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Salutary Consequence of Spirulina *(Arthrospira platensis)* for Nourishing & Revitalization

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Abstract

Dried spirulina contains about 60% (51–71%) protein with all essential amino acids, though with reduced amounts of methionine, cysteine and lysine when compared to the proteins of meat, eggs and milk. It is, however, superior to typical plant protein, such as that from legumes. Spirulina's lipid content is about 7% by weight, and is rich in γ-linolenic acid (GLA), and also provides α-linolenic acid (ALA), linoleic acid (LA),stearidonic acid (SDA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and arachidonic acid (AA) along with vitamins B1 (thiamine), B2(riboflavin), B3 (nicotinamide), B6 (pyridoxine), B9 (folic acid), vitamin C, vitamin A and vitamin E. and various minerals viz. K, Ca, Cr, Cu, Fe, Mg, Mn, P, Se, Na, & Zn. Spirulina contains many pigments which may be beneficial and bioavailable, including β-carotene, zeaxanthin, chlorophyll-a, xanthophyll, echinenone, myxoxanthophyll, canthaxanthin, diatoxanthin, 3'- ydroxyechinenone, β-cryptoxanthin andoscillaxanthin, plus the phycobiliproteins c-phycocyanin and allophycocyanin. Spirulina is not considered to be a reliable source of Vitamin B12. In recent years, spirulina has attracted scientific attention, not only for its various health benefits, but also at a micro level of understanding the mechanisms of action of its various components. From being a 'complete' protein source, spirulina and its components have been shown to have positive benefit across a range of human health indications from malnutrition to antioxidant properties. These reports come from in *vitro*, animal and human studies. Human evidence suggests that spirulina can improve lipid and glucose metabolism, while also reducing liver fat and protecting the heart. Animal studies are very promising as well, as spirulina has been shown to be of similar potency as commonly used reference drugs, when it comes to neurological disorders. These effects also extend to arthritis and immunology. Spirulina has phycocyanobilin, (~ 1% of spirulina) which mimics the body's bilirubin compound, in order to inhibit an enzyme complex called NADPH oxidase, thereby providing potent anti-oxidative and anti-inflammatory effects.

Keywords: Lipid content; Essential fatty acids; Inflammation problems; Auto-immune diseases; Phycocyanobilin; Antioxidant enzymes; Neurotransmitter function

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1. Introduction

Spirulina is a simple one celled blue-green algae (cyanobacterium) that thrives in warm, alkaline fresh-water bodies. Its scientific name is *Arthrospira platensis*, and it belongs to the cyanobacteria family. The use of spirulina as a food source dates all the way back to 9th century Chad and it is believed spirulina was used by the Aztecs in 16th century Mexico. Historical records report the harvesting (Figure 2a,b,c) and selling of cakes made from spirulina harvested from Lake Texcoco. It was rediscovered in the 1950's in the same place where it has said to have its origins by a European scientific mission. The spirulina was being harvested and sold in dried flat cakes called, "dihé" at the local markets where natives would use it as a staple for many of their meals. Spirulina didn't come into commercial production until the 1970's when a French company began the first large-scale spirulina production plant. Within a few years, America and Japan began producing their own spirulina [1-3]. Today, these nutrient-rich algae are being used around the world to help treat illness and are being seriously discussed as a sustainable source of food with the potential to end world hunger. Unlike most plants, which need to be cultivated and nurtured, spirulina is a survivor, able to withstand extreme temperature variations and neglect and still thrive.

Figure 1: a,b,c Harvesting of Spirulina

Certain desert-adapted species will survive when their pond habitats evaporate in the intense sun, drying to a dormant state on rocks as hot as 70°C (160°F). In this dormant condition, the naturally blue-green algae turns a frosted white and develops a sweet flavor as its 71 % protein structure is transformed into polysaccharide sugars by the heat. Some scientists speculate that the "manna" of the wandering Israelites, which appeared miraculously on rocks following a devastating dry spell and was described as tasting "like wafers made with hone " may have been a form of dried, dormant Spirulina. This ability of Spirulina to grow in hot and alkaline environments ensures its hygienic status, as no other organisms can survive to pollute the waters in which this algae thrives. Spirulina thrives at a pH around 8.5 +, which will get more alkaline, and a temperature around 30 °C (86 °F). They are able to make their own food, and do not need a living energy or organic carbon source. In addition, spirulina have to have an ensemble of nutrients to thrive in a home aquarium or pond. A simple nutrient feed for growing Spirulina is:

$NaHCO_3$ - 16 g/L = 60.56 g/gal
KNO_3 - 2 g/L = 7.57 g/gal
NaCl - 1 g/L = 3.78 g/gal
$KH_2 PO_4$ - 0.1 g/L = .378 g/gal
$FeSO_4 * 7 H_2O$ - 0.01 g/L = .0378 g/gal

This can all be found in aquarium or else in the agricultural division, all commonly occurring compounds except for the $FeSO_4$. The alga has actually been tested and successfully grown in human urine at 1:180 parts. After 7days, 97% of NH_4^+ $^-$N, 96.5% of total phosphorus (TP) and 85–98% of urea in the urine (ca. 120-diluted) were removed by the microalgae under autotrophic culture (30 °C). Spirulina is one of the blue-green algae due to the presence of both chlorophyll (green) and phycocyanin (blue) pigments in its cellular structure. The name "spirulina" is derived from the Latin word for "helix" or "spiral"; denoting the physical configuration of the organism when it forms swirling, microscopic strands (Fig. 2).

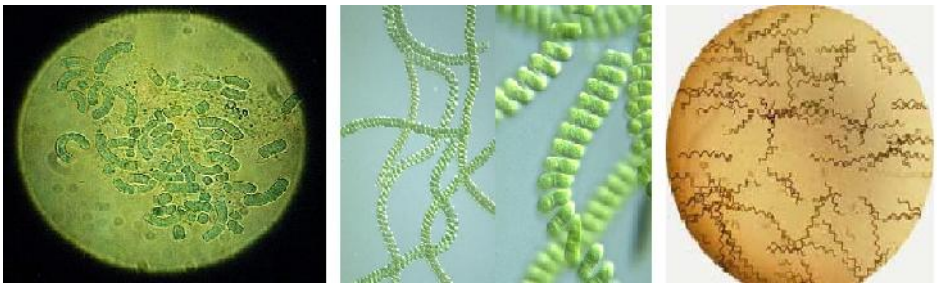

Figure 2a,b,c: Swirling Microscopic Strands of Spirulina

Even though Spirulina is distantly related to the kelp algae, it is not a sea plant. However, the fresh-water ponds and lakes it favors are notably more alkaline - in the range of 8 to 11 pH than ordinary lakes and cannot sustain any other forms of microorganisms.

In addition, Spirulina thrives in very warm waters of 32 to 45° C (~ 85 to 112°F, and has even survived in temperatures of 60° C (140°F). Since spirulina grown in an uncontrolled environment has the potential to become contaminated with heavy metals and other toxins, it is important to choose organic spirulina from a reputable source. Spirulina is being developed as the "food of the future" because of its amazing ability to synthesize high-quality concentrated food more efficiently than any other algae. Spirulina, linking bacteria and plants is primitive, has a simple structure but a complex composition. It has been a common dietary substance around the world from ancient times. Spirulina's products viz. powder, capsules and tablets, improve overall health. (Fig. 3).

2. Description

Spirulina can help people prevent various health problems, such as allergies, diabetes, oral cancer, and obesity. Spirulina contains many essential nutrients for human body. These nutrients are required by our body to grow properly. It has some important nutrients, such as B complex vitamins, vitamin E, and also β-carotene. These vitamins are good for improving our overall health. This product also contains high amount of protein. Therefore, it is considered as one of the best protein sources for many people. It also contains some other nutrients, such as minerals, cholorphyll, and also antioxidants. These active ingredients are good to improve the overall human health [3-6].

In recent years, spirulina has attracted scientific attention, not only for its various health benefits, but also at a micro level of understanding the mechanisms of action of its various components. From being a 'complete' protein source, spirulina and its components have been shown to have positive benefit across a range of human health indications from malnutrition to antioxidant properties. These reports come from in vitro, animal and human studies. Although, few adverse effects of spirulina supplementation have been reported, most of these can be addressed by 'organic' production, good culture, harvest and processing practices along with its careful usage in specific conditions such as metabolic disorders. Spirulina has been a common dietary substance around the world from ancient times. Although dietary usage and supplementation continues to be popular, there was for a long time no strong scientific evidence of spirulina's nutritive and health benefits.

These reports come from in vitro, animal and human studies. Human evidence suggests that spirulina can improve lipid and glucose metabolism, while also reducing liver fat and protecting the heart. Animal studies are very promising as well, as spirulina has been shown to be of similar potency as commonly used reference drugs, when it comes to neurological disorders. These effects also extend to arthritis and immunology. Spirulina has a few active components. The main ingredient is called phycocyanobilin, which makes up about 1% of spirulina. This compound mimics the body's bilirubin compound, in order to inhibit an enzyme complex called NADPH (Nicotinamide Adenine Dinucleotide Phosphate) oxidase. By inhibiting NADPH oxidase, spirulina provides potent anti-oxidative and anti-inflammatory effects. The neurological effects of spirulina need more human evidence. Based on animal evidence, spirulina appears to be a promising anti-oxidant and supplement for metabolic issues. Unlike the stereotypical association of microorganisms with "germs" and "scum", Spirulina is in fact one of the cleanest, most naturally sterile foods found in nature. Its adaptation to heat also assures that Spirulina retains its nutritional value when subject to high temperatures during processing and shelf storage, unlike many plant foods that rapidly deteriorate at high temperatures. Spirulina is also unusual among algae because it is a "nuclear plant" meaning it is on the developmental cusp between plants and animals. It is considered somewhat above plants because it does not have the hard cellulose membranes characteristic of plant cells, nor does it have a well-defined nucleus. Yet its metabolic system is based on photosynthesis, a process of direct food energy production utilizing sunlight and chlorophyll, which is typical of plant life forms. In essence, Spirulina straddles that fork in evolutionary development when the plant and animal kingdoms differentiated. Thus it embodies the simplest form of life. In contrast, other algae such as Chlorella have developed the hard indigestible walls characteristic of plants. Recent advances in biochemistry and molecularly biology techniques provide new, powerful tools for studying the antioxidant enzymes and for elucidating the mechanisms of the actions of antioxidants. Thus the future of antioxidants hold promise to ensure a better, disease-free lifestyle for mankind by scavenging free radicals and consequently preventing mutagenic changes and associated disorders [5-9].

Dried spirulina contains about 60% (51–71%) protein. It is a complete protein containing all essential amino acids, though with reduced amounts of methionine, cysteine and lysine when compared to the proteins of meat, eggs and milk. It is, however, superior to typical plant protein, such as that from legumes. Spirulina's lipid content is about

7% by weight, and is rich in γ-linolenic acid , and also provides alpha-linolenic acid, linoleic acid ,stearidonic acid , eicosapentaenoic acid , docosahexaenoic acid &arachidonic acid . Spirulina contains vitamins B1 (thiamine), B2(riboflavin), B3 (nicotinamide), B6 (pyridoxine), B9 (folic acid), vitamin C, vitamin A and vitamin E. It is also a source of K, Ca, Cr, Cu, Fe, Mg, Mn, P, Se , Na & Zn. Spirulina contains many pigments which may be beneficial and bioavailable, including β-carotene, zeaxanthin, chlorophyll-a, xanthophyll, echinenone, myxoxanthophyll, canthaxanthin, diatoxanthin, 3'-hydroxyechinenone, β- andoscillaxanthin, plus the phycobiliproteins c-phycocyanin and allophycocyanin.

To reason why Spirulina is reported to have so many health benefits is due to its high concentration of nutritional properties. However, it must be said that these same nutrients can be found in other food sources but you would need to eat large quantities across a broad spectrum of food types to attain the same levels of nutrition that a small, singular amount of Spirulina will provide. Spirulina contains about 60 to 70 % high quality protein which contains all the essential amino acids that cannot be synthesized by the human body. One of the nutritional properties of

spirulina that is often referred to is that of Vitamin B12 but many sources that refer to this fail to mention that the particular kind of B12 that is abundant in Spirulina is pseudo vitamin B12 and of little use to humans [8-13]. So, if you are considering using it as a means to supplement your B12 intake then be forewarned that it will not provide much benefit. Spirulina lipid content is 7 % by weight and contains essential fatty acids which are inherent in vegetable oils such as γ- linoleic acid sometimes independently marketed as a dietary supplement credited with treatment of inflammation problems and auto-immune diseases.

The primary active component of spirulina is Phycocyanobilin, which constitutes about 1% of Spirulina by weight. This compound inhibits NADPH oxidase. Spirulina has been studied in vitro against HIV, as an iron-chelating agent, and as a radioprotective agent [14-18]. Animal studies have evaluated spirulina in the prevention of chemotherapy-induced heart damage, stroke recovery, age-related declines in memory,[] diabetes mellitus, in amyotrophic lateral sclerosis, and in rodent models of hay fever. In humans, small studies have been undertaken evaluating spirulina in undernourished children, as a treatment for the cosmetic aspects of arsenic poisoning,in hay fever and allergic rhinitis, in arthritis, in hyperlipidemia and hypertension, and as a means of improving exercise tolerance [19-22] .

Figure 3: Spiruina products [a, b. c (i) powder, c (ii) capsules, c (iii,iv) , d. tablets]

Figure 4: Yummy dishes of dry fruits having one of the ingredients i. e. spirulina & appetizing juices

How spirulina regulates Cu-toxicity: A study was conducted, examining the effects that dietary spirulina have on reducing toxic amounts of Cu in carp. Copper (Cu) reduction based on food utilization of spirulina, phosphatases activities and selected haematological (blood) parameters was studied. The fish species in the study, C. mrigala, contained toxic amounts of Cu concentrations in body tissue. It was set out to also study Cu amounts in the fish's fecal matter as spirulina was administered. The researchers added spirulina to the fish's diet, and they watched as 6% increases of dietary spirulina began showing positive results. The fish, which were overloaded with the metal,

began expelling it from their bodies through their waste. Copper measurements in fecal matter increased from the start. Furthermore, large dietary amounts of the blue-green algae reduced haematological parameters, lowering chances of blood disease, and liver and kidney toxicity.

The most effective dose of spirulina was a 6% addition to the fish's diet. This amount maximized the elimination of Cu without completely depleting the body of it. It improved the fish's growth, healthy blood levels and phosphatases activities. According to studies, spirulina is being successfully used to treat a wide variety of ailments, including those who've been poisoned by As-contaminated water. Drugs such as AZT used to treat HIV and AIDS patients can actually cause the symptoms they are supposed to cure. However, spirulina has been shown to help inactivate the human immunodeficiency virus associated with HIV and AIDS. According to a study done on elderly male and female patients ages 60-87, those given 8 grams of spirulina /day for 16 consecutive weeks showed lower cholesterol levels than those who were given a placebo. In a study done at the Institute of Pharmaceutical Technology in India, it was found that a dosage of 180mg/kg of spirulina had a protective effect on the brain and nervous system of rats exposed to high amounts of free radicals, compared to rats not given the spirulina before the experiment. This lab test shows the promising effect of spirulina on stroke prevention [20-23].

Many of the articles, reviews and marketing materials written about the health benefits that Spirulina provides will allude to the extensive scientific research carried out on it. However, they fail to mention that much of this extensive testing has been conducted on animals and although results of this testing have been positive there is no way of knowing if they will replicate with humans until further studies are conducted. However, the little scientific research that has been conducted with humans and a plethora of postive testimonials from those who use Spirulina as part of their daily diet shows that it can produce positive results. It is also accredited with combating stress and helping to calm nerves. - Spirulina aids the reparation damage tissues, increases organ function and energy levels, while also helping to aid digestion by increasing intestinal flora such as lactobacillus and bifidus. In addition, Spirulina is alkalizing and because many foods ingested during modern times are highly-acidic, choosing alkalizing Spirulina will counteract acidic levels, thereby supporting a more robust and effective immune system. Spirulina is also an excellent source of powerful antioxidants, which slow down cell damage [21-36].

Figure 5: Sample collection, filtration, slurry formation, powder conversion & culture examination

Examples of antioxidants found in Spirulina include β-carotene, vitamin E, Chlorophyll, Zeaxanthin, Superoxide dismutase and phycocyanin. Spirulina is not a weight loss product, however, due to the high concentration of nutrients you can diet safely while still receiving abundant nutrients which are free of excess calories. In essence you can eat less without feeling hungry while still providing your body with the essential vitamins, minerals and protein that it need to function. To get the most benefit from Spirulina for weight loss it is recommended that you take it one hour before eating. In addition to the above mentioned benefits research studies have shown that Spirulina helps lower blood cholesterol, inflammation and also cleanses the body of toxin build-up and can help reduce incidences of chronic fatigue, anemia, low blood sugar and ulcers. Spirulina contains vital amino acids, including tryptophan and leucine, which promote optimum brain chemistry by supporting premium neurotransmitter function [4,7,9.21].

3. Conclusion

Though spirulina can not instantly reduce ones weight, it comprises the necessary nutrients for our bodies that are quickly assimilated. It contains a compound known as γ- linolenic acid; it is present in human breast milk and helps to enhance healthy baby development. Spirulina can also benefit individuals who suffer from both malnutrition and poor nutrition due to its high level of nutrients as well as ease of assimilation properties and helps our systems to absorb nutrients from the foods we take. Dried spirulina contains about 60% (51–71%) protein. It is a complete protein containing all essential amino acids, though with reduced amounts of methionine, cysteine and lysine when compared to the proteins of meat, eggs and milk. It is, however, superior to typical plant protein, such as that from legumes. Spirulina's lipid content is about 7% by weight, and is rich in GLA, and also provides ALA, LA, SDA,

EPA, DHA and AA. Spirulina contains thiamine, riboflavin, nicotinamide, pyridoxine, folic acid, vitamin C, vitamin A and vitamin E. It is also a source of K, Ca, Cr, Cu, Fe, Mg, Mn, P, Se, Na, & Zn.

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