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Spirulina -"As a complete food supplement"

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Abstract

Background: Multicellular and filamentous cyanobacteria, spirulina have gained significant traction in the food business, aquaculture, and health sectors. It grows and develops in water, and harvesting and processing it is simple. Antioxidants, proteins, lipids, vital amino acids, vitamins, minerals, and macro and micronutrients are all highly present. One comprehensive dietary supplement that can help combat hunger in underdeveloped nations is spirulina. Given its lengthy culinary history and the most recent scientific research, spirulina is considered safe for human ingestion. Spirulina has garnered a lot of interest recently from the scientific community and industry as a thriving source of medications and nutraceuticals.Scope and methodology: This paper's main goal is to examine how the food sector uses spirulina as a dietary supplement.

Spirulina species, also known as "blue-green microalgae," are filamentous, photosynthetic microorganisms. Spirulina is rich in nutrients. In addition to being high in many vitamins, minerals, and bioactive compounds, it has 60–70% protein that includes all of the essential amino acids. Antioxidants and vital fatty acids are also abundant in spirulina. Spirulina's high nutritional content offers it a number of health advantages, such as immunomodulatory, anti-inflammatory, antioxidant, and insulin-sensitizing qualities, as well as beneficial effects on a number of illnesses. The blue-green algae known as spirulina is rich in protein, vitamins, minerals, and antioxidants. It has long been considered a superfood. Spirulina was first consumed as a dietary supplement by the ancient Aztecs and was later used by NASA astronauts on space missions. Many of the possible advantages of spirulina are now supported by research, and scientists are still looking into how it might be used to treat medical issues. Spirulina is added to several protein bars, smoothies, and drinks and comes in powder, pill, and tablet form.

Keyword

Spirulina , health food, potential aplication

Introduction

In 1519, Spanish scientists Hernando Cortez and conquistadors made the initial discovery of spiralina. During his journey to Lake Texcoco in the Valley of Mexico, Cortez noticed that the Aztecs were eating spirulina at their tables. When Pierre Dangeard noticed that flamingos were living by eating blue-green algae, he realized that spirulina had health benefits. In order to benefit from the benefits of spirulina, individuals quickly began commercializing it when botanist Jean Leonard endorsed Dangeard's results (Ugwu, Aoyagi, & Uchiyama, 2008). The French established Sosa Texcoco, the first facility for processing spiralina, in 1969. In tropical and subtropical bodies of water with high concentrations of salts like carbonate and bicarbonate with alkaline, the planktonic photosynthetic cyanobacterium Spirulina creates massive populations. 9.5 pHAlgae are photosynthetic organisms that use the process of photosynthesis to transform solar light energy into chemical energy. Algae have a basic reproductive system. Algal biomass comprises a variety of chemicals with a wide range of structures and purposes. According to Becker (2007), algal biotechnology is separated into three categories: cyanobacteria, macroalgae, and microalgae. Microalgae can occasionally incorporate cyanobacteria as well. Prokaryotic and eukaryotic unicellular and multicellular microalgae are included in this classification. Prokaryotic microorganisms include cyanobacteria and microalgae. Spirulina is the oldest plant on Earth, having existed for over 3.6 billion years. It was the first photosynthesising organism to produce our oxygen atmosphere, which allowed all life to emerge. The evolutionary link between bacteria and green plants is made up of blue-green algae. SPIRULINA Blue green algae is a synonym. Spirulina, which comes from the species Spirulina platensis, Spirulina maxima, Spirulina fusiformis, or Arthrospim platernsis and is a biomass of Cyanobacteria (blue-green algae) that humans and animals may eat, is a member of the

Oscillatoriaceae family. Originally assigned to the genus Arthrospira, it was subsequently moved to the genus Spirulina. The dried biomass of A. platensis, a photosynthetic bacterium that is a member of the Cyanobacteria and Prochlorophyta families, is commonly referred to as spirulina. Africa, Asia, and South America are home to A. platensis, while Central America is home to A. maxima. The majority of cultivated spirulina is grown in open-channel raceway ponds where the water is stirred by paddle wheels. Spirulina grows best at temperatures about 30°C (86°F) with a pH of 8.5 and higher, which becomes increasingly alkaline. The United Nations established the Intergovernmental Institution for the use of Micro-algae Spirulina against Malnutrition in 2003. In 1974, the World Health Organization described spirulina as an interesting food or super food for multiple reasons, rich in iron and protein, and able to be administered to children without any risk. Both NASA and the European Space Agency suggested spirulina as one of the main foods to be grown on extended space missions in the late 1980s and early 1990s.

Components 5% water, 24% carbs, 8% fat, and roughly 60% (51–71%) protein make up dried spirulina. 290 calories are provided by 100 grams of spirulina, which is also a rich source (20 percent or more of the Daily Value, DV) of many important nutrients, especially protein, vitamins (thiamin and riboflavin, 207% and 306% DV, respectively), and dietary minerals, including iron (219 % DV) and manganese (90% DV).

The fatty acids gamma-linolenic acid, alpha-linolenic acid, linoleic acid, stearidonic acid, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and arachidonic acid are all present in spirulina's 8% by weight lipid composition. Because spirulina supplements mostly contain pseudo vitamin B12, which is physiologically inactive in humans, they are not regarded as a trustworthy source of vitamin B. Spirulina is not a dependable source of active vitamin D, according to the American Dietetic Association. Similarly, the medical literature suggests that spirulina is not a viable source of vitamin B12. Because it includes all of the essential amino acids, particularly leucine, valine, and isole-ucine (Babadzhanov et al. 2004), spirulina is a complete protein source (Hosseini et al. 2013). According to García et al. (2012), it has methionine, which is lacking in the majority of other microalgae. Arthrospira platensis has essential amino acids in the amounts that the Food and Agriculture Organization of the United Nations (FAO) recommends (Becker 2007). These amino acids are of higher quality than vegetable proteins (Ahsan et al. 2008) and can be compared to protein standards like those of meat, eggs, or milk. According to Benehaila et al. (2015), phycobiliproteins, which are thought to be the main protein constituents with large positive health effects, are also present in spirulina in addition to regular protein. Phycoerythrin, allophycocyanin, and phycocyanin are the three categories into which the microalgal phycobiliproteins are divided (Lupatini et al. 2017). One of the main proteins found in spirulina, phycocyanin makes up to 20% of the dry weight of microalgae (Khan et al. 2005) and is frequently utilized as a natural pigment in the food and cosmetics industries. Additionally, it is recognized to have antioxidant and anti-inflammatory qualities (Deng and Chow 2010). The classification of cyanobacteria is based on their capacity to produce phycocyanin, a blue pigment known as a phycobilin. The bluish hue of these organisms led to their designation as "blue-green algae," which is due to the blue phycobilin pigment they contain.

Spirulina plantensis

Brief Biological Classification of Spirulina platensis:

Kingdom : Eubacteria

Subkingdom : Negibacteria

Phylum : Cyanobacteria

Class : Cyanophyceae

Subclass : Oscillatoriophycidae

Order : Spirulinales

Family : Spirulinaceae

Genus : Spirulina

Species : Spirulina platensis

Source: Algae Base, last accessed: 17th April, 2019

The common Spirulina species, Arthrospira and Spirulina, are members of the same order, Oscillatoriales, which includes all filamentous, non-heterocystous cyanobacteria that reproduce in plane by binary fusion without producing alkinetes. What sets Arthrospira and Spirulina apart from oscillatoriaceean genera is their helical trichome shape. Arthrospira's life cycle is representative of the Oscillatoriales' conventional and straightforward life cycle. The formation of specialized cells known as necridia, which are the ones that experience cell lysis, is typically the cause of the trichome's apex breaking. The information on Arthrospira platensis above is based on reports from Castenholz and Cifferi from the early and late 1980s, respectively.

Isolation and occurrence of spirulina

Naturally occurring in tropical areas, Spirulina platensis lives in alkaline lakes (pH 11) with high bicarbonate and NaCl concentrations. Microalgae can be grown in open reactors due to these restrictions on other microorganisms [5]. Carotenoids, phycobiliproteins, and chlorophyll-a are among the pigments that cyanobacteria use to harvest light. According to their structure, the latter are proteins with linear tetrapyrrole prosthetic groups known as allophycocyanin, phycocyanin, and phycoerythrin [6]. Lakes, ponds, and tanks are examples of aquatic environments where spirulina is frequently found. Being able to directly convert light for intricate metabolic processes, it is among the earliest photosynthetic organisms found in nature. Tribes in the region of Chad Lake, Africa, have long eaten spiralina as food. Spirulina platensis is the most common phytoplankton species in the lake. In Mexico, the algae known as "Tecuitlatl" was consumed [7]. The pH range of 9 to 11 is ideal for spirulina growth, and there is less danger of other microorganism contamination.

According to research by Orio Ciferri [8], Spirulina is a common organism. Numerous habitats, including soil, sand, marshes, brackish water, sea water, and fresh water, have been home to Spirulina species since Turpin isolated them for the first time in 1827 from a freshwater stream. For example, species of Spirulina have been separated from fish ponds, thermal springs, salt pans, warm water from power plants, and tropical oceans to the North Sea. As a result, the organism seems to be able to adapt to a wide variety of habitats and colonizes areas where it is extremely difficult, if not impossible, for other microorganisms to survive. Examples of this include the populations of Spirulina maxima in Lake Texcoco in Mexico and alkalophylic Spirulina platensis in some alkaline lakes in Africa. In some of these lakes spirulina grows as a quasimonoculture.

PHYCOCYANIN:-

The blue pigment that gives spirulina its bluish hue is called phycocyanin, and it dissolves in water. Spirulina and other blue-green algae contain it. Researchers in Spain demonstrated that phycocyanin, a strong water-soluble antioxidant, is a strong free radical scavenger and prevents microsomal lipid peroxidation in a Spirulina extract [19]. Spirulina contains phycocyanin, which may help prevent renal failure brought on by specific medication treatments. Additionally, phycocyanin has demonstrated potential in immune system stimulation and cancer treatment in animals [20]. A hot water extract of phycocyanin-rich spirulina enhanced interferon production and NK cytotoxicity (cancer killing), according to a human clinical investigation.

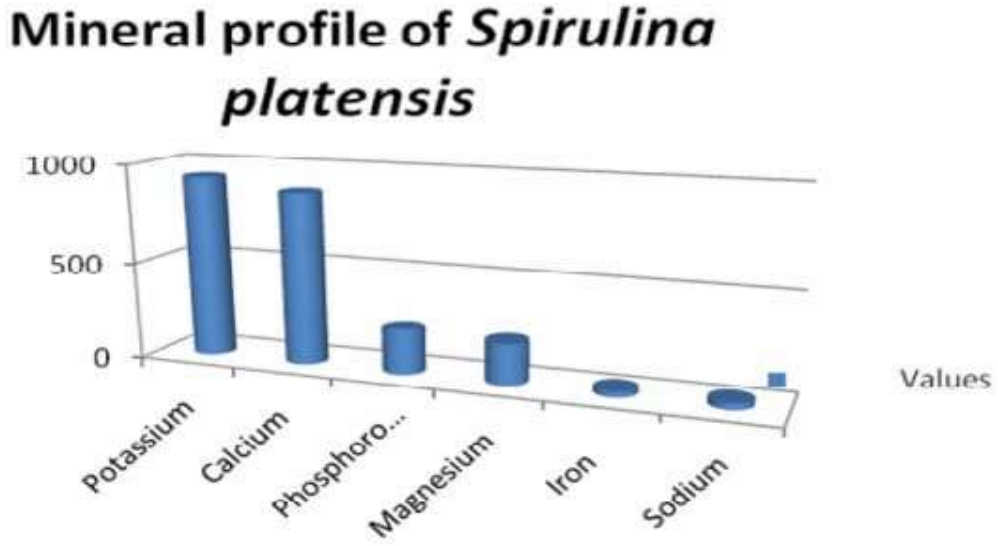
Physical and chemical properties of phycocyanin:--

The phycobilisome, a macromolecular protein complex whose primary role is to operate as a light harvesting complex for the photosynthetic apparatus of cyanobacteria and eukaryotic groups, is made up of a small group of extremely conserved chromoproteins known as phycobiliproteins. Allophycocyanin, phycocyanin, and phycoerythrin are the most prevalent types of phycobiliproteins. They are all made up of a and b protein subunits and contain distinct isomeric linear tetrapyrrole prosthetic groups (bilin chromophores) with varying double bond arrangements.

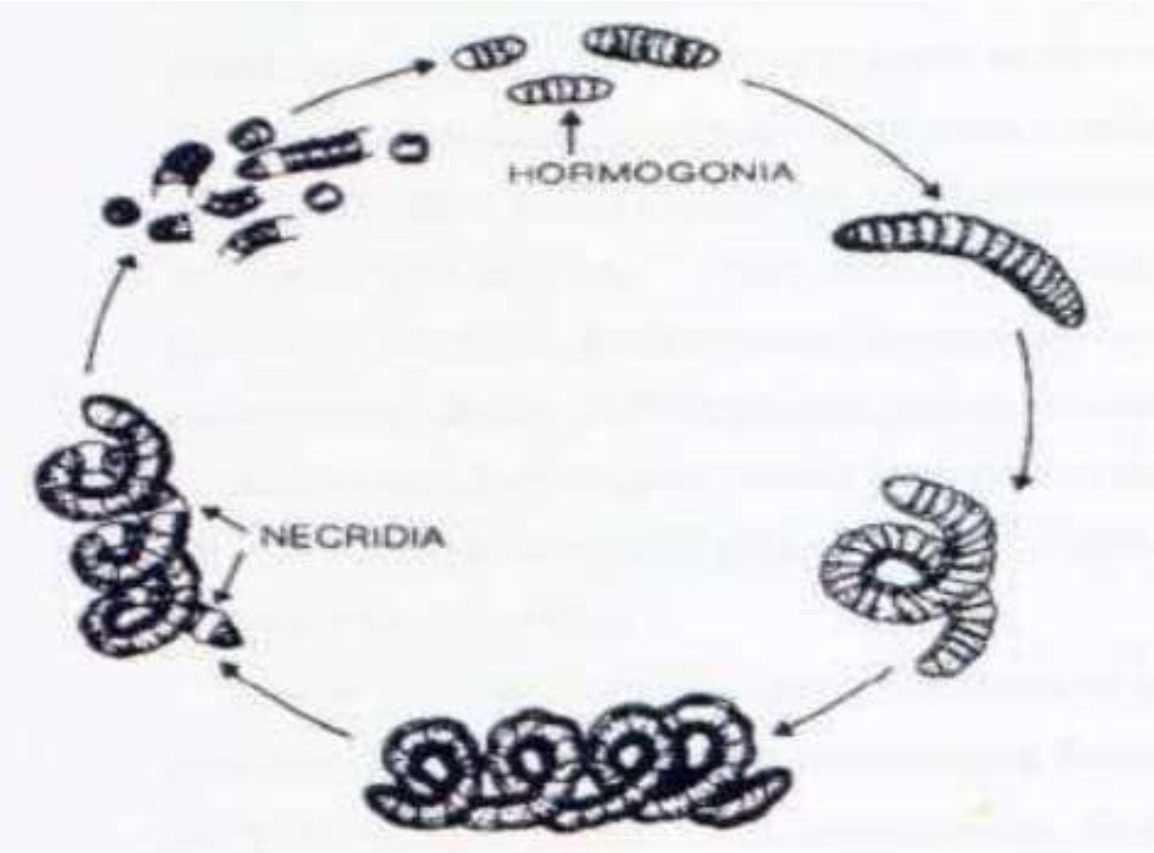
Two distinct protein subunits, a and b, each weighing 17,000 and 19,500 Da, make up phycocyanin. The a subunit, an 84, has one bilin chromophore, while the b subunit has two (b 84, b 155). PC is a complicated mixture of hexamer, decamer, and trimer aggregates that interact with one another. Both the visible absorption band and the fluorescence will decrease in intensity when the protein's secondary, tertiary, and quaternary structures are denatured. The bilin chromophores in PC share a chemical structure with the heme-degradative product bilirubin. It is believed that bilirubin is a physiologically significant antioxidant that protects against reactive species [22].

Average nutritional analysis of *Spirulina* per 100 g (Roberto, 2015).

Components	Nutritional Value (in mgs)
Plant Protein	63000
Carbohydrates	22000
Fat	2200
Minerals	8000
Dietary Fibre	7000
Vitamin A	212
Chlorophyll	600
Vitamin E	10
Vitamin B1	3.5
Vitamin B2	0.4
Vitamin B3	1.3
Vitamin B5	0.2
Vitamin B6	6



Components	Nutritional Value (in mgs)
Calcium	1000
Phosphorus	800
Magnesium	400
Iron	58
Zinc	3
Copper	1.2
Manganese	0.5
Chromium	0.03
Potassium	1.4
Gamma-linoleic acid	1
Vitamin B8	0.005
Vitamin B9	0.05
Vitamin B12	0.35



Reproductive cycle of spirullina

Uses of spirulina:-

*As a complete dietary supplement.

Protein:--

Depending on the source, spirulina has an exceptionally high protein content of 55–70% by dry weight (Phang et al., 2000). Although it has lower levels of methionine, cystine, and lysine than standard proteins like those from meat, eggs, or milk, it is still a complete protein with all the essential amino acids; it is also better than all typical plant proteins like those from legumes. Polyunsaturated fatty acids (PUFAs), which make up 1.5–2.0 percent of 5–6% of total lipid, are abundant in spirulina. Eicosapentaenoic acid, stearidonic acid (SDA), linoleic acid (LA, 36 percent of total PUFAs), and γ-linolenic acid (ALA) and arachidonic acid (AA) are all abundant in spirulina.

Vitamins:--

Thiamine, riboflavin, nicotinamide, pyridoxine, folic acid, cyanocobalamin, vitamin B12, vitamin C, vitamin D, and vitamin E are all found in spirulina.

Minerals:--

In addition to calcium, chromium, copper, iron, magnesium, manganese, phosphorus, selenium, sodium, and zinc, spirulina is a rich source of potassium.

Photosynthetic pigments:--

Chlorophyll a, xanthophyll, beta-carotene, echinenone, myxoxanthophyll, zeaxanthin, canthaxanthin, diatoxanthin, 3-hydroxyechinenone, beta-cryptoxanthin, oscillaxanthin, and the phycobiliproteins c-phycocyanin and allophycocyanin are among the several colors found in spirulina.

Amino acids:--

The amino acid composition of spirulina protein is balanced, and depending on the growth medium, its quantities of methionine, tryptophan, and other amino acids are nearly identical to those of casein.

Vitamins with β-carotene:--

The spirulina's β-carotene, B-group vitamin, vitamin E, iron, potassium, and chlorophyll can support the reproduction of skin, muscle, and mucosa as well as the metabolism of carbohydrates, fats, proteins, and alcohol. Natural β-carotene, which is abundant in spirulina, is transformed into vitamin A.

*As a therapeutic agent:--

Spirulina SCP is advised for patients who want to lose weight, cholesterol, and blood sugar levels in diabetics. It also promotes wound healing by boosting skin metabolism. Women who take 3 grams of Spirulina the night before their period experience less premenstrual stress. The presence of Phycocyanin in Spirulina boosts the immune system to provide resistance to the body against many pathogenic diseases. The β-Carotene in Spirulina acts as an anticancer agent to prevent cancer risks. Spirulina biomass increases lactation in nourishing mothers.

* health properties and effects in human's:--

Antioxidant, anti-inflammatory, immunomodulatory, anticancer, antiviral, and antibacterial properties, as well as beneficial effects against hyperlipidemia, obesity, diabetes, malnutrition, and anemia, were demonstrated by numerous studies on the health benefits of spirulina (Lee et al. Citation1998; Lorenz Citation1999; Kulshreshtha et al. Citation2008; Hosseini et al. Citation2013).

*Antioxidant activity of spirulina:--

Ascorbate (vitamin C), glutathione, tocopherol (vitamin E), flavonoids, alkaloids, and carotenoids are among the many non-enzymatic antioxidants found in spirulina. These antioxidants have great therapeutic potential for a variety of senile diseases caused by an excessive buildup of free radicals (Han et al. Citation2021). Spirulina supplementation has been proposed as an effective treatment strategy for a number of diseases by scavenging free radicals and increasing antioxidant capacity, according to a number of studies (Mao et al. Citation2005; Selmi et al. Citation2011; Shetty et al. Citation2013; Ismail et al. Citation2015; Ngo-Matip et al. Citation2015; Ge et al. Citation2019) and recent reviews (Han et al. Citation2021; Naeini et al. Citation2021). The general health of arsenicosis patients of various ages, genders, and nutritional status following Spirulina treatment was pinvestigated by Rahman et al. (Citation 1970). They found that consuming spirulina considerably improved the health of 60% of individuals with arsenicosis. In healthy older participants, spirulina also shown positive antioxidant effects

*Anti-inflammatory activity of spirulina:--

Inflammation is the immune system's response to harmful stimuli; it acts by removing injurious stimuli and initiating the healing process (Ferrero-Miliani et al. Citation2007).

Relatively few clinical trials have been conducted to assess the anti-inflammatory properties of Spirulina in humans, in contrast to the large number of animal research (Wu et al. Citation2016). Spirulina has anti-inflammatory properties, as evidenced by a study with older women in which 8 weeks of Spirulina ingestion (7.5 mg/d) dramatically reduced serum IL-6 levels and IL-6 generation from peripheral blood cells (Kim and Kim Citation 2005). Spirulina's abundance of β-carotene and phycocyanin is primarily responsible for its anti-inflammatory properties. According to research conducted on animals and in vitro, phycocyanin suppresses the expression of cyclooxygenase-2 (COX-2), inhibits the formation of proinflammatory cytokines like TNFα, and lowers the production of prostaglandin E(2) (Romay et al. Citation2001; Remirez et al. Citation2002; Patel et al. Citation2006; Cherng et al. Citation2007).

*Hypolipidemic effects of spirulina:--

Low levels of high-density lipoproteins (HDL) and raised triglycerides (TG) are known to be residual risk factors for cardiovascular disease (CVD), while increased levels of low-density lipoproteins (LDL) and very-low-density lipoproteins (VLDL) are the main independent risk factor for cardiovascular events

Numerous clinical experiments on humans have been conducted to assess Spirulina's hypolipidemic properties. Healthy male volunteers with moderate hypertension or hyperlipidemia participated in the first human trial in 1988 (Nakaya et al. Citation 1988). The authors demonstrated that consuming spirulina considerably reduced total serum cholesterol, with the reduction being more pronounced in individuals with mild hypercholesterolemia than in those with normocholesterolemia. According to Torres-Duran et al. (Citation2007), consuming 4.5 g/d of spirulina for 6 weeks reduced triacylglycerols and total plasma cholesterol by 28% and 10%, respectively. According to lipoprotein research, HDL cholesterol rose by 15% while LDL cholesterol sharply dropped. It's unclear exactly which active ingredients in spirulina provide its hypolipidemic benefits. C-phycocyanin, the primary component of spirulina, lowers lipid contents by scavenging free radicals, preventing lipid peroxidation and NADPH oxidase production, and boosting GSH peroxidase and SOD activity

***Spirulina's Antiviral Activity:--**

Spirulina, a cyanobacterium, has been found to exhibit antiviral activity against various viruses. This review summarizes the current state of knowledge on spirulina's antiviral properties.

Mechanisms of Antiviral Activity:

1. Inhibition of viral replication: Spirulina's polysaccharides and glycoproteins have been shown to inhibit viral replication.

2. Interference with viral adsorption: Spirulina's sulfated polysaccharides can bind to viral particles, preventing them from adsorbing to host cells.

3. Activation of immune responses: Spirulina's immunomodulatory effects can stimulate the host's immune system to produce antiviral cytokines and antibodies.

Antiviral Activity Against Specific Viruses:

1. HIV: Spirulina's sulfated polysaccharides have been shown to inhibit HIV replication.

2. Herpes simplex virus (HSV): Spirulina's polysaccharides have been found to inhibit HSV replication.

3. Influenza virus: Spirulina's glycoproteins have been shown to inhibit influenza virus replication.

4. Human papillomavirus (HPV): Spirulina's sulfated polysaccharides have been found to inhibit HPV replication.

5. COVID-19: Some studies suggest that spirulina may have antiviral activity against SARS-CoV-2, although more research is needed

***Spirulina as Immunity Booster Activity**:

Spirulina, a cyanobacterium, has been found to exhibit immunomodulatory effects, enhancing the body's natural defense mechanisms. This review summarizes the current state of knowledge on spirulina's immunity booster activity.

Immunomodulatory Effects:

1. Activation of immune cells: Spirulina stimulates the activation of immune cells, such as macrophages, natural killer cells, and T-cells.

2. Cytokine production: Spirulina induces the production of cytokines, such as interferon-gamma (IFN-γ) and tumor necrosis factor-alpha (TNF-α), which play a crucial role in immune responses.

3. Antioxidant activity: Spirulina's antioxidant properties help protect immune cells from oxidative damage, maintaining their function and viability.

Immune System Support:

1. Enhanced phagocytosis: Spirulina increases the phagocytic activity of immune cells, enhancing their ability to engulf and eliminate pathogens.

2. Improved antibody response: Spirulina stimulates the production of antibodies, which helps to neutralize pathogens and prevent infections.

3. Increased immune cell count: Spirulina supplementation has been shown to increase the count of immune cells, such as white blood cells and lymphocytes.

Clinical Applications:

1. Prevention of infections: Spirulina's immunity booster activity may help prevent infections, such as the common cold and flu.

2. Treatment of immunodeficiency diseases: Spirulina may be beneficial in the treatment of immunodeficiency diseases, such as HIV/AIDS.

3. Cancer immunotherapy: Spirulina's immunomodulatory effects may enhance the efficacy of cancer immunotherapy.

***Spirulina as a supplement in animal feed**:--

Spirulina-supplemented feed enhances lactation in cows and buffalo. Pigs and goats grow faster and produce more meat when fed spirulina-supplemented feed; calves grow well when fed spirulina-supplemented feed; silkworms fed Morus alba and spirulina leaves produce more silk in their cocoons; and fish fed spirulina-supplemented fish feed grow faster and weigh more. For instance, Moss ambica, Tilapia, and Catla catla In poultry, spirulina promotes layering. Spirulina, a cyanobacterium, has been increasingly used as a supplement in animal feed due to its nutritional and health benefits

Nutritional Benefits:

1. High-quality protein: Spirulina is rich in protein (60-70% protein content) and essential amino acids.

2. Rich in vitamins and minerals: Spirulina is a good source of vitamins (B12, E, K) and minerals (iron, calcium, magnesium).

3. Antioxidant-rich: Spirulina contains antioxidants, such as phycocyanin and other pigments, which help protect against oxidative stress.

Health Benefits:

1. Improved growth and performance: Spirulina supplementation has been shown to improve growth rates and feed efficiency in various animal species.

2. Enhanced immune function: Spirulina's immunomodulatory effects may help boost the immune system of animals, reducing the incidence of diseases.

3. Reduced oxidative stress: Spirulina's antioxidant properties may help reduce oxidative stress and inflammation in animals.

Animal Species and Spirulina Supplementation:

1. Poultry: Spirulina supplementation has been shown to improve growth rates, feed efficiency, and egg production in chickens.

2. Aquaculture: Spirulina is used as a feed supplement in aquaculture, improving growth rates and reducing mortality in fish and shrimp.

3. Livestock: Spirulina supplementation has been shown to improve growth rates, feed efficiency, and immune function in cattle, pigs, and sheep.

Recommended Inclusion Rates:

1. Poultry: 0.5-2.0% of total feed
2. Aquaculture: 1.0-5.0% of total feed
3. Livestock: 0.5-1.5% of total feed

***Spirulina as a raw material for cosmetics:--**

Essential amino acids and vitamins A and B, which are necessary for hair growth, are abundant in spirulina. Phycocyanin, a bluish pigment that is isolated from spirulina, is used to make herbal lipsticks and face creams. It is also used to make hair oils that encourage hair growth.

Spirulina, a cyanobacterium, has gained popularity in the cosmetics industry due to its unique composition and potential benefits for skin and hair care. This page summarizes the current state of knowledge on the use of spirulina as a raw material for cosmetics.

Cosmetic Applications:

1. Skin care: Spirulina's antioxidants, vitamins, and minerals may help protect the skin from environmental stressors, promote collagen production, and improve skin elasticity.
2. Hair care: Spirulina's nutrients, such as iron and zinc, may help promote hair growth, improve scalp health, and reduce dandruff.
3. Color cosmetics: Spirulina's pigments, such as phycocyanin, may be used as natural colorants in cosmetics.

Benefits for Skin and Hair:

1. Antioxidant activity: Spirulina's antioxidants may help protect the skin and hair from oxidative damage caused by UV radiation, pollution, and other environmental stressors.
2. Anti-inflammatory activity: Spirulina's anti-inflammatory compounds may help reduce inflammation and promote healing in the skin and scalp.
3. Moisturizing properties: Spirulina's polysaccharides and glycoproteins may help retain moisture in the skin and hair, leaving them feeling soft, smooth, and hydrated.

Formulations and Products:

1. Creams and lotions: Spirulina can be incorporated into creams and lotions to provide antioxidant, anti-inflammatory, and moisturizing benefits.
2. Face masks: Spirulina can be used in face masks to provide an intense dose of antioxidants and nutrients to the skin.
3. Shampoos and conditioners: Spirulina can be added to shampoos and conditioners to promote hair growth, improve scalp health, and reduce dandruff.

Regulatory Status:

1. Cosmetic Ingredient Review (CIR): Spirulina has been reviewed by the CIR Expert Panel and is considered safe for use in cosmetics.

2. European Cosmetics Regulation: Spirulina is listed in the European Cosmetics Regulation as a permitted ingredient for use in cosmetics.

*Spirulina use as a fertilizer:--

Utilize as a fertilizer The FAO published research in 1981 on the potential use of blue-green algae to restore the structure of deficient soils and replace artificial fertilizers. In shallow clay ponds in India, blue-green algae are cultivated. They collect the dried algae and sell them to rice farmers once the water evaporates. The average yearly rice output in India is increased by 22% thanks to this natural nitrogen supply, which is only one-third the price of artificial fertilizer. The benefits of algae are equivalent to those of 25–30 kg of chemical nitrogen fertilizer per acre when chemical fertilizers are not employed. By using algae instead of chemicals, an equivalent amount of inorganic fertilizer can be employed.

Environmental and Biotechnological Uses of Spirulina

Spirulina, a cyanobacterium, has been increasingly recognized for its potential environmental and biotechnological applications. Here are some of the most significant uses of spirulina in these fields:

Environmental Applications

1. Wastewater Treatment: Spirulina can remove pollutants, heavy metals, and excess nutrients from wastewater, making it a potential tool for wastewater treatment.

2. CO2 Sequestration: Spirulina can absorb CO2 from the atmosphere, making it a potential tool for carbon sequestration and mitigation of climate change.

3. Soil Remediation: Spirulina can be used to remediate contaminated soils by removing heavy metals and other pollutants.

4. Biofertilizers: Spirulina can be used as a natural biofertilizer due to its ability to fix nitrogen and produce plant growth-promoting substances.

Biotechnological Applications

1. Biofuels: Spirulina's biomass can be converted into biofuels, providing a sustainable alternative energy source.

2. Bioplastics: Spirulina's biomass can be used to produce biodegradable plastics.

3. Animal Feed: Spirulina can be used as a nutritious feed supplement in aquaculture, poultry, and livestock.

4. Bioremediation: Spirulina can be used to clean up environmental pollutants, such as oil spills and industrial waste.

Conclusion:--

the trend in Spirulina research and its applications are highlighted in this review, which also demonstrates the significance of microalgae for people, animals, and the environment. Spirulina seems like a good option for pharmaceuticals, food, biofuels, cosmetics, bioplastics, and biofertilizer production because these uses touch on important facets of human and environmental life.

Increased production of Spirulina and its prudent application would benefit humanity much in this era of environmental pollution and population growth. Since several studies have already revealed positive health potentials from microalgae clones, efforts like safe laboratory multiplication and bulk cultivation of Spirulina in landlocked nations could boost its availability. Research on the isolation and analysis of all as-yet-unidentified chemicals in Spirulina is still ongoing.

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