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Coffee pulp valorization: effects of fermentation and brewing conditions on chemical composition and functional properties

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Coffee processing generates substantial amounts of residual biomass, including coffee pulp and husk, which represent promising sources of bioactive compounds for the development of value-added food products. However, their utilization remains limited by variability in chemical composition and by the influence of processing conditions on the quality of derived products. In this context, the valorization of coffee cascara through controlled fermentation and optimized extraction processes offers opportunities to improve its functional properties and promote the sustainable use of coffee by-products. Cascara contains phenolic compounds, caffeine, organic acids, sugars, and minerals, whose concentrations and interactions influence its physicochemical characteristics and potential sensory attributes. Fermentation with native coffee yeasts, particularly *Wickerhamomyces anomalus* and *Kazachstania humilis*, promotes biochemical transformations involving sugar consumption, organic acid production, and changes in volatile compounds. These transformations may increase phenolic content and antioxidant activity while modifying the aromatic profile through the formation of compounds associated with floral and fruity notes. In addition, brewing conditions significantly affect the chemical characteristics of cascara beverages. Cold brewing at different temperatures influences the concentrations of phenolic compounds, flavonoids, caffeine, minerals, and melanoidins, as well as color, acidity, and antioxidant capacity. High-performance liquid chromatography, gas chromatography–mass spectrometry, spectrophotometric methods, and inductively coupled plasma mass spectrometry provide complementary analytical approaches for characterizing these changes. Nevertheless, improvements in chemical composition do not necessarily translate into greater sensory acceptance, highlighting the need to integrate instrumental characterization with descriptive sensory analysis and consumer studies. Overall, controlled fermentation and appropriate extraction conditions represent promising strategies for transforming coffee cascara into value-added beverages, contributing to the valorization of residual biomass, product diversification, and more sustainable coffee production systems.

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