Metabolic Engineering of Cyanobacteria for Efficient Production of Carotenoids

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Organisms smaller than a grain of salt can convert carbon dioxide into carotenoids, which have a market demand of $2.5 billion. Carotenoids can reduce the risk of type 2 diabetes, cancer, and cardiovascular diseases. However, current commercial carotenoid production relies on chemical synthesis, which has environmental drawbacks. However, a bacteria called Synechocystis sp. PCC 6803 can produce them naturally, though its natural production is low. So, this research employed metabolic engineering, salt stress, and sodium pyruvate supply to the culture to increase the production of two carotenoids, namely ß-cryptoxanthin and zeaxanthin, in Synechocystis sp. PCC 6803. The novelty lies in transferring a specific combination of three genes into Synechocystis sp. PCC 6803 to target ß-cryptoxanthin and zeaxanthin production. Specifically, heterologous dxs and ispA genes from Escherichia coli were overexpressed in Synechocystis sp. PCC 6803 to increase precursor supply for carotenoid biosynthesis. An efficient Citrus clementina ß-carotene hydroxylase enzyme was also utilized to direct the precursor supply toward ß-cryptoxanthin and zeaxanthin synthesis. Experimental results demonstrated that ß-cryptoxanthin production increased by a significant 22 fold, reaching 1.581 ± 0.038 mg/l, and zeaxanthin production increased by 3 fold, reaching 3.7706 ± 0.05 mg/l. It was also found that salt stress with 0.25% of sodium chloride significantly increased the production of carotenoids. Moreover, sodium pyruvate supply increased the production of ß-cryptoxanthin by 14%. These production levels are promising for commercialization in the food and pharmaceutical industries, as these carotenoids can be used as food colorants or supplements due to their various health benefits.

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