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## Review Article

# Harnessing The Power of Spirulina as A Nutraceutical in HIV Patient Health Booster

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### ABSTRACT

The most prevalent one of the diseases in the world is HIV, HIV is a single-stranded RNA retrovirus. Malnutrition worsens the impact of HIV by causing chronic fatigue and speeding up disease progression, leading to earlier death. Diagnosing of HIV usually involves identifying HIV-specific antibodies in serum, plasma or detecting the virus itself using nucleic acid detection techniques such as polymerase chain reaction (PCR), p24 antigen testing, or viral culture. Engaging in unprotected sex with an infected individual elevates the risk of HIV transmission. Some complications of HIV infection are the direct result of long-term infection, whereas others are the indirect result of aging, antiretroviral therapy, or other patient factors. In this nutraceutical, spirulina is a superfood which is a cyanobacterium which shows its potential role in managing HIV. Spirulina is a microorganism, which is photosynthetic and reproduces rapidly. Consumption of spirulina is a way to supplement protein and vitamins in a person's diet. It also contains thiamin, riboflavin, niacin, folate, and vitamins A, B6, and K. Spirulina can be consumed in various ways which is a power booster for HIV patients.

## INTRODUCTION

### Introduction about spirulina:

Spirulina, a fascinating type of blue-green algae, has been capturing the attention of health enthusiasts worldwide for its incredible nutritional profile and potential health benefits. This remarkable microalga, with its diverse species including the well-studied *Arthrospira platensis* and *Arthrospira maxima*, thrives in the alkaline

waters of our planet. What sets spirulina apart is exceptionally high protein content, which can account for up to 70% of its dry weight, making it a true superfood and a valuable addition to any diet. [1] Interestingly, spirulina has been a part of traditional diets in various cultures, particularly in Africa and Asia, where it has been harvested from natural sources and incorporated into meals for centuries. However it was in the 20th century that

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spirulina gained widespread recognition, especially when NASA included it as a sustainable food source for astronauts during space missions. This innovative move not only highlighted spirulina's potential to combat malnutrition but also showcased its ability to support human health in extreme environments.[2] Spirulina boasts an exceptional biochemical composition, including essential amino acids, vitamins (particularly B12), minerals, and bioactive compounds like phycocyanin, which exhibit antioxidant and anti-inflammatory properties. Recent studies have explored spirulina's potential in managing obesity, diabetes and dyslipidemia due to its ability to improve lipid profiles and glucose metabolism. [3]

#### **Introduction About Disease:**

One of the most prevalent diseases in the world is HIV. It is estimated that about 37.7 million people are infected with the virus globally. 8.2 million are infected in South Africa only [4]. HIV is a single-stranded RNA retrovirus that uniquely carries out reverse transcription of proviral DNA from viral RNA [normally RNA is transcribed from DNA] with the help of a viral RNA- dependent DNA polymerase [reverse transcriptase]. Primary infection of HIV refers to the first stage of HIV when a person is infected when antibodies against HIV show up on blood tests. People may or may not have symptoms at this stage, but if they do get sick, it can lead to an early HIV diagnosis. This stage is known as seroconversion illness because it happens when seroconversion (antibody production) occurs.[5] Malnutrition worsens the impact of HIV by causing chronic fatigue and speeding up disease progression, leading to earlier death. It affects patient care, and treatment, and can cause other infections like tuberculosis both malnutrition and HIV weakens the immune system, reducing T-cell levels and weakening response to vaccines. This creates a cycle where weakened immunity increases the risk of other infections. People with HIV/AIDS need healthy

diets with extra protein and nutrients to support their immune system. While organizations suggest integrating food assistance into HIV programs, specific guidance on how to do this effectively is lacking. Therefore, many turn to dietary supplements like vitamins and herbs to boost their immune system, but their effectiveness varies.[6]

#### **History:**

AIDS is caused by HIV, which stands for Human Immunodeficiency Virus. It originally came from non-human primates like monkeys and apes in central and west Africa. The type of HIV that causes the current AIDS pandemic started with one specific strain of the virus, called HIV-1 Subgroup M. This strain first spread to humans in the 1920s in Leopoldville, a city now called Kinshasa in the democratic republic of the Congo.[7]

#### **Structure of HIV**

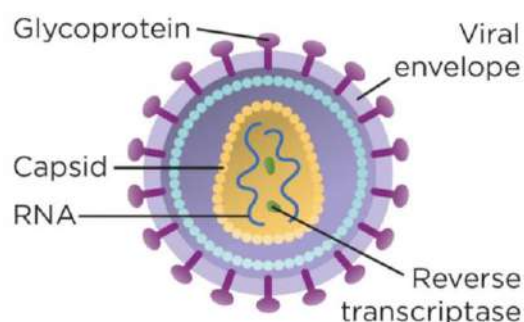


Fig.1.1 structure of HIV

#### **Types of HIV**

##### **HIV is classified into two sorts:**

**HIV 1:** HIV 1 is the foremost destructive and irresistible strain of the human immunodeficiency virus, responsible for the larger part of HIV contaminations worldwide. HIV-1, to begin with, distinguished as a lymphadenopathy-associated virus (LAV) and human T-lymphotropic virus (HTLV-III), is the infection found. [8] **HIV 2:** It exhibits lower infectivity, which suggests that fewer people exposed to HIV-2 will contract the infection exposure. Thus, the spread of HIV-2 is at first restricted to West Africa due to its generally poor transmission capacity.

### Symptoms of HIV:

1. Symptoms of HIV may vary from person to person, the starting stage of HIV is called the acute infection stage.
2. Early-stage symptoms include fever, chills, swollen lymph nodes, general aches and pains, skin rash, sore throat, headache, nausea, and upset stomach. These symptoms can be similar to common illnesses like flu and healthcare providers may find it difficult to suspect the disease as HIV.
3. After a few initial weeks, HIV transitions into the clinical latency stage. This stage can persist for several years, even decades in some cases. During this period, some individuals may not be directly linked to another disease or condition.
4. The nonspecific symptoms that may manifest during the clinical latency stage include: Headaches, swollen lymph nodes, recurrent fever episodes, night sweats, fatigue or lack of energy, unexplained weight loss, frequent oral or vaginal yeast infections, pneumonia, shingles (herpes zoster)

### Diagnosis of HIV:

Diagnosing of HIV usually involves identifying HIV- specific antibodies in serum, plasma or detecting the virus itself using nucleic acid detection techniques such as polymerase chain reaction(PCR), p24 antigen testing, or viral culture. Antibody testing, particularly with highly sensitive HIV-1/HIV-2 enzyme immunoassays (EIAs), is the most commonly used method and can detect seroconversion within two or three weeks of infection in most cases. Alternatively, DNA PCR may be employed to detect viral DNA integrated into host cells genomic DNA, especially in infants born to HIV-positive mothers or in individuals with agammaglobulinemia or symptoms suggestive of advanced HIV infection but who do not yet have detectable HIV-specific antibodies.[9]

**Prevention:** To prevent HIV, there are various effective methods suggested by health authorities:

- Condom use: Male and female condoms are highly effective in preventing HIV transmission.
- Treatment as Prevention: When someone with HIV consumes prescribed treatment, it can reduce their viral load to undetectable levels, which makes it impossible to transfer the virus.
- Pre-exposure prophylaxis(PrEP): HIV-negative individuals at high risk can take PrEP medication before exposure to reduce the risk of infection.
- Avoid sharing Needles: individuals who inject drugs refrain from sharing needles to reduce the risk of HIV and other blood borne virus transmission.

These prevention strategies, when followed correctly and consistently, play an important role in decreasing the risk of HIV transmission and promoting overall public health.

### Side effects of HIV-

Side effects from HIV medicines may last only a few days or weeks. For example, nausea, fatigue and trouble sleeping are some short-term side effects of HIV.[10]

The side effects range in severity from mild to life-threatening but can often be prevented or managed.

### Causes & Risk Factors:

1. The virus can spread through various means, including sexual contact, sharing needles during drug use, contact with infected blood, and from a mother to child during pregnancy, childbirth, and breastfeeding.
2. HIV can't be transmitted through casual contact or sharing food utensils.
3. The fewer CD4 T cells a person has, the weaker their immune system becomes, making them more susceptible to infections and diseases.[11]



4. Engaging in unprotected sex with an infected individual elevates the risk of HIV transmission.
5. Sharing needles or syringes while injecting illicit drugs exposes individuals to infected blood, increasing the likelihood of contracting HIV.
6. The presence of sexually transmitted infections (STIs) causing open sores on the genitalia facilitates HIV entry into the body.
7. The risk of HIV transmission varies depending on the type of exposure behavior.
8. Certain biological factors such as a high viral load, acute and late-stage HIV infection, and the presence of other STIs can elevate the risk of HIV transmission.[12]
9. High cholesterol can be a side effect of some HIV medicine.

#### **Complications:**

**Neurological complications-** HIV does not directly invade nerve cells (neurons) but puts their function at risk by infecting cells called glia that support and protect neurons. HIV also triggers inflammation that may damage the brain and spinal cord (central nervous system) and cause symptoms such as:

- Confusion and forgetfulness
- Inability to concentrate
- Behavioral changes
- Headaches
- Mood disorders (anxiety disorder and depression)
- Movement problems (loss of movement control) including a lack of coordination and difficulty walking

Damage to the peripheral nerves can cause progressive weakness and loss of sensation in the arms and legs. Research has shown that HIV infection can cause shrinking of brain structures involved in learning and information processing. HIV-associated neurocognitive disorders (HAND) include a spectrum from no symptoms to severe

neurocognitive impairment. The more serious forms of HAND also are referred to as AIDS dementia complex (ADC) or HIV-associated dementia and primarily occur in people with more advanced HIV infection. People with ADC also show progressive slowing of motor function and loss of dexterity and coordination. When left untreated, ADC can be fatal.[13]

Some complications of HIV infection are the direct result of long-term infection, whereas others are the indirect result of aging, antiretroviral therapy, or other patient factors.

**Cardiovascular complications-** Direct effect of HIV infection on cardiovascular is HIV-associated cardiomyopathy, Atherosclerosis.[14]

#### **Pathophysiology Of Disease:**

The seven stages of the HIV life cycle are as follows.

- **Attachment:** The infection starts when HIV first sticks to the host cell.
- **Fusion:** The viral membrane becomes one with the host cell surface and unleashes the viral core into the cytosol.
- **Reverse transcription:** In the presence of reverse transcriptase enzyme, viral RNA is converted to DNA.
- **Integration:** Viral DNA gets integrated into the host's genetic material.
- **Replication:** Transcription and translation of integrated viral DNA leads to the production of new virus parts.
- **Assembly:** Host cells build new capsids or complete virions inside their structures.
- **Release:** Ready to enter other cells, mature viral particles emerge from infected ones.

These stages illustrate how HIV reproduces sequentially as well as spreads inside a person's body.[12]

#### **Pharmacology Of Hiv**

HIV targets resistant cells such as helper T cells (CD4+), macrophages, and dendritic cells. It diminishes CD4+ T cell levels by murdering



contaminated and adjacent infected cells, directly assaulting them, and kindly focusing on CD8+ cells. When the CD4+ Cells level drops, the immune system weakens, expanding defenselessness to infections and possibly advancing to AIDS.[15]

#### **Mechanism of action:**

1. HIV entry: HIV entry into host cells involve interaction with CD4 membrane receptor and activation of Co- receptors CCR5 and CXCR4
2. Role of chemokine receptors: CCR5 and CXCR4 are essential chemokine receptors for HIV-1 cellular tropism, with CCR5 mainly expressed on macrophages and CXCR4 on T-lymphocytes.
3. Viral tropism: The ability of HIV to utilize either CCR5 or CXR4, or both, determines viral tropism, with strains using CXCR4 associated with a higher incidence of AIDS development.
4. Dual antagonism: Dual Co-receptor antagonists targeting both CCR5 and CXR4 are being explored as potential next-generation AIDS prophylaxis drugs to prevent the viral spread of AIDS.
5. CCR5,CXCR4 signaling: Both receptors are G-protein coupled receptors that translate ligand binding into intracellular signals through the activation of G-proteins, influencing various cellular functions beyond HIV infection.[16-20]

#### **Revised WHO clinical staging of HIV/AIDS**

The World Health Organization (WHO) has updated the clinical staging of HIV/AIDS for adults and adolescents to offer a comprehensive framework for managing the disease at various phases. The revised staging consists of Primary HIV Infection: Initial stage with rapid replication and flu-like symptoms. Asymptomatic: Individuals show no outward symptoms but have weakened immune systems.

Acute Retroviral Syndrome: It is the early phase of HIV, exhibiting flu-like symptoms and seroconversion.

**Clinical Stage 1:** asymptomatic individuals and generalized lymphadenopathy.

**Clinical Stage 2:** moderate unexplained weight loss, recurrent respiratory tract infections and other minor mucocutaneous manifestations.

**Clinical Stage 3:** severe weight loss, chronic diarrhea, persistent fever, oral candidiasis, pulmonary tuberculosis and other conditions necessitating confirmatory diagnostic testing.

**Clinical Stage 4:** advanced HIV disease. This stage includes conditions like HIV wasting syndrome, Pneumocystis jiroveci pneumonia (PCP), cryptococcal meningitis, Kaposi Sarcoma. The WHO staging system helps health care providers diagnose and manage HIV/AIDS effectively by categorizing disease progression into distinct clinical stages based on symptoms and diagnostic criteria.

#### **Allopathic Remedies**



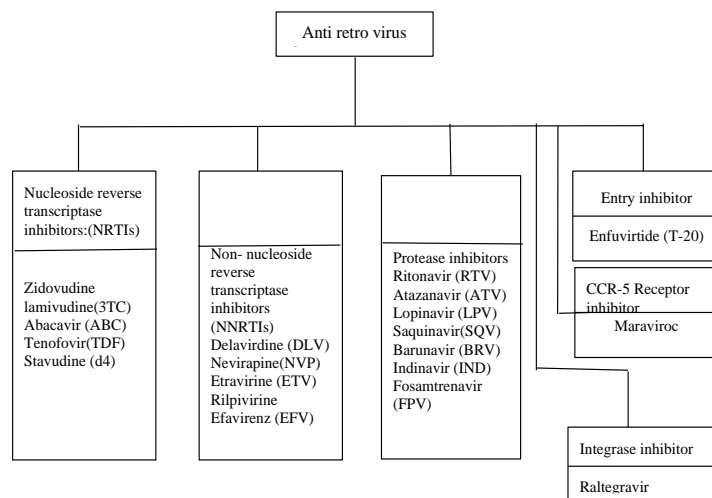


Fig.2

**Pharmacology Of Spirulina:** Spirulina, a cyanobacterium, exhibits a variety of pharmacological properties that have been explored in numerous studies.

**Antioxidant Activity:** Spirulina contains a large content of antioxidants, mainly phycocyanin, and is known to have strong antioxidant and anti-inflammatory properties. This compound protects cells from oxidative stress and the potential damage associated with various diseases, including cancer and cardiovascular disorders through scavenging free radicals. [21]

**Immuno modulatory effects:** Spirulina supplementation has been shown to promote immune function through enhanced interleukin and interferon production, which play important roles in the immune process. Positive effects of spirulina supplementation on immune function parameters like natural killer cells and other immune parameters have been reported in healthy subjects and in athletes under physical stress. [22]

**Anti-Diabetic Properties:** Spirulina has indicated a promising avenue for its application in the management of diabetes: it increases sensitivity to insulin and reduces blood glucose. The clinical tests have demonstrated to reduce fasting and postprandial glucose in patients suffering from type 2 diabetes as well as to reduce levels of

glycosylated hemoglobin, HbA1c. This was through the increase of hexokinase activity as well as through the modulation of plasma insulin levels.[23]

**Anti-Inflammatory Properties:** Spirulina has high anti-inflammatory activity, primarily due to the inhibition of pro-inflammatory cytokines such as TNF- $\alpha$ , IL-1 $\beta$ , and IL-6 via pathways of NF- $\kappa$ B. It reduces histamine release from mast cells, which is an integral component of allergic reactions. In animal studies, Spirulina significantly decreased inflammation in arthritis models, while clinical studies demonstrated that it may help reduce chronic pain and inflammation symptoms. Additionally, it affects gut health by adjusting the balance of gut microbiota, thereby minimizing metabolic inflammation due to a diet containing high fats. Altogether, Spirulina's anti-inflammatory properties lead to more significant positive health effects, such as the amelioration of cardiovascular health and prevention of cancer by the reduction of chronic inflammation. More research on its mechanisms and uses would be required to tap further into these areas.[24]

**Hypolipidemic Effects:** Spirulina significantly decreased lipid profiles, with a major role in total cholesterol reduction and low-density lipoprotein (LDL) cholesterol, thereby preventing the onset of

dyslipidemia, which, in turn, would prevent the cardiovascular problems. This hypolipidemic effect is associated with bioactive compounds: phycocyanin and others, which might inactivate cholesterol absorption within the gut and enhance antioxidant activity. Clinical studies had demonstrated significant reductions of total cholesterol and triglyceride levels among supplemented Spirulina test subjects, thereby it might be viewed as an adjunctive treatment for hyperlipidemia. In addition, Spirulina appears to modulate endothelial function through the augmentation of production of nitric oxide, leading to enhanced relaxation of blood vessels and consequently to cardiovascular protection.

**Antimicrobial activity:** Spirulina has considerable antimicrobial effects against many pathogens - both bacteria and viruses. It is said to affect the herpes simplex virus and decrease HIV replication. Studies further reveal that it inhibits Gram-positive and Gram-negative bacteria, Escherichia coli and Staphylococcus aureus, and fungi, such as Candida albicans. The antimicrobial effects have been largely attributed to bioactive compounds such as phycocyanin, which improves the efficiency of immunity and disrupts viral replication. Spirulina extracts can even enhance the activity of other antimicrobial agents while treating the resistant form. Thus, spirulina occupies a promising place in natural treatments against growing antibiotic resistance. Its mechanism and clinical application further await further research.[25]

**Anti-cancer potential:** Research has shown that Spirulina exhibits some anticancer activity and, in particular, active compounds like phycocyanin, which may induce apoptosis in cancer cells. Such a view has been strongly supported by the recorded studies showing its effectiveness in fighting several cell lines of stomach, liver, lung, and breast cancers. In addition, Spirulina has been proven to enhance immunity by activating NK cells, which

is a critical part of the natural defense mechanism that attacks and destroys tumor cells. A few clinical studies have shown that Spirulina protects against myelosuppression and improves the immune system in chemotherapy patients, reducing some effects of chemotherapy. In addition to this, antioxidants in Spirulina are known to minimize oxidative stress that has been related to cancer progression and were observed to have anticancer effects.

#### **Nutraceutical Management:**

Spirulina, a type of cyanobacterium, has been studied for its potential role in managing HIV. A clinical trial found that six months of supplementation of *S. platensis* in HIV-infected, ART-naïve patients in the early stages of disease significantly delayed the time to HIV disease progression and reduced the viral load [6]. Another study demonstrated that spirulina supplementation combined with a balanced diet significantly increased CD4 cells and reduced the viral load in HIV-infected antiretroviral-naïve patients. Spirulina is rich in proteins, vitamins, and minerals, which are important nutrients for individuals on antiretroviral therapy (ART). Spirulina also has shown high-quality protein, iron, gamma-linolenic fatty acid, carotenoids, and vitamins B1 & B2. Its chemical composition varies widely when grown in open reservoirs. Still, its efficiency as an additional remedy in the treatment and prophylaxis of various diseases has been proven in numerous experimental and clinical trials. During the cultivation of Spirulina in open reservoirs and especially in closed photobioreactors, its biomass can be enriched with trace elements such as iron, iodine, selenium, zinc, copper, manganese, and chromium in a highly bioavailable form.[26]. However, more clinical studies are needed to confirm the mechanism of antioxidant and anti-inflammatory effects of spirulina in HIV patients. The recommended concentrations of spirulina for daily

supplementation vary, with studies using 19 g, 5 g, and 10 g[27]. In Ghana, Tabi et.al noted that the primary cause of death among HIV/AIDS patients is often attributed to their poor nutritional status rather than the disease itself. Protein- Calorie malnutrition hampers the immune function of macrophages, exacerbating the severity of HIV infection. Persistent infections create infection. Persistent infections create a substantial energy requirement, leading to protein breakdown for energy production through gluconeogenesis. Inadequate protein intake exacerbates this situation. Additionally, HIV/AIDS patients undergoing ART treatment experience various

metabolic abnormalities, including dyslipidemia, glucose metabolism disorders, and alterations in body composition.[28]. Arthrospira Spirulina (Filamentous Cyanobacteria) can be the best food for future declared by the UNWFC. Microalgae cyanobacteria is the traditional food in the past in several countries. Some of the algal and cyanobacterial species are already legally present in the market to be used along with the food [29]. Consumption of spirulina is a way to supplement protein and vitamins in a person's diet. According to the United States Department of Agriculture (USDA), 1 tbsp or 7gm of dried spirulina can contain Trusted Source of:

Calories	20.3	Iron	2mg
Protein	4.02g	Magnesium	13.6mg
Carbohydrate	1.67g	Phosphorus	8.26mg
Fat	0.54g	Potassium	95.2mg
Calcium	8.4mg	Sodium	73.5mg
Vitamin c	0.7mg		

**Table: 1.1**

It also contains thiamin, riboflavin, niacin, folate, and vitamins A, B6, and K. A range of antioxidants, including phycocyanin, a blue-green pigment, are also present in Spirulina.

Free radicals form Trusted Sources in the body due to natural processes and exposure to harmful substances, such as alcohol, tobacco, and some foods. They can cause tissue damage and may contribute to inflammation and possibly some cancers. Antioxidants, which are present in spirulina, help to fight free radicals and protect our body from cell damage.

### **Nutritional aspects of Spirulina**

- Spirulina is a microorganism, which is photosynthetic and reproduces rapidly. Its scientific name is Arthrospira platensis because of its spiral filament appearance under the microscope.

- Because of its remarkable protein concentration, spirulina initially caught the interest of scientists and business professionals. Later, a number of very intriguing nutritional characteristics were discovered, including a balanced protein composition, the presence of uncommon necessary fats, and an abundance of minerals and vitamins.
- Raw or dried, spirulina has no cellulose wall and is easily absorbed. Its micronutrients' bioavailability has been demonstrated by numerous nutritional studies. [30].

**Different ways to consume Spirulina for HIV Patients:** Spirulina can be consumed in various ways by HIV patients. Here are some methods:

- Spirulina powder can be incorporated into salads, soups, energy balls, or blended into



fruit or vegetable juices, offering a convenient way to increase protein and vitamin intake in one's diet.



**Fig.2 salad containing spirulina**

**VIMERGY USA GROWN  
SPIRULINA**



**Fig.3 Spirulina powder**

- Alternatively, Spirulina tablets are available as a dietary supplement. Research suggests that daily supplementation with Spirulina platensis for 12 months notably decreased clinical symptoms such as sexually transmitted infections, malaria, and Zona in HIV-infected individuals who had not yet started antiretroviral therapy. [31]



**Fig.4 Spirulina tablets**



**Fig.5 Spirulina juice**

- Spirulina can also be taken in the form of noodles.



**Fig.6 Spirulina noodles**

- Additionally, combining brown seaweed (*Undaria pinnatifida* sporophyll) with Spirulina has shown promise in enhancing immune function among HIV patients.
- Another dosage regimen explored is the use of fucoidan supplements, derived from brown seaweed, which have demonstrated the ability to lower proviral serum concentrations in individuals with human T-lymphotropic virus type 1-associated myelopathy.

It's important to recognize that the optimal components and duration of nutritional support for HIV patients remain unclear, and dietary supplements are often utilized to enhance immune function. However, the precise mechanism through which Spirulina exerts its beneficial effects in HIV patients necessitates further investigation. Further research is needed to fully understand how Spirulina brings about its positive effects in HIV patients. It is always recommended to seek advice from a healthcare professional

before starting any new supplement regimen.[6] Spirulina preparations enhance immune function by increasing phagocytic activity of macrophages, stimulating the antibody and cytokine production, and boosting the NK cell accumulation in tissues. Also helps in regulating lipid and carbohydrate metabolism, correcting glucose and lipid profiles in experimental animals and diabetic patients. Additionally, Spirulina exhibits antiviral activity against various enveloped viruses, including herpes, cytomegalovirus, influenza, and HIV[32]. The animal studies and Test tubes studies suggest that spirulina may boost the immune system, and can give protection against allergic reactions, and is having antiviral and anticancer properties. However, there is no proof that spirulina has these, or any, benefits in people. More research is needed. Like any other blue-green algae, Spirulina can also be contaminated with toxic substances like microcystins. It can also absorb heavy metals from the water where it is grown. For such reasons, A person needs to buy spirulina from a trusted brand [33] Anticoagulant activity may be present in some Spirulina-derived polysaccharides and this is important to consider in patients taking blood thinners or who are genetically prone to bleeding. Finally, allergy to Spirulina is more frequent in patients suffering from allergic rhinitis Cross-reactivity with pollen and other volatile allergens has been hypothesized in some patients. Considering such reasons, medical supervision is strongly recommended[34].

**CONCLUSION:** HIV and AIDS are significant health challenges affecting the immune system. Understanding the history, structure, types, symptoms, diagnosis, prevention and complications of HIV/ AIDS is crucial for effective management. The emergence of HIV/AIDS in the early 1980s marked a turning point in global health, leading to extensive research, treatment advancements and improved understanding of the virus. HIV, a retrovirus,

targets white blood cells, weakening the immune system and making the body susceptible to infection. Living with HIV can lead to side effects from the virus and antiretroviral medications, emphasizing the importance of adherence to treatment and lifestyle modifications. Understanding the modes of HIV transmission, such as unexpected sex and needle sharing, is crucial in addressing risk factors and implementing preventive measures to curb the spread of the virus. Combining allopathic treatments with nutraceutical management, like spirulina, can enhance overall health outcomes for HIV patients addressing nutritional deficiencies and supporting immune health. Spirulina, a nutrient rich supplement, offers potential benefits for HIV due to its nutritional profile. Spirulina can be consumed in various forms, such as powder or tablets, and it can be added to smoothies, juices or meals. Exploring different consumption methods can help HIV patients to optimize their nutritional intake and complement their treatment regimen.. Consumption of spirulina is a way to supplement protein and vitamins in a person's diet. It also contains thiamin, riboflavin, niacin, folate, and vitamins A, B6, and K. Spirulina can be consumed in various ways which is a power booster for HIV patients.

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