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Review for uses and therapeutic effects of spirulina, Spirulina platensis microalgae

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Abstract

Spirulina is a filamentous cyanobacteria with many applications in food and drug industries, as a food in human, aquaculture, vet and poultry industries. Semi and mass culture of Spirulina carries out in different countries. it contains large amounts of protein (70% dry weight), carotenoid (4000 mg/kg), (omega-3 and omega-6 polyunsaturated fatty acids ,gamma linolenic acid (GLA), sulfolipids, glycolipids, polysaccharides, provitamins; vitamin A vitamin E, various B vitamins; and minerals, including calcium, iron, magnesium, manganese, potassium, zinc and selenium. Pre-clinical and clinical studies suggest that Spirulina has certain therapeutic effects such as reduction in blood cholesterol, protection against some cancers, enhancement of the immune system, increase of intestinal lactobacilli, reduction of nephrotoxicity by heavy metals and drugs, radiation protection, reduction of hyperlipidemia and obesity. In this paper, uses and therapeutic effect of spirulina have been reviewed according to new researches.

Keywords: spirulina, use, therapeutic.

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1. Introduction

Spirulina is a "Super food." It is the most nutritious, concentrated whole food known to humankind. It has a rich, vibrant history, and occupies an intriguing biological and ecological niche in the plant kingdom. Spirulina is truly an amazing food, full of nutritional wonders [29].

Spirulina is a blue-green microalgae has a spiral cellular structure, and has an extraordinary capacity to survive under conditions that are much too harsh for other algae. Habitats with extensive Spirulina growth include the Pacific Ocean near Japan and Hawaii, large fresh water lakes in Africa, North America, Mexico, and South America. Two species of Spirulina that are most commonly used in nutritional supplements are Spirulina platensis and Spirulina maxima [14]. Spirulina, contains large amounts of protein (70% dry weight), carotenoid (4000 mg/kg), (omega-3 and omega-6 polyunsaturated fatty acids ,gamma linolenic acid (GLA), sulfolipids, glycolipids, polysaccharides, provitamins; vitamin A, vitamin E, various B vitamins; and minerals, including calcium, iron, magnesium, manganese, potassium, zinc [14] and selenium. It is, therefore, a potential therapeutic agent for treating oxidative stress-induced diseases [30]. Pre-clinical and clinical studies suggest that Spirulina has certain therapeutic effects such as reduction in blood cholesterol, protection against some cancers, enhancement of the immune system, increase of intestinal lactobacilli, reduction of nephrotoxicity by heavy metals and drugs, radiation protection, reduction of hyperlipidemia and obesity [6]. Besides Spirulina pills and capsules, there are also pastries, blocks, and Spirulina containing chocolate bars, marketed as health food. Other Spirulina products are formulated for weight loss and as an aid for quitting drug-addictions [4].

2. Use of spirulina

2.1. Human Consumption

Clinical trials have shown that spirulina can serve as a supplementary cure for many diseases. Spirulina capsules have proved effective in lowering blood lipid level, and in decreasing white blood corpuscles after radiotherapy and chemotherapy, as well as improving immunological function. Spirulina also is used for health food, feed and for the biochemical products since 1980s [13, 1].

2.2. Use as Feed and Feed Additives

Since many of the existing blue-green algae species are known to produce toxin (microcystins, in particular MCYST-LR), it is very important to clarify the specific species used for human consumption as in all likelihood there is a danger of species substitution and/or contamination of spirulina with other cyanobacteria. It is particularly important in countries where no such regulation exists on this type of products. When the algal cells or filaments of spirulina are transformed into powder it can provide the basis for a variety of food products, such as soups, sauces, pasta, snack foods, instant drinks and other recipes. Spirulina is also used to prepare food with other ingredients. For example, instant noodles, stylish noodles, nutritious blocks, beverages and cookies [13]. In addition microalgal biomass has been studied in several food products oil-in-water emulsions, vegetable puddings, biscuits and pastas. The effect of microalgal concentration on the products color parameters was investigated, as well as its stability through the processing conditions and along storage time [3]. Many foods aimed at the juvenile market were advertised as containing the delicious Spirulina with its pretty blue-green color. Add it to milk shakes, jellies, biscuits or cakes [10]. The enrichment of Spirulina platensis has been studied in wheat flour to prepare fresh pasta to evaluate the green color and nutritional enrichment in addition to functional properties due to the presence of the bioactive compounds in the cyanobacterium [2]. Also Sharma and Dunkwal [27] have been enriched biscuit by spirulina.

2.3. Use of Spirulina in Poultry

About one third of the world compound feed production is for poultry and this new green marketplace has challenged manufacturers to formulate feeds using high quality components [23]. Spirulina is one of the high quality natural feed additives that can be used in animal and poultry nutrition. In this respect, Ross and Dominy [31] and Nikodémusz et al [32] reported that hens fed Spirulina-containing diets achieved superior productive and reproductive performance compared to the control birds. Moreover, Sakaida Takashi [33] found that egg yolk color was significantly improved by the addition of Spirulina to laying hen diets [34].

2.4. Use of Spirulina in Aquaculture

Spirulina is a cheaper feed ingredient than others of animal origin. China is using spirulina as a partial substitute of imported feed to promote the growth, immunity and viability of prawns (example Penaeus monodon). Spirulina-containing feed was found to reduce the cultivation time and mortality, and increase shell thickness of scallop. The survival rate of abalone (Haliotis midae) was improved by 37.4 percent. Feeding on spirulina helped to improve disease resistance of high value fish resulting in an improvement in their survival rate from 15 to 30 percent [13]. Ghaeni [15] has been used spirulina as a supplement in green tiger prawn larvae diet. Also effect of spirulina platensis meal has been evaluated as feed additive on growth and survival of Litopenaeus schmitti shrimp larve [5].

3. Summary of studies on therapeutic effects of Spirulina

3.1. Effects against Hyperlipidemia

The antioxidant activity of Spirulina maxima has been evaluated against lead acetate-induced hyperlipidemia and oxidative damage in the liver and kidney of male rats. The results showed that Spirulina maxima prevented the lead acetate-induced significant changes on plasma and liver lipid levels and on the antioxidant status of the liver and kidney. On the other hand, Spirulina maxima succeeded to improve the biochemical parameters of the liver and kidney towards the normal values of the Control group [9] Decreases in blood pressure and plasma lipid concentrations, especially triacylglycerols and low density lipoprotein-cholesterol have been demonstrated as a result of oral consumption of Spirulina. It has also been shown to indirectly modify the total cholesterol and high density lipoprotein cholesterol values. A water extract from Spirulina may inhibit the intestinal absorption of dietary fat by inhibiting pancreatic lipase activity [25].

3.2. Anti-cancer and immune system effects

Chemotherapy is one of the main treatments used to cure cancer. Besides that, a group of drugs are used to kill or inhibit the growth of cancer cells. These drugs are associated with toxicity, which at best is unpleasant and at worst may threaten life. Many side effects of chemotherapeutic drugs include hair loss, mouth sores, diarrhea, nausea and vomiting, loss of appetite and fatigue. Hence new anticancer agents should be investigated from various resources. Spirulina preparations increase phagocytic activity of macrophages and stimulate antibodies and cytokines production. It may also faciliate lipid and carbohydrate metabolism. Studies also demonstrate its benefits against several types of virus (e.g. HIV), toxicity and cancers [18]. NK activation by Spirulina has some advantage in combinational use with BCG-cell wall skeleton for developing adjuvant-based antitumor immunotherapy [28]. The molecular mechanism of the human immune potentiating capacity of Spirulina has been evaluated by analyzing blood cells of volunteers with pre and post oral administration of hot water extract of Spirulina. As a result, in humans Spirulina acts directly on myeloid lineages and either directly or indirectly on NK cells [26].

3.3. Radiation protective effects

Radiation protection offered by Spirulina may be due to the phytopigments (carotenoids, chlorophyll, phycocyanin) as well as polysaccharides. Spirulina can elevate the activity of all the antioxidant related enzymes viz., superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase significantly. The effect may be due to the high phytopigments (carotenoids, chlorophyll, phycocyanin) in Spirulina [22].

3.4. Effects against nephrotoxicity

The hepatoprotective action of Spirulina fusiformis is against GalN induced hepatotoxicity in mice. The protective efficacy of Spirulina fusiformis is very promising as evidenced by the reversal of the altered values following administration probably by promoting regeneration of hepatocytes that restore integrity and it was confirmed by the histopathological studies. The hepatoprotective property of the extract may be attributed to the presence of various constituents which are present in Spirulina fusiformis. Still extensive research is required for understanding of the mechanism of action of Spirulina fusiformis for providing protection against galactosamine induced hepatotoxicity [19].

3.5. Effects against diabetes, obesity and hypertension

According to Takai et al. [35] a water-soluble fraction of Spirulina was found effective in lowering the serum glucose level at fasting while the water-insoluble fraction suppressed glucose level at glucose loading. Similar results were found in other studies. In a human clinical study involving 15 diabetics, a significant decrease in the fasting blood sugar level of patients was observed after 21 days of 2 g/day Spirulina supplementation.83 In a double-blind-crossover study versus placebo, Becker et al. [36] have found that a supplementary diet of 2.8 g of Spirulina 3 times d-1 over 4 weeks resulted in a statistically significant reduction of body weight in obese outpatients. Spirulina has also been found to suppress high blood pressure in rats. A vasodilating property of rat aortic rings by Spirulina possibly dependent upon a cyclooxygenase-dependent product of arachidonic acid and nitric oxide has been reported by Paredes-Carbajal et al. (1991) Cheng-Wu Z et al. (1992) did a preliminary study on the effect of polysaccharides and phycocyanin on peripheral blood and hematopoietic system of bone marrow in mice. Their studies showed that C-phycocyanin and polysaccharides from Spirulina had a high erythropoetin (EPO) activity [1].

3.6. Anti-viral effects

Many researchers have attempted to search for effective and inexpensive anti-viral agents from natural sources.The inhibitory effects of polysaccharides from marine algae on virus replication were first reported almost four decades ago. Gerber et al. [37] reported that algal polysaccharides exhibited antiviral activity toward mumps and influenza B virus. Further, Hayashi et al. [38] reported the anti HSV-1 activity of aqueous extracts from S. platensis [21].

3.7. Anti-inflammatory effects

Recent research reveals that free bilirubin functions physiologically as a potent inhibitor of NADPH oxidase activity. The chromophore phycocyanobilin (PCB), found in blue-green algae and cyanobacteria such as Spirulina, also has been found to be a potent inhibitor of this enzyme complex, likely because in mammalian cells it is rapidly reduced to phycocyanorubin, a close homolog of bilirubin. In light of the protean roles of NADPH oxidase activation in pathology, it thus appears likely

that PCB supplementation may have versatile potential in prevention and therapy—particularly in light of rodent studies demonstrating that orally administered Spirulina or phycocyanin (the Spirulina holoprotein that contains PCB) can exert a wide range of anti-inflammatory effects. Until PCB-enriched Spirulina extracts or synthetically produced PCB are commercially available, the most feasible and least expensive way to administer PCB is by ingestion of whole Spirulina [16].

3.8. Probiotic effects

Probiotic microorganisms are 'live microbial food consumed as human food supplement for centuries supplement which beneficially affect the host animal by because of its best known nutritional value. Spirulina contains improving its microbial balance. The probiotic efficiency of S.platensis is for lactic acid bacteria and also a potent antibacterial activity against human pathogenic bacteria [7].

3.9. Other effects

Spirulina contains phenolic acids, tocopherols and ß-carotene which are known to exhibit antioxidant properties. Miranda et al. [17] evaluated the antioxidant capacity of a Spirulina extract. The antioxidant activity of a methanolic extract of Spirulina was determined in vitro and in vivo. The results obtained indicate that Spirulina provides some antioxidant protection for both in vitro and in vivo systems Spirulina has been shown to prevent cataract [24], acute allergic rhinitis [12], cerebral ischemia [14] and vascular reactivity [8] and has also been shown to be effective against cadmium [11] and arsenic induced-toxicities [39]. In recent years some of its properties have been confirmed through studies while additional pharmacological properties need to be proved. Spirulina platensis is effectively suppressed peripheral sensitization via modulation of glial activation, improved motor recovery in collagen-induced arthritic rats [20].

3.10. The side effects could be:

Upset stomach, feeling a bit sick, hiccups, and mild diarrhoea. Nausea and constipation could come from gastric over acidity and poor digestion. Feeling hungry, dizzy and low on energy could be side effects in people who suffer from hypoglycaemia and anaemia. Slight fever could be a reaction of the body's metabolism. Spirulina is a concentrated protein and could increase body temperature. Excitement and sleeping problems could come from the fact that the body burns excessive fats. It is advisable in these cases to take Spirulina only in the morning. Headaches could come from a poor digestion and is normally only a very brief and rare healing crisis. Perspiration Detoxification goes through the lung, the skin and the stools. During the detoxification, perspiration can change for a period of time depending on the level of toxification [10].

4. Conclusion

Despite the few human studies done so far on the health benefits of Spirulina, the evidence for its potential therapeutic application is overwhelming in the areas of immunomodulation, anti-cancer, anti-viral, and cholesterol-reduction effects. Traditional therapies always rely on the use of natural products and have been the source of information for the discovery of many drugs we have today. Currently, increased cost of health care has become a driving force in the shift towards interest in wellness, self-care, and alternative medicine, and a greater recognition between diet and health care.

Spirulina is already in use in these new health care approaches. Further clinical research will help solidify the merit of its use.

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