

***Spirulina* spp. in nutritional and clinical practices : A review of applications**

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ABSTRACT : *Spirulina* is Cyanobacterium blue green algae that contains diverse concentrations of nutrients and has emerged as a wonder drug or super food. *Spirulina* has long been in use as a Nutraceutical due to presence of high quality and quantity of protein, vitamins, minerals and presence of pigments like Chlorophyll a, carotenoides, and phycobilins etc., essential amino and fatty acids. Due to presence of certain pigments and secondary metabolites *Spirulina* has played very important role in metabolic diseases like diabetes, hypertension, hyperlipidemia, cancer, anaemia etc. and acts as immune booster, anti-oxidant, anti-inflammatory and many others. Most of the animal studies and further human trials have approved the importance of *Spirulina* and the requirement of its commercialization for therapeutic purposes. In the present paper, therapeutic and nutritional applications of *Spirulina* have been reviewed according to various researches.

Key Words : *Spirulina* (*Spirulina platensis*), Cyanobacterium blue green algae, Nature's Superfood, nutritional and therapeutic values, nutraceutical values.

Spirulina is a type of cyanobacteria which consists a history of human consumption dating back from 16th century till now and according to FAO (2008) report the immortal organism *Spirulina* has a photosynthetic life form originated some 3.5 billion years ago, these blue green algae created our oxygen atmosphere so other life could evolve. Since then, algae have helped to regulate our planet's biosphere. Algae are found two-thirds of the Earth's biomass. *Spirulina* is a spiral shaped Cyanobacterium which is found in lakes, freshwater bodies, in sea water and brackish water bodies. It is so named due to its coiled or spiral structure of its filaments. It flourish best at pH of 10-12 in an alkaline medium (Capelli and Cysewski, 2010). In a statement NASA has been found that nutritional value of 1000 kg vegetable and fruits is equal to 1 kg of supplementary food *Spirulina* (Ravi *et al.*, 2002).

Microalgae are suggested to involved in food a lot of benefits like gain in body weight, biological value, betterment of digestive system and better protein efficiency ratio. Due to a very rich nutrient profile and clinical uses *Spirulina* has been proved to be very beneficial (Khan *et al.*, 2005; Srivastava, 2005).

Nutrient Profile: *Spirulina* has been found to be one of the best sources of protein i.e. about 58-67% protein can be obtained from different species of *Spirulina*. *S. platensis*, *S. maxima* and *S. fusiformis* are main *Spirulina* species which have very high nutrient profile (Thomas, 2010). *Spirulina* also provides about all essential and non-essential amino acids. According to a research *Spirulina* contains 180% more calcium than whole milk, 3100% more beta carotene than car-

rots, and 5100% more iron than spinach (Moorhead *et al.*, 2005). *Spirulina* is generally recognized as safe non-toxic dietary supplement for normal consumption purposes (Gershwin and Belay, 2008). After *Spirulina* supplementation a positive impact have been analyzed on weight, arm circumference pre-albumin and albumin protein and haemoglobin (Azabji-Kenfack *et al.*, 2011).

Applications of *Spirulina*

For complete supplementation: The food supplement *Spirulina* is proved very effective for victims of malnutrition diseases like Kwashiorkor where the ability of intestinal absorption has damaged. As *Spirulina* is found to be easily digestible thus it is proved more effective than milk powders as the lactic acid of milk could difficult to absorb (Kelly *et al.*, 2011).

Syahril *et al.* (2012) and Patro *et al.* (2011) described that *Spirulina platensis* having high quality of components could be better used as feed and feed additives for human and poultry purposes.

In a research cell wall of *Spirulina* is found to be composed of protein, carbohydrates and fat while indigestible cellulose is totally absent thus bioavailability of nutrients from *Spirulina* is higher than any other food sources (Selmi *et al.*, 2011). The reason behind the popularity of *Spirulina* is the high percentage of protein (about 65%) and also because of the presence of all 8 essential amino acids. It is found to be a great source of protein for vegetarians which boosts the protein intake of body as the protein found in *Spirulina* is highly absorbable (Sharoba, 2014).

As *Spirulina* contains exceptionally high content of

Vitamin B12 which is of great importance as animal origin foods. So it is found to be a good source of Vitamin B12 for vegan (Gabriela *et al.*, 2015).

For diabetes and obesity: A study has been done on anaemic children by providing them Spirulina food supplement, as a result a prominent decrease has been found the level of anaemia (Branger *et al.*, 2003). Another study showed a stable increment in average values of mean corpuscular Haemoglobin, when Spirulina has been supplied to the old age women for a period of 12 week (Selmi *et al.*, 2011).

15 diabetics patients were provided 2g Spirulina per day supplementation which resulted in a significant decrease in the fasting blood sugar level of the individuals (Kumar *et al.*, 2011). Balasubramanian *et al.* (2013), found the anti-obesity effects of *Spirulina platensis* in animal model. As a result there was found reduction in the weight of high fat diet induced obese rats after treatment with *Spirulina platensis*.

Miczke *et al.* (2016) has done an experiment on 40 patients having high blood pressure that have been given 2 grams of Spirulina or placebo for 3 months. As a result no any change found in weight or body mass index either in Spirulina or placebo groups.

A study have been done on 64 healthy obese individuals. 34 individuals got 1 gram of Spirulina capsules while rest 32 individuals placebo (excused) for period of 12 weeks. As a result the body weight and body mass index were considerably inhibited in treated vs untreated groups (Zeinalian *et al.*, 2017).

Anticancer : The main treatment used to cure cancer is Chemotherapy. Alongside many drugs are also given to kill the cancer cells and these drugs include many side effects. So from various resources new Spirulina preparations have been introduced which could stimulate antibodies and cytokines production and enhance the phagocytic activity of macrophages (Haque and Gilani, 2005). Effects of Spirulina have been studied on tobacco chewers in Kerala, India for chemoprevention of cancer. They found that the supplementation with 1g/day of Spirulina for one year resulted in complete regression (Jalaja *et al.*, 2011).

An animal study have been done, taken rat as model to demonstrate the chemopreventive effects of Cisplatin with Spirulina and Vitamin C. It was found that the risk of hepatotoxicity could be reduced by treatment of Cisplatin along with the supplementation of Spirulina and Vitamin C (Bhattacharyya and Mehta, 2012).

In a study at BHU, Varanasi Spirulina strain along with other five cyanobacteria found to be most potent

possibility to have anticancer drug like structures (Srivastava *et al.*, 2015).

Hypertension and Hyperlipidemia

Ponce-conchihuaman *et al.* (2010), conducted an experiment on the liver and kidney of male rats to evaluate the effect of Spirulina against lead acetate- induced hyperlipidemia and oxidative damages. As a result they found that Spirulina maxima prevented liver lipid levels and lead acetate induced changes on plasma and it also prevents the antioxidant status of the liver and kidney. A significant improvement was also found in biochemical parameters of liver and kidney after the study. Some observers found hypolipidemic, hypoglycaemic, antipertensive properties, microbial modulating, antioxidant and anti inflammatory properties of Spirulina.

Eyes problems: In a research by Seshadri (1993) it was found that being a very rich source of betacarotene, Spirulina overcomes the deficiency of vitamin A and cures the eyes related diseases.

Antioxidant and Anti-inflammatory: In a review article Martínez-Galero *et al.* (2016) studied on the antitoxic effect of Spirulina. The searching criterion involved the effects of Spirulina on experimental poisoning from arsenic, cadmium, carbon tetrachloride, deltamethrin, fluoride, hexachlorocyclohexane, iron, lead, lindane and mercury. As a result of the studies resemble in altering degrees the protective activity of Spirulina generally based on its antioxidant properties. Due to presence of phycocyanin and beta-carotene, Spirulina contains antioxidant and anti-inflammatory activities (Riss *et al.*, 2007; Manconia *et al.*, 2009).

According to Patel *et al.* (2006) and Cherng *et al.* (2007) phycocyanin acts as anti-inflammatory by suppressing cyclooxygenase-2 expression, inhibiting cytokine formation i.e. TNF- α and by decreasing prostaglandin E (2) production. Helliwell *et al.* (2011) revealed that free bilirubin acts to inhibit the activity of NADPH oxidase and Polycyanobilin (PCB) a chromophore found in Spirulina acts as a potent inhibitor of this enzyme complex. Thus Spirulina exerts a wide range of anti inflammatory effects.

Immune booster : Due to deficit of nutrients changes takes place in immunity like T-cell production, NK-cell activity, changes in antibodies responses and cytokines activity in this favour many researches taken place. A Japanese study has been taken place by oral administration of hot water Spirulina extract and found higher levels of natural killer (NK) cells, IFN- γ and also effected production of interleukins (Hirahashi *et al.*, 2002).

Borchers *et al.* (2007) found the regulatory effects of Spirulina on the immune system and also found that Spirulina play very important role in T-cells, NK-cells and macrophages activation. As a result of which viral inactivation takes place by the process of induction of interferon gamma (IFN-g) release (Borchers *et al.*, 2009).

A study was done on HIV-infected 73 women for a 3 months using antiretroviral therapy. As a result of the study no any benefit of Spirulina on CD4T cells was found but a very little increase in the creatinine level was observed the study also resulted in a positive effect of Spirulina in weight stabilization (Winter *et al.*, 2014).

Another recent study by Appel *et al.* (2018) had taken two commercial products Immulina® and immunLoges® of high molecular weight polysaccharides extract Spirulina. The researcher found Immulina® and immunLoges® to have a property to inhibit the IgE- antigen complex induced production of TNF α , histamine, IL-4 and leukotrienes. Thus their results recommended the Immulina® and immunLoges® exhibits anti-inflammatory properties and inhibited the release of histamine from mast cells.

Due to its high nutritional values, chemical components and safety for its biomass for human consumption Spirulina is nowadays referred to be a genius wonder super food supplement or as nutraceutical supplement. After analysing the reviews it could be said that with very few adverse effects and having diverse nutritive nature Spirulina is said to be very effective in the treatment and management of various diseases like it could be used as food supplement, for diabetics and obese persons, for the treatment of cancer, hypertension hyperlipidemia and eyes diseases and it also acts as anti-oxidant, anti-inflammatory and immune-booster. Furthermore researches are required to identify the active elements of Spirulina and to uncover its working mechanism for development of new drugs and implement for Spirulina, the nature's gift, more useful for welfare of mankind and other organisms.

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