Junior Science Communications
Faculty of Applied Sciences, UiTM Shah Alam
https://journal.uitm.edu.my/ojs/index.php/JSC

E-ISSN 2637-0689
Vol 65 2026

Colloquium on Applied Sciences 1 2026
19-22 January 2026, Faculty of Applied Sciences, UiTM Shah Alam, Malaysia

Preparation and Physicochemical Characterization of Microcapsules Loaded with Postbiotics for Topical Cream Development

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Structured Abstract

Background: Postbiotics have emerged as promising bioactive agents for skin enhancement purposes, but hindered by its susceptibility to degradation and induced skin irritation upon direct application. This study introduced microencapsulation via extrusion technique using combined alginate and xanthan gum formulation as encapsulating materials as an effective strategy to maintain postbiotic stability while ensuring safety upon skin application. Despite the addressed reliable encapsulating properties across multiple studies, their application for postbiotic delivery in topical formulation remains underexplored. The postbiotic-loaded microcapsules were characterised to evaluate polymer-postbiotic interactions, structural organisation, thermal stability, and morphological features. Surface and pore characteristics were further assessed following incorporation of the postbiotic-loaded microcapsules into a topical cream over an 8-hour period to determine structural integrity and formulation compatibility.

Methods: The postbiotic-loaded microcapsules were prepared through an extrusion technique using Alginate and Xanthan gum as wall materials and postbiotics from *L. johnsonii*. The physicochemical properties were characterised using Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Scanning Electron Microscopy (SEM), and Brunauer-Emmett-Teller (BET). Statistical Analysis was performed using One-way Analysis of Variance (ANOVA).

Results: FTIR analysis confirmed non-covalent interactions via hydrogen bonding and electrostatic interactions in postbiotic-polymer matrix. XRD results showed postbiotic incorporation induced amorphization, suggesting homogeneous dispersion of postbiotic components. Thermal analyses (TGA and DSC) demonstrated that postbiotic-loaded microcapsules remained thermally stable below ~180 °C, suitable for manufacturing processes. SEM observations revealed smoother, more homogeneous surfaces compared to the rough, crystalline morphology of empty microcapsules. Finally, BET analysis demonstrated statistically insignificant changes in surface area and pore properties following incorporation into the cream ($p > 0.05$), reflecting compromised overall structural integrity.

Conclusion: In conclusion, the physicochemical properties of postbiotic-loaded microcapsules were successfully determined using FTIR, XRD, TGA, and DSC. The morphological properties of postbiotic-loaded microcapsules were also determined using SEM, and BET analysis confirmed the maintained structural integrity of postbiotic-loaded microcapsules after incorporation in topical cream.

Keywords: Postbiotics, Alginate, Xanthan Gum, Microcapsules, Topical Application

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