

Harnessing the bioactive potential of coffee extracts: comparative analysis of green and roasted coffee-based semisolid formulations for antioxidant and antimicrobial skin care applications

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Abstract. Significant interest in plant-derived bioactive compounds has been fueled by the demand for effective, sustainable, and natural skincare solutions. Coffee and caffeine stand out as particularly promising ingredients, thanks to their well-established antioxidant, anti-inflammatory, and antimicrobial characteristics. This study investigates the formulation and assessment of innovative semisolid products enhanced with extracts from coffee beans and caffeine, responding to the increasing need for natural, sustainable, and effective options in both pharmaceutical and cosmetic skincare. The formulations utilized aqueous extracts from both green and roasted coffee beans (Arabica and Robusta), alongside synthetic caffeine, to facilitate a comparative analysis. These formulations demonstrated enhanced sensory properties and optimal compatibility with skin pH levels. Rheological analysis revealed thixotropic and pseudoplastic behavior with variable hysteresis loops. Four formulations with optimal characteristics were further evaluated for antioxidant activity (using photo-chemiluminescence) and antimicrobial properties (using the diffusion method). This study highlights the impact of coffee species and processing methods on the antioxidant activity of pharmaceutical formulations. Composites containing green Arabica coffee aqueous extract obtaining at room temperature (e.g., C11) exhibited slightly higher antioxidant activity compared to those with roasted Arabica coffee aqueous extract obtaining by hot water infusion (e.g., C2), indicating a processing-related enhancement (C11 > C2). Similarly, formulations with green Robusta coffee aqueous extract obtaining at room temperature (e.g., C12) showed superior antioxidant activity compared to those with roasted Robusta coffee aqueous extract obtaining by hot water infusion (e.g., C3), emphasizing the influence of coffee type and preparation on the bioactive properties (C12 > C3). Notably, two formulations (C2 and C3) containing roasted coffee extracts demonstrated antimicrobial activity against reference strains *Staphylococcus aureus* 25923 (Gram-positive) and *Escherichia coli* ATCC 25922 (Gram-negative), forming inhibition zones of 11 mm and 15 mm. These findings highlight the potential of caffeine-based formulations with coffee extracts for skin protection and care. Overall, this study highlights the potential of caffeine-based formulations enriched with coffee extracts for dermatological applications. The influence of coffee species, processing methods, and extraction techniques on antioxidant and antimicrobial properties underscores their significance in the development of effective and multifunctional skincare solutions.

Keywords: caffeine; antioxidant capacity; antimicrobial activity; cosmetic formulations; skin care.

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