

Development, Production and Market Value of Microalgae Products

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ABSTRACT

Micro-algae are an important nutrient source. The most essential products available in algae dried biomass with high nutrients contented and high valued compounds such as fatty acids, pigments and polysaccharides. This review analyses the valuable products of micro-algae such as Porphyridium species, biomass cultured to produce polysaccharides, pigments and lipids. Behind these things of microalgae, increasingly played crucial role in pharmaceuticals, cosmeceuticals, nutraceuticals and functional food. Additionally, *P.cruentum* biomass may contain the carbohydrates of up to 57% has been reported. Accordingly, the collective quantity of carbohydrates and exopolysaccharides of red micro-algae could potentially provide the source of bio-fuel and pharmaceuticals. Thus, red algae produce high nutritional food sources which are cost-effective and can be easily and rapidly yields for human consumption. To support human health algae provides important diverse sources of essential nutrients. In the last century, microalgae had importance as commercial sources in market of these valued foodstuffs. Currently microalgae have a potential with new wide range ability to produce high-valued compound and other applications freshly gained in industrial value. This review describes major, recent advances in the understanding natural high value products from microalgae products can be developed for foreign markets, and the enhanced worldwide production.

Keywords: Micro-algae; Red algae; Polysaccharides; Pigments; Lipids; High valuable products

INTRODUCTION

Microalgae are the source of nutrients for agricultural products which can be used to increase the production of agricultural plants and productivity of yield on non-productive land and non-potable water. It is a great source of nutrients to decrease the pollution globally. Nowadays, there is substantial economic interest in microalgae due to their application as a natural source of compounds. Such as polysaccharides, pigments, proteins, lipids, and other bioactive compounds, these compounds have much attraction for using in daily life and market potential [1], like, in pharmaceuticals, nutraceuticals, biofuel, and functional food. The marine unicellular *Porphyridium cruentum* (red algae) belongs to the family Rhodophyta, genus *Porphyridium* is evolutionarily one of the most primitive eukaryotic algae [2], with spherical cells that lacking cellulose microfibrils components in their cell wall [3]. These microalgae are encapsulated within a sulphated polysaccharides gel (with acidic

characteristics) [4]. Polysaccharides have attracted the attention because of their anti-oxidant [5], anti-tumour [6], anti-bacterial, anti-inflammatory [7], anti-cancer [8], anti-viral including anti-herpes virus and anti-irritation medication [5], anti-allergic and as well as therapeutic agent activity [9]. In addition, the applications in pharmaceutical, cosmetics, functional food, and bioethanol [3], the pigments produced by the *Porphyridium* spp are unique in nature which mainly used in industries such pharmaceuticals, food and cosmetics [10]. Pigments consist of three basic classes; chlorophylls, carotenoids and phycobiliprotein [11]. Chlorophyll's have four types (chl a, chl b, chl c, and chl d) [12]. The all families of algae have pigments as chlorophylls which are soluble in lipids. Chlorophyll consists of pheophytin, pyropheophytin and pheophorbide and they are used in food and as well as for human benefits, for example they show anti-mutagenic effect which plays best role in cancer prevention [13]. The most widespread pigments in nature as well as in algae are 'Carotenoids'. They represent photosynthetic

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Received: September 23, 2019; Accepted: October 03, 2019; Published: October 10, 2019

Citation: Gujar A, Cui H, Ji C, Kubar S, Li R (2019) Development, Production and Market Value of Microalgae Products. Appl Microbiol Open Access 5:162. DOI: 10.35248/2471-9315.19.5.162

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pigments, and derived from five carbon isoprene units [14]. The benefits of carotenoids (lutein, β -carotene, lycopene) to human health showed properties of anti-oxidant and anti-inflammatory [15]. Phycobiliprotien, which are the main light-harvesting pigments of photo system II in red algae, are the only water-soluble pigments [16]. Phycobiliprotien are categorized into three types (phycoerythrins, phycocyanins, and allophycocyanins [17]. Phycobiliprotien, in particular phycoerythrins, can constitute a major proportion of the red algae cell protein. Phycobiliprotien, are currently use in colorants of food and cosmetics [18], and have shown different bioactivities such as anti-oxidant, anti-tumor, anti-diabetic, and anti-cancer properties [19]. The general composition of microalgae dry biomass as a source of protein is 60% crude protein [20]. The quality of proteins is depending on digestibility and availability of essential amino acids [21]. Different nutritional properties are depending on the different source of protein. According to the world health organization (WHO) proteins having high concentration of amino acids are considered high quality proteins [22]. Algal proteins can be described as the fraction of ingested food components [23], and also anti-cancer, anti-tumour, anti-inflammatory activity [18]. Various photosynthetic microalgae have shown the ability to synthesize and accumulate considerable yield amount of lipids [24]. Natural lipids are generally considered to encompass partial to full glyceride, wax esters, free fatty acids, free fatty alcohols, carotenoids sterols, tocopherol and lignin-type antioxidant and biological-derived hydrocarbon's [25]. In addition, Complex lipids are including phospholipids and glycolipids [26]. However, Lipids also used for different application such as the production of high-value compounds for food supplements, medical treatment and in health care products [27]. Currently, algae have been used successfully to produce lipids especially n-3 poly unsaturated fatty acids (PUFAs) and they are being considered seriously as sources of biodiesel [28]. Microalgae biomass is of interest for human nutrition progressively applied as dietary or "health food" due to high protein content [29], which consist of biopolymers of amino acids, some of beneficial and essential for human beings. In accumulation, for health benefits beside the nutritional assistance some specific protein like smaller peptides and amino acids play big role and contribute in the human body [30].

EXPERIMENTAL

Valuable products of microalgae

Microalgae formed and contain high-value chemicals include polysaccharides, protein these are beneficial special compounds produced by these organisms such as pigments, enzymes, lipids with valuable fatty acids, sterols and minerals for food and feeding purpose, and these are the source of commercialization [29-31]. Microalgae, unicellular red algae such as *Porphyridium* and *Rhodella* produced large amount of polysaccharides [6], and have much attention because of the detection of different biological activities, such as immunomodulatory, anti-bacterial, anti-coagulant, anti-mugentic, radio protective, anti-oxidants, anti-cellular, anti-cancer and anti-inflammatory [32-34]. It's easy and rapidly increasing sources of nutrients with cost-effective

produced large amounts of products of high nutritional value are needed as intensification of world population. For support of human health algae can provide major source of divergent number of essential nutrients [35]. In addition to positively affect the health of humans and animals, microalgae are capable to enrich with the nutritional contents of conventional food preparation. About 9-14% lipids, 40-57% carbohydrates and 28-39% proteins are structurally composed normally of nutritious standards of *Porphyridium cruentum* [36]. Feed stocks for maintainable supply of commodities for together with food and non-food products the microalgae are considered as one of the most significant [37]. The numbers of species of microalgae at least 145 are used worldwide and 27 tons of algae dry products per year is projected as the consumption. Red algae possess a nutritive assessment as a source of proteins including fiber or minerals. Food industries are interested, the presence of unique microalgae pigments such as phycoerythrin is enable the development of functional components (e.g. natural colorant). Algae are rarely concerned in allergy risk compared to supplementary marine food products (e.g. fish) [38]. Nowadays, isolation and identification of bioactive composites from sea weed developed as current trend. Marine micro algae color is one of important feature which is defined by pigments. Such colored chemical substances are the integral fragment of microalgae photosynthetic system [39]. Moreover, various natural pigments isolated from marine microalgae having role in photosynthetic and pigmentation effects, attracts much thoughts in the field of food, cosmetics, and pharmacology. Marine algae comprise three important classes of natural pigment such as chlorophylls, carotenoids and phycobiliprotien. [40]. The chlorophyll found in marine algae are divided in four categories such as chlorophyll a, chl b, chl c, and chl d, these chlorophyll mainly present in red algae [41]. The β -carotene and astaxanthin are the two major part of carotenoid [42]. The light energy harvest and antioxidants function of carotenoids (linear polyenes) inactivates the reactive oxygen species (ROS) after light and air exposure [40]. The phycobilisomes (PBSs) are the complex light harvesting main accessory structure present in Cyanobacteria and red algae, whereas phycobiliprotien a large and highly structured assembly of PBSs is associated to the cytoplasmic surface of the thylakoid membrane. Generally, PBSs are divided in to three main categories allophycocyanins, Phycocyanins, and phycoerythrins [43], the phycoerythrins are mostly present in red algae species as the most abundant part of the phycobiliprotien [44]. Microalgae are a source of biofuels as considered as most promising feed stocks. The algae photosynthetic system is converting carbon dioxide in to carbon-rich lipids [45,46]. Polar and neutral are the two major classes of lipids. They are soluble in water but soluble in mostly organic diluters. Polar lipids are distributed in to two classes such as, glycolipids and phospholipids whereas neutral lipids have three classes comprise acylglycerides (tri, di- and monoglycerides) and free fatty acids. The neutral lipids used as energy source by microalgae, while to form cell membranes polar lipids are used [47]. Furthermore, fatty acids are components of lipid molecules together in neutral and polar and the key to biodiesel production is composition of fatty acids. It is noted that hydrocarbon, sterol, ketones, pigments, (carotenes and chlorophyll) are neutral lipids that do not comprises fatty acids.

They are not convertible to biodiesel the fraction of lipids are soluble in organic solvent [46]. Some microalgae are affiliation and taxonomic in properties these are cultivated for having very wide range of phytosterols comprising brassica sterol, sito sterol and stigma sterol, entirely, eukaryotic organisms made up and components of membranes they hold essential sterols. These functions are fluidity and permeability they are control by membrane (Figure 1). The algal phytosterols have properties of pharmacology and also used in functional food. Although, the phytosterols remains to be fully explored from prospective of microalgae [44-48].



Figure 1: Representation of prospective microalgae products such as lipids, pigments, carbohydrates, polysaccharides and bio hydrogen. In accumulation, the area of these of final application of these products such as agriculture, aquaculture, generation of green energy carriers, and pharmaceutical and nutritional purposes are indicating.

Polysaccharides: The Porphyridium species cell consists of membrane these are surrounded by capsule. The capsule is made up of a water-soluble sulphate polysaccharide, a high molecular weight poly anionic polymer [49]. Extra polysaccharide have explained that, structure and composition of extracellular polysaccharides is composed of 36% hexose, 30% pentose, 8.5% uranic acid, 9% sulphate, and 1.5% amino acids, and the water contact where microalgae live having 13.9% of polymer is considered. In accumulation, Polysaccharides are manufactured by all living organisms. Up to 40 different monosaccharaides combination and linked with glycosidically and based on chemical structure and have exhibition of enormous varieties [50]. Moreover, to their bio lubricant activities, the red micro algal polysaccharides have various application suggested for the use in nutritional, cosmetics, pharmacological, and anti-herpes drugs, as progression organizers in agriculture, and in the healthiness foodstuff market [6,51,52]. Microalgae polysaccharides play vital role in the field of pharmaceuticals such as antiviral, anticancer and cancer preventive properties [53-55]. Reported that, some fungal polysaccharide with immune-stimulatory activity have been found to act as antineoplastic compound when use in combination with chemotherapy and/or radio therapy in

patients having brain, lung, or gastric cancer [56]. It is reported that, the polysaccharides are effecting the virus-related replication and also advantageous tools due to their immune-modulator and antitumor activity, their interference in the clotting system and in the inflammatory processes, in dermatology in dietary programs [57]. Polysaccharides have inflammatory abilities in cosmetics, when directed against specific parameters of human skin inflammation [58]. The physiological functions of microbial polysaccharides are extremely diverse and depend on their structure and architecture.

These communities and structure of flocs and biofilm play major role in multipart of microalgae. Microalgae produced large number of polysaccharides beside the Porphyridium and Rhodella species produced maximum number of polysaccharides [6], report the Porphyridium sp. polysaccharide was shown the anti-tumor activity was demonstrated against sarcoma inoculated in the peritoneal cavity of mice and against myeloid Graffiti tumor. In addition sulphate polysaccharides may be used in functional food components for remitting diarrhea and have anti-diarrheal activity established to evaluate against ETEC-K88 in mice [59]. The fact is that the Porphyridium spp; polysaccharide is not toxic. In addition, the microalgae possess therapeutically value and nutritional, that are rich in indigestible polysaccharides such as (agrarians, carrageenan alginate) are widely use as food additives. These algae also constitute potential sources of dietary fiber, and thus may have different physiological effect on human body [60,61]. The polysaccharides from red marine algae are one the cost-effect production because of the problem is that limiting source of the industrial development, polysaccharides from plant, microalgae, or above all non-photosynthetic microorganisms is not inexpensive rather than produced from red marine algae. While in the context these polymers are niches available only for some markets. The intensification of small companies the production of maximum microalgae biomass developments of bio refineries strategies are used for treatment of biomass and next change in to the high assessment of complexes, in this situation the price of algae high value compound is decreased significantly [6], actually the properties and potential application of algae required extensive scientific research and study; Nevertheless, as yet, the important way and acceptance is not found, essential because the cheaper substitutions form of microalgae (e.g. carrageenan, fucoidan, agar) [44].

Lipids: Lipids are the main part of algae that can be categorized into two classes polar and neutral. They are water insoluble but in most organic solvents it is soluble which includes phospholipids and glycolipids, while acylglycerides (tri, di-and monoglycerides) are the free fatty acids found in neutral lipids, which are primarily deposited in cytosolic lipid bodies [62]. Moreover, neutral lipids are used as an energy source by Microalgae and polar lipids from cell membrane. Lipid, a reserve of energy in the microalgae cell, is a favorable feedstock for biodiesel and have an extensive spectrum of suitability where food and pharmaceutical industries can get advantage [63,64]. In the field of oil the microalgae have great potential in bio fuel have oil content ranging (20% to 70%), algae produce lipids such as triacylglyceride (TAG) that can be converted into

biodiesel [62-65]. While invention of biodiesel and the practice of flue gas is key methodology selected till now; bio ethanol, bio methane, and bio hydrogen are also the important bio energies obtain from microalgae [66]. Freshly studies have determined that industrial-scale production of microalgae biodiesel can only progress sustainable economics if a bio refinery centered invention approach is followed. In a bio refinery, the crude lipids are to be segmented in to efficient constituents which have been interconnected with the up gradation of anti-oxidant, anti-inflammatory as well as anti-carcinogenic events in the human bodies and are usually used as food supplements [54], such as Omega-3 traditionally extract from fish oil. Also they may be sources of material such as eicosapentaenoic acid (EPA) and decosahexaenoic acid (DHA) for the pharmaceuticals industries [62]. In addition, they have exceptional capability of making a huge quantity of high value bioactive compounds that can be used in pharmaceutical compound health food and natural pigments. Few well studied include acrylic acid, β -carotene vitamin B, ketocarotenoid, polyunsaturated fatty acids and lutein [66]. For the accomplishment of industry, targeted product must have a high harvest and stable end-products. Though microalgae gather lipid throughout stress condition where biomass production is adversely affected, to solve this challenge is via the genetic engineering [63].

Pigments: Oceanic algae have support as imperative foundations of bioactive natural constituents. Moreover, outlying Marine algae possess countless metabolites having properties and exposed of biological activities and prospective of healthiness advantages. Therefore, marine algae have arisen as new hope and development to quarantined and recognize bioactive compound and elements. Here as, this is Unique and the important physical appearance of marine algae is natural pigments. These pigments are natural in colored chemical and physical substances that are involved in the photosynthetic structure of marine algae. They are categorized into three groups' carotenoid or β -carotene, chlorophylls and phycobiliprotien. In the field of food, cosmetics and pharmacology such pigments have been reported to give health benefits. In pigments carotenoids are most common one in nature and re synthesized in microalgae. Carotenoid usually used in animal feed for their color properties, the natural carotenoids are fish feed also to support fish color and used for the improvement of the yellow color in egg. Carotenoids and especially β -carotene as pigments can be used in food and beverage that is margarine, soft drinks, fruit juices, baked, dairy products, and confectionary, mostly in the preparation of the health food [67,68]. Carotenoid contains pharmaceuticals properties, such as anti-oxidant, anti-tumor, anti-ageing, anti-inflammatory, anti-angiogenic cardio and hepato protective. In addition in the field of cosmeceuticals which aims cosmetics create product to improve skin and hair. Chlorophylls is the most prominent and greenish pigment, is known to be convert pheophytin, pyropheophytin and pheophorbide in processed vegetable food and have anti-inflammatory anti-carcinogenic and anti-mutagenic effect and may have involved in prevention and therapeutic purposes in cancer [69]. Currently, in pharmaceuticals, cosmetics and in food industries neutral pigments produced by chlorophyll have drawn much attention

towards microalgae [39]. Other natural pigments found in microalgae are phycobiliprotien which are water soluble protein are also used as accessory or antenna for photosynthetic light collection which absorb energy. In many algae phycobiliprotien are arranged in sub-cellular structures called phycobilisomes and there are three major categories of phycobiliprotien which are Phycocyanins, allophycocyanins and phycoerythrin with phycoerythrin is most abundant in phycobiliprotien found in many red algae species. These pigments have been shown to exhibit anti-oxidant, anti-inflammatory, neuroprotective, hypocholesterolemic, hepatoprotective, anti-viral, anti-tumor, liver protecting ,atherosclerosis treatment, serum lipid-reducing and lipase activity [18]. Phycobiliprotien are currently being used as natural colorants for food, cosmetics, printing dyes and textile. Application and are used in food known as dairy products and chewing gum, in addition to lipsticks and eyeliners [70].

Valuable compounds

Cosmetics: Marine-algae derived subordinate metabolites are well known for their skin benefits, and many algae grip and helpfulness is used in cosmetics and other properties of valuable products, which defense fortification from ultraviolet radiations and prevention of rough texture, wrinkles, and skin softness. It also avoids the skin aging in the occurrence of antioxidant compound. The skin barrier function and preservation is improved with the ability of Cosmetics [71]. To avoid cell destabilization and block reactive oxygen species (ROS) skin naturally possesses antioxidant agents [72]. Nevertheless, the accumulation might hence be responsible for photo aging complication; the defenses can be over run when the amount of reactive oxygen species (ROS) is increased by ultra violet (UV), and clearly noticeable with the presence of wrinkles and skin dryness [73]. Cosmetics comprising algae peptides can be used in skin and hair care products, hair coloring agent, face lotion, milky lotion, hair restorer, cream, rinse, skin lotion, solution for enduring wave, shampoo, and body soap or bath agents [74].

Here the role of active peptides (less than 20 amino acids) in skin and hair care has attracted considerable attention in industry. Moreover, peptides are ability to protect the hair loses and alternative sources to synthetic ingredient and may contribute to anti-aging [75]. For the whitening cosmetics products which constrain tyrosine enzyme inhibiting hyper skin coloration and exciting bleaching unadulterated extract of nannochloropsis oculata, which comprises zeaxanthin an antityrosinase constituent was original to be used in cream, only the brown algae that revealed the actual tyrosinase inhibition activity due to their capability to chelate cooper [76]. Extract of *Monodus* sp., *Thalassiosira* sp., *Chaetoceros* sp., and *Chlorococcum* sp. are proposed for formulation to prevent hair loss [77]. Aluronic Acid is used to form a new cosmetic product from algal which is purified extract of polysaccharide from heterotrophic green algae [42]. This obtain from several other microalgae-derived cosmetics constituent known as polysaccharides from *Porphyridium*, in addition, red algae contain polysaccharides such as carrageenan has been used as viscosity altering and thickening agent in cosmetics products [78]. Carotenoids are significant lipid-soluble pigments that

direct affect photo protection against UV light-induced oxidation in the skin. The extracts of Spirulina, chlorella and, Aphanizomenon protein-rich extracts from Spirulina and other algae extracts are commercially available in cosmetics products. Spirulina extract is rich protein which repairs the signs of early skin aging, exerts a tightening effect and prevents striae, and extract of chlorella act against wrinkles and stimulates collagen synthesis in skin and also protect harmful environment aggression [79,80]. The skin dryness prevention and water holding capacity of the skin is increased by Alginates which act as humectants. Hence, alginic acids and its calcium salt are water-soluble it fulfill cosmetics function is also used as a consistency agent. Algae have great potential treatment for acne.

Pharmaceuticals: The imperative of oceanic algae is well recognized due to their valuable health beneficial effect as a source of functional ingredients which is produced by algae. Consequently, biological activities of marine algae having attracted with deal of attention for isolation and investigation of novel ingredients. Amongst the well-designed constituents acknowledged from marine algae, such as natural pigments [40], carbohydrate unaccompanied with protein and lipids [81], algal phenolic compound, polysaccharides, fatty acids, algal alkaloids, sterols and carotenoids [82], have used and received an individual helpfulness in pharmacology field. Furthermore, a growing interest shown in monitoring and development of such composites in micro-algae as an integral and innovative products with pharmacological properties. With great benefit of consuming microalgae related to conventional properties such as natural, nontoxic, and abundant. Although, diverse kinds of bioactive molecules situated in microalgae are offered together with their possible practices as antioxidant, anti-inflammatory, anti-tumoral, anticancer, antimicrobial, antiviral, anti-coagulant, anti-fungal, anti-diabetic and anti-allergic agents along with other pharmaceutical properties [51].

Various anti-inflammatory activities suggested for survive under extreme conditions and scarcity interval, it is known that polysaccharides of red algae has vital role in protection under such lethal conditions [83]. Furthermore, Porphyridium cruentum a sulphate extracellular polysaccharide exhibited antibacterial activity against salmonella enteritis at 1%, and also antiviral activities against an extensive variety of viruses, and most of the polysaccharides an excessive deal of effort has been dedicated on determining anti-cancer and complex for the improvement of effective therapeutic for numerous human cancers [84]. Described, that cyanobacteria, red and green algae strain are well known for anti-allergic properties. Moreover, hyaluronidase activation can be inhibited by Porphyridium Purpureum and D. Salina with IC₅₀ value of 180 and 150 mg/mL, respectively [82]. Report phycobiliprotien have shown crucial importance in various human beings' activity many years ago, because of their potential pharmaceutical and biological properties. Phycocyanins one of the phycobiliprotien classes has been reported to be major phycobiliprotien in red algae. Phycocyanins have pharmacological properties include anti-oxidant, anti-inflammatory, anti-cancer properties [85]. The marine algae are regarded as a promising source for the production of therapeutic drugs agent of viral diseases. In addition Porphyridium sp. Spirulina plantensis and blue green

algae shown inhibit the replication activity against several enveloped viruses both in vitro (cell culture) and in vivo (rats and rabbits) [86,87]. Red alga was the source of three anti-bacterial and anti-fungal diterpene-benzoate compound bromophycolide and a non-halogenated compound was cytotoxic against several human tumor cell lines by specific induction of apoptosis [88].

Functional Food: The principal guideline to follow in the design of a new functional food is the increase as much as possible the benefit and risk ratio. Increase the benefit indicates to express for a physiological varied influence, promising that prevailing bioavailability and that the maintained bioavailability are going to kept beside all the beneficial life of the food [89]. Moreover, microalgae bio technology states the production of dissimilar products: Phycobilins, carotenoids (β -carotene, astaxanthin), fatty acids, lipids, vitamins, polysaccharides that find an application in health food, feed and food supplement [80]. The microalgae cell constituents consulted because organisms are considered as ideal participant for existing fashion-able health food [20]. Long chain poly unsaturated fatty acids has earned significantly as a dietary supplement or nutraceuticals. Examples of microalgae Isochrysis galbana biomass enriched with ω -3 fatty acids which is used as a functional food in bakery products such as biscuits [90]. Furthermore, to enhance the usage of seaweeds in the human nutrition might be the induction of the reserve as efficient constituent in food processing. For example, R-phycoerythrin (RPE) extract richer, pigment red in colour obtained from red algae might be treated as a food coloring agent [37]. Phycobilins, such as phycobiliprotien are a group of colored proteins with tetrapyrrole prosthetic group (bilins), which in their functional state, phycobiliprotien are high value photosynthetic accessory pigments in red algae, find application of health food (widely use in synthetic food colorant) [85]. Lipids are vital for entire living organisms as constituents of membranes, energy storing composite and vital for nutritional or fats. Lipids membranes contain sterols such as fucosterols and β -sitosterols that also have reported health benefit [91]. Proteins are biopolymers of amino acids, which are vital for human being. Furthermore, some proteins, smaller peptides and amino acids have function that contribute to some health benefits, besides the nutritional profit [30]. Protein content differ widely across group of algae, among the red algae prophyra spp. ("laver"), pyropia spp. ("nori") often content high level protein (as % dry wt.) which is used as nutraceuticals or be included in functional food [91]. Carotenoids are organic lipophilic compound that are formed by plant and algae. Carotenoids are divided in two groups: carotenes and xanthophyll. In humans, one molecule of β -carotene can be cleared by the intestinal enzyme β , β -carotene 15, 15'-monooxygenase in two molecules of vitamin A, and human use vitamins supplement in daily life and also food coloring [92]. The biological activity and application of polysaccharides, active bio compound synthesize by marine unicellular algae, include, Porphyridium spp. which are, most of the times released in the surrounding medium (exo- or extracellular polysaccharides, EPA), which inhibit properties of nutraceuticals and functional food [93]. Although, currently the market place for efficient food by for exceeds all other practices of microalgae.

Approximately 2400 t microalgae biomass was marketable per year for health [20]. Currently, In Germany, food making and delivery enterprises have initiated thoughtful events to market useful foods with microalgae and cyanobacteria. Examples are pasta, bread, yogurt and soft drinks. Correspondingly progresses can be detected, for examples in France, Japan, USA, China, and Thailand [93].

Others Bioactive compounds: Numerous bioactive compounds had drawn the attention towards microalgae due to the inspiring productive biological properties, such as various anti-bacterial or anti-microbial, anti-algal, anti-viral, anti-fungal, and anti- protozoa, composites. The agar diffusion assay is known as most common anti-microbial compound detecting assay. This technique supports the invention of anti-microbial composites that can work against gram-positive bacteria, gram-negative bacteria, and fungi [30]. The investigators also stressed on the statistics that some marine unicellular algae, as Porphyridium, Rhodophyta and Cyanobacteria, such as Arthrospira, can yield sulphate polysaccharides, which is previously used as anti-viral agent both in vivo or in vitro. Furthermore, freshly investigator provided a wide-ranging review on the production of diverse compound of microalgae having anti-biotic and anti-mycotic properties. Moreover two marine dinoflagellates produce ciguatoxin and okadaic acid which exhibited to have an anti-fungal property [93], is another marine dinoflagellates is Amphidium that yields innovative compounds, karatungiols with anti-fungal and anti- protozoan properties [94].

Market values: Because of abundant accessibility in the marine ecology, microalgae have the ability to become tremendous sources of high biological valued composites with health benefits that is lipids, polyunsaturated fatty acids, pigments, minerals, protein and vitamins which might be consumed in diverse market [68]. The actual market situation and market price is depending on algal biomass and its esteemed continents are fluctuating conditions of comprehensive area where the microalgae grow. The actual situation of strong market it's depend on purity of high value products. The complete algal biomass the quantities is not exceeding an insufficient per cent mass. Those algal products could be taken in to account whose featuring the maximum market values, measuring few percent per quantity not more than entire algal biomass [29]. The micro algal market is dominated by the Chlorella and Spirulina. The microalgae biomass was mainly practiced in the markets of food health during past decades, for the manufacture of powder, tablets, capsules, or pastilles more than 75% of biomass production of microalgae used annually [93]. Market size of recommended omega-3 based pharmaceuticals together represent 1.5 billion dollar [95]. It is believed that about 20% of whole food market could be constituted by the functional foods in coming few years. The functional foods is believed to be the most dynamic sector in the food industry and could constitute up to 20% of the whole food market within the next few years. The current estimate worldwide market size for nutraceuticals product is 30 to 60 billion dollars, primarily in the United States, Japan, and Europe with a capability of short-term market demand of over 197 billion dollars with the upsurge in demand for nutritional and food supplement [96]. The market potential pigments include C-Phycocyanins sells for between US dollar

500 to 100,000 kg⁻¹ depending on purity, the value for phycobiliprotein products (include fluorescent agents) is estimated to be greater than US dollar 60 million, in addition, market of carotenoids in 2016 was about US dollar 1.24 billion [96]. The annual market of seaweed polysaccharides is around (90, 000) for hydrocolloids cosmetics and pharmaceutical industries for there are average price of 20 (low value market such as hydrocolloids) and 3000 (high value biological agents) US dollar per kg [97,98].

CONCLUSION AND FUTURE PROSPECTIVE

The microalgae (red algae) have a potential with new wide range ability to produce bioactive functional high-valued products like polysaccharides, Pigments, algal extracts and their by-products as pharmaceuticals nutraceuticals, cosmeceuticals, health food and other applications freshly gained in industrial development for foreign market and worldwide production, which enhances the economic value for the consumption of human being. Moreover, further research effort is required on the genetic transformation and manipulation of micro algal strains to favors a high level production of target compounds, it also indicates appropriates criteria for future direction, developments and marketing.

ETHICAL STATEMENT

The Research is not involved against human or animal.

EXPERIMENT CONSENTS

The main objective of this review was to elaborate the importance of microalgae in terms of production of beneficial products such as food supplements, therapeutic agents, cosmeceuticals and other valued by products for human being consumption. Furthermore it also indicates appropriates criteria for future direction and developments.

FOUNDATION

Key Research and Development (R&D) Planning Project of Shanxi Province (Grant No. 201803D31063), China Postdoctoral Science Foundation (2018M631768), the State Ministry of Agriculture "948" Project (2014-Z39), Shanxi Province Key Projects of Coal-based Science and Technology (FT-2014-01), Shanxi Scholarship Council of China (2015-064)

Key Research and Development (R&D) Planning Project of Shanxi Province (Grant No. 201803D31063), Applying Basic Research Planning Project of Shanxi Province (Science and Technology Foundation for Youths) (Grant No. 201801D221250)

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