Fostering the Transition to Sustainable Food Systems:

Embracing Novelty and Overcoming Challenges

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Aim: The valorisation of agro-industrial by-products represents a strategic approach toward reducing food processing waste while fostering circular bioeconomy practices. Peanut skin, a by-product of peanut processing, is particularly rich in phenolic compounds with significant antioxidant and antimicrobial properties, making it a promising candidate for sustainable applications in the cosmetic and textile industries.This study explores the upcycling of peanut skin via eco-friendly extraction technologies to obtain phenolic-rich bioactives suitable for skin-related applications and functional textiles.

Method: We investigated the impact of four extraction methodologies - hydroethanolic, aqueous, alkaline, and ultrasound-assisted extraction (UAE) - on the yield and chemical composition of peanut skin extracts. Analytical assessments included quantification of protein, total carbohydrates, total phenolic content (TPC), total flavonoid content (TFC), and antioxidant capacity via the ORAC assay. The phenolic composition was further elucidated through LC-ESI-QqTOF-HRMS. Additionally, the antimicrobial efficacy of the extracts was tested against representative Gram-negative and Gram-positive bacteria. Furthermore, the metabolic impact of the extracts on a human keratinocyte cell line (HaCat) was also assessed to evaluate biocompatibility.

Results: Among the methods tested, the UAE yielded the highest total phenolic content (512.93 mg GAE/g DE) and antioxidant activity (2770.17 µmol TE/g DE). The phenolic profile revealed that peanut-skin extracts were rich in type-A and type-B procyanidin dimers and trimers, with type-A dimers being the most abundant, accounting for up to 36.47% of the total phenolics in UAE. These compounds are known for their strong antioxidant and antimicrobial efficacy. Antimicrobial assays showed that alkaline extracts exhibited the most potent activity, inhibiting *Staphylococcus aureus* and *S. epidermidis* at 5 mg/mL and 2.5 mg/mL, respectively. Hydroethanolic and UAE extracts exhibited moderate inhibition at higher concentrations. In contrast, the aqueous extracts were inactive against all tested bacteria. When considering the extracts impact on HaCaT cells, the lowest cytotoxicity was observed for the hydroethanolic extract (500 µg/mL), and the highest for UAE (62.5 µg/mL).

Conclusion: These findings highlight the potential of UAE for enhancing the recovery of phenolic compounds from peanut skin. The high antioxidant and antimicrobial activities of the enriched extracts, supports their application in skin-related products including textiles.