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REVIEW ARTICLE

POTENTIAL HEALTH BENEFITS OF SPIRULINA PLATENSIS

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ABSTRACT:

Spirulina is free-floating filamentous micro algae growing in alkaline water bodies. With its high nutritional value, *Spirulina* has been consumed as food for centuries in Central Africa. It is now widely used as nutraceutical food supplement worldwide. Recently, great attention and extensive studies have been devoted to evaluate its therapeutic benefits on an array of diseased conditions including hypercholesterolemia, hyperglycerolemia, cardiovascular diseases, inflammatory diseases, cancer, and viral infections. The cardiovascular benefits of *Spirulina* are primarily resulted from its hypolipidemic, antioxidant, and anti-inflammatory activities. Data from preclinical studies with various animal models consistently demonstrate the hypolipidemic activity of *Spirulina*. Although differences in study design, sample size, and patient conditions resulting in minor inconsistency in response to *Spirulina* supplementation, the findings from human clinical trials are largely consistent with the hypolipidemic effects of *Spirulina* observed in the preclinical studies. However, most of the human clinical trials are suffered with limited sample size and some with poor experimental design. The antioxidant and/or anti-inflammatory activities of *Spirulina* were demonstrated in a large number of preclinical studies. However, a limited number of clinical trials have been carried out so far to confirm such activities in human. Currently, our understanding on the underlying mechanisms for *Spirulina*'s activities, especially the hypolipidemic effect, is limited. *Spirulina* is generally considered safe for human consumption supported by its long history of use as food source and its favorable safety profile in animal studies.

KEYWORDS: *Spirulina platensis, Diabetes, Hypertension, hypolipidemic, and antioxidants.*

INTRODUCTION

Spirulina is classified within the phylum of Cyanobacteria. Popular food and nutritional supplements, this Cyanobacterium exists as either blue-green bacteria or blue-green algae. *Spirulina* is a specific type of blue-green vegetable micro-algae, and is unique to only lakes which exhibit a high alkalinity. Certain African, Asian, and Mexican civilizations located within the vicinities of such lakes began to unravel spirulina's beneficial medicinal properties thousands of years ago. Today, its

worldwide popularity continues to grow as many health conscious consumers recurrently praise its extraordinary nutritional qualities.

Spirulina's nutritional qualities are truly "one-of-a-kind." With its structure consisting of nearly 71 percent total protein, spirulina represents the highest natural source of protein ever discovered. Its protein is fives times that of meat, and nearly three times greater than the protein of the ever-popular soybean. In addition to this astounding amino acid profile, spirulina also contains a host of other beneficial nutrients including; carotenoids, essential fatty acids, B complex vitamins, vitamin E, copper, manganese, magnesium, iron, selenium, and zinc. [1] In fact, spirulina's minerals and growth factor qualities are only second to milk and evening primrose oil. Preparations of *Spirulina* are also used for their therapeutic properties in the treatment of many diseases, including hypercholesterolemia and atherosclerosis [2, 3] as well as to reduce body weight in obese humans [4]. The *Spirulina* components which are responsible for these therapeutic properties are thought to be compounds with antioxidant abilities such as polyunsaturated fatty acids, phycocyanin and phenolics [6, 5, and 7].

SPIRULINA AND CHRONIC FATIGUE.

Spirulina has been promoted as "the food of the future" with "exceptional constituents" that contribute to high energy levels. A few of these constituents such as polysaccharides (Rhamnose and Glycogen) and essential fat (GLA) are absorbed easily by human cells and help in energy release. *Spirulina* increases healthy lactobacillus in the intestine, enabling the production of Vitamin B6 that also helps in energy release. Despite this promotion, the only available placebo-controlled randomized trial showed that the scores of fatigue were not significantly different between *spirulina* and placebo. Spirulina administered at a dose of 3 g day−1 did not ameliorate fatigue more than the placebo in any of the four subjects and possibly it has no effect on chronic fatigue [7].

ALLERGY, RHINITIS, AND IMMUNOMODULATION.

It has been well documented that *Spirulina* exhibits anti-inflammatory properties by inhibiting the release of histamine from mast cells [8, 9]. In a recent randomized, double-blind placebo-controlled trial [10], individuals with allergic rhinitis were fed daily, either with placebo or *Spirulina* for 12 weeks. Peripheral blood mononuclear cells were isolated before and after the *Spirulina* feeding and levels of cytokines (interleukin- 4 (IL-4), interferon-γ (IFN-γ) and interleukin-2), which are important in regulating immunoglobulin (Ig) E-mediated allergy, were measured. The study showed that high dose of *Spirulina* significantly reduced IL-4 levels by 32%, demonstrating the protective effects of this microalga toward allergic rhinitis. Ishii et al. [11] studied the influence of *Spirulina* on IgA levels in human saliva and demonstrated that it enhances IgA production, suggesting a pivotal role of micro alga in mucosal immunity. A Japanese team identified the molecular mechanism of the human immune capacity of *Spirulina* by analyzing blood cells of volunteers with pre- and post-oral administration of hot water extract of *Spirulina platensis*. IFN-γ production and Natural Killer (NK) cell damage were increased after administration of the micro alga extracts to male volunteers [12]. In a recent double-blind, placebo-controlled study from Turkey evaluating the effectiveness and tolerability of *Spirulina* for treating patients with allergic rhinitis, *Spirulina* consumption significantly improved the symptoms and physical findings compared with placebo ($P < .001$), including nasal discharge, sneezing, nasal congestion and itching [13]. It is well understood that deficiency of

nutrients is responsible for changes in immunity, which manifests as changes in production of T-cells, secretory IgA antibody response, cytokines and NK-cell activity. The above studies suggest that *Spirulina* may modulate the immune system by its role in covering nutritional deficiencies.

ANTIVIRAL APPLICATIONS: IN VITRO STUDIES.

There are no *in vivo* studies providing strong evidence supporting the possible antiviral properties of *Spirulina*. The active component of the water extract of *S. platensis* is a sulfated polysaccharide, calcium spirulan (Ca-Sp). According to Hayashi et al. [14], Ca-Sp inhibits the *in vitro* replication of several enveloped viruses including Herpes simplex type I, human cytomegalovirus, measles and mumps virus, influenza A virus and human immunodeficiency virus-1 virus (HIV-1). Another more recent study showed *in vitro* that an aqueous extract of *S. platensis* inhibited HIV-1 replication in human T-cells, peripheral blood mononuclear cells and Langerhan cells [15]. The advantage of using herbs and algal products with proven antiviral properties in fighting certain viruses is that they can be used—through immunomodulation—even when the infection is established. Of course, the above promising effects need to be studied further in animal models and humans before any definitive conclusions are drawn.

CHOLESTEROL-LOWERING EFFECTS AND EFFECTS ON DIABETES.

Cardiovascular disease remains the number one cause of death in developed countries, despite increased awareness, and high cholesterol is one of the most important risk factors in atherosclerosis. Nakaya et al. [16], in the first human study, gave 4.2 g day−1 of *Spirulina* to 15 male volunteers and, although there was no significant increase in high-density lipoprotein (HDL) levels, they observed a significant reduction of Low-density lipoprotein (LDL) cholesterol after 8 weeks of treatment. The atherogenic effect also declined significantly in the above group [16]. Ramamurthy and Premakumari [17] in a more recent study administered *Spirulina* supplements in ischemic heart disease patients and found a significant reduction in blood cholesterol, triglycerides and LDL cholesterol and an increase in HDL cholesterol. More research is needed before *Spirulina* can be recommended to lower cholesterol levels but its role as a natural food supplement in combating hyperlipidaemia, in combination with other therapeutic options, should not be overlooked. Finally, Mani et al. [18] in a clinical study, found a significant reduction in LDL: HDL ratio in 15 diabetic patients who were given *Spirulina*. However, this study was small and better studies are needed before *Spirulina* can be recommended in diabetes.

ANTICANCER EFFECTS

It has been argued that the combined antioxidant and immune modulation characteristics of *Spirulina* may have a possible mechanism of tumor destruction and hence play a role in cancer prevention. Whilst there are many animal and *in vitro* studies, there has been only one trial with human subjects. This study looked specifically at the effects of *Spirulina* on oral carcinogenesis, in particular leukoplakia [19]. It is not surprising that few human studies exist to date as cancer prevention trials with lower cancer incidence as an endpoint have logistic problems, rendering them essentially impossible to conduct for most malignancies. The study conducted by Mathew et al. on a cohort of 77 patients originates from previous trials on hamsters that showed tumor regression after topical application or enteral intake of *Spirulina* extract [20–22]. They reported that 45% of their study cohort showed complete regression of leukoplakia after taking *Spirulina* supplements for 1 year. The authors

also reported that there was no rise in the serum concentration of retinal β-carotene despite supplementation and concluded that other constituents within *Spirulina* may have been responsible for the anticancer effects. Whilst their results appear promising, it was an unblended, non-randomized trial and as such cannot be regarded as evidence of a positive effect.

CHRONIC ARSENIC POISONING: A RANDOMIZED TRIAL

Millions of people in Bangladesh, India, Taiwan and Chile are consuming high concentration of arsenic through drinking water and are at risk of chronic arsenic poisoning for which there is no specific treatment. A placebo-controlled, double blind study was conducted to evaluate the effectiveness of spirulina extract plus zinc in the treatment of chronic arsenic poisoning [23]. Forty-one patients with chronic arsenic poisoning were randomly treated by either placebo (17 patients) or spirulina extract (250 mg) plus zinc (2 mg) (24 patients) twice daily for 16 weeks. Each patient was supplied with arsenic-safe drinking water by installing a locally made water filter at household level. Effectiveness of spirulina extract plus zinc was evaluated by comparing changes in skin manifestations (clinical scores) and arsenic contents in urine and hair, between the placebo- and spirulina extract plus zinc-treated groups. Results showed that spirulina extract plus zinc twice daily for 16 weeks may be useful for the treatment of chronic arsenic poisoning with melanosis and keratosis.More randomized trials are required but the results are promising.

ANTIOXIDANT EFFECTS: No *Invivo* Studies.

C-phycocyanin (C-PC) is one of the major biliproteins of *Spirulina* with antioxidant and radical scavenging properties. C-PC, a selective cyclooxygenase-2 inhibitor, induces apoptosis in lipopolysaccharide-stimulated RAW 264.7 macrophages. It is also known to exhibit anti-inflammatory and anticancer properties [24]. To date though, there are no *in vivo* human studies on possible antioxidant effects of *Spirulina*.

CONCLUSIONS

The positive effects of *Spirulina* in allergic rhinitis are based on adequate evidence but larger trials are required. It is believed that the anticancer effects of *Spirulina* are perhaps derived from β-carotene, a known antioxidant; however, the link between β-carotene level and carcinogenesis cannot be established as the etiology of carcinoma is frequently multifactor [25, 26]. There are some positive studies on the cholesterol-lowering effects of *Spirulina* but larger studies are required before any definitive conclusions can be made. Finally, there are no high-level evidence trials on the role played by *Spirulina* in chronic fatigue and in antiviral applications. At the moment, what the literature suggests is that *Spirulina* is a safe food supplement without significant side-effects but its role as a drug remains to be seen.

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