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Review Article

Therapeutics role of spirulina platensis in disease prevention and treatment

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ABSTRACT

Spirulina are multicellular and filamentous blue-green microalgae belonging to two separate genera Spirulina and Arthrospira and consists of about 15 species. Of these, Arthrospira platensis is the most common and widely available spirulina and most of the published research and public health decision refers to this specific species. It grows in water, can be harvested and processed easily and has significantly high macro- and micronutrient contents. In many countries of Africa, it is used as human food as an important source of protein and is collected from natural water, dried and eaten. It has gained popularity in the human health food industry and in many countries of Asia it is used as protein supplement and as human health food. Spirulina has been used as a complementary dietary ingredient of feed for poultry and increasingly as a protein and vitamin supplement to aqua feeds.

Spirulina can play an important role in human and animal nutrition, environmental protection through waste water recycling and energy conservation. Spirulina is free floating filamentous microalgae growing in alkaline water bodies The present review was focused on the various characteristics of Spirulina platensis**.** Spirulina is rich in proteins (60-70%), vitamins and minerals used as protein supplement in diets of undernourished poor children in developing countries. One gram of Spirulina protein is equivalent to one kilogram of assorted vegetables. The amino acid composition of Spirulina protein ranks among the best in the plant world, more than that of soya bean. The mass cultivation of Spirulina is achieved both in fresh water and waste water. Spirulina grown in clean waters and under strictly controlled conditions could be used for human nutrition. The micro algae gown in waste water is used as animal feed and provide a source of the fine chemicals and fuels. The waste water system is highly applicable in populated countries like India where wastes are generated in high quantities and pose environmental problem.

1. Introduction

Spirulina platensis is non-toxic blue green algae which is filamentous cyanobacteria taken by the human as dietary supplement and use it as a food. Spirulina platensis is a biomass which is dried form of Arthrospira platensis. This blue green algae is the primary diet in humans, animals and aquatic life. Spirulina platensis is easily digested due to absence of cell wall. This blue green algae is an important diet in humans and in animals. In humans it is used as a source of protein and vitamin without causes any harmful effect. It is rich in phenolic acids, tocopherol and y-linoleic acids. Spirulina platensis is most commonly available and widely used genus which has been extensively studied in different fields specially food and medicine. Spirulina platensis was originally discovered in ponds and lakes.

Spirulina is a well-known source of valuable food supplements, such as proteins, vitamins, amino acids, minerals, fatty acids, etc. It is widely used in human and animal nutrition, as well as in the cosmetic industry.

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Fig. 1: Spirulina plantesis powder

Both in vivo and in vitro trials have shown effective and promising results in the treatment of certain cancers and allergies, anemia, hepatotoxicity, viral infection, vascular diseases, radiation protection, and obesity. The antioxidant activities of Spirulina were demonstrated in a large number of preclinical studies. Antioxidant drugs and foods are used in prevention of many human diseases. Findings of this study showed Spirulina can be used a source of antioxidants.

Spirulina platensis has been proven to boost the immune system, bolster the energy and reduce the risk of many cancers and infection. The nutritional quantity of the Blue-green algae Spirulina platensis has been evaluated on the basis of its chemical and amino acid composition and feeding trails with rats. Due to high content of highly valuable proteins, indispensable amino acids, vitamins, beta carotene and other pigments, mineral substances, indispensable fatty acids and polysaccharides, Spirulina platensis has been found suitable for use as bioactive additives. Numerous strains of Spirulina platensis are easily cultured and harvested and are rich in carotenoids and other valuable products. Chemical analyses of microalgae indicate that it is the excellent source of macro and micronutrients. Biological properties of Spirulina platensis include Anticancer, Antimicrobial, Antioxidant and immuno-stimulant effects. [1,2]

1.1. General characteristics

Spirulina platensis is symbiotic, multicellular and filamentous blue green microalgae with symbiotic bacteria which fix the nitrogen from air. The shape of Spirulina platensis can be like rod or disk. The main morphological feature of Spirulina platensis genes would be the arrangement of the multicellular cylindrical trichome. The photosynthetic pigment of Spirulina platensis is phycocyanin, its color is blue. This type of bacteria contains chlorophyll a and carotenoids. Some of the bacteria contain pigments like phycothrin which bacteria red and pink colour. Spirulina platensis are photosynthetic, so therefore it is autotrophic in nature. The reproduction of Spirulina platensis is due to binary fission. Spirulina platensis have a crew like trichome which have generally closed, uniform, and narrow diameter from 0.5-3um. Cells with cross walls are visible under light microscope, without gas vacuoles and with prominent granules. The trichomes have a length of 50 to 500um and its width is up to 4um. Gram negative bacteria have similar cell wall to cyanobacteria which contain peptidoglycan, lysozyme sensitive heteropolymer. Environmental factors those affect the helix geometry are temperature, physical and chemical condition. One of the drastic alteration is the geometry is the reversible transition from helix to spiral shape while transferring the filaments from liquid to solid media.

1.2. Natural habitat and source

After Lake Texcoco, the largest Spirulina platensis lakes are in central Africa and also in east Africa. The stable monoculture of Spirulina platensis found in Lake Chad. Spirulina platensis survive in alkaline lakes where it is most difficult or impossible for the other microorganisms to survive. In lakes, the supply of nutrients is limited to regulate the growth cycle. Spirulina platensis dies off when nutrients are exhausted. Spirulina platensis is found in lakes, soil, marshes, seawater, brackish water etc. Alkaline saline water is favorable for the good production of Spirulina platensis. Spirulina platensis cannot grow in dark on media which contain organic carbon compounds and reduce carbon dioxide in light. The main product of Spirulina platensis photosynthesis is glycogen. [3,4]

1.3. Environmental factors influencing growth of spirulina platensis

Spirulina platensis plants for the mass cultivation are done in the suitable environmental conditions. But it is difficult to have a proper ideal growth of the Spirulina platensis due to different environmental factors like temperature, pH, light, salinity, nutrients etc.

1.4. Temperature

Temperature in the range of 30-35C is well suited for the maximum growth of Spirulina platensis. Temperature above than 35C leads to the bleaching of the culture. Rafiqul Islam reported that, the maximum growth rate of Spirulina platensis which was 0.141 was found at 32C and 0.144 was found at 37C for Spirulina platensis fusiformis. Maximum production of biomass of 2.4g and chlorophyll a production of 16.6mg were observed at 32C for Spirulina platensis.

1.5. PH

PH is the important environmental factor which influences the Spirulina platensis cultivation for most. PH determines directly or indirectly the solubility of mineral and carbon source in the culture. Spirulina platensis well suited growing pH value ranges between 9-11. During the mass cultivation of the medium of Spirulina platensis was shifted from 8.4 to 9.5 due to the composition of bicarbonate and sodium ions.

1.6. Light

During the growth phase of Spirulina platensis light intensities required. The optimum light intensity was between 20 and 30K lux. The light was provided to the culture for 10 hours at 2K LUX intensity by using lamp or fluorescent bulb. Yellow, white, red and green light yield less protein content than the blue light.

1.7. Water quality

The quality of water plays an important role in the algal mass production of Spirulina platensis. It had two influences, firstly by affecting the solubility of nutrients added in the medium and secondly by the accumulation of certain heavy metals by algae during the growth phase of Spirulina platensis.

1.8. Nutrient medium

Spirulina platensis required high amount of nutrients and salt concentration. Because of this salt concentration Spirulina platensis naturally grows in the salt lakes Spirulina platensis required a medium of high alkalinity and continuous supply of bicarbonate ions.

1.9. Inoculum size

According to the report of Fatma, that the synchronous growth of Spirulina platensis was failed to grow both in liquid and solid media. It was also observed that minimum population of cell is necessary to initiate and sustain Spirulina platensis culture.

1.10. Agitation

The advantages of uniform distribution of carbon dioxide and prevention of thermal stratification due to the agitation of algal culture. So many devices of agitation had been introduced which range from motor driven paddles, pumps, and gravity flow and air light systems. The aeration to Spirulina platensis is achieved by rotators and also provides agitation to growing cells and maintained these cells in suspension and it is very necessary for the better yield of Spirulina platensis species.

1.11. Contamination

According to the report of Venkatraman and Sindhukanya, about the insect contamination in Spirulina platensis culture. The larvae of mosquito fed on the algal biomass for 2-3 days before entering into purple stage and the decrease in biomass yield was up to 10 percent. By using fine wire mesh removed all extraneous material. The forms of bacterial and pathogenic occurred in the culture were identified as aerobic spore formers.[5,6]

1.12. Morphology and taxonomy

Belongs to Phylum: Cyanophyta, Family: Oscillatoriaceae (Ciferri and Tiboni, 1985). A ubiquitous organism, found in brackish water, sand, marshes, soil, seawater and fresh water. Under the microscope appeared as cylindrical in shape with helicoidal trichomes which are branched also bearing motile filaments gliding along the axis and absence of heterocyst has been noticed (Ciferri, 1983). The genus has the helical shaped trichome as its special characteristic.

Table 1: Taxonomic position of spirulina platensis (spirulina)

Class	Myxophyceae
Order	Hormogonalas
Family	Oscillatoriaceae
Genus	Spirulina platensis

1.13. Review of literature

A long been dietary supplement for people living near to the alkaline lakes region spirulina a multicellular, blue green filamentous algae has gained the popularity in dietary industry and act as a protein and vitamin supplement to humans and aquaculture life. It is very easy to grow and is very easily harvested and processed having high content of micro and macro nutrients. Among all the algae spirulina has a great importance as it is considered to be the superfood due to its high protein content and other valuable vitamins present in it and also pigments like phycocyanin which has many important aspects. Spirulina were one of the ancient species existing from 3 billion years in these earth they are best situated in nature, mostly found in alkali, mineral rich lakes and water bodies that are not contaminated with pollution.

1.14. Phytonutrients

Table 2: Amount of pigments in one gramspirulina powder taxonomic position of spirulina platensis (spirulina)

Sr. No.	Pigment	Quantity
1	Beta-carotene	6.8mg
2	Zeaxanthine	9mg
3	Chlorophyll	30mg
4	Total carotenoids	15mg
5	C-phycocyanine	240mg
6	Total phycocyanins	519mg
7	Superoxide dusmutase	1080 units

1.15. Active compounds of spirulina platensis (spirulina)

The composition of the content in Spirulina species varies from each other due to factors like climate, nutritional factor

and culture environment in the similar way the composition of the commercial product differs due to the processing and harvesting mechanism.

Table 3: Compound composition of spirulina spp. in percentage (%)

Biochemical constituents	Content (%)
Protein	55-69
Lipids	05-07
Carbohydrate	07-15
Minerals	06-09
Moisture content	2.5-06

Table 4: Phytopigments content in spirulina spp. (mg/100g)

Constituent	Content
Beta Carotene	150-250
Chlorophyll	1300-1700
Phycocyanin	15000-19000
Zeaxanthin	125-200
Xanthophylls	250-470
Total Carotenoids	400–650

Table 5: Vitamin content of spirulina spp. (per 100g)

Vitamin	Content
Thiamine (Vit.B1)	0.5mg
Riboflavin (Vit.B2)	4.53mg
Niacin (Vit.B3)	14.9mg
Pyridoxine (Vit.B6)	1mg
Cobalamin (Vit.B12)	162mcg
Folate (Vit.B9)	0.5-3mg
Inositol (Vit.B8)	70-90mg
Vitamin K	1090mg

1.16. Chlorophyll

Chlorophyll is an essential compound in many everyday products. It is used not only as an additive in pharmaceutical and cosmetic products but also as a natural food coloring agent.

Additionally, it has antioxidant and antimutagenic properties.

1.17. Carotenoids

Spirulina extracts containing carotenes and various carotenoids are frequently used as natural colouring materials. Carotenoids are vitally important antioxidants. Numerous studies have indicated that people whose diets contain a lot of foods rich in carotenoids lower their risk of developing various types of cancer. They possess antioxidant activity, especially in the presence of light. Carotenoids also have important metabolic functions in animals and man, including conversion to Vit A, enhancement of the immune response and protection against diseases such as cancer by way of scavenging free radicals, β-carotene, as a major carotenoid of Spirulina is a potential antioxidant having anti-carcinogenic and radio-protective effects. Spirulina contains up to 2,000 U/g dry weight of β-carotene. Eating foods rich in antioxidants such as carotenoids, phycocyanin, superoxide dismutase and vitamins C and E is another great way to help prevent cancer.

1.18. Chemical constituents

1.18.1. Phycocyanin

Phycocyanin is a water soluble blue pigment that gives Spirulina its bluish tint. It is found in blue green algae like Spirulina. Phycocyanin is a powerful water soluble antioxidant, scientists in Spain showed that an extract of Spirulina containing phycocyanin is a potent free radical scavenger and inhibits microsomal lipid peroxidation. Phycocyanin in Spirulina that is though to help protect against renal failure caused by certain drug therapies. Phycocyanin has also shown promise in treating cancer in animals and stimulating the immune system.

Phycocyanin is one of the key ingredients that make Spirulina such a wonderful Super food, and a vital difference between Spirulina and other green foods like chlorella, wheat grass and barley. The Japanese have found that phycocyanin protects the liver and the kidneys during detoxification, as well as activating the immune system. Researchers at the Osaka Medical Center for cancer and Cardiovascular Diseases said ‗Spirulina is surmised to potentiate the immune system leading to suppression of cancer development and viral infection. Spirulina selectively inhibited development of some tumoral cell lines, showing potential anticancer activity against human stomach cancer cells (AGS), human liver cancer cells (Hep3B), human lung cancer cells (A549), and breast cancer cells (MCF-7). Phycocyanin is a powerful water soluble antioxidant. A great deal of research has been done in Japan on phycocyanin. The Japanese have found that phycocyanin protects the liver and the kidneys during detoxification, as well as activating the immune system. Researchers at the Osaka Medical Center for Cancer and Cardiovascular Diseases said ‗Spirulina is surmised to potentiate the immune system leading to suppression of cancer development and viral infection. C-phycocyanin (C-PC) is one of the major Bili proteins of Spirulina with antioxidant and radical scavenging properties.

1.19. Physical and chemical properties of phycocyanins

Phycobiliproteins are a small group of highly conserved chromoproteins that constitute the phycobilisome, a macromolecular protein complex whose main function is to

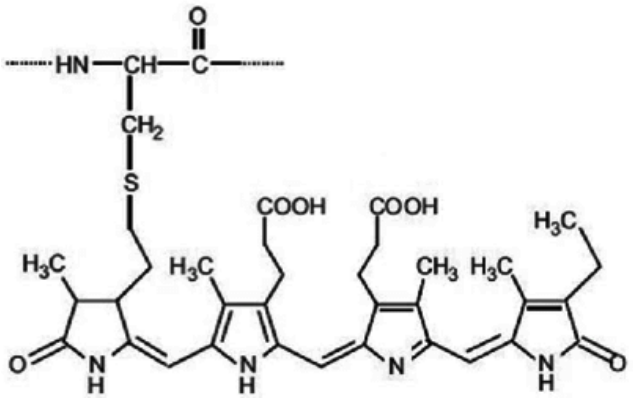

Fig. 2: Structure of phycocyanin

serve as a light harvesting complex for the photosynthetic apparatus of cyanobacteria and eukaryotic groups. The most common classes of phycobiliproteins are allophycocyanin, phycocyanin and phycoerythrin all of which are formed by a and b protein subunits and carry different isomeric linear tetrapyrrole prosthetic groups (bilinchromophore) which differ in the arrangement of their double bonds.

Phycocyanin is composed of two dissimilar a and b protein subunits of 17 000 and 19 500 Da, respectively, with one bilinchromophore attached to the a subunit (a 84) and two to the b subunit (b 84, b. Pc exists as a complex interacting mixture of trimer, hexamer and decamer aggregates. When the secondary, tertiary and quaternary structures of the protein are denatured, the visible absorption band as well as the fluorescence will drop in intensity. The chemical structure of the bilinchromophores in Pc is very similar to bilirubin, a heme degradative product. Bilirubin is considered to be a physiologically important antioxidant against reactive species. The mass culture of spirulina platensis (nordstedt) geiteler in kitchen wastewater and fermented solution of oil-extracted soybean.

1.20. Biochemical composition of spirulina platensis

The basic biochemical composition of Spirulina platensis can be summarized as below:

1.21. Proteins

Spirulina plantensis contain high amount of protein between 55-70% by the dry weight. Protein contains all the essential amino acids which are very useful for the better yield of the biomass from Spirulina platensis.

1.22. Essential fatty acids

Spirulina platensis has a high amount of polyunsaturated fatty acids 1.5-2.0% of 5-6% total lipid. Spirulina platensis is rich in linolenic acid, stearidonic acid, eicosapentaenoic acid and arachidonic acid

1.22.1. Vitamins

Spirulina platensis contains vitamin B1, B2, B3, B6, B12, Vitamin C, Vitamin D and Vitamin E.

1.22.2. Minerals

Spirulina platensis is a rich source of potassium, calcium, chromium, copper, iron, magnesium, manganese, phosphorus, sodium and zinc.[7]

1.23. Value added substances in spirulina

The microalgae Spirulina has been cultivated for many purposes as it is an effective source of many valuable biochemical and a major source of protein. The biochemical substances which are found in spirulina are polysaccharides, linoleic acid, beta carotene, phycobiliproteins and chlorophyll. These biochemical are commonly used in many food and cosmetic industries, also used in pharmaceutical industries for medicinal purpose. Among the biochemical compounds GLA have the potential to fight with hypocholesterolmic, pre-menstrual problems and atopic eczema they are also found in many plants and fungi but the concentration level is low as compared to Spirulina species (Cohen et al., 1993). Bio fuel plays vital role in replacing the non-renewable fuel sources, Spirulina species due to their fast growing availability in few requirements produce large amount lipids and carbohydrates which were processed as biofuel and other valuable co-products (Brennan and Owende. et al., 2010). Moreover study conducted by Dartsch PC, 2008 revealed the antioxidant and anti-inflammatory property of these species which are far better than any plant.

1.24. Spirulina platensis as a single cell protein

The increasing population in the world increases the demand of necessary food sources among the people. In particular, protein supply generates a problem since essential amino acids cannot be replaced. The deficiency of protein increasing in the world becomes a major problem for mankind. So many efforts have been made to produce new, alternate and unconventional protein. In the year 1996, Bacteria, yeast, fungi and algae. In particular, the microalgae Spirulina platensis contains about 60 to 70% of protein. Spirulina platensis was cultured near Lake Chad in Africa. After drying use it as food Supplement. Spirulina platensis is most widely used algae, during space travel astronauts take it to space also as supplement. Spirulina platensis should be encouraged in patients suffering from malnutrition, immune suppression and hepatic.ae were used to produce protein biomass which is known as Single Cell Protein. In 1966, Single Cell Protein was invented by Carol L. Wilson. Single Cell Protein is used as a protein supplement in human food and animal feeds. Single Cell Protein is the dried cells of microorganisms like yeast,

algae, bacteria and fungi. As a source of single cell protein, Cyanobacteria have certain advantages over microorganism because of its quality, quantity and rapid growth.

As per the survey conducted by Spirulina. Company, Spirulina platensis is now available in the form of tablets or powder. In 1970, at which Spirulina platensis was launched in the market, the market for food supplements was not well organized. In 1981, the marketing of Spirulina platensis as the supplement was started. The consumption of Spirulina platensis was increased due to the front page article which was publish in a US daily newspaper, that the -Spirulina platensis as a hunger reducer for people on a diet. Media took up the subject and demand of Spirulina platensis exploded in the USA. Hundered and thousands of companies entered the market to offer their Spirulina platensis. Now today, companies produce high quality Spirulina platensis and at the same time, they are developing products with higher added value. The main producer of Spirulina platensis is located in Asia and the USA. The companies produce around 350 tons of Spirulina platensis per year. Market value: As per the survey conducted by Spirulina. Company, the annual production of Spirulina platensis is 5000 tons. It is difficult to determine the exact production because of the many relatively small producers in Asia, but the capacity exists to expand production of Spirulina platensis to meet any growing market demand. Now, the market price of Spirulina platensis is around Rs 1200-1500 for 1kg.

1.25. Why it is important?

This emerged as a wonder drug due to its diverse concentration of nutrients and its varied uses which increases the resistant factor to numerous infection in other words we can say that it boost the immunity. Moreover it is well known for its antioxidant and anticancer action. Also in diseases like diabetes, hypertension, anemia and others it plays an important role due to its multi beneficiary action it is an important natural product which also content the potential ability for production of biofuels because of high content of lipids and fatty acids.

1.26. Importance of spirulina towards health

Spirulina got its benefits that can't be achieved by any other organism in the present scenario it has many importance starting from the food to medicine. Due to his therapeutic values it is being used as dietary nutritional supplement and shows anti-inflammatory effect by inhibiting cytokine formation (CM et al., 2009). It also shows anti-arthritic effect by reducing betaglucuronidase, histopathological and ultra-structural studies revealed these property, also shows the antioxidant side of the microalgae (Remirez D. et al., 2002). Due to its high content in proteins, amino acids, vitamins, carotenes and other compounds it is used as bioactive additive that help in increasing the immunity level by stimulating the production of antibodies and cytokines (Blinkova LP. et al., 2001). Other than these studies Spirulina has many health benefits like,

1. Helps in weight loss of the body
2. It has counter- mechanism for the toxins present in the body
3. It helps in purification of liver
4. Helps in lowering down the blood cholesterol level
5. Help to against the viral infections
6. Used in the treatment of radiation sickness
7. Has the ability to generate new blood cells

1.27. Nutritional values

Arthrospira (Spirulina) is among the richest source of proteins. Its protein content is about 60–70%. In a study that attempted using Spirulina as a protein supplement, it was observed that it can replace up to 40% of protein content in tilapia diets. Rabelo have explained the development of cassava doughnuts enriched with S. platensis biomass. Unlike many other cyanobacteria that have proven toxicity, no such property has been attributed to Spirulina. While testing for mutagenicity, acute, sub chronic, and chronic toxicities and teratogenicity in animal experimentations, Chamorro have shown that spirulina did not exhibit any potential for organ or system toxicity even though the doses given were elevated above those for expected human consumption. Rather, Spirulina was shown to protect fish from sub lethal levels of some chemicals. Likewise, dietary supplementation of Spirulina has helped in alleviating the incidence of anaemia experienced during pregnancy and lactation. In the study conducted by Kapoor and Mehta, dietary supplementation of S. platensis was found to increase the iron storage of rats, better than achieved from the combination of casein and wheat gluten diets, during the first half of pregnancy and lactation. A review that treats the influence of different compounds from spirulina on the immune system has been written.

1.28. Medicinal uses of spirulina platensis

Studies have shown that Spirulina consumption during 4 weeks reduces serum cholesterol levels in human beings by 4.5% and significantly reduces body weight. Spirulina extract induces the tumor necrosis factor in macrophages, suggesting a possible tumor destruction mechanism (Shklar and Schwartz, 1988). An extract of sulfated polysaccharides, called Calcium-Spirulina (Ca-SP), made up of rhamnose, ribose, mannose, fructose, galactose, xylose, glucose, glucuronic acid, galacturonic acid, and HIV, calcium sulfate, obtained from Spirulina, showed activity against Herpes Simplex Virus, Human Cytomegalovirus, Influenza A Virus, Mumps Virus and Measles Virus. Cell extract of Spirulina maxima has

shown antimicrobial activity against Bacillus subtilis, Streptococcus aureus, Saccharomyces cerevisiae, and Candida albicans. Spirulina reduces: hepatic damage due to drug abuse and heavy metal exposure, inflammatory response, cells degeneration, anaphylactic reaction. Spirulina contains vitamin A, important in preventing eye diseases; iron and vitamin B12, useful in treating hypoferricanemia and pernicious anemia, respectively; γ-linolenic acid, appropriate in treatment of atopic child eczema therapy; to alleviate premenstrual syndrome, and in immune system stimulation. Spirulina has been studied as an animal cellgrowth stimulant and in the treatment of residual waters using alginate.

1.29. Therapeutic implications of spirulina and its ingredients in health malnutrition

Spirulina platensis gives a few huge and amazing medical advantages to malnourished kids, particularly the individuals who are under five years of age. The protein constituents of Arthrospira platensis and its Vitamin-B complex give a significant nourishing advancement in grown-ups and youngsters' eating regimen, since it supplies the attractive characteristics of beta carotene that can defeat eye issue or eye sicknesses brought about by inadequacy of nutrient An and propose to dietary prerequisite of β carotene which can help or counteract the eye infections of kids. It is the main nourishment source fusing huge measures of fundamental amino acids, gamma-linoleic-corrosive (GLA) and basic unsaturated fats, which helps to decide the whole hormonal framework. Spirulina platensis assumes an incredible job in treating individuals who are experienced kwashiorkor. Kwashiorkor is the ailment brought about by a protein lacking eating routine in newborn children and youngsters. Spirulina protein is significantly more proficient and successful than some other protein sources like drain and milk powder. These Spirulina benefits considered as solid nourishment and diet with high dietary and therapeutic worth.

1.30. Antidiabetic activity

Water dissolvable division of Spirulina was found reasonable in bringing down the serum glucose level at fasting while the water covered glucose level at glucose stacking. In a human clinical study with 15 diabetics, a huge diminishing in the fasting glucose level of patients was seen following 21 days of 2 g/day Spirulina supplementation.[8] Cholesterol bringing down impacts and consequences for diabetes, cardiovascular malady, and stays most significant hazard factors by supplemented with the 4.2 g on day 1 of Spirulina to 15 male volunteers and what's more, in spite of the fact that there was no huge increment in high-thickness lipoprotein (HDL) levels, they watched a huge decrease of high-thickness lipoprotein (LDL) cholesterol following two months of treatment. The atherogenic impact additionally declined essentially in the above gathering demonstrating Spirulina to be up and-comer liable for this impact. In a later report regulated Spirulina supplements in ischemic coronary illness patients and discovered a huge decrease in blood cholesterol, triglycerides what's more, LDL cholesterol and an expansion in HDL cholesterol. In a clinical report, found a noteworthy decrease in LDL: HDL proportion in 15 diabetic patients who were given Spirulina. Be that as it may, this examination was little and better investigations are required before Spirulina can be suggested in diabetes.

1.31. Anticancer activity

Strong evidences have shown that S. platensis is also imbued with antitumor and anticancer functions. In this regard, it was discovered that significant to full tumour regression was obtained with intravenous injection of Radachlorin, a new chlorine photosensitizer that was derived from S. platensis. It was shown that hot-water extract of S. platensis facilitated enhanced antitumor activity of natural killer (NK) cells in rats. Recently, complex polysaccharides from Spirulina have brought about suppression of glioma cell growth by down regulating angiogenesis via partial regulation of interleukin-17 production. High production of tumour necrosis factor-(TNF) in macrophages, was recorded in the presence of acidic polysaccharides from A. platensis. Li et al have shown that with increased phycocyanin concentration, expression of CD59 proteins in HeLa cells was promoted while Fas protein that induces apoptosis was increased with an attendant decline in the multiplication of HeLa cells. These findings are an evidence for the multidimensional applications of phycocyanin content of S. platensis.

1.32. Antioxidant activity

Cancer is now a major cause of mortality throughout the World. In the developed world, it is generally exceeded only by cardiovascular disease but developing countries are responsible for the globally increasing trend. Over 10 million new cases and over 7 million deaths from cancer occurred worldwide in 2000. The contribution of developing countries was 53% for incidence and 56% for deaths. From 1990 to 2000, the incidence and deaths increased by 2.4% per annum by 2020, it is predicted that these diseases will be causing seven out of every 10 deaths in developing countries. static of cancer incidence and deaths in 2012. Based on high costs cancer treatment strategies, in recent years antioxidants therapy has been developed to prevent cancer. Studies showed that free radicals can lead to degenerative disease like cancer, aging, age related macular degeneration etc. Cost of cancer care by phase of care, in 2010. Antioxidants help to protect the body against free radicals; these are substances that neutralize free radicals or

their actions. Antioxidants include carotenoids, flavonoids and related polyphenols, α-lipoic acid, glutathione etc. The main source of antioxidants for the body is vegetables and fruits. Unavailable of fruit and vegetables in many aria of world, scientists rethought to provide antioxidants from other sources. at middle 1980's, great efforts and extensive investigations have been turned to the development of nutraceuticals or functional food for preventing or managing various diseases.

The reports on antioxidants employed for food lipids were about using natural sources; in 1852, Wright reported that elm bark was effective in preserving butterfat and lard. Spirulina was initially classified in the plant kingdom because of its richness in plant pigments as well as its ability of photosynthesis. It was later placed in the bacteria kingdom based on new understanding on its genetics, physiology and biochemical properties. Spirulina naturally grows in high-salt alkaline water reservoirs in subtropical and tropical areas including America, Mexico, Asian and Central Africa. The nutritional value of Spirulina is well recognized with its unusual high protein content (60–70% by dry weight) and its richness in vitamins, minerals, essential fatty acids and other nutrients. Recent studies suggest that Spirulina, a unicellular blue-green algae may have a variety of health benefits and therapeutic properties and is also capable of acting as an antioxidant and anti-inflammatory agent. Spirulina is also used for health food, feed and for the biochemical products since 1980s. In fact, Spirulina is the most concentrated and nutritious whole food known to science, Cardiovascular Activity The cardiovascular benefits of Spirulina use are described in many papers. A review published in 2009 noted several reports suggesting that Spirulina (Arthrospira) may have a beneficial effect in the prevention of cardiovascular diseases. Decreases in blood pressure and plasma lipid concentrations, especially triacyl-glycerols and low density lipoprotein cholesterol have been demonstrated as a result of oral consumption of Spirulina. Spirulina has also been shown to indirectly modify the total cholesterol and high density lipoprotein- cholesterol values (40). A recent human trial validates the above referenced review in an open sample of the population. Results showed that total cholesterol and tricyclic glycerols were significantly decreased in the Spirulina group, and HDL levels saw a significant increase, while both systolic and diastolic blood pressure decreased. Again Spirulina showed a hypolipidemic effect.

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1.33. Antiviral activity

Many compounds with antimicrobial activities have been isolated from different marine organisms, and a number of evidences are put forward for the antiviral activity of Spirulina. This antiviral activity, in a large part, is attributable to the richness of S. platensis in vital proteins, fatty acids, minerals, and other important constituents. Spirulina, calcium spirulan (Ca-SP), a novel sulfated polysaccharide that was isolated from hot water extract of S. platensis, has shown antiviral activities against different enveloped viruses such as Herpes simplex virus type-I, measles virus, HIV-I and influenza virus. This high sought for antiviral activity has been suggested to be due to the effect that chelation of calcium ions to sulfate groups has on molecular conformation. Both extracellular and intracellular spirulan-like molecules from the polysaccharide fractions of A. platensis displayed significant antiviral activities against wide range of viruses, including human cytomegalovirus and HIV-I. About 50% and 23% reductions in viral load were recorded for methanolic and aqueous extracts of S. platensis, respectively. Reduction in viral load was attributed to inhibition of HIV-I replication in human T cells, langerhans cells, and peripheral blood mononuclear cells (PBMCs), with up to 50% reduction accorded to PBMCs. Antiviral and immune stimulatory properties of S. platensis preparations were elicited through increased mobilization of macrophages, cytokine production, antibodies generation, accumulation of NK cells, and mobilization of B and T cells. A recent study on the antiviral activity of Spirulina has resulted in the isolation of CyanovirinN (CV-N), a novel cyanobacterial carbohydrate-binding protein that inhibits HIV-I and other enveloped viral particles. The kanenbu tribe of Chad and most people in Korea and Japan, who consume Spirulina diet daily, have been shown to display lower cases of HIV/AIDS than their surrounding neighbours who do not take such diet. Therefore, it is expected that consistent intake of diets containing Spirulina can help in reducing the prevalence of HIV/AIDS. Antiherpetic activities were noted for the crude extracts of s.fusiformis. While Hern´andez-Corona et al.have reported antiviral activity of S. maxima against HSV-2, Shalaby et al. reported similar activity for S.

platensis against HSV-I.

1.34. Antibacterial activity

Spirulina is not without antibacterial activity. In 3-weekold chicks injected with either Escherichia coli or Staphylococcus aureus suspensions, 0.1% Spirulina was found to enhance their bacterial clearance abilities, as shown by the improvement in the activities of different phagocytotic cells, including heterophils, thrombocytes, macrophages, and monocytes in the chickens. Microalgal cultures of A. platensis have displayed significant antibacterial activity against six Vibrio strains: Vibrio parahaemolyticus, Vibrio anguillarum, Vibrio splendidus, Vibrio scophthalmi, Vibrio alginolyticus, and vibriolentus. Antibacterial activity against Streptococcus pyogenes and/or S. aureus was proven for the phycobiliproteins isolated from A. fusiformis. Purified C-phycocyanin from S. platensis markedly inhibited the growth of some drug resistant bacteria: E. coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, and S. aureus. This shows the potentials of compounds isolated from these cyanobacterial species in the fight against drug resistance.

1.35. Dosage and preparation

There is not enough scientific data to provide a recommend dose of spirulina, various doses of spirulina have been used in research. For example, in several studies examining the benefits of spirulina for high cholesterol, doses of 1-8grams daily for four weeks to six months has been used. To learn about its effects on hypertension, one study administered a dose of 4.5grams of spirulina blue green algae daily for six weeks. Another study of type 2 diabetes patients administered a product containing 1gram of spirulina twice daily for two months.

The appropriate dose for patients may depend upon factors including your age, gender and medical history.

1.36. Possible side effects

Although few adverse effects are associated with the use of spirulina, consuming spirulina may cause headaches, allergic reactions, muscle pain, sweating, and insomnia in some cases. People with allergies to seafood, seaweed, and other sea vegetables should avoid spirulina. If you have a thyroid condition, an autoimmune disorder, gout, kidney stones, phenylketonuria, or are pregnant or nursing, spirulina may not be appropriate for you. You should check with your healthcare provider before taking it. It's possible that spirulina grown in the wild can absorb toxins from water, such as microcystins (known to cause severe liver damage), pollutants, and heavy metals. Most spirulina sold in the United States is grown in laboratories. As with all supplements, it's important to consult your healthcare provider before using spirulina to discuss whether it's appropriate for you and whether it can be consumed in combination with other medications and/or supplements you may be taking.

2. Conclusion

Popularity of natural products or their derivatives role in diseases cure and prevention is increasing worldwide due to less side effect properties. Spirulina and its ingredients have therapeutics implication and have been traditionally used worldwide especially in Indian Subcontinent since ancient time. Clinical based studies confirmed that spirulina plays pivotal role in prevention of various diseases. The role of active ingredients as chemopreventive effect has been noticed in various tumour via modulation of numerous cell signalling pathways. The detailed study should be made based on animal to know the exact mechanism of action in the diseases management.

Spirulina is a potent mixture of antioxidants and most of Spirulina's health benefits are associated with its antioxidant pigments. These are carotenoids (mixture of carotenes and xanthophyll's), chlorophyll and the unique blue pigment phycocyanin. A little of its usage in medicine has been established by numerous studies still more of its hidden properties are yet to be explored. Some of its properties such as Antioxidant, Anti-inflammatory, Anticancer, Ant aging (prevents cell death), Drug delivery system., etc. Along with these actions in Humans has been described briefly in this Review. Hope this review will serve the purpose of aiding in future Research work to unleash the further components present in Spirulina.

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4. Conflict of Interest

The author declares that there is no Conflict of interest.

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