

## Medical Applications of Algae: A Review

**BIRIȘ-DORHOI Elena-Suzana, Maria TOFANĂ\*, Delia MICHIU**

University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca,  
Faculty of Food Science and Technology, Department of Food Science,  
Technology Transfer Centre BIOTECH,

3-5 Calea Mănăștur, 400372, Cluj-Napoca, Romania

\*Correspondence: maria.tofana@usamvcluj.ro

**Abstract:** Algae are known as powerful agents since ancient times. In recent years, more and more studies suggest algae's potential in the medical field. This review aims to show the most important advances in the uses of algae in the medical field. Due to their bioactive compounds (such as polyphenols, polysaccharides and more) algae (both micro-and macro-algae) have a variety of uses. They were proven to have antioxidant activity, were used as anti-viral agents or for anti-cancer treatment. Also due to their polysaccharides, they were also shown to possess anti-hyperglycaemic and anti-hypertensive effects. Species of micro-algae were used with success in urinary tract infections treatment. Some algae found uses in dentistry. They were included in toothpaste in order to reduce the chance of cavities (they possess anti-microbial activity which can help protect against cavities). Bioactive compounds from algae were also found to have neuroprotective potential.

**Keywords:** algae, anticancer, bioactive potential, dentistry, medical applications.

### Introduction

Algae, both micro- and macro-algae (Figure 1), exist for millions of years. They are part of every water ecosystem (sea, ocean, pond etc.). In Asian countries they are used for a variety of uses. Some of the algae are edible and are viewed as a delicacy (nori, *Ulva*, etc.). Some can be used for wastewater treatments (*Ulva*, *Cystoseria* genus) (Biris-Dorhoi et al., 2018).

Biological compounds found in both types of algae present incredible possibilities for humans. Many studies found different

kinds of potential applications for algae, including in medical field. Species of algae can be found in large quantities and are often considered “useless”. Nature provides us with a large variety of algae from which we can choose to help cure different diseases or help alleviate some symptoms. Some can be used for faster cancer diagnosis, thus ensuring a much better chance of survival (Kanwal et al., 2022).



Figure 1. Macro- and micro-algae

Source: <https://www.nuwen.com/en/health-and-food/the-benefits-of-algae-in-our-food/>

They can be used for different bioactive properties (Alves et al., 2013; Rasala and Mayfield, 2015). Algae were proved to be an antiviral agent (Wu et al., 2011; Zhang et al., 2020b). Also, their antioxidant potential is being studied in many articles (Kelman et al., 2012; Costa et al., 2010). Some studies have shown that algae polysaccharides can be used as an anti-coagulant alternative to heparin (Liu et al., 2018) and they also present an anti-hyperlipidemic potential (Abdel-Raouf et al., 2015; Yoon et al., 2008).

More and more studies have focused on the anti-proliferative algae potential against cancer cells. Not only that, for diseases where the immune system is damaged or disabled the therapy plan included algae extracts (Castro et al. 2006; Leiro et al., 2007). A study from 2010 (Ghisalberti) suggested that algae can also be used in the treatment of musculoskeletal disorders.

Hydrogel-forming polysaccharides from algae are also used for their medical applications (Beaumont et al., 2021).

Purified algal-expressed options were studied in order to find another route to administrate antibiotics to animals and it was found to be able to stimulate the secretion of mucin<sub>3</sub> in the human

intestinal epithelial cell line (harvested from *Chlamydomonas reinhardtii*) (Manuell et al., 2007). Therefore, orally-active substances could have a major impact in redesigning the administration of medicine to animals (including in feed).

Nanoparticles obtained from micro-algae, due to their biological activity, can be used in diverse areas such, medical diagnosis, cancer treatment and anti-biofilm applications (Uzair et al., 2020; Chauhan et al., 2022).

Below there is a short immersion which includes algae potential uses in the medical field.

### Anti-cancer effect

The term cancer is used as an umbrella for diseases which can be deadly. Each year different types of cancer affect more and more people. Cancer can have multiple causes and, most of the times; it's hard to pinpoint a cause to a cancer. Many studies try to find connections in order to decrease the chance of cancer development. Kanwal et al. (2022) researched an artificial algae algorithm (AAA). A model for cancer prognosis and prediction was developed and it showed an improved cancer diagnosis.

Cancer can be slowed or stopped through cell apoptosis. A possible mechanism for apoptosis is presented in Figure 2.

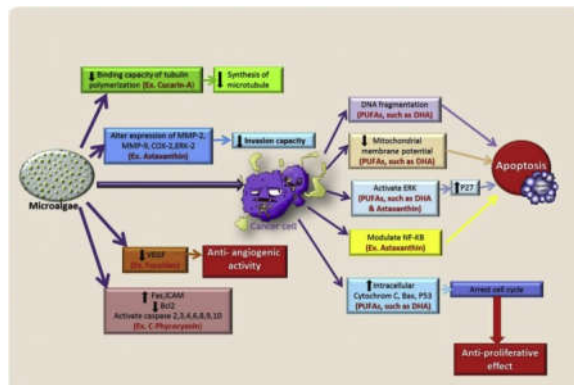


Figure 2. The possible mechanism for anti-cancer effect of microalgae  
Source: Mohamed et al., 2019

Regarding the constituents, *ulvan* is one of the most researched. Some of his effects are similar to hyaluronic acid, at

cellular level (Alves et al., 2013a; Alves et al., 2013b). *Carrageenan* (Degraded  $\kappa$ -carrageenan) is also a constituent that was found to have anticancer effect. *Carrageenan* from *Kappaphycus alvarezii* induced apoptosis (cell death) in many types of human cancer: human epithelial colorectal adenocarcinoma, normal human small intestine, human hepatocellular carcinoma (Zainal et al., 2014; Yao et al., 2022).

Ancient civilizations owned knowledge which allowed them to use the green algae to treat different diseases, including hyperlipidaemia and urinary diseases (Pengzhan et al., 2003). Species like *Ulva lactuca* and *Enteromorpha linza* were found to have potent antifungal effect on species commonly found in urinary tract infections (El-Baky et al., 2009; El Zawawy et al., 2020).

Marine algae polysaccharides were studied regarding their anticancer effect. Polysaccharides extracted from red alga *Gracilariopsis lemaneiformis* exhibited an inhibitory effect that was correlated to the concertation. The extracts were tested on human breast cancer cells, human hepatoma cells, and human cervical cancer cells with favourable outcome. However, they showed no cytotoxic effects on Madin-Darby canine kidney cells (Chen et al., 2018; Yao et al., 2022).

Brown alga *Laminaria japonica* was studied regarding its apoptosis potential (mostly late apoptosis) in human nasopharyngeal carcinoma cells with success (Zeng et al., 2017).

Regarding human gastric carcinoma cells, polysaccharides extracted from the red alga *Porphyra haitanensis* induced apoptosis with a maximum in the concentration range of 10–500  $\mu\text{g}/\text{mL}$ . Green alga *Capsosiphon fulvescens* induced apoptosis in human colon cancer cells (Choi et al., 2019).

*Fucus vesiculosus* possess *fucoidan* which was found to have anti-cancer activity against large B cell lymphoma cells (Yang et al., 2015).

The metabolism of polysaccharides and oligosaccharides from *Saccharina japonica* produces a large number of SCFAs, especially acetic acid, propionic acid, and butyric acid, therefore the extracts are proved to help with gut microbiota (Zhang et al., 2020a).

## **Anti-viral and anti-bacterial effect**

Algae also present anti-viral and anti-bacterial potential. Studies became more and more specific regarding which species of algae presents what potential and in what dosage. Similar to the anti-cancer effect, the biological compounds that present anti-viral and anti-bacterial effect are also polysaccharides. Polysaccharides extracts from *Chlamydomonas reinhardtii* (Chlorophyta) showed two potential usages. One usage includes the ability to inhibit the formation of biofilm and the second one the ability to dissolve the preformed biofilms (Vishwakarma and Vavilala, 2019).

Some of the studies led to the first drug used to treat different diseases produced by viruses. For Human immunodeficiency virus (HIV) which is the retrovirus that causes acquired immune deficiency disease syndrome (AIDS), a specific polysaccharide extracted from brown alga *Saccharina japonica* (Phaeophyceae) was included in the first drug anti-AIDS and it inhibited HIV replication (Wu et al., 2011). Another study showed that polysaccharides from *Sargassum fusiforme* also show the positive impact in inhibiting the infection and replication of HIV-1 at various stages of the viral life cycle (Zhang et al., 2020b).

Algae derivated vaccines are on the way. One study presented a possibility for algal produced vaccine to be used in the treatment of malaria (Dauville'e et al., 2010).

The marine green alga *Dunaliella salina* was used with a good outcome in the treatment of hepatitis B by adding a surface antigen (Geng et al., 2003).

## **Anti-hypertensive and anti-hyperglycaemic effect**

*Ecklonia cava* is a species of algae which contains *phlorotannins* which were isolated and reported for angiotensin-converting enzyme inhibitory effect (Wijesinghe et al., 2011). *Sargassum fusiforme* is another species of algae that presents anti-hypertensive and anti-hyperglycaemic effect. Not only that, the extracts were proved to help improve liver and kidney function in diabetic rats (Jia et al., 2020b), and also promote glycogen synthesis in the liver and skeletal muscles (Jia et al., 2020a).

*Ulvan* is also considered heparinoid agent, meaning it has anti-coagulant activity (Alves et al., 2013a; Alves et al., 2013b).

Brown alga *Hormophysa cuneiformis* influences creatinine level therefore it has been proved to possess an anti- hyperlipidaemic activity used for the medical field (Abdel-Raouf et al., 2015).

### **Algae use in dentistry**

Algae have found their uses including in dentistry. Usually, their use is due to their anti-microbial potential and was used in the formulation of oral hygiene products such as toothpaste, mouthwash, or chewing gum (Balasubramaniam et al., 2022). *Carrageenan* is a polysaccharide derived from seaweed which is used in the food industry. It can be used as a thickener and stabilizer in toothpaste. The reason for its use is its antimicrobial ability which can help to prevent dental cavities (Jung et al., 2013). Different extracts from algae *Laminaria japonica*, and blue-green algae (*Aphanizomenon flos-aquae*) were added to toothpaste in order to help prevent cavities also because of their antimicrobial potential (Kim et al., 2013; Gade et al., 2013). The administration of extract from *Ecklonia cava* (400 mg/kg) significantly inhibited alveolar bone loss and metalloproteinases expression in gingival tissue (Kim et al., 2019).

*Fucoidan* extracted from the algae was found to suppress the development of two dental bacterial plaques (*S. sobrinus* and *S. mutans*) (Jun et al., 2018).

Species like *Ulva pertusa* was found to have antimicrobial effect and can be used in the treatment of periodontal diseases (Choi et al., 2012).

### **Neuroprotective potential**

Algae present anti-inflammatory effect and this was studied in relation with some neurodegenerative diseases. *Neorhodomela aculeate* was proved to have the potential to inhibit inflammation in neuronal and microglial cells (Lim et al., 2006). *Diekol* extracted from *Ecklonia cava* species is known to be able to suppress endotoxin-stimulated pro-inflammatory enzymes and COX-2 production in the murine microglia (Jung et al., 2009).

*Tisochrysis lutea* and *Nannochloropsis oceanica* microalgae were used in a study to assess their neuroprotective, anti-inflammatory and anti-oxidant potential. The extracts showed an anti-inflammatory ability which, through study, can be used in the

medical field, especially in the treatment of neurodegenerative diseases (Gallego et al., 2022).

## Conclusions

Algae, both micro- and macro- algae, have a bioactive potential which can be exploited in the medical field. Algae present antimicrobial potential, antiviral potential, they were used in dentistry (toothpaste) and they also possess an anti-hyperglycaemic effect. Moreover, their potential to help with angiotensin enzymes recommends them for anti-hypertensive treatments. Cancer is becoming more and more significantly present in our society. Cancer treatments are often hard and can damage more cells. Some algae present anti-cancer potential and soon we will have vaccines and easier treatments which will help ease the suffering of the patients. Neurodegenerative diseases often decrease the life quality of the person suffering from it. Algae derived extracts were found to possess anti-inflammatory effect which means that they can be included in the treatments of neurodegenerative diseases. Still, more studies are necessary.

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