematic cells produces a thallus that is parenchymatous (Paul John L. Geraldino, Lawrence M. Liao and Sung Min Boo, 2005).

Sargassum: It is a brown alga belonging to *Phaeophyta* , order *Fucales* and family *Sargassaceae*. The plant stretches and grows on abundantly widely on the surface and also on the sea shore of the red sea. The plant has leaf, stem and branches along with the air bladders for floating. (*Mohamed S.M. Abdel-Kareem, 2009)*

Sargassum angustifolium: Thallus erect, Up to 30-60 cm long, elegant and supple, attached by a small perennial, parenchymatous disc 1 cm in diameter; perennial stipe very short, hardly visible, bearing the annual branches; these are terete, 1 mm in diameter. Branching distichous, alternate, sometimes somewhat sympodial; phylloids very narrow, simple, linear (rare1y forked), 1-3 mm broad, 10-50 mm long, margin dentate, apex pointed, midrib slightly deve10ped only in the broader phylloids; cryptostomata small and not conspicuous; aerocysts on the side branches, lateral, pedicellate, spherical, sometimes mucronate, 2-4 mm in diameter; light to dark brown (F. Krupp, A.H. Abuzinada and LA. Nader, 1996).

Sargassum crassifolium: Thallus up to 30 cm long, tough, attached to the substratum by a small disc-shaped holdfast up to2 cm in diameter, with short stipe giving rise to manybranches. Main axis of the branch was cylindrical,1 mm in diameter, giving rise to many branchlets, up to 5 cm long. Branchlets alternate, basa l branchlets longer than upper ones .Phylloids oblong-elliptical, margins toothed dentate, midrib slightly fainted near apex which was obtuse, 1.5-3 cm long and 0.5-1 cm broad. Cryptostomata not absolutely conspicuous.Vesicles spherical, up to 3 mm in diameter, pedicellate. Receptacles arise in the axils of the phylloids, simpleor branched (Mohamed S.M. Abdel-Kareem, 2009).

Sargassum denticulatum: Thallus up to 40 cm long, attached to the substratum by small discoid holdfast. Main axis cylindrical, 0.5 mm in diameter. Branches were alternate, longer branches towards the base, up to 7 cm long.Phylloids linear, narrow, up to 2 cm long and 1 mm wide, with tapering end, margins distantly serrate or dentate. Cryptostomata inconspicuous. Vesicles obovate, up to mm wide, linear-lanceolate, simple or, on the .Receptacles in clusters, simple, up to 4 mm long.(Mohamed S.M. Abdel-Kareem, 2009).

Sargassum filipendula: Thallus up to 25 cm long, erect, attached to the substratum by a small lobed holdfast. The main branches bearing alternate branchlets, up to 7 cm long, exceedingly slender. Phylloids long and 0.5-3 mm broad, linear, simple, margins nearly entire or slightly serrate, midrib inconspicuous.Vesicles were spherical or ovate upto 3mm in diameter and stalk upto 3mm long(Mohamed S.M. Abdel-Kareem,2009).

Sargassum latifolium: Thallus up to 25 cm long, erect, attached tothe substratum by a small perennial discoid holdfast, withshort and perennial stipe, giving rise to main axis 3 mmbroad, markedly zigzag-shaped. Phylloids were alternate, lanceolate 1.5-2.5 cm long and1-3 mm broad, margins serrate but with more prominentteeth Vesicles were spherical to subspherical, up to 5 mm in diameter, pedicellate, smooth. Receptacles in axillary clusters, cylindrical, furcated, up to 6 mm long.

Sargassum muticum **:** It is a brown seaweed, normally brown to yellowish with a length up to 10 m. It is an autotroph that uses energy from sunlight. The photosynthesis is facilitated thanks to aerial vesicles which allows the algae to raise to the surface (https://en.wikipedia.org/wiki/Sargassum_muticum).The thallus is composed of two distinct parts: a perennial part, which contains the holdfast and one or more short main axes; and an annual part: the secondary axes, which develop on the main axis, whose growth is unlimited and the size is variable. Laterals with foliaceous expansions called fronds, laterals with fronds and aerocysts and laterals with fronds, aerocysts and reproductive organs called receptacles (Mohamed S.M. Abdel-Kareem, 2009). *Sargassum muticum* is brown seaweed, normally brown to yellowish with a length up to 10 m. It is an autotroph that uses energy from sunlight. The photosynthesis is facilitated thanks to aerial vesicles which allow the algae to raise to the surface.

Sargassum natans: Thallus up to 25 cm long, erect, widely branching, tangled, pelagic, without a dominant axis. Annual branches up to 20 cm long with smooth axis, giving rise to alternate branchlets up to 4 cm long. Phylloids firm, linear, apex acute or obtuse, margins serrate, 1-4 cm long, 1-3 mm wide. Cryptostomata scattered. Vesicles subspherical to elliptical, 2-5 mm long, 1-3 mm broad, stalked, stalk up to 5 mm long, typically mucronate, tipped with a long spine. Receptacles were in axillary clusters, cylindrical, simple or furcated, up to 3 mm long (Mohamed S.M. Abdel-Kareem, 2009).

Sargassum palmeri: Thallus perennial, up to 20 cm long, attached to the substratum by a solid, discoid holdfast. Main axis terete or slightly angled, rough or may be spiny. Phylloids were alternately dissected into many slightly flattened divisions up to 4 mm long, midrib was inconspicuous.

Cryptostomata were usually inconspicuous. Receptacles were usually solitary in phylloids axils, mostly racemose (Mohamed S.M. Abdel-Kareem, 2009).

***Sargassum platycarpum*:** Thallus up to 25 cm tall, erect, attached to the substratum by a small discoid holdfast up to 3 mm in diameter. The main axis was cylindrical, 1 mm diameter. Lateral branches slender, smooth and alternate on the main axis. Phylloids scattered or alternate, stalked, lanceolate, up to 2 cm long and 3 mm wide, apex acute, some tapering into a petiole, margins were coarsely serrate. (Mohamed S.M. Abdel-Kareem, 2009).

***Sargassum vulgare*:** Thallus up to 25 cm long, erect, attached to the substratum by lobed holdfast. Branches usually smooth. Phylloids firm, lanceolate, up to 3.5 cm long and 4 mm wide, margins were sharply serrate, apex usually acute, midrib was conspicuous. Vesicles were spherical to ovate, up to 3 mm in diameter, on pedicle up to 3 mm long (Mohamed S.M. Abdel-Kareem, 2009).

***Turbinaria*:**It is brown alga belonging to *Phaeophyta* , order *Fucales* and family *Sargassaceae.* Thallus composed of a well-developed prostrate, stolonoidal part and some erect axes with peltate branchlets; the whole structure is stiff and tough: stolonoids 1 mm in diameter, more or less dichotomous, forming an extended network; erect axes unbranched, 3-4 cm high, margin strongly dentate, generally with 2-3 intramarginal teeth , no aerocysts; dark brown. Receptacles in dense axillary clusters, 3 mm long, simple. (F. Krupp, A.H. Abuzinada and LA. Nader, 1996). Leaves in most species of *Turbinaria* have an air vesicle embedded within the peltate enlargement. Thalli are usually attached by a well-developed system of spreading hapterous branches emanating from the main axes. Short, densely branched receptacles arise on the upper sides of the stalks of the leaves (Michael J. Wynne, 2002).

Rhodophyta

***Acanthophora*:** It belongs to the class *Rhodophyta,* order *Ceramiales,* Family *Rhodomelaceae.* Thallus 5-30 cm high, erect, bushy and stiff (even somewhat brittle) when young, older specimens becoming more elegant; attached by a parenchymatous, irregular disc, bearing one or several main axes; branching radial, in four rows; main axes terete, 1-2 mm in diameter at the base, with scars of broken ramelli but without spines; side axes similar to the main axis, densely set with short determinate branchlets (0.5-2 mm long), covered by small spines (0.5 mm long). (F. KRuPP, A.H. ABUZINADA & LA. NADER, 1996)

***Galaxaura*:**It is red alga belonging to *Rhodophyta ,* order *Nemaliales* and family *Galaxuraceae*. It is a branched siphonous phase (diploid sporophyte) of sparse to dense erect siphons, the latter sometimes appearing brush like, to about 3 (-5) cm. tall, arising from rhizoidal siphons which are perennating in at least one species, bearing one or several main axes; branching radial, in four rows; main axes terete, 1-2 mm in diameter at the basis, with scars of broken ramelli but without spines. (F. KRuPP, A.H. ABUZINADA & LA. NADER, 1996)

***Gelidium*:**It is red alga belonging to *Rhodophyta ,* order *Ceramiales* and family *Rhodomelaceae*. Species of *Gelidium* is identified by the morphological structure of the thallus which has an erect axes which is compressed and irregularly branched attached to a prostrate axes or haptera . The thallus is orange or dark brown in colour. Erect fronds can be cylindrical at the base or subcylindrical above the base and are frequently compressed at their apical end (Kyeong Mi Kim, Il Ki Hwang, Hwan Su Yoon, and Sung Min Boo, *2012*).

***Hypnea*:**It is red alga belonging to the class *Rhodophyta ,* order *Gigartinales,* family *Cystocloniaceae*. It is found on the surface of the marine waters as clumps of loosely intertwined cylindrical branches ending in flat, broad hooks at their tips. Thallus 10-20 cm high, erect, forming dense , relative1y stiff tufts; attached by a small parenchymatous disc bearing several main axes; branched, spiny, 5-10 mm long; dark red to purplish (F. KRuPP, A.H. ABUZINADA & LA. NADER, 1996).

The University of Hawai'i describes *H. musciformis* as, "Clumps or masses of loosely intertwined, cylindrical branches, 10 - 20cm tall, 0.5 - 1.0cm diameter, that become progressively more slender towards tips. Firm, cartilaginous, highly branched.

The ends of many axes and branches are flattened with broad hooks. Holdfasts are small, inconspicuous, or lacking. Usually red, but can be yellowish brown in high light environments or nutrient poor waters. Smith *et al.* (2002) states that, "*H. musciformis* has ''apical hooks'' at the tips of its branches that attach or anchor the alga onto other macroalgae and any other available substrate. "(Marit Ruge Bjaerke).

***Laurencia*:** It is red alga belonging to *Rhodophyta,* order *Ceramiales* and family *Rhodomelaceae*. Thallus 3-6 (to 20) cm high, forming supple, erect, bushy plants; large specimens conoidal; attached by a small disc bearing a single or several main axes, 1 mm in diameter throughout the thallus; all parts terete; branching radial, lateral axes obscuring the main axis, all of them relatively densely covered by short, radially placed branchlets; these frequently grouped in twos or threes, resulting in a sub opposite or pseudoverticillate appearance, becoming shorter towards the apices of the axes, (F. KRuPP, A.H. ABUZINADA & LA. NADER, 1996).

Microcladia: It belongs to the phylum *Rhodophyta*, order Order *Ceramiales* Family *Callithamniaceae*. The pictures shows red colour of the thallus spread on the herbarium sheet due to the presence the pigment phycoerythrin .It is a marine branched alga with feather like thallus . Thallus planar 35-40 cm tall (usually smaller); main axis with many highly branched delicate laterals. Thallus is profusely branched, dark red to olive brown, reaching 15 cm (6 in) tall. Primary branching is alternate, lateral branches are comblike (pectinate), and branch tips are forcipate. Branches are corticated, and the holdfast is rhizoidal. Habitat: Plant epithytic, dark blood-red, subfastigiate, subsetaceous. *Holdfast* ramifying within host and forming an external nodule, about 2 mm in diam., on the surface ofthe host. *Axes* several, arising from nodule, stem flattened bilateral branched upto 8 cm high and 1 mm thick tapering slightly upwards and downwards (R.H. Simons).

CONCLUSION

The present study focused on the collection and preservation of macroalgae in the form of samples and herbarium from five regions Jizan, Al Shuqaiq, Al Huraidha, Al Qahma and Al Birkb ordering the vast coast line of Jizan province. The collected samples were identified and classified into the three classes Chlorophyta, *Phaeophyta* and *Rhodophyta*. This study adds valuable information on the biodiversity of the marine macroalgae of red sea from Jizan Coastline. A total of sixteen genera along with ten species of Sargassum were studied of which *Derbesia* and *Microcladia* are the two rare and uncommon genera reported during this study. All the macroalgae are economically important either as food, fodder, in various ways. All the macro algae collected during this study is economically important. They are used medicinally, industrially and pharmaceutically. Hence the macroalgae can be exploited in further research to extract maximum benefits in the herbal drug industry etc. Hence these algae can be collected and then utilized in various ways to get the maximum benefit with low cost thereby helping in the improvement of the health and also the economic position of the country.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

A. A. Aleem (1978). CONTRIBUTIONS TO THE STUDY OF THE MARINE ALGAE OF THE RED SEA, Marine Algae from Obhor, in the vicinity of Jeddah, Saudi Arabia. Institute of Marine Sciences, K.A.U *Bull. Fac. Sci. K.A. U. Jeddah, 1978, 2,539- 118.*

Armisen, R. (1995). https://doi.org/10.1007/BF00003998, J Appl Phycol, 7: 231, Kluwer Academic Publishers. Print ISSN0921-8971 Online ISSN1573-5176.

Al-Harbi, S.M. (2017). Epiphytic Microalgal Dynamics and Species Composition on Brown Seaweeds (*Phaeophyceae*) on the Northern Coast of Jeddah, Saudi Arabia. J Oceanogr Mar Res 5:153. doi: 10.4172/2572-3103.1000153.

A.N. Khalil, B.A.H.El Tawil (1982). Phytochemical studies on marine algae from Jeddah, Red Sea, Bull. Fac. Sci., K.A.U., Jeddah, Vol.6, pp . 49-69.

Arraj et al. (2016). First records of two Padina species (Dictyotales, Phaeophyceae) from the Syrian coast (eastern Mediterranean) ,Biodiversity Records (2016) 9:93.DOI 10.1186/s41200-016-0090-x.https://www.cabi.org/isc/datasheet/107763#tab1-nav 2018.

CIMI blog (2017). Catalina Island Marine Institute Kelptastrophe! Mystery of the Missing Kelp ,Posted on March 30,2017.(http://www.clarku.edu/faculty/robertson/Laboratory%20Methods/Pigments.html http://eol.org/pages/906815/details

Cynthia Layse, F. de Almeida, Heloina de S. Falcão, Gedson R. de M. Lima, Camila de A. Montenegro, Narlize S. Lira, Petrônio F. de Athayde-Filho, Luis C. Rodrigues, Maria de Fátima V. de Souza, José M. Barbosa-Filho, and Leônia M. Batista (2011). Bioactivities from Marine Algae of the Genus *Gracilaria ,* Int J Mol Sci. 2011; 12(7): 4550–4573. doi: 10.3390/ijms12074550 , PMCID: PMC3155369

Ethan M. Cox and Yuji Arai (2014). Environmental Chemistry and Toxicology of Iodine in Advances in Agronomy, 2014.

KRuPP, F., A.H. Abuzinada and La. Nader (eds) (1996). Marine algae of the Jubail Marine Wildlife Sanctuary; Saudi Arabia A Marine Wildlife SanctuaJJI Jor the Arabian Gu/f Environmental Research and Conservation Following the 1991 Gulf Wár Oil Spill. NCWCD, Riyadh and Senckenberg Research Institute, Frankfun a.M. Olivier De Clerck and EricCoppejans

MacRaild, G. N. and H. B. S. Womersley (1974). The morphology and reproduction of Derbesia clavaeformis (J. Agardh) De Toni (Chlorophyta). Phycologia: June 1974, Vol. 13, No. 2, pp. 83-93. https://doi.org/10.2216/i0031-8884-13-2-83.

Hanan Omar, Molouk Mohamed El-Kazan and Adel El-Gendy (2013). Red sea water and biochemical composition of seaweeds at Southern Coast of Jeddah, Saudi Arabia.

Omar, H. H., H. M. Shiekh, N. M. Gumgumjee, M. M. El-Kazan and A. M. El-Gendy (2012). Antibacterial activity of extracts of marine algae from the Red Sea of Jeddah, Saudi Arabia. African Journal of Biotechnology Vol. 11(71), pp. 13576-13585, 4 September, 2012, Available online at http://www.academicjournals.org/AJB ,DOI: 10.5897/AJB12.780 ,ISSN 1684-5315 ©2012 Academic Journals. https://en.wikipedia.org/wiki/Sargassum_muticum

Kingdoms and Domains (Fourth Edition), 2009. Lynn Margulis University of Massachusetts at Amherst, Michael J Chapman Marine Biological Laboratory Woods Hole, Massachusetts, USA, Pr-17 Phaeophyta(Brown algae).

Sweat, L.H. (2010). Indian River Lagoon Species Inventory, Smithsonian Marine Station at Fort Pierce.

Marit Ruge Bjaerke Section for Marine Biology and Limnology < Department of Biology , University of Oslo , Norway: *Hypnea musciformis* (University of Hawai'i, UNDATED). National Biological Information Infrastructure (NBII) & IUCN/SSC Invasive Species Specialist Group.

Matteo Francavilla, Massimo Franchi , Massimo Monteleone and Carmela Caroppo (2013). The Red Seaweed Gracilaria gracilis as a Multi Products Source. ISSN 1660-3397 www.mdpi.com/journal/marinedrugs Mar. Drugs 2013, 11, 3754-3776; doi:10.3390/md11103754

EL-NAGGAR, M.E.E. (1995). Distribution of Iodine in Egyptian Marine Algae, JKAU: Mar. Sci., vol. 6, pp. 151-100, University of Mansoura, Mansoura, Egypt.

Mohamed Ali Deyab and Fatma Mohamed Elnabawy Ward (2016). Ecological and biochemical analyses of the brown alga Turbinaria ornata (Turner) J. Agardh from Red Sea coast, Egypt. Journal of Coastal Life Medicine 2016; 4(3): 187-192. doi: 10.12980/jclm.4.2016j6-10.

Ibraheem Borie Mohammad Ibraheem Reem Mohammed Alharbi Neveen Abdel-Raouf Nouf Mohammad Al-Enazi (2014). Contributions to the study of the marine algae inhabiting Umluj Seashore, Red Sea, Beni-Suef University , Journal of Basic and Applied Sciences. Volume 3, Issue 4, Pages 278-285.

Palaniveloo, K. (2014). Chemical relationship between red algae genus Laurencia and sea hare. https://link.springer.com/article/10.1007/s10811-013-0127.

Kyeong Mi Kim, Il Ki Hwang, Hwan Su Yoon and Sung Min Boo (2012). Four novel Gelidium species (Gelidiales, Rhodophyta) discovered in Korea: G. coreanum, G. jejuensis, G. minimum and G. prostratum. Phycologia: the International Phycologia Society, Vol. 51, No. 4, pp. 461-474.

Michael J. Wynne (2002). *Turbinaria foliosa* sp. nov. (Fucales, Phaeophyceae) from the Sultanate of Oman, with a census of currently recognized species in the genus. *Phycological Research,* 2002; 50:283–293. Department of Ecology and Evolutionary Biology and Herbarium, University of Michigan, Ann Arbor, MI 48109, USA.

Mohamed Ali Deyab, Fatma Mohamed Elnabawy Ward (2016). Ecological and biochemical analyses of the brown alga Turbinaria ornata (Turner) J. Agardh from Red Sea coast, Egypt. doi:10.12980/jclm.4.2016j6-10 ©2016 by the Journal of Coastal Life Medicine.

Mohamed S.M. Abdel-Kareem (2009). Phenetic Studies and New Records of Sargassum Species (Fucales, Phaeophyceae) from the Arabian Gulf Coast of Saudi Arabia Academic Journal of Plant Sciences 2 (3): 173-181, ISSN 1995-8986 ,© IDOSI Publications.

Mostafa M. El-Sheekh, Mohamed M. Gharieb, Sabha M. El-Sabbagh and Walaa T. Hamza (2014). Antimicrobial Efficacy of Some Marine Macroalgae of Red Sea. International Journal of Microbiology and Immunology Research Vol.3 (3), pp. 021-028, June, 2014, Available online at http://www.apexjournal.org .ISSN 2315-8743© 2013 Apex Journal International.

Nadine M.S. Moubayed, Hadeel Jawad Al Houri, Manal M. Al Khulaifi and Dunia A. Al Farraj (2017). Antimicrobial, antioxidant properties and chemical composition of seaweeds collected from Saudi Arabia (Red Sea and Arabian Gulf) .Saudi Journal of Biological Sciences (2017) 24, 162–169.

Nahid Abdel Rahim Osman, Mona Mohamed Alhassan and Braa Karar Abas (2016). The content of some selected metabolites of Hypnea valentiae (Turner) Montagne from the Red Sea coast of Sudan. CC BY-NC-ND 4.0. DOI 10.12980/jclm.4.2016J6-49.

Nasser A. Al-Asgah, El-Sayed M. Younis, Abdel-Wahab A. Abdel-Warith and Faozi S. Shamlola (2016). Evaluation of red seaweed *Gracilaria arcuata* as dietary ingredient in African catfish, *Clarias gariepinus*, Saudi J Biol Sci. 2016 Mar; 23(2): 205–210.Published online 2015 Nov 10. doi: 10.1016/j.sjbs.2015.11.006 ,PMCID: PMC4778581.

National Biological Information Infrastructure (NBII) & IUCN/SSC, *Hypnea musciformis* (University of Hawaiʻi, UNDATED), Invasive Species Specialist Group (ISSG).

Paul John L. Geraldino, Lawrence M. Liao and Sung Min Boo (2005). Morphological Study of the Marine Algal Genus Padina (Dictyotales, Phaeophyceae) from Southern Philippines: 3 Species New to Philippines. Algae Volume 20 (2): 99-112.

Neelesh T. Laminaria: Occurrence, Features and Reproduction. http://www.biologydiscussion.com/algae/laminaria-occurrence-features-and-reproduction/46978

Neveen Abdel-Raouf, Nouf Mohammad Al-Enazi, Ibraheem B.M. Ibraheem and Reem Mohammad Al-Harbie (2015). Antibacterial and anti-hyperlipidemic activities of the brown alga Hormophysa cuneiformis from Ad Dammam Seashore, Journal of Applied Pharmaceutical Science Vol. 5 (08), pp. 114-125, August, 2015 Available online at http://www.japsonline.com DOI: 10.7324/JAPS.2015.50818 ISSN 2231-3354

Baweja, P., I. Levine, in Seaweed in Health and Disease Prevention, 2016.

Rabiei R., Phang S.M., Lim P.E., Salleh A., Sohrabipour, J., Ajdari D. and Zarshenas, G.A. (2016). Productivity, biochemical composition and biofiltering performance of agarophytic seaweed, Gelidium elegans (Red algae) grown in shrimp hatchery effluents in Malaysia .Iranian Journal of Fisheries Sciences 15 (1) 53-74 2016.

Simons, R.H. The Genus Microcladia (Red Algae) in South Africa *,Bothalia 9, 2* : 351-355.

Sarah Saleh Abdu-llah Al-Saif, Nevein Abdel-Raouf, Hend A. El-Wazanani Ibrahim A. Aref (2014). Antibacterial substances from marine algae isolated from Jeddah coast of Red sea, Saudi Arabia Saudi Journal of Biological Sciences (2014) 21, 57–64.

Shimaa M. El Shafay, Samh S. Ali, Mostafa M. El-Sheekh (2016). Antimicrobial activity of some seaweeds species from Red sea, against multidrug resistant bacteria National Institute of Oceanography and Fisheries, Egyptian Journal of Aquatic Research , 42, 65–74.

Seham M. Hamed, Amal A. Abd El-Rhman, Neveen Abdel-Raouf, Ibraheem B.M. Ibraheem (2018). Role of marine macroalgae in plant protection & improvement for sustainable agriculture technology. Contents lists available at Science Direct Beni-Suef University Journal of Basic and Applied Sciences journal homepage: www.elsevier.com/locate/bjbas.

Siham Esserti, Amal Smaili, Lalla Aicha Rifai, Tayeb Koussa, Kacem Makroum, Malika Belfaiza, El Mostafa Kabil, Lydia Faize (2017). Protective effect of three brown seaweed extracts against fungal and bacterial diseases of tomato, Journal of Applied Phycology.

Stephan Kremb, Constanze Müller, Philippe Schmitt-Kopplin, and Christian R. Voolstra, Sylvia Urban (2017). Bioactive Potential of Marine Macroalgae from the Central Red Sea (Saudi Arabia) Assessed by High-Throughput Imaging-Based Phenotypic Profiling. 2017 Mar; 15(3): 80. Published online 2017 Mar 20. doi: 10.3390/md15030080 PMCID: PMC5367037.

Stefania Rocca, Alessandro Agostini, Jacopo Giuntoli and Luisa Marelli (2015). Biofuels from algae: technology options, energy balance and GHG emissions; Insights from a literature review EUR 27582; doi 10.2790/125847.

Subhash R. Yende, Uday N. Harle, and Bhupal B. Chaugule (2014). Therapeutic potential and health benefits of *Sargassum* species. Pharmacogn Rev. 2014 Jan-Jun; 8(15): 1–7. doi: 10.4103/0973-7847.125514.

http://www.thierrykarsenti.ca/sitesweb/peer_evaluation/vf/readings/phase1/tekere_readings.pdf.

Walied M. Alarif, Sultan S. Al-Lihaibi, Seif-Eldin N. Ayyad, Mohamed H. Abdel-Rhman, Farid A. Badria (2012). Laurene-type sesquiterpenes from the Red Sea red alga Laurencia obtuse as potential antitumore antimicrobial agents ,European Journal of Medicinal Chemistry 55 (2012) 462e466.

Yousef S. Al-Hafedh, Aftab Alam, Alejandro H. Buschmann and Kevin M. Fitzsimmons (2012). Experiments on an integrated aquaculture system (seaweeds and marine fish) on the Red Sea coast of Saudi Arabia: Efficiency comparison of two local seaweed species for nutrient biofiltration and production.

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