Vegetos
https://doi.org/10.1007/s42535-025-01269-z

RESEARCH ARTICLES

Studies on stability of extracellular red *Monascus* pigments and impact on viability of probiotic bacteria

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Received: 10 December 2024 / Revised: 27 February 2025 / Accepted: 19 March 2025
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Abstract
In this study, the application of extracellular red pigment produced by non-toxic *Monascus purpureus* (NMCC-PF01) was explored in the food sector. The red Monascus pigments (RMPs) underwent various assessments, including stability testing, and examination of its effect on the viability of probiotic bacteria (Lactobacillus and Bifidobacterium). The results demonstrated that the RMPs exhibited stability above 80% at pH levels ranging from 6 to 8, 71–97% at temperatures between 30 and 60 °C, and more than 84% when exposed to elevated salt concentrations. However, the stability of the RMPs was significantly reduced under acidic conditions, high temperatures (>60 °C), and direct exposure to sunlight. Furthermore, the presence of RMPs did not adversely affect the viability of probiotic bacteria, indicating their compatibility with these beneficial microorganisms. These results suggest that the non-toxic RMPs can be incorporated into food products as colorants to enhance their visual appeal, and also contribute to enhance the antioxidant activity without compromising the viability of probiotic strains.

Keywords Monascus · Extracellular pigment · Lactic acid bacteria · Stability · Non-toxic

Introduction

The influence of colors on our lives goes beyond mere aesthetics, as they possess a unique power to convey symbolic and associative information about various products (Garber et al. 2000). In the realm of gastronomy, colors play a pivotal role, adding an essential characteristic to food that is renowned for its visual appeal. Food colors not only contribute to the aesthetic value of dishes but also provide important visual cues for identifying flavors, determining taste thresholds, assessing overall quality and moreover indication of food spoilage (Aberoumand et al., 2011; Bridle and Timberlake 1997). Recognizing these benefits, food manufacturers have incorporated colors into their products for various purposes, such as enhancing color intensity, compensating for color loss during processing, reducing batch variations, and coloring uncolored foods with vibrant hues (Vendruscolo et al. 2013).

When it comes to food additives, both natural and synthetic colorants have been authorized for use (Mapari et al. 2005). However, the remarkable stability exhibited by synthetic dyes under various conditions, including temperature, pH, and high pressure, presents a significant challenge in replacing them with colorants derived from natural sources (Vendruscolo et al. 2013). Although synthetic colors offer stability, concerns about their potential toxic effects are widespread (Amchova et al. 2015; El-Wahab and Moram 2013; Malabadi et al. 2022).

Within the realm of natural colors, pigments produced by fungal species, have emerged as a promising solution for various applications, ranging from food to pharmaceuticals and textiles, as highlighted by Lagashetti et al. (2019). The food industry, in particular, has witnessed the rise of fungal pigments as desirable alternatives to traditional synthetic colorants. Monascus pigments, arpink

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Published online: 23 April 2025