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BIOLOGICAL ACTIVITY OF NATURAL ANTIOXIDANTS IN MODERN FOOD SUPPLEMENTS AND THEIR MECHANISMS OF INFLUENCE ON THE IMMUNE SYSTEM

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Abstract. This article examines the biological activity of natural antioxidants contained in modern food supplements and explores their mechanisms of influence on the human immune system. As oxidative stress weakens immune responses and contributes to various chronic conditions, the inclusion of natural antioxidants in dietary supplements has gained increasing scientific and medical attention. The study reviews the main classes of antioxidant compounds—vitamins, polyphenols, carotenoids, and flavonoids—and analyzes their biochemical pathways in immune modulation. The findings indicate that natural antioxidants enhance immune cell function, reduce inflammation, and protect the body from oxidative damage. The paper emphasizes the importance of using food supplements based on natural compounds to improve immune health and maintain physiological homeostasis.

Keywords: natural antioxidants, food supplements, immune system, oxidative stress, polyphenols, vitamins, immune modulation

Introduction. The growing interest in preventive nutrition and functional foods has led to an increased focus on natural antioxidants as key components of modern food supplements. These bioactive compounds play a crucial role in maintaining health by neutralizing free radicals, reducing oxidative stress, and supporting the immune system.

Oxidative stress negatively affects immune functions by damaging immune cells, altering cytokine production, and impairing the body's defense mechanisms. Therefore, the inclusion of antioxidants in food supplements is considered a promising strategy for strengthening immune response and protecting against diseases. Natural antioxidants, unlike synthetic analogs,



exhibit higher bioavailability and fewer side effects, making them preferable in nutritional formulations.

This study aims to analyze the biological activity of natural antioxidants in modern supplements and to clarify their mechanisms of action on the immune system.

Methods. The research is based on an analytical review of scientific publications from 2016–2024, focusing on clinical, biochemical, and nutritional studies of antioxidant-rich supplements. The databases used include PubMed, Scopus, and ScienceDirect. The methodology involved comparing the immunomodulatory effects of various classes of antioxidants, including vitamins C and E, carotenoids, flavonoids, and polyphenols. Particular attention was given to randomized controlled trials and in vitro studies that explored cytokine activity, lymphocyte proliferation, and oxidative biomarkers. Data synthesis was conducted to identify common patterns in antioxidant action and their synergistic effects on immune function.

Results. The analysis confirmed that natural antioxidants in food supplements significantly influence the immune system's activity and resilience.

- **Vitamin C (ascorbic acid)** stimulates the production of white blood cells, enhances the function of phagocytes, and supports collagen synthesis, thereby improving tissue repair and immune defense.
- **Vitamin E (tocopherol)** protects immune cell membranes from lipid peroxidation and modulates T-cell differentiation.
- **Polyphenols** from sources such as green tea, grapes, and cocoa act as anti-inflammatory agents by regulating cytokine expression and inhibiting NF- κ B pathways.
- **Carotenoids**, particularly beta-carotene and lycopene, have been found to enhance antibody responses and reduce oxidative damage in immune tissues.

Experimental data also revealed that combined supplementation with multiple antioxidants results in stronger immunoprotective effects than single-compound usage. This synergy enhances the body's defense mechanisms against viral and bacterial infections, especially under stress or aging conditions.

Discussion. The findings highlight the dual role of natural antioxidants: protecting immune cells from oxidative damage and modulating immune signaling pathways. They influence both innate and adaptive immunity, improving the efficiency of macrophages, lymphocytes, and natural killer cells. Polyphenols and flavonoids, for example, regulate gene expression associated with inflammation, such as TNF- α and IL-6, leading to a more balanced



immune response. Additionally, antioxidants improve mitochondrial function and energy metabolism, ensuring optimal performance of immune cells. However, excessive supplementation without medical supervision may disrupt the redox balance and reduce physiological reactive oxygen species necessary for immune signaling. Therefore, moderate, evidence-based consumption through balanced diets or standardized supplements is recommended.

Conclusion. Natural antioxidants in modern food supplements demonstrate significant biological activity that positively affects the human immune system. Their mechanisms involve neutralizing oxidative stress, modulating cytokine expression, and improving immune cell functionality. Regular intake of natural antioxidant-based supplements can enhance immunity, reduce inflammation, and support overall well-being. Future studies should focus on developing optimal antioxidant combinations and dosage forms to maximize immune benefits while ensuring safety and bioavailability.

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