Biotechnological production of pigments from residues of orange processing using the filamentous fungi *Monascus purpureus* and *Penicillium purpurogenum*

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Interest in fungal pigments is flourishing, due to rapid fungal growth, wide color range and production of different chemical structures. Microbial pigments are produced as secondary metabolites with known or unknown functions. Current industrial production of natural pigments in Asian countries is prevailed by fungal strains belonging to the *Monascus* genus. *Monascus* pigments are secondary metabolites including yellow (monascin and ankaflavin), orange (rubropunctatin and monascorubin) and red (rubropunctamine and monascorubramine), constituents, depending on the culture conditions. Apart from pigments, lovastatin (monakolin K), γ-aminobutyric acid, dimerumic acid and citrinin (a hepato-neuro-toxic mycotoxin) comprise other *Monascus* important metabolites. Red and yellow pigments from *Monascus sp*. are characterized as GRAS 1 in Asian countries enabling industrial manufacture and implementation as food additives. However, the plausible side effects by citrinin restrain the commercial application of *Monascus* pigments in the European Union and the United States. In this study, *Penicillium purpurogenum* CBS 113139 was employed for the production of *Monascus* like pigments (monascorubramine and monascin) in the absence of mycotoxins. Previous reports on *P. purpurogenum* pigment production in solid and liquid media demonstrated the absence of toxicity (Hailei et al., 2011). To the best of our knowledge, little information is available on the production of *Monascus* like pigments by *P. purpurogenum* specifically on agro-industrial waste streams and by-products.

The orange processing industry generates significant quantities of by-product streams, such as orange peels that contain pectin (42.5% w/w) and D-limonene (4.0% w/w) that could be extracted as added-value products. Solid residues from citrus processing are currently utilized as animal feed or for energy generation. In this study, solid residues from orange processing were used as the sole nutrient substrate for the production of pigments by *Monascus purpureus* ATCC 16365 and the chemo-taxonomically selected non-toxigenic strain *Penicillium purpurogenum* CBS 113139. Pigment production was performed in solid-state fermentation focusing on the evaluation of different extraction methods for intracellular and extracellular pigment production, the effect of particle size as well as the effect of nitrogen sources and incubation time. Moreover, submerged fermentations were conducted aiming to valorize orange peel residues without the addition of conventional nutrient supplements. Consumption of sugars and free amino nitrogen was determined in order to elucidate microbial growth and pigment synthesis. The total phenolic content and antioxidant capacity were also assessed. Comparison in terms of pigment production was carried out for both fungal strains under the same cultivation conditions. The present study demonstrates the potential of implementing orange peel residues as substrate for fermentative production of natural pigments without mycotoxin synthesis.

References

Hailei A, Zhifang R, Ping L, Yanchang G, Guosheng L, Jianming Y. 2011. Improvement of the production of a red pigment in *Penicillium* sp. HSD07B synthesized during co-culture with *Candida tropicalis*. Bioresource Technology, 102:6082-6087.