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Extended Abstract

A Review of Phycobiliproteins of Cyanobacteria: Structure, Function and Industrial Applications in Food and Pharmaceutical Industries

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Abstract
Phycobiliproteins are accessory photosynthetic pigments with a tetrapyrrole structure derived from bacterial strains that are organized on a thylakoid membrane inside a structure called phycobilisomes. Phycobiliproteins have been extensively commercialized in the manufacture of fluorescent probes for clinical and immunological analysis, in addition to their ability to dye with proven antioxidant and medicinal properties. Phycocyanin, Phycoerythrin and Allophycocyanin are the main types of phycobiliproteins that are widely used as useful food supplements today; however, in Iran, the true value of this natural pigment with bioactive properties has not been realized. Todays, the use of artificial colors and antioxidants in food product has led to an increase in cancer in many people. Therefore, awareness of the presence of natural food pigments of natural origin is of particular important. On the other hand, since so far no review article on extraction, separation and purification as well as evaluation of the biological activity of the pigment Phycoerythrin and Phycocyanin, has been published in Iran, so such review articles can pave the way for the introduction of natural edible pigments from cyanobacteria are considered to be usable in the food industry. Therefore, the purpose of this review article is to introduce the structure, function, biosynthesis and different methods of extraction of Phycobiliproteins in industrial dimensions along with different applications of Phycocyanin in food and pharmaceutical industries.

Keywords: Cyanobacteria, Food and pharmaceutical industries, Natural pigments, Phycobiliproteins, Phycocyanin

Introduction

Phycobiliproteins are large protein masses that play an important role in light collection and are classified into Phycoerythrin and Phycocyanin based on their spectral properties. Phycobiliproteins have many applications in the food, cosmetics, biotechnology, diagnostic, and pharmaceutical industries (Sekar & Chandramohan, 2008). The therapeutic value (anticancer activity) of Phycocyanin has been accepted for many years. The addition of Phycocyanin is the most important aqueous pigment used in the food and biotechnology industries and has many properties in the field of fluorescein and antioxidants (Carvalho *et al*., 2013) focus on Phycocyanin pigments. The use of various synthetic preservatives, which have been used for more than half a century to increase the shelf life of food products, has led to an increase in cancer in humans. On the other hand, the widespread use of bioactive compounds that have been used to treat humans and animals for more than half a century has led to a significant reduction in the effectiveness of many of them (Nowruzi, Haghighat, Fahimi, & Mohammadi, 2018). In addition, the number of new bioactive compounds introduced in today's world has decreased dramatically. Therefore, the search for natural food pigments with new antioxidant properties is of particular importance (Nowruzi, Sarvari, & Blanco, 2020a, 2020b). In the present article, first the structure and function of Phycobilin, biosynthesis pathways and their maps are examined, then, with the review of the latest scientific achievements, the extensive applications of phycobiliproteins in industry are discussed.

Applications of phycobiliproteins

When phycobilisomes are extracted in aqueous buffers, they break down, lose their excitatory energy, and become fluorescent. In fact, phycobiliproteins have high molar coefficients and high fluorescence quantum efficiencies (Jaiswal, Singh, & Prasanna, 2008). Phycobilisomes are the most widely used in fluorescent probes and have a quantum fluorescence efficiency of 98-82% (Encarnação, Pais, Campos, & Burrows, 2015).

C-phycocyanin trimmers with chemical stabilization can be used as fluorescent probes. Phycobilisomes consisting of c-phycocyanin and allophycocyanin isolated from *spirulina platensis* are also chemically combined with streptavidin and grown as fluorescent probes in cytometry under the conditions of the bacterium.

Today there is a growing demand for the use of natural dyes in food, medicine, cosmetics and textiles. But problems such as low durability limit their use. However, due to the toxic effect of several synthetic dyes, there is a greater tendency to use natural dyes for different uses. Phycobiliproteins are used as a natural protein dye in the food and cosmetics industries (de Amarante, Braga, Sala, & Kalil, 2020). Phycocyanin, despite its low stability to heat and light, is more effective than gardenia and indigo and produces a light blue color in coated chewing gums and candies. Phycocyanin pigment is also used to color many foods, fermented milk, ice cream, soft drinks, desserts, cake decorations, chocolate milk, and cosmetics (de Amarante et al., 2020).

Industrial extraction of phycobiliproteins

C-phycocyanin can be extracted from cyanobacteria and microalgae in a variety of ways. The use of dried biomass at low temperatures, high temperatures and freeze/thaw cycles are the most efficient methods for extracting c-phycocyanin from the biomass of cyanobacteria. Of course, disruption of cell mechanism, high pressure exposure, and sonication are other methods of extraction. In industry, not only phycobilin pigments are used, but also water-soluble forms, namely the forms of allophycocyanin and phycocyanin, are used by various industries (Nowruzi, Fahimi, & Sturion Lorenzi, 2020).

Extraction from cyanobacteria is not easy due to the special nature of their multilayer cell wall and the presence of contaminants, therefore, extraction generally results in high purity or high efficiency. Isolation typically consists of two steps: (1) release of intracellular content by pretreatment to produce crude extract (e.g., sedimentation, centrifugation, or other treatments, including microwave extraction; (2) stepwise phase separation / Separates by conventional methods (Nowruzi, Fahimi, *et al*., 2020).

Today, the spirulina extract is used in the food industry to color food instead of phycobilin, which is a very expensive refined protein. In fact, during the production of spirulina on a large scale, due to the presence of biotic and non-living stressors (contamination with microorganisms or heavy metals), considerable amounts of low quality spirulina are obtained. Low-quality spirulina is not suitable for direct human consumption, but may be used as a source for the separation and purification of food coloring or other phycobiliprotein food coloring (Eriksen, 2008).

Conclusions

In the last 10 to 15 years, the use of phycobiliprotein pigments has become very common in the food and pharmaceutical industries. Today, many of the limitations of using protein pigments with genetic engineering techniques have been removed and stabilized, and new purification methods have resulted in highly pure pigments with high yields. The successful nutritional or pharmacological applications of the produced c-phycocyanin depend on fully controlled conditions that are difficult to achieve in open culture media. Therefore, the production of recombinant pigments with new synthesis methods on an industrial scale can be very economical and increase its use in the pharmaceutical and food industries.

Extended Abstract

References

Carvalho, L. R., Costa-Neves, A., Conserva, G. A., Brunetti, R. L., Hentschke, G. S., Malone, C. F., . . . Rangel, M. (2013). Biologically active compounds from cyanobacteria extracts: in vivo and in vitro aspects. *Revista Brasileira de Farmacognosia, 23*(3), 471-480. doi:https://doi.org/10.1590/S0102-695X2013005000037

de Amarante, M. C. A., Braga, A. R. C., Sala, L., & Kalil, S. J. (2020). Colour stability and antioxidant activity of C-phycocyanin-added ice creams after in vitro digestion. *Food Research International, 137*, 109602. doi:https://doi.org/10.1016/j.foodres.2020.109602

Encarnação, T., Pais, A. A., Campos, M. G., & Burrows, H. D. (2015). Cyanobacteria and microalgae: a renewable source of bioactive compounds and other chemicals. *Science progress*, *98*(2), 145-168. doi:https://doi.org/10.3184/003685015X14298590596266

Eriksen, N. T. (2008). Production of phycocyanin—a pigment with applications in biology, biotechnology, foods and medicine. *Applied microbiology and biotechnology, 80*(1), 1-14. doi:https://doi.org/10.1007/s00253-008-1542-y

Jaiswal, P., Singh, P. K., & Prasanna, R. (2008). Cyanobacterial bioactive molecules—an overview of their toxic properties. *Canadian Journal of Microbiology, 54*(9), 701-717. doi:https://doi.org/10.1139/W08-034

Nowruzi, B., Fahimi, H., & Sturion Lorenzi, A. (2020). Recovery of pure C-phycoerythrin from a limestone drought tolerant cyanobacterium Nostoc sp. and evaluation of its biological activity. *Anales de Biología, 42*, 115-128. doi:http://dx.doi.org/10.6018/analesbio.42.13

Nowruzi, B., Haghighat, S., Fahimi, H., & Mohammadi, E. (2018). Nostoc cyanobacteria species: a new and rich source of novel bioactive compounds with pharmaceutical potential. *Journal of Pharmaceutical Health Services Research, 9*(1), 5-12. doi:https://doi.org/10.1111/jphs.12202

Nowruzi, B., Sarvari, G., & Blanco, S. (2020a). Chapter 28- Applications of cyanobacteria in biomedicine *Handbook of Algal Science, Technology and Medicine* (pp. 441-453): Elsevier.

Nowruzi, B., Sarvari, G., & Blanco, S. (2020b). The cosmetic application of cyanobacterial secondary metabolites. *Algal Research, 49*, 101959. doi:https://doi.org/10.1016/j.algal.2020.101959

Sekar, S., & Chandramohan, M. (2008). Phycobiliproteins as a commodity: trends in applied research, patents and commercialization. *Journal of Applied Phycology, 20*(2), 113-136. doi:https://doi.org/10.1007/s10811-007-9188-1