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BIOTECHNOLOGY FOR OBTAINING BIOLOGICALLY ACTIVE SUBSTANCES FROM MICROALMS

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Abstract
This article analyzes modern biotechnological methods for obtaining biologically active substances (BAUs) from microalgae, their nutritional and pharmaceutical value, as well as their industrial applications. The increasing global demand for natural and safe products has made microalgae biotechnology one of the most promising areas. The article provides a detailed description of the technological stages of cultivation, biomass collection, and extraction processes.

Keywords: Microalgae, Chlorella, Spirulina (Arthrospira), and Haematococcus, Haematococcus pluvialis, Dunaliella salina.

Introduction

Currently, global population growth, environmental problems, and the negative impact of artificial chemical additives on human health necessitate the rational use of natural resources. One such source is microalgae. Microalgae are characterized by high photosynthetic activity, rapid reproduction, and adaptability to various climatic conditions. They are rich in proteins,

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carbohydrates, lipids, vitamins, and antioxidants necessary for the human body.[6]
Polyunsaturated fatty acids (PUFAs): In particular, omega-3 and omega-6 fatty acids (EPA, DHA, and GLA) play an important role in protecting the cardiovascular system.
Pigments: chlorophyll, carotenoids (beta-carotene, astaxanthin, lutein), and phycobiliproteins. They possess potent antioxidant and anti-inflammatory properties.
Polysaccharides: Complex carbohydrates that stimulate the immune system and fight viruses.[6]

Main types of microalgae and substances derived from them

Type of microalgae	Main biologically active substance	Field of application
Spirulina platensis	Spirulina platensis Phycocyanin, Gamma-linolenic acid, Protein Immunomodulator, Food	Immunomodulator, Food
Chlorella vulgaris	Chlorophyll, Growth Factor (CGF), Lutein	Detoxification, Dietetics
Haematococcus pluvialis	Astaxanthin (potent antioxidant)	Cosmetics, Pharmaceuticals
Dunaliella salina	Beta-carotene Source of	Vitamin A, Dyes

The first and most important stage of obtaining high-quality BFM from microalgae is their effective cultivation. Today, two main systems are used:
This method is mainly used in open pools in the form of a "raceway." Advantages: low cost, allows for the cultivation of large volumes of biomass. Nevertheless, there are some disadvantages.
there is a higher risk of pollution from the environment (bacteria, other algae), and it is more difficult to control temperature and light. For this purpose, the method of closed photobioreactors is currently used. Photobioreactors can be tubular, flat-panel, or spiral-shaped. In this system, all parameters (pH, temperature, CO_2 content, lighting) are monitored in a fully automated manner. The advantage of this method is its high productivity and the possibility of

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controlling the synthesis of a sterilized, targeted substance. Despite this, high energy and construction costs are observed. The resulting biomass is collected and separated.[7]

Due to the fact that microalgae cells are very small (2–20 µm) and are found in water in low concentrations (usually 0.5–5 g per 1 liter), biomass collection is the most costly part of the overall biotechnological process (approximately 20–30%).

The process of collecting microalgae includes the following methods:

1. Flocculation: Combining cells into large groups (lobes) using chemical or electrical means.
2. Centrifugation: Separating cells from water through high-speed spinning (the most efficient, but energy-intensive method).
3. Filtration: Filtration using membrane filters.
4. Flotation: Buoyancy of biomass using air bubbles.

Biologically active substances must be extracted from the collected microalgae. We know that the cell walls of many microalgae (e.g., Chlorella) consist of a very dense layer of cellulose. Breaking down this wall is required for the effective extraction of biologically active substances.

Currently, there are several methods of extraction;

1. Mechanical methods: High-pressure homogenization, milling.
2. Physical methods: Ultrasound and microwave radiation.

These methods create microcracks in the cell wall, accelerating the release of substances.

3. Chemical and enzymatic methods: Use of organic solvents (ethanol, hexane) or cell wall-dissolving enzymes (cellulose).
4. Supercritical liquid extraction: The most environmentally friendly and cleanest method available today. Under high pressure and temperature, carbon dioxide is transferred between the liquid and gas states, isolating pure lipids and pigments without harmful chemical solvents.[1]

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Microalgae powders (in tablet and capsule form) are widely used to boost immunity, cleanse the body of heavy metals, and compensate for vitamin deficiencies.

Lipids derived from microalgae reduce cholesterol levels. Pigments such as phycocyanin and astaxanthin are being studied for cancer (anti-tumor) prevention and as part of anti-inflammatory drugs.[6]

Due to its ability to protect the skin from ultraviolet (UV) radiation, slow down the aging process, and moisturize the skin, microalgae extracts are being added to expensive creams and masks.

Although microalgae biotechnology has enormous potential, there are a number of challenges on the path to commercialization:

• High production costs in closed systems.
• High energy consumption during the extraction process.
• The difficulty of maintaining sterility on an industrial scale.

In the future, the creation of transformed strains that synthesize more target substances using genetic engineering and the introduction of waste-free production methods (producing biofuel from biomass residues) based on the principle of "Green Technologies" will serve to solve these problems.[5]

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