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RESEARCH ON THE USE OF SPIRULINA (SPIRULINA PLATENSIS) ALGAE IN  
ENHANCING THE EFFECTIVENESS OF ART FOR HIV INFECTION

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✓ **Resume**

*The article presents the results of spirulina supplementation in HIV-infected patients on the background of antiretroviral therapy. The use of spirulina bio-additive improves clinical condition, which was expressed in the increase of activity, efficiency, improvement of general condition. The immunity indices in this category of patients also improved, which makes it possible to recommend its use in treatment as an adjunct to the main therapy.*

**Keywords:** HIV infection, antiretroviral therapy (ART), CD4 lymphocytes, (spirulina platensis)

ИССЛЕДОВАНИЕ ПРИМЕНЕНИЯ ВОДОРОСЛЕЙ СПИРУЛИНА (SPIRULINA  
PLATENSIS) В ПОВЫШЕНИИ ЭФФЕКТИВНОСТИ АРТ ВИЧ-ИНФЕКЦИИ

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✓ **Резюме**

*В статье приведены результаты применения биодобавки спирулины у ВИЧ инфицированных пациентов на фоне антиретровирусной терапии. Применение биодобавки спирулины улучшает клиническое состояние, которое выражалось в повышении активности, работоспособности, улучшении общего состояния. Также улучшились показатели иммунитета у данной категории пациентов, что даёт возможность рекомендовать её применение при лечении, как дополнение к основной терапии.*

**Ключевые слова:** ВИЧ инфекция, антиретровирусная терапия (АРТ), CD4 лимфоциты, спирулина платенсис



## OIV INFEKSIYALI BEMORLARDA ART SAMARASINI OSHIRISHDA SUV O'TLARIDAN SPIRULINA (SPIRULINA PLATENSIS) QO'LLANILISHINI O'RGANISH

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### ✓ Rezyume

*Maqolada antiretrovirus terapiya fonida OIV bilan kasallangan bemorlarda spirulina biologik qo'shimchasidan foydalanish natijalari keltirilgan. Spirulina qo'shimchasidan foydalanish klinik holatni yaxshilaydi, bu faollikning oshishi, ishlash va umumiy holatning yaxshilanishi bilan ifodalanadi. Bemorlarning ushbu toifasida immunitet ko'rsatkichlari ham yaxshilandi, bu esa uni davolashda asosiy terapiyaga qo'shimcha sifatida foydalanishni tavsiya qilish imkonini beradi.*

*Kalit so'zlar: OIV infeksiyasi, antiretrovirusli terapiya (ART), CD4 limfotsitlar, spirulina platensis*

### Relevance

HIV infection is characterized by a multiyear course with a defined stage and a decline in CD4 T-lymphocytes, resulting in severe immunodeficiency, opportunistic infections and death [13]. Chronic immune activation has been shown to be a cause of CD4+ T-cell depletion [19], which is common to both CD4+ and B-lymphocytes, monocytes/macrophages, CD8+ T cells, and NK cells [14, 17, 19, 24, 28, 29, 32].

The long course and slow progression of HIV infection and the presence of side effects of antiretroviral drugs require systematic clinical follow-up of HIV-infected patients, determining clinical and immunological efficacy through laboratory methods to assess not only CD4 lymphocytes but also other immune factors.

Among the remedies of natural origin that have an adaptogenic effect on the body, the microalgae *Spirulina (Arthrospira) platensis*, which has an exceptionally high nutritional density, attracts particular attention. *Spirulina platensis* contains a unique biochemical composition of great importance and practical interest for pharmacy and medicine. These are vitamins of groups B, C, and E, low-molecular-weight proteins, polyunsaturated fatty acids, functional pigments chlorophyll, carotenoids and phycocyanin, polysaccharides, macro- and microelements, and amino acids, including essential ones. Along with a high (up to 62%) protein content, which is close to "ideal" in its composition, it contains almost a full spectrum of carotenoids, essential gamma-linolenic acid, and a number of trace elements [5].

In recent years, spirulina has been used as a source for the biotechnological production of new food forms of essential trace elements, primarily selenium (Se) [4].

The effects of spirulina have also been studied on oral cancer and anemia, the effects on bone metabolism in ovariectomized rats have been studied in experimental studies, the antioxidant and protovoinflammatory effects in an experimental steatohepatitis model, and the effects on improving endurance in various types of fitness, such as diabetes mellitus. During the coronavirus infection pandemic, a decrease in cytokine storms has been proven [9, 15, 27, 31, 35, 37, 38, 39, 40, 41].

**Therefore**, the aim of our study was to compare changes in the immune status of HIV-infected patients against the background of ART and spirulina bioactive supplementation on clinical condition and laboratory parameters.

### Materials and methods

Seventy HIV-infected patients on antiretroviral therapy were examined to determine their immune status. Among the studied patients, 87% were male and 13% were female. The mean age was 42.3±0.34 years. All

the patients were informed about the study, and all of them signed voluntary informed consent to participate in the study.

In analysing the age structure, 71% of the patients were in the working age group of 30-49 years. Fifty-five percent of the patients were between 30 and 39 years old, and 36% were between 40 and 49 years old. Before the initiation of ART, 88.8% of the patients were in advanced stages of HIV infection. Sixty percent of the patients were in the third stage of HIV infection, and 27.8% were in the fourth stage of HIV infection. Only 11.5% of the patients were in the early stages of the disease, 7.5% of them were in stage 1 and 3.5% in stage 2, which is significantly less ( $P<0.001$ ) than the number of patients in the advanced stages of HIV infection.

Fifty patients received spirulina 3 tablets 3 times a month (NuaYang, No. Licence: C256 2002 registered by the Ministry of Health of the Republic of Uzbekistan № 012-3/1685 date of registration 2004), and 20 patients formed a control group. All patients underwent a blood test for a detailed immunogram at the start of the study and after taking a month's course of spirulina.

Total numbers of leukocytes and lymphocytes, T-lymphocytes (T3), the main subpopulations T-helper-inducers (T4), T-cytotoxic lymphocytes (T8), natural killer (T16) and B-lymphocytes (T20) were determined in all subjects. In addition, activation markers were also studied: SD-38+, which is a marker of early cell activation, apoptosis factor SD-95+ and allergy factor SD-23, and circulating immune complexes (CICs). Studies were performed by the indirect rosette method according to the recommendations of M.V. Zalyalieva [5].

### Result and discussions

After 1 month of spirulina treatment, the clinical condition and quality of life improved in 84% of patients. Their ability to work improved, and their general condition improved.

Before spirulina treatment, absolute and relative lymphocyte values in 60% of patients were below the reference values. (Figure 1, 2) After taking spirulina, only 20% of HIV-infected patients had relative values, and 24% of absolute values of HIV-infected patients were below the reference values ( $P<0.001$ ), while there was an increase in their number in the dynamics. CD4-lymphocytes after 1 month of spirulina supplementation increased from 487.9 to 592.1. The results of the analysis of average leucocytes before spirulina supplementation were 5679,7+256,3/ $\mu$ l, after - 6320,0+401,4 kl/ $\mu$ l. There was an increase in leucocytes in the dynamics, but the figures were not reliable. Before spirulina treatment, absolute and 36.6% of the relative indexes of lymphocytes were lower compared with the control values in 60% of patients. The analysis of CD3 lymphocyte values showed that the mean absolute values before spirulina intake were 926+58.09, and after intake were 1089+93.0 ( $P>0.05$ ). The number of patients with lowered absolute values of CD3 lymphocytes was 36,7%. After taking spirulina, this number was significantly less than 20% ( $P<0.001$ ), and 80% of patients showed improvement in absolute values of CD3 lymphocytes. The absolute values of CD4 lymphocytes after spirulina treatment increased from 487,7+32,20 to 615,96+45,0 kl/ $\mu$ l ( $P<0.001$ ). The number of patients with CD4 values below the control values decreased from 65% to 28% ( $P<0.001$ ).

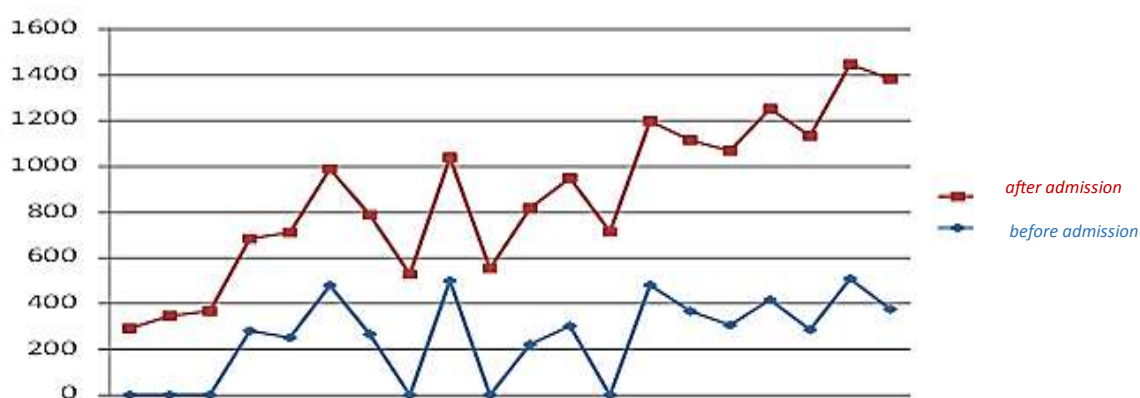
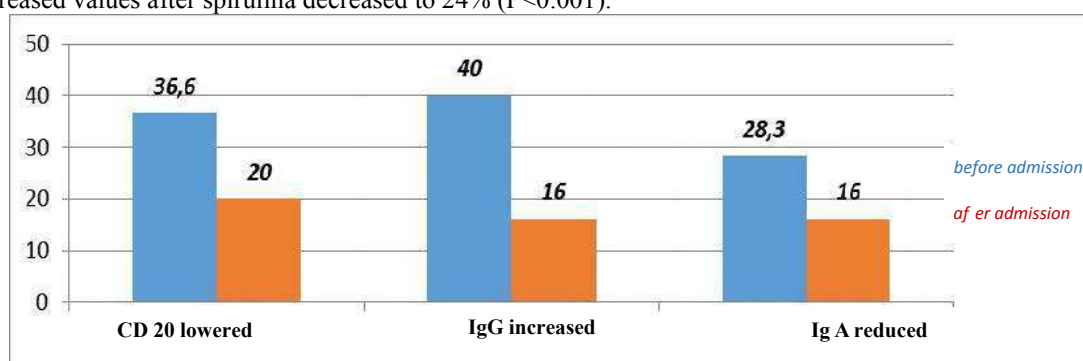


Figure 1. CD4 lymphocyte counts after spirulina intake

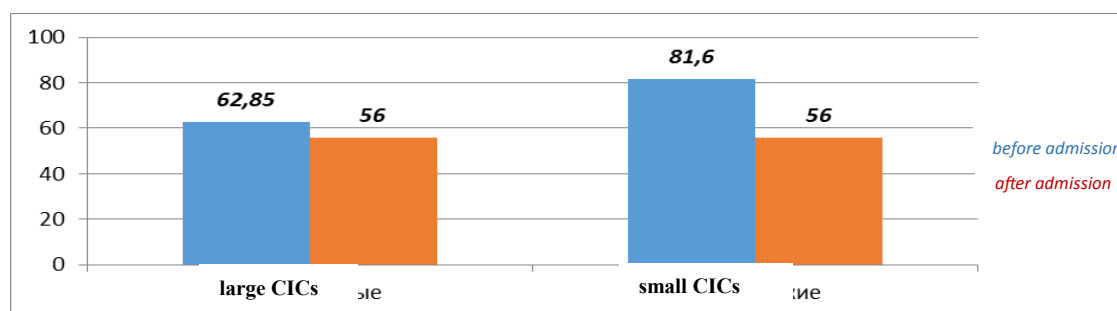
CD8 lymphocytes were significantly elevated in 43.3% of patients, and after spirulina treatment, the number of patients decreased significantly to 16% ( $P<0.001$ ). The IRI was reduced in 88% of patients before spirulina treatment, and after spirulina treatment, the number of patients with reduced IRI decreased significantly to 72%. Natural killer CD16 lymphocytes were elevated in 80% of patients before spirulina intake, and afterwards, the number of patients with elevated indexes decreased significantly to 20%. IgG and IgA levels before spirulina

treatment were elevated in 40% and 28.3% of patients, respectively, and declined significantly to 16% after spirulina treatment. CD20 lymphocytes were decreased in 36.6% of patients, and the number of patients with decreased values after spirulina decreased to 24% ( $P < 0.001$ ).



**Fig. 2. Proportion of patients before and after taking spirulina with changes in some humoral immunity parameters**

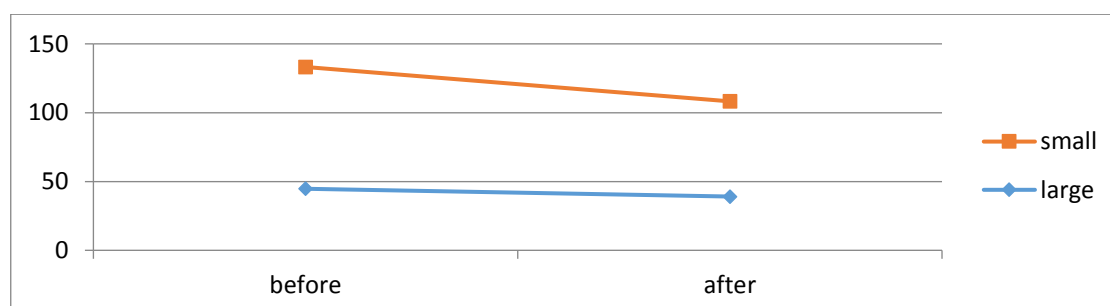
CD38 cells were elevated in 23.3% of patients before taking spirulina, and after taking spirulina, the number of patients with elevated CD38 lymphocytes decreased significantly to 16%. CD95 cells were elevated in 56.6% of patients before spirulina administration, and after spirulina administration, the number of patients decreased significantly to 48%. Before spirulina administration, large CICs were elevated in 62.9% and small CICs in 81.6% of patients; after spirulina administration, the number of patients with elevated CICs, both large and small, decreased significantly to 56%. **Figure 3**



**Fig. 3. Proportion of patients before and after spirulina supplementation with changes in CICs**

The reduction in CICs in HIV-infected patients on spirulina demonstrates the beneficial effects of these supplements on the immune system. **Figure 4.**

Circulating immune complexes are known to form after each antigen-antibody encounter and are destroyed by the efforts of mononuclear phagocytes upon completion of complement activation. The formation of circulating immune complexes is a physiological defense mechanism resulting in rapid elimination of both endogenous and exogenous antigens (viruses, microorganisms, plant antigens, parasites, fungal, food or pollen antigens) through the reticuloendothelial system. The authors have shown an association between CEC levels and T-lymphocyte activation. The concentrations of CICs containing immunoglobulin G directly correlated with the relative numbers of activated CD4<sup>+</sup> and CD8<sup>+</sup> T-lymphocytes.



**Fig. 4 Dynamics of large and small CICs in HIV-infected patients before and after spirulina administration**

## Conclusion

The study showed that the use of spirulina in HIV-infected patients improves the clinical condition, which was expressed in increased activity and efficiency and improved general condition. The immunity indicators of this category of patients have also improved, which makes it possible to recommend its use in treatment as an adjunct to the main therapy. The social significance of the method consists of improving the quality of life of HIV-infected patients on the background of improved general condition and immunity indicators in HIV-infected patients on the background of spirulina application. Restoration of immunological parameters in HIV infection prevents the development of various opportunistic infections, such as tuberculosis, CMV infection, and various bacterial and fungal infections.

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