



NUTRITIONAL COMPOSITION AND PHARMACOLOGICAL ACTIONS OF SPIRULINA

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Received on: 06-03-2016; Revised on: 28-04-2016; Accepted on: 15-05-2016

ABSTRACT

The popular edible algae, *Spirulina* are use as food worldwide. It is riched with large number of nutrients. C-phycoyanin, 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 contenins high concentration of minerals like Iron. It also posses 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 phycocanin [16].

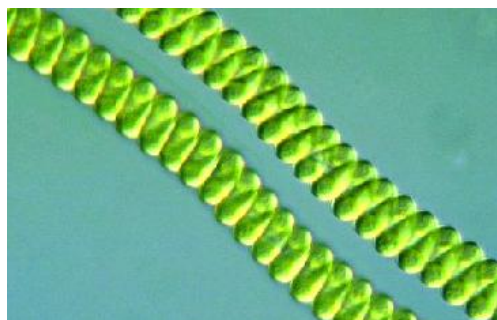


Figure 1: Microscopical Structure of Spirulina

It is a concentrated source of food containing nutraceutical, antioxidants, probiotics properties. *Spirulina* is an important source of the blue photosynthetic pigmented protein C-phycoyanin, which has strong antioxidant and anti-inflammatory properties. *Spirulina* is known for its wide ranging biological activities, like prevention of anemia because of high iron and vitamin contents [17] inhibition of herpes simplex infection [18] reduction in HIV replication velocity [19] increased production of antibodies, prevention of proliferation of neoplastic cells [20] hypoglycemic [21, 22] hypolipemic [23] and antihypertensive properties in experimental animal and humans models [24] furthermore, it shows hepatoprotective properties through decreasing of the liver lipid profiles and lipoperoxidation products [25] anti-mutagenic, anti-viral, immune enhancing, cardio protective and anti-cancer properties [26].

Now a day's increasing population of the world need food from alternative sources other than traditional sources so *Spirulina* can meet the demand of this need. Another advantage of cultivation of *Spirulina* is it grows in water and larger part of the world is covered with water and *Spirulina* can also grow in saline water also. So we can cultivate it in saline water also to meet the demand of food supplement. This article systematically explores different nutritional composition and its pharmacological properties of *Spirulina*.

COMPOSITION OF NUTRITION

Spirulina composition may vary according to the culturing conditions, and the methods of analysis.

1. Protein and Amino Acids

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-phycoyanin, a molecule which contains phycoyanobilin, 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 B₁₂ 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 prevent 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 rich 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-phycoyanin 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* possesses 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 increase the lipid peroxidation and

decreases glutathione and other antioxidant enzymes in liver and serum supplementation of *Spirulina* can decrease oxidative stress and shown antioxidant action [50].

Bhat *et al.*, studied that *S. platensis* is rich with C-phycoyanin which is a potent peroxy 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 show antioxidant and anti-proliferative 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-phycoyanin isolated from cyanobacterial species *Lyngbya*, *Phormidium* and *Spirulina* spp. Can produce antioxidant action by scavenging peroxy 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 used as better nutrition rehabilitation of HIV-infected and HIV-negative persons and it can be used 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 placebo-controlled study. The present study shows 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 keratosis. 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.

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