PLANT METABOLIC ENGINEERING AS A PROMISING METHOD FOR ALKALOID PRODUCTION

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Alkaloids are important pharmacologically active compounds widely used in medicine as analgesics, antitumor agents, antimalarial drugs, and neurotropic medications [1]. Their synthesis in natural plant systems is typically limited due to low biomass content, seasonality, and dependence on climatic conditions. In this context, the use of metabolic engineering methods aimed at optimizing alkaloid synthesis directly in plant cells becomes highly relevant. Metabolic engineering involves the rational modification of metabolic pathways in plant cells to increase the production of desired compounds.

Literature analysis has shown that the main strategies include: overexpression of enzymes catalyzing key reactions in alkaloid biosynthesis; introduction of foreign genes encoding enzymes from alternative pathways; suppression of competing metabolic branches; and redesign of regulatory elements using CRISPR/Cas systems [1–3]. Tropane alkaloids, in particular hyoscyamine and scopolamine, are valuable pharmacological substances with anticholinergic effects that are widely used in neurology and ophthalmology. Naturally, scopolamine is present in *Atropa belladonna* in only trace amounts, with hyoscyamine being the predominant alkaloid. An essential step in the biosynthesis of scopolamine is the enzyme hyoscyamine 6β-hydroxylase (H6H), which catalyzes the hydroxylation of hyoscyamine into scopolamine [2].

Literature analysis has shown that overexpression of the H6H gene in transgenic lines of *Atropa belladonna* significantly increases the conversion of hyoscyamine into scopolamine, leading to a higher final content of the latter in the plant. This approach not only optimizes the qualitative composition of the alkaloid profile but also makes the production of scopolamine more economically feasible. This example demonstrates the effectiveness of a single-point modification of a biosynthetic pathway to obtain a more pharmacologically valuable product by converting a dominant precursor.

Thus, plant metabolic engineering is a promising direction for the scalable biosynthesis of alkaloids, potentially reducing dependence on traditional medicinal plant cultivation. Future efforts in this field may focus on optimizing the regulation of metabolic pathways, improving the resistance of transgenic plants, and scaling up production processes for industrial application [2].

References:

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