

Valorization of Black Cumin and Pumpkin Seed Press Cakes: Comparative Evaluation of Enzymatic and Ultrasound-Assisted Protein and Antioxidant Recovery

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Abstract

In this study, protein and antioxidant recovery from cold-pressed black cumin (*Nigella sativa*) and pumpkin seed (*Cucurbita pepo*) press cakes was evaluated using enzymatic extraction (EE) and ultrasound-assisted enzymatic extraction (EE-UAE) within a green extraction framework. Oilseed press cakes, often underutilized despite their high protein and bioactive compound content, represent a promising resource for sustainable valorization.

Pumpkin seed press cake exhibited a composition of 7% moisture, 6% ash, 53% protein, 7% fat, and 18% carbohydrates, confirming its strong potential as a protein-rich by-product. Ultrasound-assisted enzymatic hydrolysis resulted in a process yield of approximately 34% (w/w) after freeze-drying, indicating effective recovery of soluble components. However, this value represents total dry matter recovery, and precise protein recovery will depend on the protein content of the hydrolysates, which is currently under analysis. The combined effect of enzymatic hydrolysis and ultrasound facilitated matrix disruption and enhanced the release of bioactive compounds.

Although comparative numerical results between EE and EE-UAE are still under evaluation, the obtained yield confirms the feasibility of producing protein-rich hydrolysates from oilseed residues. Previous studies report that enzymatic hydrolysis enhances the release of bound phenolics and bioactive peptides, while ultrasound improves extraction efficiency through cell disruption and mass transfer, increasing protein recovery and antioxidant capacity (Chemat et al., 2017; Görgüç et al., 2019; Sert et al., 2022).

This study aims to validate these improvements and support the sustainable valorization of oilseed processing by-products.

Keywords: Black cumin press cake, pumpkin seed press cake, enzymatic extraction, ultrasound-assisted extraction, Alcalase, protein recovery, antioxidant activity, green extraction, life cycle assessment