

FABRICATION, PHYSICOCHEMICAL PROPERTIES AND ANTIBACTERIAL ACTIVITY OF GELLAN GUM HYDROGEL CONTAINING CURCUMIN/QUERCETIN AS BIOACTIVE WOUND DRESSINGS

Hooi Yee Wee¹, Yoon Yee Then¹, Yun Khoon Liew¹, Lai Chun Wong¹, Chun Wai Mai²

¹School of Pharmacy, IMU University, Bukit Jalil, Kuala Lumpur, Malaysia

²Institute of Research, Development and Innovation, IMU University, Bukit Jalil, Kuala Lumpur, Malaysia

Abstract

Background: Gellan gum hydrogel is a natural biopolymer that has gained interest in the development of wound healing scaffolds for its good biocompatibility, biodegradability and water retention. However, it was known to have weak mechanical strength and lacks in antibacterial properties. Therefore, gallium(III) nitrate, curcumin and quercetin were incorporated into gellan gum hydrogel to overcome the drawbacks. Gallium(III) nitrate was added to enhance the structural stability of the hydrogel; while curcumin and quercetin were added to improve the antibacterial and antioxidant properties of the hydrogel.

Methods: Gellan gum hydrogels containing different ratios of curcumin and quercetin were fabricated via ionic gelation with gallium(III) nitrate as crosslinker, followed by lyophilization. Physicochemical properties of the samples were characterised using Fourier transform infrared (FTIR) spectroscopy and scanning electron microscopy (SEM). Gel fraction, encapsulation efficiency, swelling analysis, degradation analysis, in vitro release analysis, antioxidant activity (DPPH assay), antibacterial activity, and cytocompatibility analysis were evaluated. Data were analysed using one-way ANOVA ($p < 0.05$).

Results: **Gel fraction** confirmed strong crosslinking in curcumin and quercetin loaded hydrogels, with values exceeding 85%, while **encapsulation efficiency** also remained above 85% across all samples. In **swelling analysis**, the addition of curcumin and quercetin led to higher swelling index. Low **degradation** rate have reflected poor solubility of the compounds, whereas **in vitro release** remained low, with higher ratio of curcumin and quercetin showed limited diffusion. **Antioxidant analysis** showed moderate radical scavenging ability, with no synergistic effect between the phytochemicals. **Antibacterial analysis** demonstrated improved inhibition of Gram-positive bacteria, while **cytocompatibility analysis** confirmed all samples were not cytotoxic with cell viability above 75%.

Conclusion: Incorporation of curcumin and quercetin into gellan gum hydrogels with gallium(III) nitrate improved in structural stability, antibacterial properties towards Gram-positive bacteria, and biocompatibility, thereby supporting the potential use as wound dressings.

Introduction

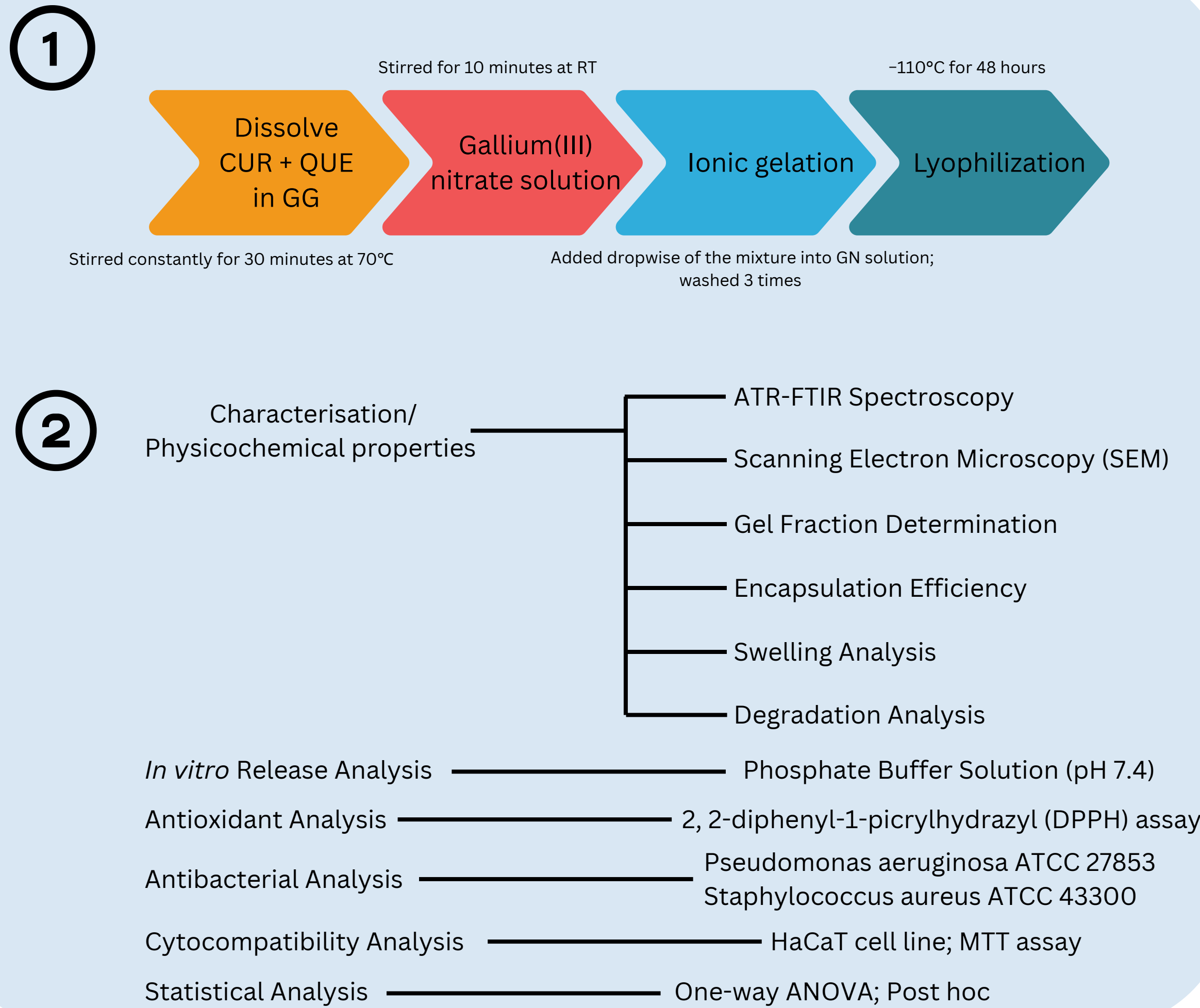
- Effective wound care is critical for rapid wound healing, prevent infection, and protect the wound bed (1).
- Hydrogel have been developed to address the limitations of traditional wound dressings by maintaining moisture, absorbing exudates and reducing infection risk (2). But gellan gum hydrogel exhibit weak mechanical strength and lack antibacterial activity (3).
- Incorporating **curcumin** (antioxidant, antibacterial), **quercetin** (anti-inflammatory, antioxidant), and **gallium(III) nitrate** (crosslinker, antibacterial) aims to enhance GG hydrogel properties (4-6).
- This study developed a GG hydrogel crosslinked with Ga^{3+} and loaded with CUR–QUE to improve structural, biological, and therapeutic characteristics for advanced wound healing applications.

Research Objectives, Hypotheses

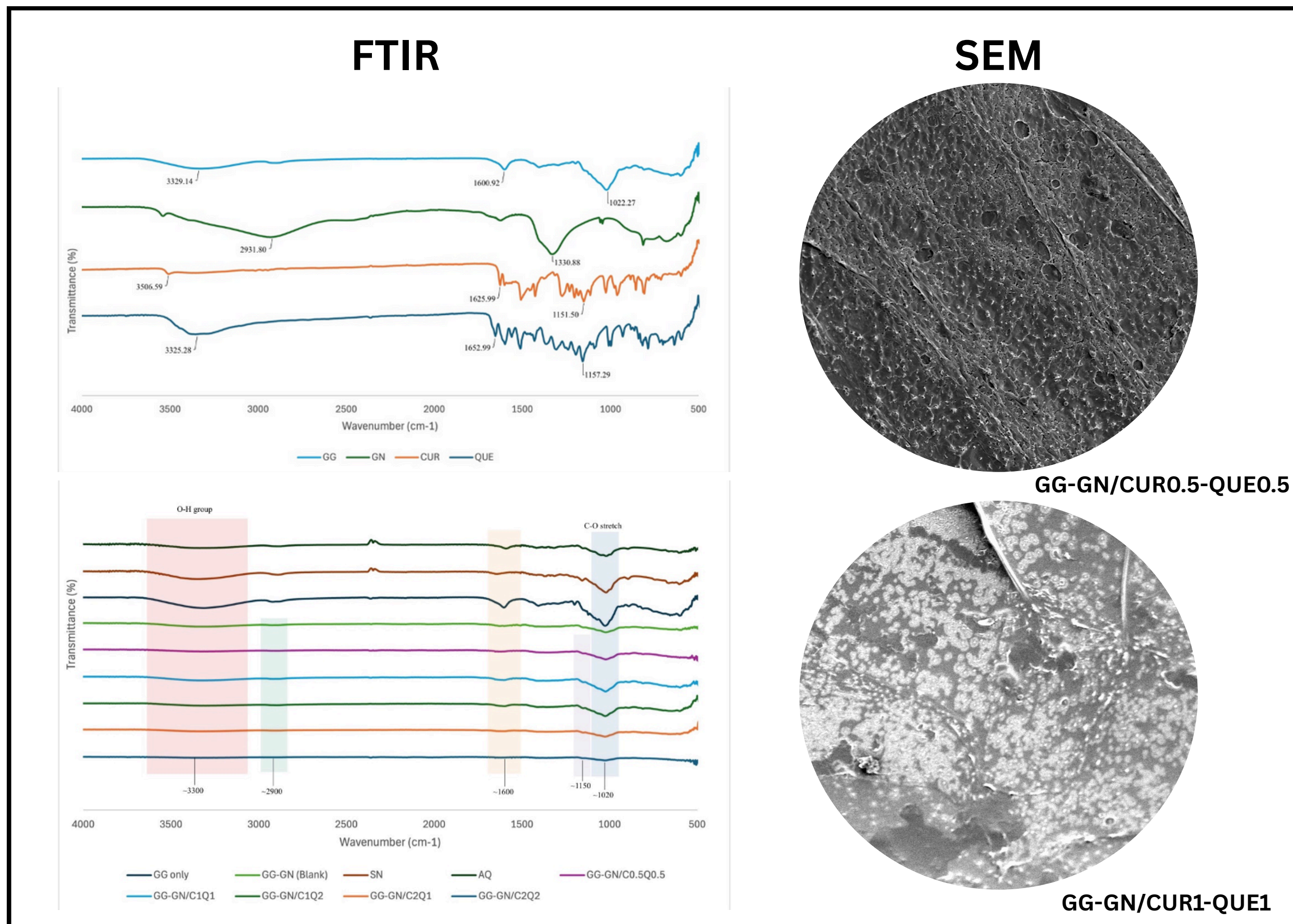
- To prepare gellan gum hydrogels containing curcumin and quercetin via ionic gelation and lyophilisation.
- To investigate the physicochemical, biological properties and antibacterial activity of gellan gum hydrogels containing curcumin and quercetin.

- H0: There is no significant difference in the physicochemical, biological properties, and antibacterial activity of gellan gum hydrogels before and after loading with Curcumin and Quercetin
- H1: There is significant difference in the physicochemical, biological properties, and antibacterial activity and biocompatibility of gellan gum hydrogels before and after loading with Curcumin and Quercetin

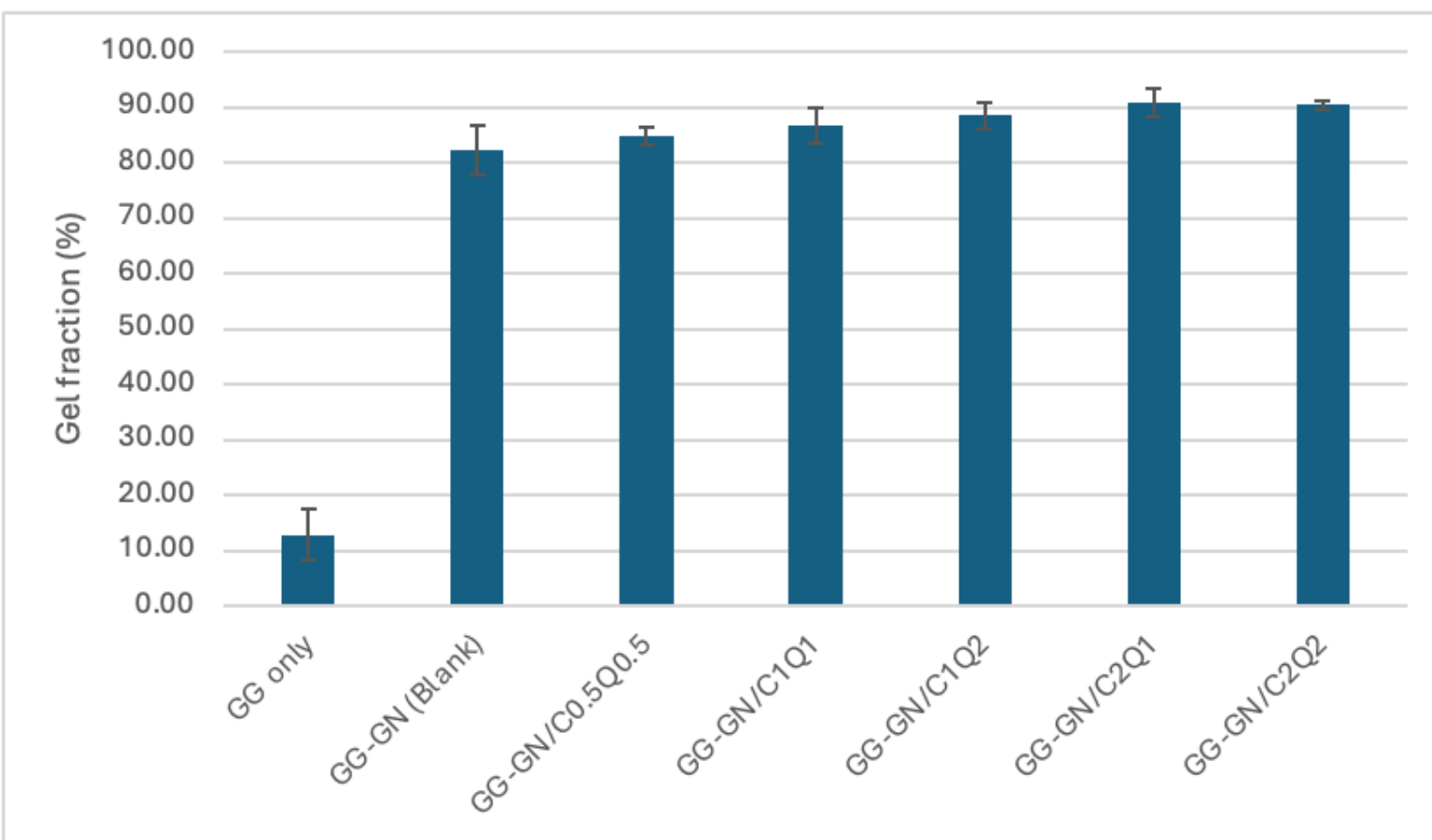
Methodology



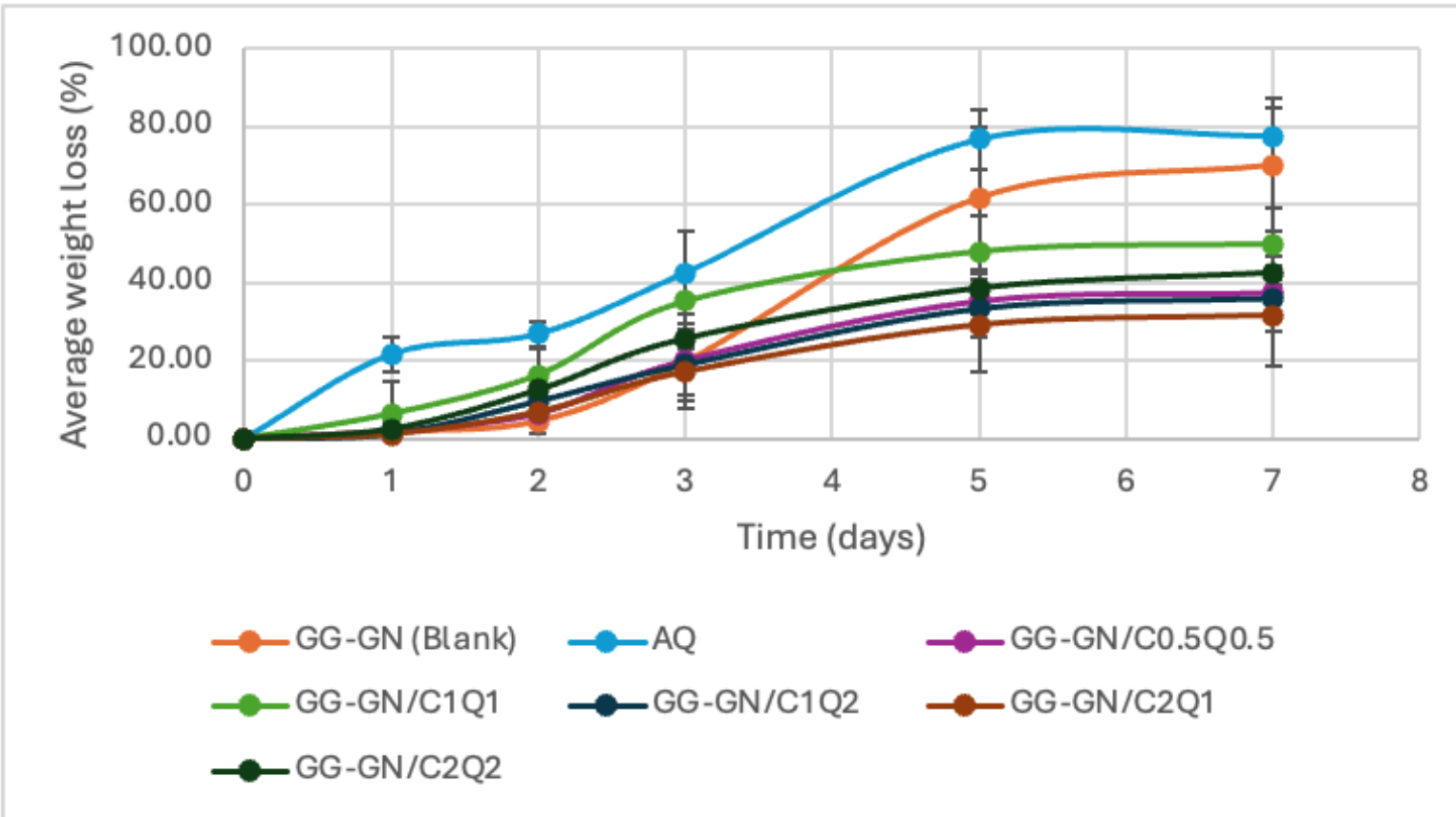
Results



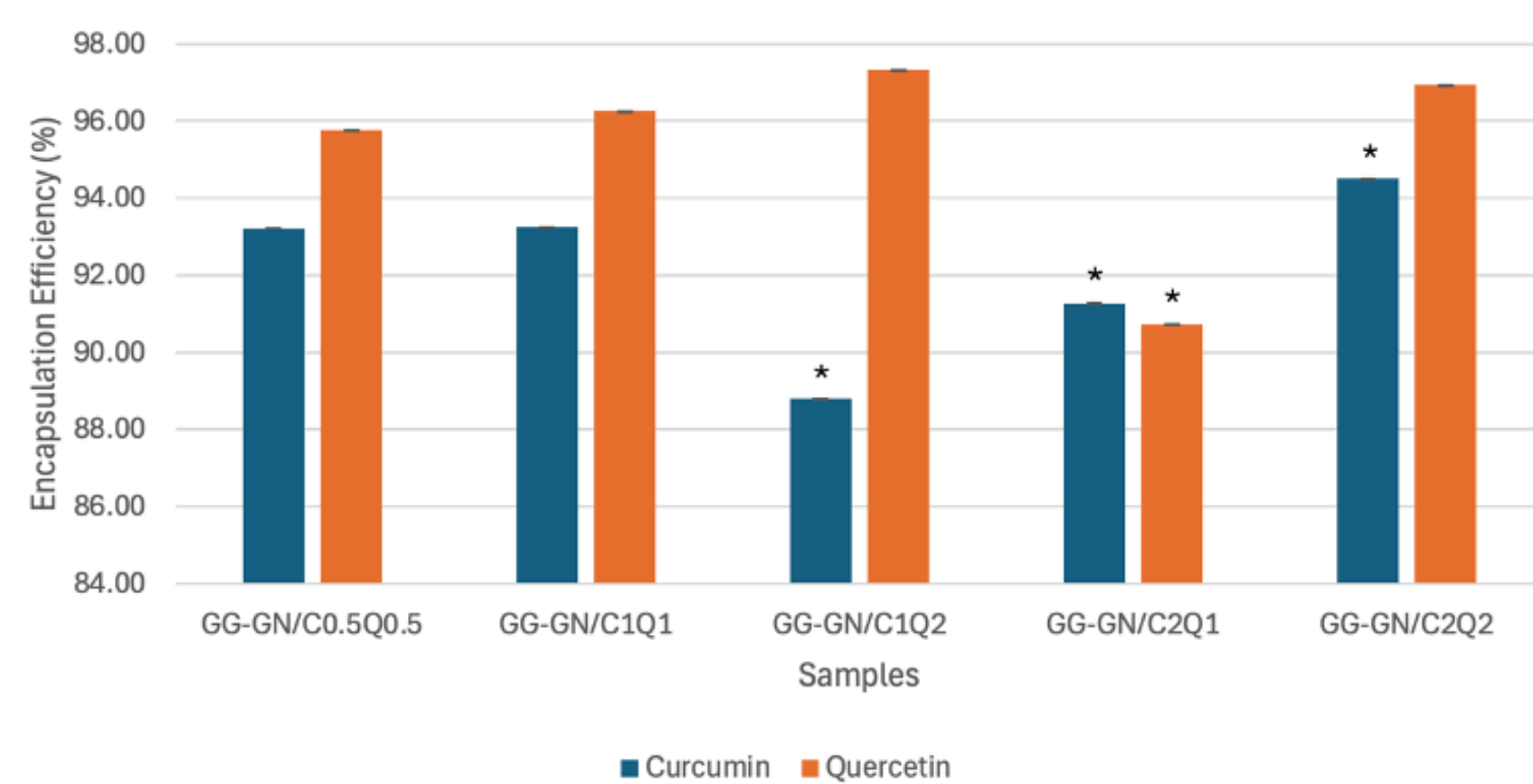
Gel Fraction Determination



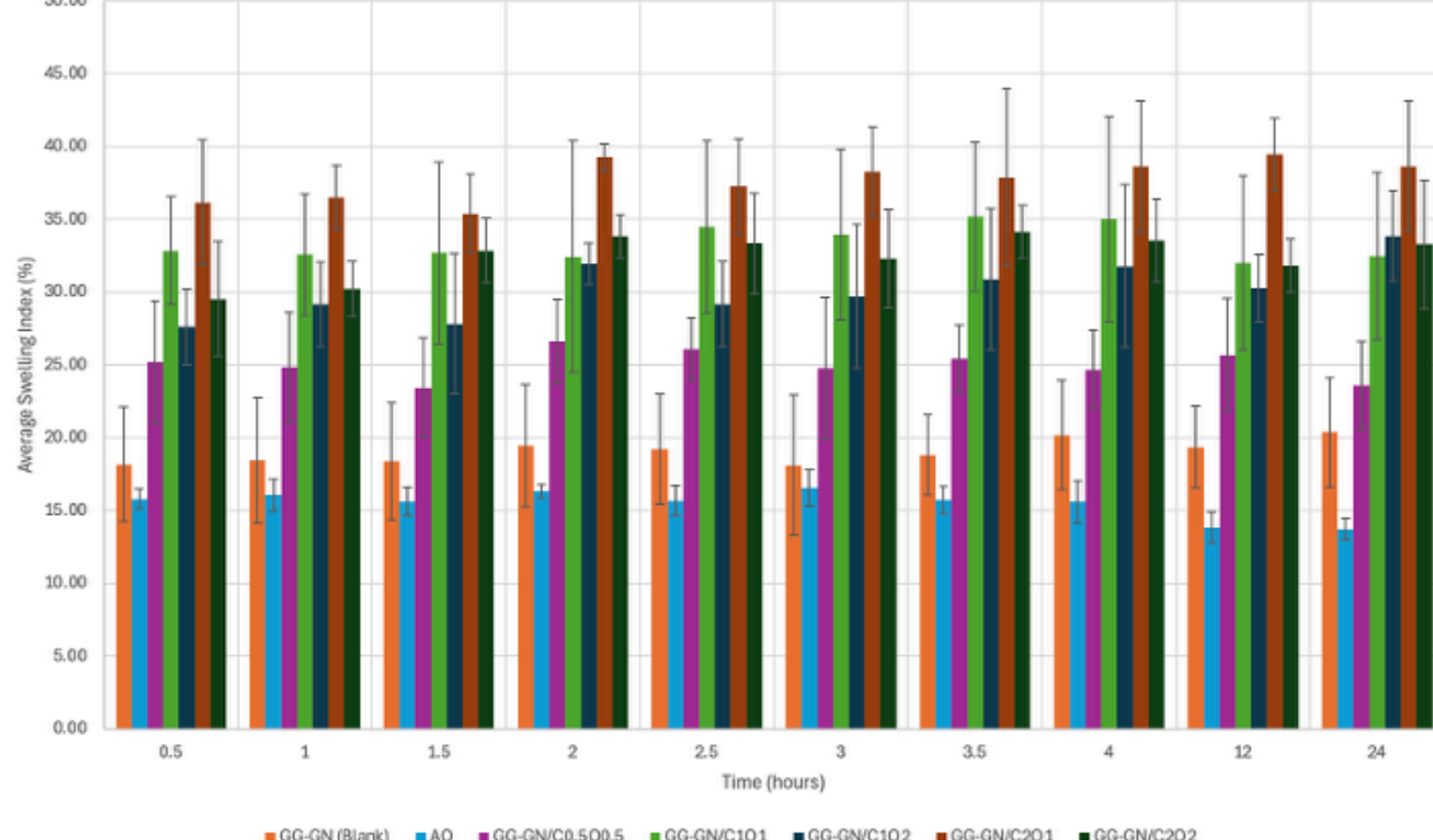
Degradation Analysis



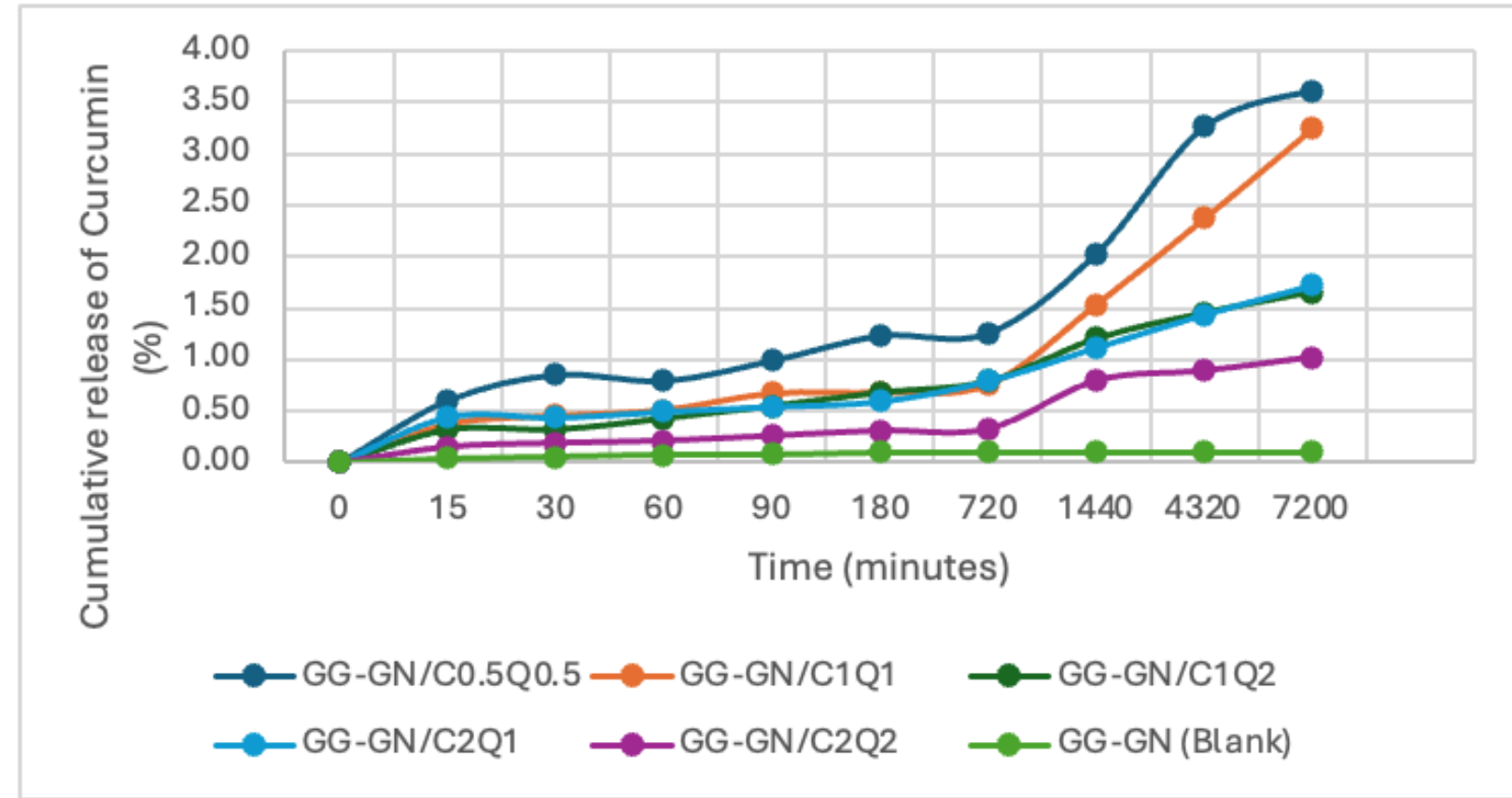
Encapsulation Efficiency



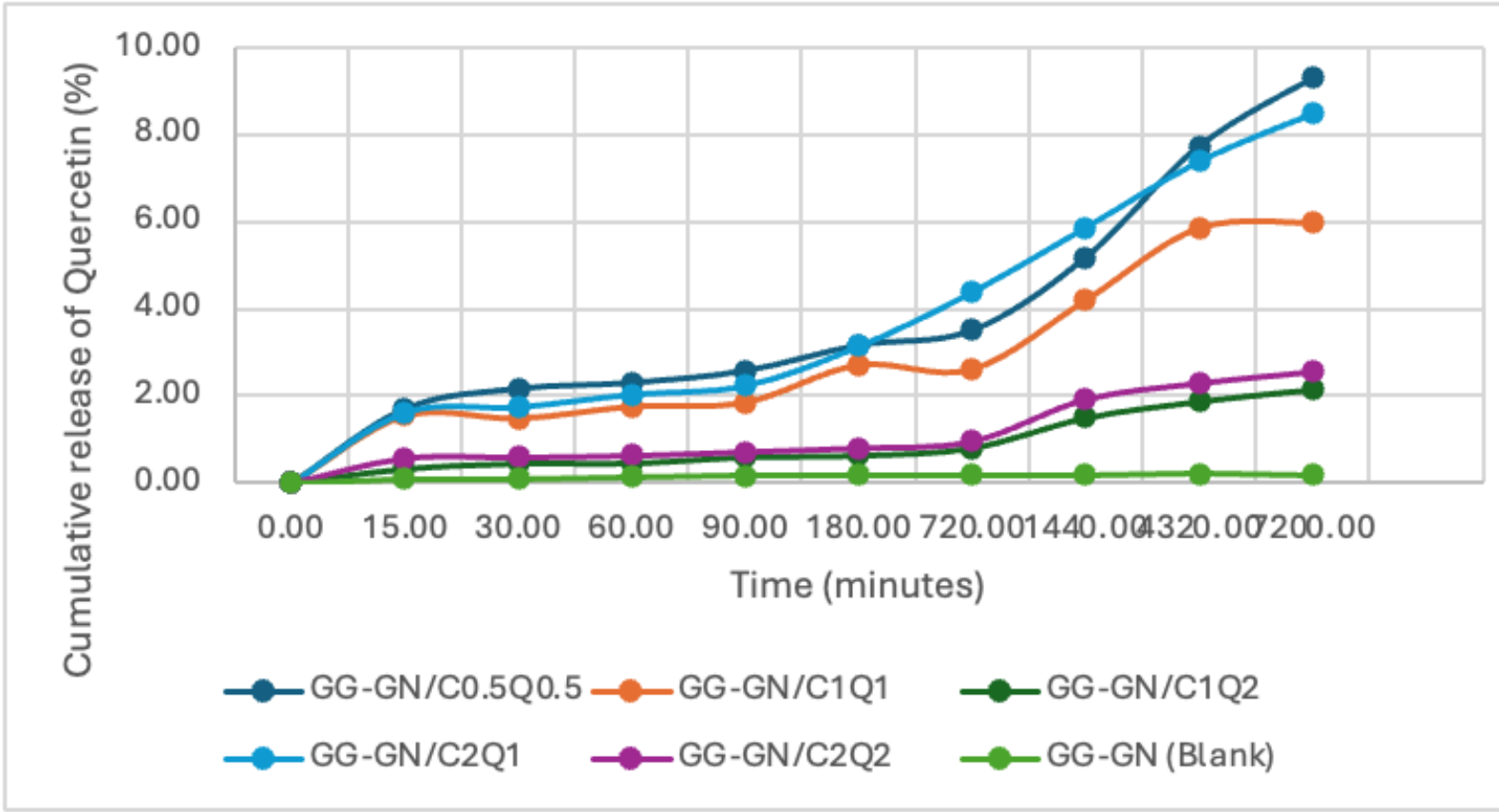
Swelling Analysis



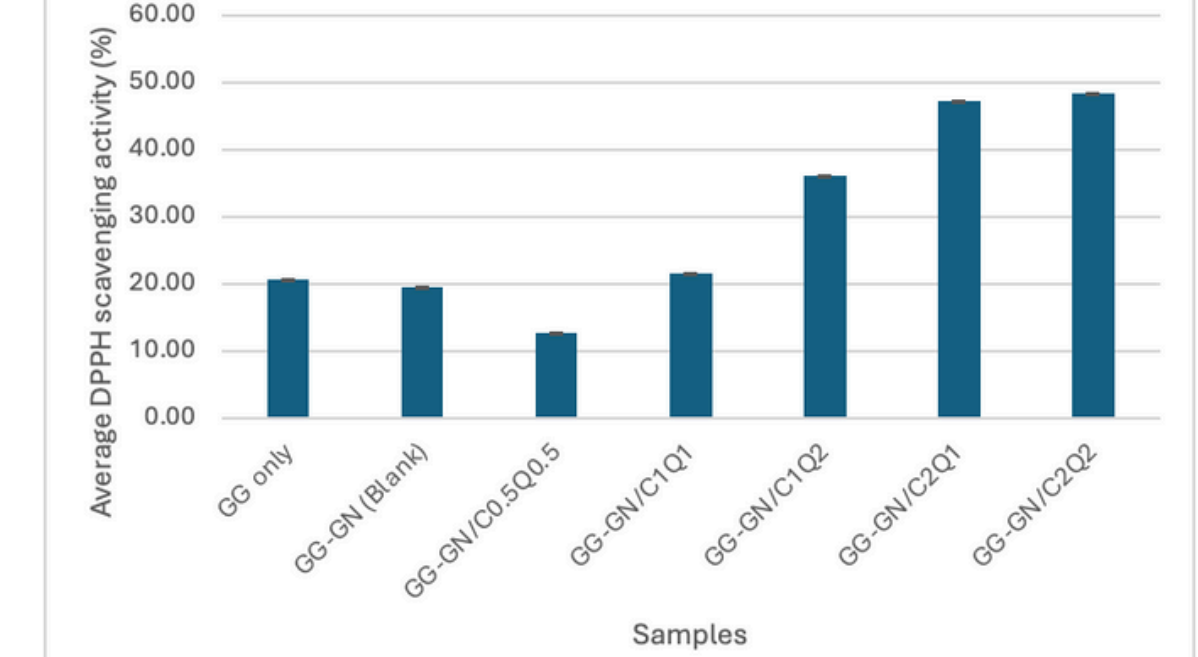
In vitro Release Analysis



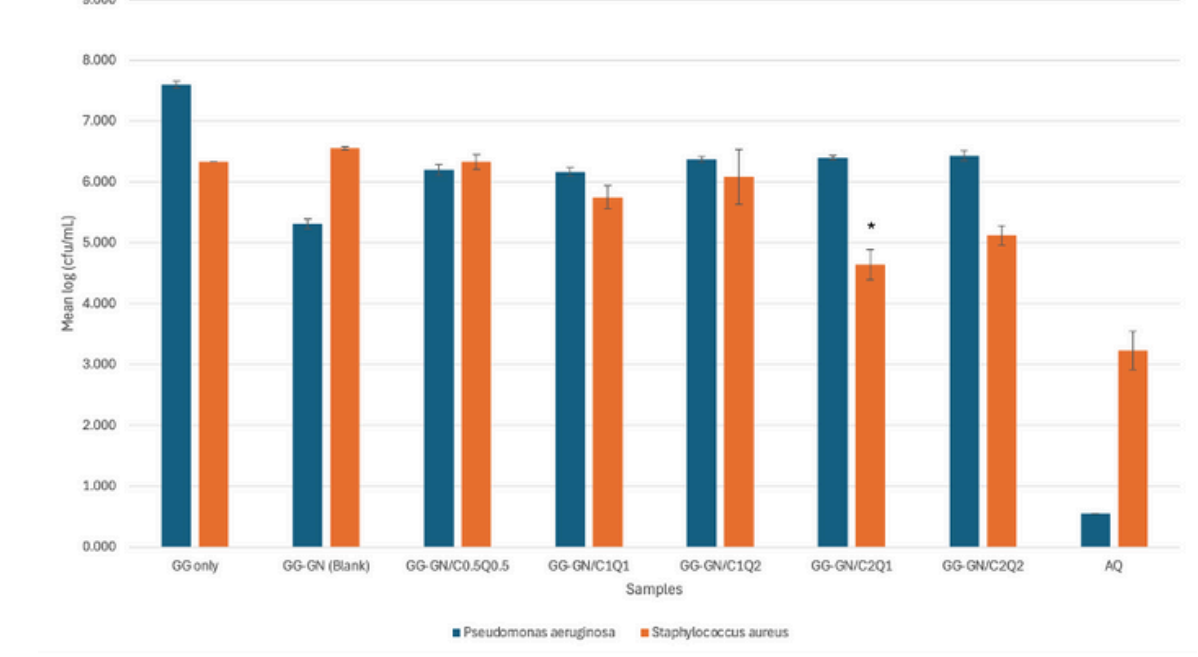
QUE



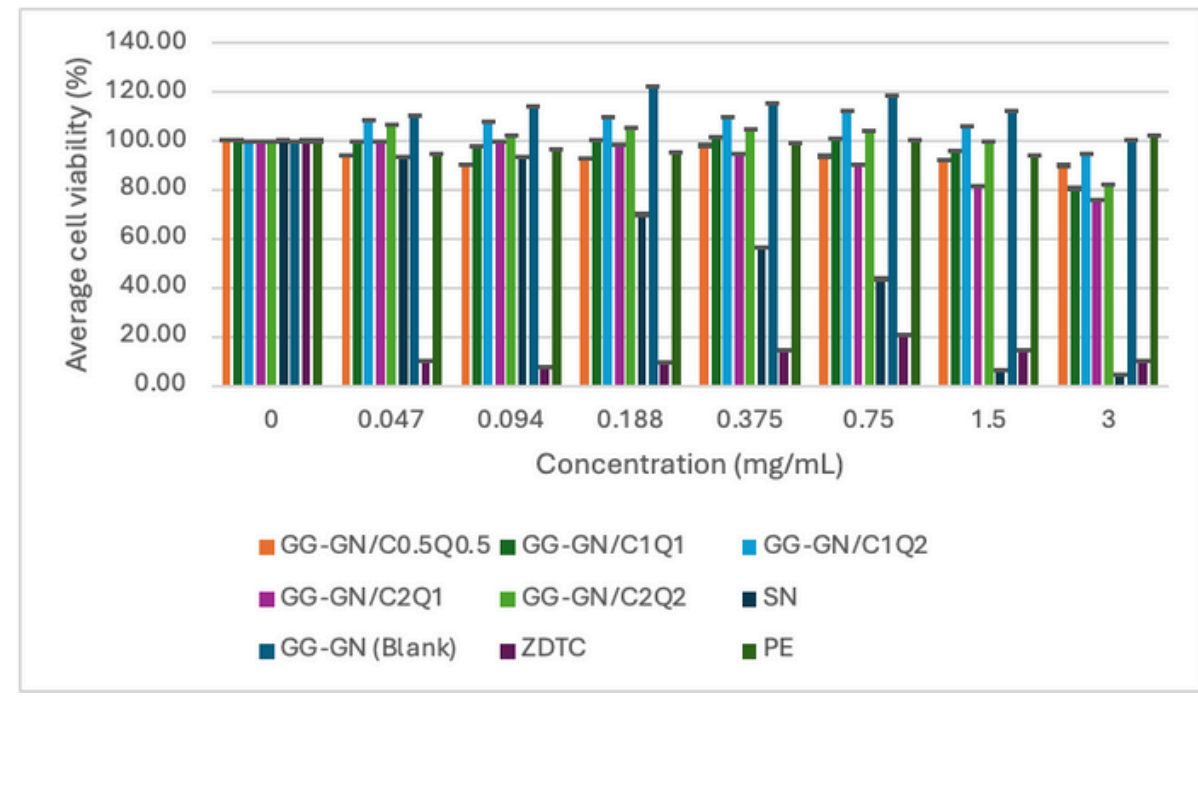
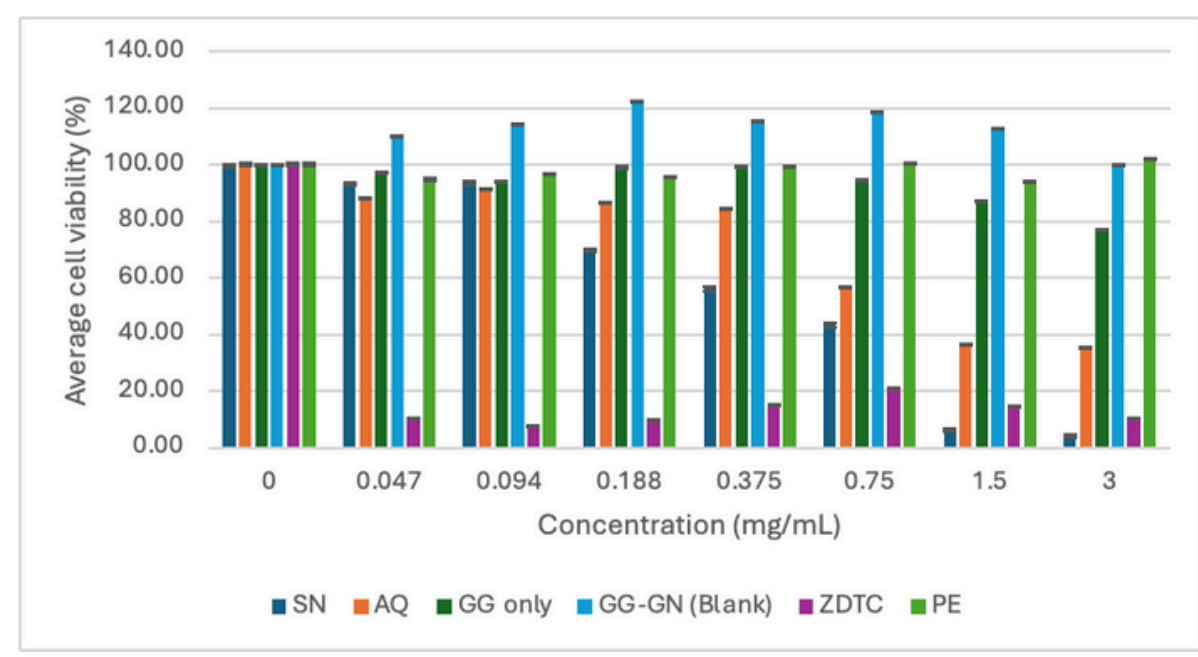
Antioxidant Analysis



Antibacterial Analysis



Cytocompatibility Analysis



Conclusion

- GG hydrogels with CUR and QUE loaded were successfully prepared via ionic gelation and lyophilization.
- This research found that incorporation of gallium(III) nitrate into gellan gum hydrogel improved structural stability. The addition of curcumin and quercetin further enhanced the antioxidant and antibacterial activity, while regulating swelling, degradation and in vitro release properties.
- To conclude, the research objectives were achieved with alternative hypothesis accepted.

References

- Wound Management - an overview | ScienceDirect Topics [Internet]. [cited 2025 Feb 14]. Available from: <https://www.sciencedirect.com/topics/medicine-and-dentistry/wound-management>
- Britto EJ, Nezwek TA, Popowicz P, Robins M. Wound Dressings. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 [cited 2025 Feb 22]. Available from: <http://www.ncbi.nlm.nih.gov/books/NBK470199/>
- Sibusiso Alven, Xhamla Ngqoro, Blessing Atim Aderibigbe. Polymer-Based Materials Loaded with Curcumin for Wound Healing Applications. Comprehensive Review.
- Yao Li, Jiaying Yao, Chunyan Han, Jiaxin Yang, Maria Tabassum Chaudhry, Shengnan Wang, et al. Quercetin, Inflammation and Immunity.
- Jiajun Qin, Ming Li, Ming Yuan, Xingfei Shi, Jiliang Song, Yiyang He, et al. Gallium(III)-Mediated Dual-Cross-Linked Alginate Hydrogels with Antibacterial Properties for Promoting Infected Wound Healing.