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

Morphological Properties of Microcapsules Loaded with Postbiotics and Its Release Properties in Simulated Skin Condition

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Structured Abstract

Background: Postbiotics derived from lactic acid bacteria have shown promise for topical therapeutic application. However, their stability and controlled release under skin conditions remain challenging and poorly reported in literatures. This study investigated alginate-xanthan gum microcapsules loaded with *Lactobacillus johnsonii* postbiotics, focusing on morphological properties and release behaviour in a skin-mimicking environment. Microcapsules were prepared using an extrusion technique and morphology was characterized by Scanning Electron Microscopy (SEM). Specific surface area and porosity were analysed using Brunauer-Emmett-Teller (BET) following incorporation into a topical cream. *In vitro* release kinetics were quantified via lactic acid determination using High-Performance Liquid Chromatography (HPLC), with one-way ANOVA applied to assess temporal differences.

Methods: Heat-inactivated *Lactobacillus johnsonii* postbiotics were incorporated into alginate-xanthan gum microcapsules prepared via extrusion into $CaCl_2$/NaCl hardening solution. Beads were stored at 4 °C or freeze-dried prior to characterization. Morphological properties were examined using SEM at multiple magnifications. Encapsulation efficiency and *in vitro* release behaviour were quantified by HPLC through lactic acid analysis using standards (0-10 mM). BET analysis was performed after incorporation of microcapsules into a topical cream and rinsing at consecutive time points. To mimic skin release, study was also conducted in PBS (pH 5.5) and data were analysed using one-way ANOVA.

Results: SEM analysis revealed that postbiotics-free microcapsules were coarse, brittle, and rough with localized calcium supersaturation, whereas postbiotics-loaded microcapsules exhibited smooth, homogeneous surfaces with clearly observable bacterial structures and uniform crosslinking. BET analysis showed no significant differences in surface area, pore volume, or pore size, supporting the null hypothesis by confirming stabilization in cream topical formulations. HPLC revealed a burst release of lactic acid at 1h, followed by depletion at 4h (ANOVA, $p < 0.05$), indicating time-dependent release of the postbiotics encapsulated.

Conclusion: In conclusion, this study demonstrated that postbiotics loaded alginate-xanthan gum microcapsules enhanced morphology, structural integrity, and stability in cream formulations via SEM and BET analysis. Time-dependent release of *Lactobacillus johnsonii*-derived lactic acid was confirmed by HPLC. These findings lay a foundation for optimized topical applications, despite *in vitro* limitations.

Keywords: Postbiotics, Alginate-Xanthan Gum, Microcapsules, Skin Simulated Conditions, *In Vitro*

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