



## Spirulina, The Boon of Nature

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### ABSTRACT

Dr. Darwin, who was an algae scientist from Germany, discovered the spiral-shaped algae presence and designated it Spirulina. Spirulina, a seaweed which is a blue-green algae biomass, belongs to the class of cyanobacteria discovered by non-referenced Mexicans in the 16<sup>th</sup> century and has been used as a daily food source. The first large-scale spirulina plant was created in 1970 and is now being grown in many areas of the globe. Many species of spirulina have been identified in recent decades, but among them are spirulina platensis and spirulina maxima. It is enriched with lots of vitamins, nutrients, antioxidants, proteins, pigments, minerals, ...etc..., and is considered a wonder of nature. It is a powerful dietary supplement wealthy in nutrients and vitamins used by National Aeronautics and Space Administration and European Space Agency as a food supplement during space missions and capable of fighting against multiple microbial illnesses by enhancing immunity. Spirulina exhibits anticancer, antidiabetic, anti-inflammatory, immunomodulatory and many other activities and also found useful in the production of feedstocks.



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situated in Mexico, lakes Monbolo, and Rombou in Chad (Tomaselli *et al.*, 1987). Spirulina mass can be grown in both freshwaters as well as waste water (Usharani *et al.*, 2012). Spirulina is one of the most prominent microorganisms because of its high protein value and a large number of minerals and vitamins (Alvarenga *et al.*, 2011). It is regarded as a healthy supplement in the world because of its chemical constituents and, therefore, exhibits anticancer, immunomodulatory, anti-inflammatory, anti-diabetic activity, etc. (Shih *et al.*, 2009).

### Species

Different species of spirulina are accessible, but among them, spirulina maxima and Spirulina platensis are prominent and used for health advantages worldwide (Maddaly, 2010; Ghaeni and Roomiani, 2016). Spirulina maxima are found in Central America, whereas Arthrospira platensis species are found in Africa, South America, and Asia (Choopani *et al.*, 2008).

### Cultivation

Spirulina is discovered mostly within the marine

### INTRODUCTION

Spirulina is popularly known as blue-green algae (Saranraj and Sivasakthi, 2014). Arthrospira or spirulina platensis is a filamentous cyanobacterium because of its spiral filaments (Moraes *et al.*, 2013). Highly alkaline P<sup>H</sup> 10-12 environment is best suited to spirulina growth (Mohan *et al.*, 2014). It is discovered in nations such as South Africa, Central America, and areas such as lake Texcoco

ecosphere, such as oceans, lakes, and ponds. It is the first photoautotrophic organism that directly transforms sunlight into compound metabolic pathways (Supramaniyan and Bai, 1992). For its development, It needs 10-12 PH, NaCl, bicarbonates (Nigam *et al.*, 1981) and 18°C annual temperature (Habib *et al.*, 2008). Spirulina cultivation and collection takes place through the following processes (Dineshkumar *et al.*, 2016).

Inoculums development ↓

Outdoor cultivation ↓

Gravity filtration ↓

Sun drying

It can also be cultivated at a laboratory scale using different media like Zarrouk medium, Conway medium, F/2 medium (Seyidoglu *et al.*, 2017).

### Chemical composition

Spirulina for its useful chemical contents such as amino acids, proteins, vitamins, minerals, carbohydrates, nucleic acids, pigments, etc. Is regarded as the wealthiest algae (Sotiroudis and Sotiroudis, 2013).

**Protein:** It includes various kinds of amino acids, mostly valine, leucine, tryptophan, methionine, phenylalanine, threonine, lysine (Pyne *et al.*, 2017).

**Vitamins:** Spirulina contains an enormous amount of Vitamin B12 and Vitamin A compared to other algae. There are Antioxidants such as vitamin C, which is water-soluble ascorbate and vitamin E, which is lipid-soluble  $\alpha$ -Tocopherol (Sharoba, 2014).

**Pigments:** Phycocyanin, beta carotene, and xanthophylls are the pigments found in spirulina that are capable of inhibiting oxidative damage (Marrez *et al.*, 2014).

**Minerals:** Manganese, magnesium, phosphorus, potassium, calcium, zinc, copper, iron, selenium, sodium, chromium are the abundant minerals found in spirulina (Cefalu, 2009).

### Pharmacological actions and Applications of spirulina

#### Anti-inflammatory effect

Two thousand years ago, The Roman doctor Aurelius Cornelius Celsus was attributable to the primary recording of cardinal signs of inflammation, together with pain, tumor, rubor, and the heat. In the 1800s, Shoelson et al. noted the alliance of inflammation with macromolecule metabolism (Donath and Shoelson, 2011). It is revealed that individuals with diabetes have inflam-

matory cytokines (Nasirian *et al.*, 2018). Trace metals are necessary for certain body activity. They primarily influence diabetes pathogenesis by its role in peroxidation and inflammation. Spirulina platensis microalgae potentiate the level of trace metals and decrease the metabolic activity of functional neutrophils and thus its exhibits anti-inflammatory activity (Belay *et al.*, 1993a).

Spirulina comprises a pigment known as phycocyanobilin, which is a powerful inhibitor of an enzyme that is necessary for causing an inflammation (Soni *et al.*, 2015). C-phycocyanin subdues the inflammation by inhibiting the expressions of cyclooxygenase -2 (COX-2), nitric oxide synthase, and pro-inflammatory cytokine production. Furthermore, phycocyanin forages free radicals, including aleoxyl, hydroxyl, and peroxy radicals inhibits liver microsomal lipid peroxidation, reduces the output of prostaglandin E(2), and nitrite, reduces the development of myeloperoxidase, inhibits the aggregation of platelets, and suppresses the activation of nuclear factor- $\kappa$ B (NF- $\kappa$ B) by stopping cytosolic degradation. There all effects lead to the anti-inflammatory activity of spirulina platensis (Farg *et al.*, 2016).

#### Immunomodulatory effects

Spirulina enhances immunity by producing a huge amount of antibodies, interferon-gamma, and cytosine (Sathasivam *et al.*, 2019; Krieg *et al.*, 2012). The polysaccharide fraction of spirulina platensis was shown to boost human macrophage immune cells in in-vitro research (Alam *et al.*, 2014). It can boost innate and acquired defense processes such as cytokines, allowing the body to help itself and capable of managing a number of illness such as viral infections, various cancers and autoimmune disease (Masuda and Chitundu, 2019). Spirulina has proven effective in the treatment of HIV infected patients in which calcium spirulina a sulfated polysaccharide (ca-sp), an isolated product of spirulina platensis, inhibits numerous viral replications and exhibits antiviral activity against HSV-1, influenza virus, human cytomegalovirus (HCMV), mumps virus, measles virus and type-1 immunodeficiency virus (HIV-1) (Ramakrishnan, 2013; Hetta *et al.*, 2015; Abed *et al.*, 2016). Spirulina produces biologically active proteins capable of stimulating the intestinal immune system to improve vaccine responsiveness and allergic rhinitis (Simon *et al.*, 2018).

#### Effect on diabetes and obesity

Diabetes mellitus is caused by non-physiological metabolic imbalance. It is a global health issue where diabetes mellitus affects 7% of the world's

adult population (Fayzunnessa *et al.*, 2011). Spirulina has a distinctive nutrient mix that no single source can supply therefore exerts anti-diabetic activity (Ripa *et al.*, 2018; Palaniswam, 2018). Water-soluble Spirulina fraction was discovered to be efficient in reducing the amount of serum glucose at fasting, while water-insoluble fraction suppressed glucose levels at glucose load and also reduced cholesterol, triglycerides, LDL cholesterol in blood and thus act as anti-hyperlipidemic agent in clinical pathways that could be protective against atherosclerosis and euglycemia (Belay *et al.*, 1993b; Metwally *et al.*, 2015; Borowitzka, 1995).

### As Nutraceuticals and cosmetics

Microalgae and cyanobacteria produce components needed for cosmetic preparation (Sharma and Sharma, 2017). Frescosmetics is producing spirulina whitening face masks, which are protein-rich cosmetics, thus enhances the beauty by removing dead skins, and reduces wrinkles and thus exhibiting anti-aging property (Mourelle *et al.*, 2017). Because it is loaded with antioxidants and vitamins and can be used in the preparation of eye-liners and lipsticks, as well as in skin toning, healing of dark circles, skin purification and promote hair growth by dandruff treatment (Joshi *et al.*, 2018; Liu *et al.*, 2016). C-Phycocyanin derived from spirulina was commonly used as a food additive and cosmetic dye in Japan (García *et al.*, 2017). Spirulina is also used as a human nutritional supplement that can treat malnutrition (Usharani *et al.*, 2015).

### Antimicrobial and antibacterial activity

Spirulina, like many other cyanobacteria species, have the ability to generate a significant amount of antimicrobials, so they are deemed appropriate for use as biocontrol agents of pathogens and fungi. They also exhibit fruitful antimicrobial activity and antifungal activity against *S. aureus* and *Candida albicans* species, respectively (Chakraborty *et al.*, 2015; Mishra and Prasad, 2015; Xalxo *et al.*, 2013). Spirulina-based Phycobiliprotein may inhibit the development of shigella and klebsiella, whereas polysaccharide inhibits the growth of salmonella and streptococcus (Capelli and Cysewski, 2010).

### Anticancer activity

Antioxidants present in spirulina is responsible for the anti-tumor activity (Ranjani, 2013). Spirulina can safeguard against different types of cancer by acting on the immune system, DNA repair, antioxidant properties (Sharif *et al.*, 2014). Spirulina platensis is involved in macrophage-tumor necrosis factor-(TNF-)dependent tumor activity 23 and the polysaccharides have been found to sup-

press the development of glioma cells (murine RSV-M) by partially controlling interleukin-17 production and reducing angiogenesis (Śmieszek *et al.*, 2017). It can cause apoptosis of the HepG2 cell line of hepatocellular carcinoma, improving the Bax/Bcl-2 ratio (Patel and Goyal, 2013).

### Anti anemic effect

An enormous amount of Vitamins, minerals, nutrients present in spirulina ought to help in treating anemia and malnutrition in undernourished kids by increasing the volume of blood and the count of blood cells (Simpore *et al.*, 2005; Azabji-Kenfack *et al.*, 2011; Finamore *et al.*, 2017; Sinha *et al.*, 2018). Spirulina supplementation may be of great potential importance during pregnancy and lactation as it includes all the hematopoietic nutrients that will eventually benefit both mother and fetus (Poormoosavi *et al.*, 2019). Spirulina has powerful iron ion connections and many antioxidant and hepatoprotective characteristics and also protects cells and tissues against nephrotoxicity caused by aluminum (Rahman *et al.*, 2017).

### Spirulina in Biofuel production

Gradual depletion of fossil fuels required alternative and viable fuel capable of replacing natural fuel with minimal environmental effects to meet the energy crisis. For conventional feedstocks, microalgae are one of the most prominent alternative sources (mostafa S. S. M. and El-Gendy, 2017). Spirulina platensis is a precious candidate for biodiesel production because of its elevated growth rate of 2.23g/Ld, adequate lipid content, desiring an easy and cheap crop medium and generating other precious by-products that would reduce the global price bio-diesel production (Behera *et al.*, 2015). Cyanobacteria such as microalgae primarily involve light, carbon dioxide and certain nutrients (nitrogen, phosphorous and potassium) to evolve and generate large quantities of lipids and carbohydrates that can be further processed into various biofuels and other beneficial co-products (El-Shimi *et al.*, 2013). Spirulina platensis undergoes In-situ transesterification to generate bio-diesel (Kurashvili *et al.*, 2018).

### Spirulina in pollution control

The development of strategies for the clearance of pharmaceutical and waste residual, pesticides and heavy metals from natural and agricultural landscapes is now a matter of concern (Singh *et al.*, 2017). Cyanobacteria are aquatic prokaryotes that have an unexceptional ability for sewage treatment and bioremediation of harmful pollutants from residues and solutions for more than 3 billion years. Spirulina can store pollutants in its cells that help to

treat water pollution.

## CONCLUSION

Spirulina is one of the natural and powerful supplements blessed by nature with the lower or negligible side effects. Various dietary and therapeutic potentiates have been ascribed to metabolites of it. Spirulina is enriched with a variety of nutrients that can be beneficial in treating many diseases. Spirulina should be cultivated on a large scale to prevent environmental pollution and to found benefits in health aspects.

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