NUTRITIONAL COMPOSITION AND PHARMACOLOGICAL ACTIONS OF SPIRULINA

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ABSTRACT

The popular edible algae, *Spirulina* are used as food worldwide. It is riched with large number of nutrients. C-phyccyanin, a molecule which contains phycocyanobilin, an homolog of biliverdin, is one of the major proteins present in *Spirulina*. It is also a good source of essential fatty acids like gamma-linolenic, linoleic and oleic acids. Sea algae is riched with exceptionally high content of vitamin B12 and tocopherol. Tocopherol is responsible for antioxidant action. It also contains high concentration of minerals like Iron. It also possesses different therapeutic potentials like: Anti-diabetic, cardioprotective, anti-inflammatory, anti-cancer, anti-anemic, anti-viral, and blood improvement, hepatoprotective, heavy metal detoxification from body. It can be cultivated in both normal and saline sea water. In present scenario to meet the demand of the increasing population it can be utilize as a good source of food supplement.

Key Words: *Spirulina*, phycocyanobilin, vitamin B12, antioxidant, anti-diabetic

INTRODUCTION

*Spirulina* refers to the dried biomass of *Arthrospira platensis*, an oxygenic photosynthetic bacterium found worldwide in fresh and marine waters. *Spirulina* is a planktonic photosynthetic filamentous cyanobacterium that forms massive populations in tropical and subtropical water bodies which have high levels of carbonate [1]. Figure 1 represents microscopical structure of *Spirulina*.

In the present health food market, the filamentous cyanobacterium *Arthrospira*, has been widely used as a dietary supplement under the usual commercial designation “*Spirulina*,” due to its high nutritional value (e.g., high quantities of proteins, large amounts of essential fatty acids, polysaccharide, vitamins, minerals, and pigments) and its putative beneficial health effect (e.g., antioxidant, antiviral, anticancer activity) [2,3,4,5] biomass of *Arthrospira* used for commercial exploitation as part of the human diet, is produced nearly exclusively in outdoor open systems, either obtained through a controlled cultivation process in open raceway ponds or harvested from natural environments [2,5,6,7,8]. The main limitation of outdoor open/closed systems seems to be the risk of contamination by fungi, bacteria and protozoa, and competition by other cyanobacteria and microalgae that tend to dominate, regardless the original species used as inoculum[9]. This risk is much higher in natural environments, where the biomass harvested is essentially a mixture of multiple species of cyanobacteria and other microorganisms [10].

The microorganism called "*Spirulina*" was so named this because of its spiral filament-like appearance under the microscope (and is classified as cyanobacterium). The nutritional composition of spirulina may vary according to the growing conditions [11]. Vitamins, minerals, proteins and polyunsaturated fatty acids: gamma-linolenic acid [12] therapeutic properties [13] antioxidant activity.
[14]. It naturally grows in alkaline and warm media; in the sea and fresh water of Asia, Africa, Europe, South and North America [15].

In terms of nutrition, Spirulina is a rich food source of macro- and micronutrients including high quality protein, iron, gamma-linolenic acid, vitamins, minerals, sulfated polysaccharides and phycocyanin [16].

Spirulina’s protein content ranges between 60 to 70% of its dry weight. This is an exceptional proportion since the vast majority of plant-based foods (even the ones that are known to be “good protein sources”) contain only about 35%. In fact, C-phycocyanin, a molecule which contains phycocyanobilin, an homolog of biliverdin, is one of the major proteins present in Spirulina, accounting for about 20% of algae’s dry weight [27,28,29].

2. Lipids
Spirulina presents a lipid fraction of approximately 5-10% of its dry weight. The important thing to this respect is that fats that make up such fraction are mainly essential lipids to human. Hence, Spirulina is considered a good source of gamma-linolenic, linoleic and oleic acids. The first one has received much attention since there are not many food sources that contain a significant amount; in fact, Spirulina is considered the vegetable source with the highest quantity (representing approximately a 20% of its total fatty acid content) [30, 31].

3. Vitamins
The fact that Spirulina has an exceptionally high content of vitamin B12, vitamin B3 usually contain only in animal origin foods. Thus this alga might be considered as a good source for vegans, since they do not consume any animal origin foods [32, 33].

4. Minerals
Its iron content is substantially high: comparatively, cereals which are usually considered good sources of iron contain between 150-250 mg/kg; blue-green algae contains about 580-1800 mg/kg. Algae does not have pericardium (as cereals do), hence it does not present phytates/oxalates that could chelate iron and lower its absorption [34, 35].

PHARMACOLOGICAL ACTIONS OF SPIRULINA
1. Anti-diabetic
In type-2 diabetes mellitus patients, Spirulina can reduce both fasting and postprandial blood glucose level and reduction in the glycosylated haemoglobin (HbA-1c) level [36]. Spirulina is able to increase the hexokinase and glucose-6- phosphatase activity in diabetic rats. Spirulina has a beneficial effect on plasma insulin and C-peptide [37]. S. maxima exhibited hypolipidemic effects, especially on triacylglycerols (TAG) and the LDL Cholesterol [40] and prevented dyslipidemia induced by carbon tetrachloride [41].

In clinical research it was observed that Spirulina supplementation (2 g/day for 2 months) in the control of glycemia and lipidemia in type 2
diabetes mellitus. It was able to improve the level of glycosylated hemoglobin (HbA(1c)) levels, and lipid profiles of the diabetic subjects. These findings suggest the beneficial effect of Spirulina supplementation in controlling blood glucose levels and in improving the lipid profile of subjects with type 2 diabetes mellitus [42]. It was also observed that in diabetic condition S. maxima can prevents fatty liver formation in CD-1 male and female mice with experimental diabetes. This is responsible for better quality of life and longer survival of diabetic patients [43]. In another study of supplementation of chromium richer diet with Spirulina was able to control hyper glycaemia, lipid profile, blood pressure and weight in type 2 diabetic patients [44].

2. Cardio protective
It was observed that Spirulina was able to reduce cholesterol level in patients with hyperlipidemic nephrotic syndrome. In nephrotic syndrome, lipoprotein level increases due to enhance synthesis of lipoprotein cause a secondary hyperlipidemia. Essential fatty acids such as gamma-linolenic acid (GLA) can prevent accumulation of cholesterol in the body, and Spirulina has an appreciable amount of GLA. Spray dried Spirulina capsules, rich in antioxidants, GLA, amino acids, and fatty acids, helped reduce the increased levels of lipids in patients with hyperlipidemic nephrotic syndrome [45].

During treatment of cancer administration doxorubicin (DOX) causes cardiotoxicity. It was observed that of protective effect of Spirulina against doxorubicin induced cardiotoxicity. Spirulina, blue green algae, could serve as a cardioprotective agent during DOX treatment in a mouse model. By inhibiting the generation of free radical it shows cardioprotective action [46]. Spirulina is rich with Phycobiliprotein C-phycocyanin which is responsible for reducing oxidative stress and NADPH oxidase expression induced by an atherogenic diet in hamsters so it shows cardioprotective action by inhibiting atheroma [47]. It was also shown that S. platensis was able to inhibit plasma lipoprotein lipase activity in fructose-induced hyperlipidemic rats and useful in hyperlipidemia [48].

3. Anti-oxidant
Several studies performed on Spirulina indicate that that Spirulina posses significant antioxidant activity both in vitro and in vivo [49]. S. fusiformis provides protection against mercuric chloride induced oxidative stress in Swiss albino mice. Sharma et al., studied that mercuric chloride (5 mg/kg body weight i.p.) is able to increases the lipid peroxidation and decreases glutathione and other antioxidant enzymes in liver and serum supplementation of Spirulina can decreases oxidative stress and shown antioxidant action [50].

Bhat et al., studied that S. platensis is rich with C-phycocyanin which is a potent peroxyl radical scavenger in vivo and in vitro. It was also observed that C-Phycocyanin (from S. platensis) effectively inhibited CCl₄-induced lipid peroxidation in rat liver in vivo[51]. Chlorella water extract was able to shown antioxidant and anti-prolitative action in chronic liver fibrosis. It has been reported that antioxidants are able to inhibit the proliferation of hepatic stellate cells (HSCs) [52]. It was also observed that C-phycocyanin isolated from cyanobacterial species Lyngbya, Phormidium and Spirulina spp. Can produce antioxidant action by scavenging peroxyl radicals [53].

4. Anti-Viral
Ayehunie et al., studied that aqueous extract of S. platensis can inhibit HIV-1 replication in human T cell lines, peripheral blood mononuclear cells (PBMC), and langerhans cells [54]. A sulfated polysaccharide named calcium spirulan (Ca-SP) has been isolated from a sea alga, Spirulina platensis, and shows anti-herpes and anti-human immunodeficiency virus action in both in vitro and ex vivo [55]. Hot water extract (HWE) of a commercial preparation of S. maxima, by microplate inhibition assay, using different viruses it was found that highest antiviral activity was found HSV-2 [56].

5. Anemia and Blood Improvement
It was observed that Spirulina can be use as better nutrition rehabilitation of HIV-infected and HIV-negative persons and it can be use as nutritional for food supplement for undernourished childrens [ 57].

6. Heavy Metal Removal
In placebo-controlled double-blind study it was observed that Spirulina extract plus zinc in patients of chronic arsenic poisoning: a randomized place- controlled study. The present show that Spirulina extract (250 mg) plus zinc (2 mg) twice daily for 16 weeks may be useful for the treatment of chronic arsenic poisoning with melanosis and keratosi. It was observed that Spirulina extract with zinc is effective in the treatment of chronic arsenic poisoning [58]. Spirulina can protect from lead toxicity, it was observed that Spirulina protect rats from lead induced deleterious changes in the lipid peroxidation and serve as an endogenous antioxidants in rats. Levels of elemental lead were also measured in the organs of rats in all experimental groups. It
was observed that *Spirulina* posses free radicals scavenging effect, thereby protect the organs from damage caused by the exposure to lead. Furthermore, *Spirulina* showed a significant (p < 0.05) decrease in the deposition of lead in the brain [59]. Saha et al., studied that hexane extract of *Spirulina* can arsenic from isolated liver tissues of rat [60]. Pane et al., studied on L929 cells that *S. platensis* can prevent bio-accumulation of cadmium and zinc[61].

It was also observed that Spirulina-based dietary supplement can modulates cytokine production in allergic rhinitis patients by suppressing the differentiation of Th2 cells and inhibiting the production of IL-4 [62].

**CONCLUSION:**
This review gives broad information about the bioactive constituents and ethnopharmacology along with the scientifically claimed medicinal uses of *Spirulina*. *Spirulina* is a blue-green alga used as a dietary supplement. It is rich in proteins, carotenoids, polyunsaturated fatty acids, vitamin-B complex, vitamin-E, and minerals. It is also additionally, possesses other potent antioxidants like spirulans, C-phycocyanin, and allophycocyanin. In present scenario to meet the need of the food for increasing population it can be a good source of food. It can grow in both normal and saline water and larger part of earth is covered with saline water so it can be cultivated easily to meet the demand of food. *Spirulina* exerts a wide range of pharmacological actions like: anti-inflammatory, anti-oxidant, anti-cancer, and hepatoprotective and anti-viral actions. So extensive preclinical and clinical research should be carried out to establish its safety and Pharmacological efficacy.

**REFERENCES**


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