

## Extraction and Microencapsulation of Bromelain Enzyme from Philippine *Ananas comosus* (Pineapple) Peels: Application and Safety Evaluation in Cosmetics

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**Abstract :** The Philippines is one of the leading pineapple producers in Southeast Asia. A massive amount of pineapple peels is being discarded from the pineapple food industry, which are considerably rich sources of bromelain, a protease enzyme known for its therapeutic applications in the pharmaceutical and cosmetic industry. Throughout the year, significant progress was made in the extraction, partial purification, and microencapsulation of bromelain from pineapple peels, leveraging its antioxidant, anti-inflammatory, and natural exfoliating properties for potential cosmetic applications. Bromelain specifically hydrolyses the peptide bonds of proteins in the stratum corneum, induces biological exfoliation and faster skin regeneration, and facilitates the penetration of active substances. In this study, bromelain from pineapple peels was extracted and purified through an aqueous two-phase system (ATPS) using 30% MgSO<sub>4</sub> and 5% PEG-4000. The process resulted in the separation of two distinct phases: a polymer-rich phase containing the bromelain enzyme and a salt-rich phase. The polymer-rich phase was retained and further processed. Notably, the ATPS method yielded over 100% enzyme recovery, validating its efficiency in purifying bromelain. Quantitative determination of protease activity, which reflects the exfoliating properties of bromelain, was conducted using the Murachi method and resulted in 3.78-3.85 U/mL. The purified enzyme was freeze-dried and pulverized to extend the shelf life and subsequently analyzed for enzymatic activity resulting in 3.08 U/g. The bromelain powder was applied to standardized cosmetics formulation. The amounts of bromelain included are 2% in body serum, 5% in clay scrub, and 5% in gel cleanser at various pH ranges from 5-7, which is conducive to the stability of bromelain. These developed formulations were further assessed for safety in terms of heavy metal analysis and microbiological profiling, where all parameters passed the ASEAN Guidelines on Limits of Contaminants for Cosmetics. Moreover, results of the Repeat Insult Patch Testing of the products among normal adult subjects show that the products may be considered generally low risk for hypersensitivity reactions. No irritant reactions were found; thus, the products are generally safe to use for normal skin.

**Keywords :** active ingredient, aqueous two-phase system, bromelain, cosmetics, pineapple peels

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