SYSTEM-BASED ANALYSIS OF *PSEUDOMONAS* SPP. FOR BIOTECHNOLOGICAL AND ECOLOGICAL APPLICATIONS

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Abstract

Pseudomonas species are ubiquitous bacteria that inhabit diverse ecological niches in both terrestrial and aquatic environments, and often live in association with plants and animals. They are characterized by a remarkable biosynthetic capacity and the production of a wide range of secondary metabolites, and they possess an extensive array of enzymes and metabolic pathways. Systems biology techniques and expanding genomic databases will greatly contribute to expanding the range of products generated through the manipulation of metabolic pathways.

Keywords: *Pseudomonas, biosynthetic capacity, metabolic pathways, biotechnology, ecology.*

Introduction. Members of the *Pseudomonas* genus are widely distributed bacteria inhabiting diverse ecological niches in both terrestrial and aquatic environments. They are distinguished by their remarkable biosynthetic capacity and the ability to produce a wide range of biologically active metabolites, which are applied in agriculture, medicine, and environmental remediation. The implementation of molecular biology methods, bioinformatics, and chromatographic analysis has facilitated the identification of the genetic and metabolic potential of *Pseudomonas* spp. for application in contemporary biotechnology [1].

The aim of this study was to conduct a systematic analysis and characterize specific metabolites produced by *Pseudomonas* species that are applicable in biotechnology.

Materials and methods. Relevant data were obtained through a comprehensive review of scientific databases, including NCBI, PubMed, and Google Scholar. Literature sources were identified using targeted keyword searches, followed by critical analysis and synthesis of the findings.

Results and discussion. The integration of modern approaches combining genomic and metabolic profiling has considerably expanded the potential applications of *Pseudomonas* species. These bacteria are widely utilized in the bioremediation of environments contaminated with toxic substances, including organic solvents, petroleum hydrocarbons, alkaloids, synthetic chemicals, pesticides, herbicides, and other organic pollutants. Key species used in the biodegradation of environmental pollutants include *P. putida* (organic solvents), *P. mendocina* (toluene), *P. pseudoalcaligenes* (cyanides), *P. veronii* (aromatic compounds), *P. knackmussii*, and *P. stutzeri* (chlorinated hydrocarbons). Furthermore, some species such as *P. fluorescens*, *P. paucimobilis*, *P. vesicularis*, *P. cepacia*, *P. testosteroni*, and *P. aeruginosa* have demonstrated the capacity to degrade polycyclic aromatic hydrocarbons (PAHs), which are considered highly hazardous due to their mutagenic and carcinogenic effects [2].

Within plant-soil-microbe ecosystems, *Pseudomonas* spp. colonize plant roots and synthesize biologically active compounds that suppress the growth of competing microorganisms. This antagonistic activity, particularly exhibited by strains of *P. fluorescens*, is utilized in the biocontrol of plant diseases. Their mechanism involves the production of siderophores, such as pyoverdine, which sequester iron and deprive pathogenic fungi of this essential micronutrient. Furthermore, *Pseudomonas* species can extract iron from siderophores synthesized by other rhizospheric microbes.

The biosynthetic capacity of *Pseudomonas* spp. to produce antibiotics has been extensively studied over the past few decades. Significant antimicrobial compounds include 2,4-diacetylphloroglucinol (DAPG), amphisin, oomycin A, phenazine [3], pyoluteorin, pyrrolnitrin, tensin, tropolone, various cyclic lipopeptides, and hydrogen cyanide. Some, like mupirocin (produced by *P. fluorescens*), are used in clinical practice, while others function as biocontrol agents or plant growth promoters.

In Ukraine, research into the biotechnological potential of *Pseudomonas* is ongoing. The Zabolotny Institute of Microbiology and Virology of the National Academy of Sciences of Ukraine has developed a plant protection product known as «Hauptsyn», effective against phytopathogenic bacteria and fungi. A promising medical antibiotic is batumin, isolated from a novel species, *P. batumici*, which exhibits strong and selective activity against *Staphylococcus* spp., making it a potential treatment of choice for eradicating staphylococcal strains [5].

Conclusions. The application of systems biology approaches enables the effective evaluation of *Pseudomonas* spp. for use in various biotechnological fields. Due to their ability to synthesize a wide array of biologically active metabolites, these bacteria have proven useful in agriculture by enhancing crop productivity and protecting plants (for example, through preparations such as Hauptsyn, Proradix, and Cedomon), in environmental bioremediation of chemically polluted sites (such as *P. putida*, *P. mendocina*, and *P. stutzeri*), in the pharmaceutical industry as producers of antibiotic compounds (e.g., *P. fluorescens*), and in medicine for the treatment of infectious diseases (such as mupirocin).

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