Biological Activities of Green Macroalgae *Enteromorpha Prolifera* for Potential Applications

**Abstract**

*Enteromorpha (Ulva) prolifera*, an important member of marine green algae, contains many bioactive compounds among which polysaccharides are the major components. This seaweed attracted extensive interest due to its multiple biological activities. *E. prolifera* has been identified as a potential producer of a wide spectrum of natural substances such as carotenoids, fucoidans and phlorotannins. These compounds show different biological activities in some vital industrial applications like pharmaceutical, nutraceutical, cosmeceutical and functional foods. This review focuses on biological activities of the green macroalgae *E. prolifera* based on latest research results, including antioxidant, antibacterial, immunomodulatory and hypolipidemic effects. The facts summarized here may provide novel insights into the functions of *E. prolifera* and its derivatives and potentially enable their use as functional ingredients.

**Keywords:** Green macroalgae; *Enteromorpha prolifera*; Bioactivity; Application

**Introduction**

Algae are classified as unicellular microalgae and macroalgae, which are macroscopic plants of marine benthoses. Macroalgae, also known as seaweed, are distinguished according to the nature of their pigments: brown seaweed (*phaeophyta*), red seaweed (*rhodophyta*) and green seaweed (*chlorophyta*) [1]. Seaweeds are considered as a source of bioactive compounds as they are able to produce a great variety of secondary metabolites characterized by a broad spectrum of biological activities. In the summer of 2008, the large accumulations of green macroalgal biomass occurred in the Yellow Sea brought serious ecological damage and economic losses [2]. Morphological and molecular identification showed that the main species of the green tide is *Enteromorpha (Ulva) prolifera*, which is a macroalgae belongs to the order of *Ulvales* and the family of *Ulvaceae* (Figure 1). *E. prolifera* is one of the most popular green seaweeds in Asian countries. It is better known as *Enteromorpha prolifera*.

![Figure 1: Green tide of *Enteromorpha prolifera* in coastal waters of the Yellow Sea near Qingdao, China, in August 2014.](image)

**History, Distribution and Classification of *Enteromorpha Prolifera***

There still have some controversies about division for *Enteromorpha* and *Ulva* genera. They are widely regarded as easily recognizable sea-weed genera. Despite their obvious differences in habit, they share many cellular, ultra structural, physiological, and developmental characters, including having the same type of highly tolerant and fast-adhering spores. Woolcott & King [3] were of the opinion that *Enteromorpha* and *Ulva* should be divided into two genera after studied on the rbcL gene of the East Australian *Enteromorpha* and *Ulva prolifera* [3]. However, Hayden et al. [4] have conducted a systematic analysis to nearly 30 kinds of *Enteromorpha* and *Ulva* ITS nrDNA and rbcL gene [4]. Combined with earlier molecular and culture data, they believed that there were no significant differences between these species and the two algae should not be recognized as separate genera. All this shows that until now there has not a clear and effective standard can get *Enteromorpha* and *Ulva* completely separate.

The life history of *E. prolifera* is typically an alternation of isomorphic, unisexual haploid gametophytes and diploid sporophytes. This seaweed is distributed widely in the intertidal zones of shores and estuaries around the world by the virtue of its tolerance of a wide range of salinity and water temperature. It has been reported that the early germination of spores of *Enteromorpha* sp. required attachment to a solid substratum, such as small sand particles and the thalli, and could then grow without the need for attachment to the substratum. Santeliees & Paya [5] reported that *Chlorophyta* fragments caused by grazers or in their excreta could reproduce new individuals [5]. However, little information is available about the process by which the fragments give rise to new individuals. Fragments of the appropriate from the *E. prolifera* thalli broken by a variety of factors via producing spores to give rise to the rapid proliferation of the seaweed under field conditions [6].

**Nutrition and Medicinal Value of *Enteromorpha* in Food Industry**

Over the last decades, marine algae have received a lot of attention as functional food ingredients. Seaweeds have been...
Biological Properties of Enteromorpha Prolifera Polysaccharides

The physical properties of polysaccharides in green seaweed are closer to those of land plant leaves than to other classes of seaweeds. Algae are a diverse group of photosynthetic organisms containing polysaccharides as the main components of biomass. In green algae, the major polysaccharides are polydisperse heteropolysaccharides where glucuronoxylorhamnans, glucuronoxylohamaglactans or xyloarabinogalactans are the three main groups. Many papers have been published on the chemical characterization of polysaccharides present in Ulva. However, the structures of E. prolifera polysaccharides (EPPs) present in Enteromorpha have not yet been fully characterized [9].

Tang et al. [10] illustrated that EPPs had a high hypolipidemic activity and this activity might be due to its antioxidant potential [10]. EPPs showed decreased body weight gain, plasma triacylglycerol (TG), total cholesterol (TC), plasma low density lipoprotein cholesterol level, liver TG, liver TC and liver weight in rats [11]. Cho et al. [12] attributed the strong antioxidant activity of the extracts from E. prolifera to a chlorophyll compound, pheophorbide a, rather than phenolic compounds [12]. EPPs exhibited potent immunomodulatory properties and could be used as a novel potential immunostimulant in food and pharmaceutical industries [13]. Some research have reported that EPPs could enhance the activities of alkaline phosphatase, superoxide dismutase and lactate dehydrogenase and increase the level of NF-κB. Lü et al. [14] have studied antibacterial activities of EPPs and they found the stronger inhibitory of EPPs effect on Escherichia coli and better inhibitory effects on plant pathogenic fungi [14]. Marine algal sulfated polysaccharides also exhibit various biological activities, including antioxidant, antiviral, antioxidative, anti-tumor and anti-inflammation. It was reported that sulfated polysaccharides from E. prolifera showed it could stimulate macrophage cells and induce considerable NO and various cytokine production via enhanced mRNA expression [15].

Conclusion

E. prolifera contains many nutritional compounds and polysaccharides have been attracted extensive interest due to its multiple biological activities. The uses of these compounds span from food, cosmetic and pharmaceutical industries to microbiology and biotechnology. E. prolifera polysaccharides play a nutritional role as dietary fibre and demonstrate biological activities or gelling abilities. The facts summarized here may provide novel insights into the functions of E. prolifera and its derivatives and potentially enable their use as functional ingredients.

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