



## Spirulina algae: Pharmacology, Mechanism of Action and Uses

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### Abstract:

Spirulina (SP) (*Arthrospira platensis*) is a photosynthetic, filamentous, and bluegreen microalgae that acquired its name due to the spiral or helical shape of its filaments. It contains free radical scavenging agents and naturally occurring antioxidants, including phenolic compounds, tocopherol,  $\beta$ -carotene,  $\gamma$ linolenic acid, and phycocyanin. In addition, SP and its main constituent, Cphycocyanin, exhibit hepatoprotective, neuroprotective, anti-inflammatory, immune- modulatory, and anticancer action. SP has been reported to ameliorate organ toxicities induced by chemotherapeutic agents.

**Keywords:** Spirulina algae, anti-inflammatory, neuroprotective.

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### Introduction:

Spirulina or Arthrospira is a blue-green algae that became famous after it was successfully used by The National Aeronautics and Space Administration (NASA) as a dietary supplement for astronauts on space missions (1).

Spirulina algae is a microscopic and filamentous cyanobacterium that derives its name from the spiral or helical nature of its filaments. It has been used for a long time as a food during the Aztec civilization (2).

Spirulina algae refers to the dried biomass of *Arthrospira platensis*, an oxygenic photosynthetic bacterium found worldwide in fresh and marine waters.

This algae represents an important source of protein and vitamin supplement in humans without any significant side-effects (3).

### Geographical distribution:

There are only a few areas worldwide that have the ideal sunny climate for production of this alga, including Greece (Nigrita, Serres), Japan, India, United States and Spain (2).

### Pharmacology:

Apart from the high (up to 70%) content of protein, it also contains vitamins, especially B12 and provitamin A ( $\beta$ -carotenes), and minerals, especially iron. It is also rich in phenolic acids, tocopherols and  $\gamma$ linolenic acid. Spirulina

platensis lacks cellulose cell walls and therefore it can be easily digested (1).

Many toxicological studies have proven Spirulina's safety. Spirulina algae now belongs to the substances that are listed by the US Food and Drug Administration under the category Generally Recognized as Safe (GRAS). Spirulina algae is relatively easy to cultivate but flourishes only in alkaline lakes with an extremely high pH and in large outdoor ponds under controlled conditions (4).

#### **Mechanism of action:**

Spirulina algae has the ability to modulate immune functions and exhibits anti-inflammatory properties by inhibiting the release of histamine by mast cells. Potential health benefits of Spirulina are mainly due to its chemical composition, which includes proteins, carbohydrates, essential amino acids, minerals (especially iron), essential fatty acids, vitamins, and pigments (2).

In this respect, three major bioactive components of Spirulina, the protein phycocyanin, sulfated polysaccharides, and  $\gamma$ -linoleic acid (GLA) seem to play significant roles in imparting improved human body functions (5).

#### **Uses:**

Experimental evidence supports the immunomodulation and antiviral effects of Spirulina supplementation(6).

The following clinical uses are widely studied:

#### **✚ Anti-nephrotoxicity and Anti genotoxicity of Spirulina algae:**

Spirulina algae decreases the urea and creatinine level in rats with nephrotoxicity

produced by cisplatin. Moreover, Spirulina algae give protection against nephrotoxicity and neurotoxicity in rats induced by cyclophosphamide, cadmium and chromium (4).

Polysaccharides of Spirulina algae conserve DNA pattern from being destroyed by radiation due to the action of excision repair and configuration of unintended Spirulina algae also expressed to reduce the recurrence of micronucleus in polychromatic erythrocytes of bone mice unprotected to gamma radiation (1).

#### **✚ Antiviral activity of Spirulina algae:**

Spirulina algae has all bioactive compounds in its constitution that can build a healthy immune system, which scavenges free radicals as well. Bioactive compounds extracted from Spirulina algae have inhibitory activity against an extensive variety of viruses such as human immunodeficiency virus-1 (HIV-1), herpes simplex virus-1(HSV-1), herpes simplex virus-2 (HSV-2), human cytomegalovirus (HCMV), influenza type A, measles, etc. Spirulina algae was shown to reduce HIVI duplication in human T-cell lines, peripheral blood mononuclear cells and Langerhans cells(5).

#### **✚ Anti-inflammatory property of Spirulina algae:**

Spirulina algae displays anti-inflammatory effect adverse to Zymosan producing arthritis by decreasing the amount of beta glucuronidase in the diarthrosis fluid. Ethanolic extract of Spirulina algae keeps significant anti-inflammatory activity in both carrageenan induced raw paw edema test (4).

Spirulina algae could control the undesirable effects of acetic acid induced ulcerative colitis in rats demonstrated by raising the activity of anti-oxidant enzyme catalase (CAT) and superoxide dismutase(SOD) in addition to glutathione (GSH) content with, considerable depletion in lipid peroxidation to control prostaglandins as well as pro inflammatory cytokines (6).

#### ✚ Hypolipidemic property of Spirulina algae:

Spirulina algae has an effect on lowering blood lipids, particularly triglycerides and cholesterol linked to low-density lipoprotein (LDL), as well as an indirect effect on total cholesterol and cholesterol linked to high-density lipoprotein (HDL), due to the presence of a pigment called phycocyanin. Phenolic compounds are antioxidants that protect cells and natural chemicals in the body from the damage caused by free radicals. Free radicals are responsible for causing tissue damage in the body as well as oxidizing LDL cholesterol, which can lead to heart disease if it accumulates in the arteries. Consuming spirulina algae can help lower levels of dangerous LDL and triglycerides, and it can also play a part in the indirect modification of high cholesterol and total cholesterol levels. This is because the components of spirulina algae have antioxidant action, and the aqueous extract of spirulina algae reduces the absorption of fats from foods by reducing the activity of the lipase enzyme that is released by the pancreas(7). ( **Figure 1**).



**Figure (1):** is a diagrammatic illustration of the function that spirulina algae play in the process of reduction cholesterol (7).

#### ✚ Hypoglycemic property of spirulina algae:

Spirulina algae can act like insulin or stimulate the  $\beta$  cells of islets of Langerhans to increase the output of insulin, thereby lowering blood sugar level. Furthermore, the hypoglycemic outcome could be due to the effect of fiber content of Spirulina algae that interfered with the absorption of glucose (8).

#### ✚ Neuroprotective property of spirulina algae:

Spirulina algae has neuroprotective effect against the 6hydroxydopamine (6-OHDA)-induced toxicity in the rat striatum and found that spirulina algae decreased the level of reactive oxygen species (ROS), nitric oxide and lipid peroxidation in the striatum with developed locomotor activity with conservation of dopamine mitochondrial activity (1).

Likewise, care of rats with spirulina algae had some favourable effect in intensifying the locomotor function of hind limb and diminish the morphological injury of the spinal cord (9).

#### ✚ Anti-cancer effects:

Some studies have shown that spirulina algae extract can prevent or inhibit cancers in animals and humans. *In vitro* assessment proposes that polysaccharides of spirulina algae improve cell nucleus enzyme activity and DNA repair synthesis. The water extract of spirulina algae inhibited the growth of human colon carcinoma cells and hepatocellular carcinoma cells (HCC) in *in vitro* studies(10).

The chloroform extract of crude spirulina algae and chlorella vulgaris inhibited the viability of breast cancer cells *in vitro*. In fact, it has the antiproliferative activity against the cancer cells. The methanolic extract of the spirulina algae inhibited the growth of human breast cancer cell line and the human cancer cell line L20B within short incubation period (5).

#### ✚ Anti-anemic activity:

The constant supplementation of Spirulina algae to the old people with anemia increases the concentration of mean capsular hemoglobin (MCH) in blood. Moreover, 12 weeks supplementation of Spirulina algae shows significant increase in the mean concentration of haemoglobin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) in the children with anemia and it increases the level of iron in blood, thus the

Spirulina algae can be used as treatment for anemia (2).

#### ✚ Probiotic property of spirulina algae:

Spirulina algae reacts as a usable food sustaining favourable intestinal flora. Nourishing rats, a diet addition with 5% Spirulina algae for 100 days resulted in extension of Lactobacillus by 32.7% and extension of vitamin B1 (11).

Moreover, extracellular products produced by spirulina algae significantly increased the growth of lactic acid bacteria such as Lactococcus lactis, Streptococcus thermophilus, Lactobacillus casei, Lactobacillus acidophilus, and Lactobacillus bulgaricus (12).

#### ✚ Spirulina algae for eyesight:

Spirulina algae is rich in zeaxanthin, a xanthophyll that exists in human eyes, which decreases the chance of cataracts and age related macular degeneration. Dried spirulina algae powder contains 74000 µg of zeaxanthin and dietary supplement of Spirulina algae powder increases the serum zeaxanthin level in human. Relevant function of the extract of spirulina algae inhibit the corneal neovascularization induced by NaOH(13).

#### ✚ Immunological Applications:

Spirulina algae became well known by NASA as a nutritional complement for astronauts on space missionary, it repressed the release of histamine by mast cells, and Spirulina algae may induce numerous symptoms of anti-allergic effects. Spirulina algae has no effect on chronic fatigue. Spirulina algae extract plus zinc may be valued for the treatment of chronic arsenic poisoning with melanosis and keratosis (1).

The first human feeding study proved the defensive effects of Spirulina algae towards allergic rhinitis. Spirulina algae helps to defend against certain nutritional deficits. It plays role in the inhibition of cancer, infectious diseases, cellular ageing and reduced immune system efficiency as well as play a significant role in the working of the medulla (5).

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