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COPPER COMPOUNDS AS STRESS FACTORS AND REGULATORS IN PHYCOBIOTECHNOLOGY

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Metals are part of the structural component of the active centers of key enzymes involved in the reactions on which life is based. In the course of evolution, living organisms have developed mechanisms that allow them to acquire metals from the environment. The vast majority of metals with a known biological value belong to the category of microelements. The existence of natural habitates with a high content of metals, and recently anthropogenic pollution of the environment with metals, have led to the emergence of mechanisms for protecting cells from the harmful effects of increased amounts of these chemical elements.

Microalgae and cyanobacteria, especially freshwater ones, in their natural environment are deficient in essential metals and have effective mechanisms for their capture and active transport into cells. Under technological conditions, the replenishment of the nutrient medium with metals in various forms is an effective method for controlling cellular biosynthetic processes. At the same time, metals, especially those with variable valence, are a source of free radicals that can threaten both the biotechnological process and the quality of biomass. The effect depends not only on the amount of metal, but also on the chemical form in which it is present.

In the case of biotechnologies involving the cyanobacterium *Arthrospira platensis* (spirulina), this can be demonstrated using copper as an example. Copper is an important component of more than metalloenzymes, including superoxide dismutase and cytochrome c oxidase. At the same time, being in the ionic form, even at a concentration of 2.5 mg/l, copper disrupts the growth of the culture, and at a concentration of 0.1 mg/l causes serious changes, expressed in the deterioration of the biomass quality, a decrease in the activity of antioxidant enzymes, and accumulation of products of oxidative degradation of biopolymers.

As a structural part of the coordinating compounds, copper is tolerated by the spirulina culture in much greater amounts, even providing a stimulatory effect, the extent of which is determined by both the amount of metal and the nature of the coordinating agent used in the synthesis of compounds. Thus, using copper in the composition of the compound in an amount of from 1 to 20 mg/l, it is possible to obtain a spirulina biomass with a modified content of pigments, lipids, carbohydrates and proteins.

Copper nanoparticles also have a high biological activity against spirulina, which is determined by a number of factors, such as the size of the nanoparticles, the method of their synthesis, and their quantity. The biological activity of copper nanoparticles becomes noticeable already at a concentration of 1 μg/L. Thus, depending on the form and applied concentration, copper can be both a major stressor and an effective biotechnological regulator.

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