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The Science and Applications of Natural Red Pigments: From Extraction to Innovation

Natural Pigments: Sources, Properties, and Health Benefits • Book Chapter • 2026

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Abstract

This book chapter explores the significance of natural red pigments, focusing on their sources, extraction methods, applications, challenges, and future prospects. Natural red pigments, derived from various plant, microbial, and animal sources, have been used historically in food, cosmetics, textiles, and pharmaceuticals due to their vibrant hues and potential health benefits. The chapter examines key natural red pigments, such as betalains, anthocyanins, and carotenoids, highlighting their distinct chemical properties and diverse uses across industries. The extraction processes, ranging from traditional methods to advanced technologies like supercritical fluid extraction (SFE) and microwave-assisted extraction (MAE), are also discussed in-depth. These techniques not only improve efficiency but also address challenges related to sustainability, yield, and cost-effectiveness. Moreover, the chapter addresses the growing demand for natural colourants, driven by consumer

preferences for clean-label and eco-friendly products, and the need to replace synthetic dyes that pose health and environmental risks. Despite their advantages, natural red pigments face challenges in terms of stability, cost, and sourcing. Issues like light degradation and temperature sensitivity impact their effectiveness, while the sourcing of raw materials raises ethical and environmental concerns. The chapter provides insight into innovative solutions, such as biotechnological advancements, microbial fermentation, and synthetic biology, which offer promising alternatives for mass production. Looking ahead, the future of natural red pigments is promising, with advancements in biotechnology, sustainable sourcing, and consumer awareness driving innovation. The chapter concludes by exploring the potential for natural pigments in emerging markets, as well as the ongoing research needed to further develop cost-effective, stable, and scalable natural colourants. This work contributes to a deeper understanding of natural red pigments and their growing role in a sustainable, eco-conscious future.

Author keywords

anthocyanins; betalains; carotenoids; natural colourants; red pigments

Indexed keywords

Engineering controlled terms

Biotechnology; Carotenoids; Cost effectiveness; Extraction; Market Research; Synthetic biology; Vat dyes

Engineering uncontrolled terms

Application prospect; Betalains; Extraction method; Future prospects; Microbials; Natural colorants; Natural red; Potential health; Red pigments; Source extraction

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