COMPARATIVE IMMUNOSTIMULATING ACTIVITY OF NATURAL MEDICINAL BIOLOGICALLY ACTIVE SUBSTANCES OBTAINED FROM *CHLORELLA VULGARIS* IN EXPERIMENTAL IMMUNODEFICIENCY

Teshajonova Makhliyo Ma'rufjon kizi
Fergana State University
mteshajonova@gmail.com

Relevance. Protein deficiency remains one of the major global challenges in ensuring food security. According to the Food and Agriculture Organization (FAO), the growing world population, environmental constraints, and rising costs of livestock feed are expected to substantially increase the demand for nutritive proteins in the coming decades. In this context, identifying sustainable, renewable, and environmentally friendly biomass sources is of great scientific and practical value. One of the most promising candidates among such resources is the microalga ***Chlorella vulgaris***.***Chlorella*** is a unicellular green microalga known for its exceptionally high nutritional value, rapid growth, and rich biochemical composition. Often referred to as a "superfood," this microalga contains a diverse range of bioactive compounds essential for human health. The chemical profile of ***Chlorella*** demonstrates a high nutritive potential: its dry biomass consists of 40–55% high-quality protein, 30–35% complex carbohydrates, 5–10% lipids, and up to 10% macro- and microelements, including iron, magnesium, zinc, potassium, and phosphorus.The protein fraction of ***Chlorella*** contains more than 20 amino acids, most of which are biologically essential, including lysine, threonine, valine, leucine, and tryptophan—amino acids that cannot be synthesized by the human body. Thus, ***Chlorella*** protein may partially replace animal-based protein sources and serve as an important component of the diet in regions suffering from protein deficiency.Scientific studies report that ***Chlorella*** contains more than 650 biologically active compounds in higher concentrations than those found in many traditional food products. Among these, chlorophyll is particularly noteworthy: ***Chlorella*** possesses one of the highest chlorophyll concentrations among

all known plant organisms—up to 5–7 times more than higher plants. This makes ***Chlorella*** a unique natural agent for detoxification and antioxidant protection.

A remarkable feature of ***Chlorella*** is the presence of a naturally occurring probiotic compound called chlorellin, which exhibits strong antibacterial activity. Research has demonstrated that chlorellin is effective against ***Streptococcus***, ***Staphylococcus***, ***Escherichia coli***, and even ***Mycobacterium tuberculosis***, the causative agent of tuberculosis (Ya. Salnikova, 1977). This highlights its great potential for application in medicine, pharmacology, and veterinary science.

Chlorella was first described scientifically in 1890 by a Danish researcher. Later, in 1921, Beijerinck conducted extensive morphological and taxonomic characterization of ***Chlorella vulgaris***. The species belongs to a group of autotrophic protokoccal microalgae and is capable of rapid biomass accumulation—under optimal conditions, its biomass may double within 20–24 hours, which is a valuable property for biotechnological production.In Uzbekistan, the use of ***Chlorella vulgaris*** is especially relevant for livestock and aquaculture development. The Presidential Decree PQ-3657 (dated April 6, 2018) outlines strategic measures for the rapid development of the fisheries sector and improved production of high-efficiency feed additives. The ecological purity, low production cost, and high biological effectiveness of ***Chlorella***-derived products make them an excellent candidate for innovative applications in agriculture.Studies have shown that ***Chlorella***-based feed additives significantly enhance milk yield in cattle, accelerate growth in fish, and improve immune function in poultry. Biotechnological experiments confirm that bioactive components of ***Chlorella***—including proteins, polysaccharides, and vitamins—can stimulate immune responses and improve the overall physiological status of animals.***Chlorella vulgaris*** represents one of the most sustainable and efficient solutions to the global problem of protein deficiency. Its applications in food technology, pharmaceuticals, veterinary medicine, agriculture, and modern biotechnology have substantial scientific and practical potential.

Results and Analysis. Experimental studies were conducted to evaluate the immunostimulatory effect of natural medicinal biologically active compounds extracted from *Chlorella vulgaris*. To model immunodeficiency, experimental animals were induced with toxic hepatitis.

Results of the First Group. In intact animals, the average number of antibody-producing cells (APCs) in the spleen was 14621 ± 1029. Following the administration of CCI_4, a significant immunodeficiency state was observed, indicated by a 2.7-fold decrease in the number of APCs in the spleen. Similarly, a reduction was observed in the number of antibody-producing cells per 1 million splenocytes.Immunodeficiency was manifested not only by a decrease in APC numbers but also by a reduction in the number of nucleated splenic cells. The conformity index in this case was **–2.6**, indicating a pronounced suppression of immune function.Administration of natural biologically active compounds derived from *Chlorella vulgaris* led to an increase in APCs to 13429 ± 923, reflecting a 2.5-fold enhancement in immune activity. For comparison, animals treated with the immunomodulator Timogen showed an APC count of 11256 ± 876, confirming a high immunostimulatory effect.

Results of the Second Group. In the second group, intact animals had an average APC count of 21485 ± 1229 in the spleen. Following CCl_4 administration, APC levels dropped to 6575 ± 526**,** representing a 3.2-fold decrease**,** indicating a strong immunodeficiency state. Treatment with natural biologically active compounds from ***Chlorella vulgaris*** resulted in a significant recovery of immune function: the APC count increased to 20429 ± 800, representing a 3.1-fold **increase**. Similarly, the number of antibody-producing cells per 1 million splenocytes also increased.

The immunodeficiency state was evident not only from the reduction in APC numbers but also from a decrease in the number of nucleated splenic cells, highlighting the effect of the compounds on cellular immune recovery.

Analysis and Interpretation:

1. Natural bioactive compounds from *Chlorella vulgaris* stimulate both humoral and cellular immune responses**.**

2. The increase in APCs indicates enhanced B-lymphocyte activity and antibody production.
3. The rise in nucleated splenic cells reflects lymphocyte regeneration and recovery of the immune system.
4. Comparative results suggest that *Chlorella vulgaris* is an effective natural immunostimulant with high efficacy.

Overall, the results indicate that natural biologically active compounds obtained from *Chlorella vulgaris* can be used as an effective means to restore and enhance immune function.

References

1. Богданов, Н. Хлорелла – нетра дициональная кормовая добавка // Корм ление сельскохозяйственных животных и кормопроизводство. – 2007. – № 4. – С. 12.
2. Дудина Ю.А., Калашникова Е.А., Киракосян Р.Н. Создание фото биореактора для эффективного роста хлореллы и изучение влияния спек трального состава света на ее биомассу. Тимирязевский биологический жур нал. 2023;15-22.
3. Кулакова Т. С., Колесова Н. С. Сравнительный анализ микрофауны рубца зубров и лосей // Теоретические и прикладные аспекты современной на уки. – 2015. – № 8-1. С. 82-86.
4. Kakhorov, B. A., Rasulova, S. L., Zhumakulova, G. S., & Shavkatova, H. R. (2024). COMPLEX EVALUATION OF BIOSTIMULANTS FOR PREVENTION OF IMMUNE SYSTEM DISORDERS AND HIGHLY PRODUCTIVE COWS AND IMPROVEMENT OF MILK QUALITY. American Journal Of Biomedical Science & Pharmaceutical Innovation, 4(01), 39-45.
5. Kahorov, B. A., & Rasulova, S. L. (2023). INFLUENCE OF MODIFIED PEPTIDES FROM THE FETAL THYMUS ON THE ACTIVITY OF T-LYMPHOCYTES AND NATURAL KILLERS IN EXPERIMENTAL VIRAL HEPATITIS. American Journal Of Biomedical Science & Pharmaceutical Innovation, 3(12), 48-55.

6. GARIB, F. Y., KAKHOROV, B. A., KHUZHAMKULOVA, M. Z., & KUCHBOEV, A. E. (2021). Effect of modified peptides from fetal thymus on the activity of T-lymphocytes and natural killers and interferonindual activity of sanogen and betaleukin. International Journal of Pharmaceutical Research (09752366), 13(3).