

Phenolic Compounds from Wine Industry By-Products: Antioxidant and Antimicrobial Potential against Antibiotic-Resistant Bacteria

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Wine production represents a key economic and cultural sector in Portugal, generating significant volumes of by-products that are often underutilized and may pose environmental challenges. Grape pomace and associated residues, including seeds, skins, and stems, account for approximately one-fifth of the total grape mass processed during vinification. Despite being commonly treated as waste, these materials are rich in bioactive compounds, particularly phenolic compounds, which are recognized for their antioxidant and antimicrobial properties and their potential applications in food, cosmetic, and pharmaceutical industries.

Simultaneously, the increasing prevalence of antibiotic-resistant bacteria has intensified the search for alternative or complementary antimicrobial agents. In this study, phenolic compounds were recovered from grape seeds, skins, and stems derived from three grape varieties cultivated in the Douro region, including Touriga Nacional and Preto Martinho. The chemical profile of the extracts was characterized by high-performance liquid chromatography (HPLC), and their antioxidant capacity and antimicrobial activity were evaluated against selected antibiotic-resistant bacterial strains.

The analysis revealed that anthocyanins were the predominant phenolic compounds in grape skins, while catechins were more abundant in seeds and stems. All extracts exhibited antioxidant activity, highlighting their potential role in mitigating oxidative stress and supporting cellular regeneration processes. Additionally, the phenolic extracts demonstrated inhibitory effects against several antibiotic-resistant bacteria, with greater efficacy observed against Gram-positive strains. Although the antimicrobial activity was not sufficient to replace conventional antibiotics, the results suggest that grape by-product extracts may serve as valuable complementary agents.

Overall, this work demonstrates the potential of wine industry by-products as sustainable sources of high-value bioactive compounds. Their valorization contributes to waste reduction and resource efficiency while offering promising perspectives for addressing antimicrobial resistance within a circular economy framework.

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