Extraction, characterization and optimization of marine algal-derived hydrogels for three-dimensional biomaterials

T. M. D. Darshanamala, U. Rajagopalan

Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo, Sri Lanka

Marine algae are valuable sources of polysaccharides with wide ranging applications in biomaterial development. In the present study, four marine algae species, *Kappaphycus alvarezii*, *Sargassum* spp. (two species), and *Turbinaria conoides* were selected for evaluation as potential biomaterial sources. Identification of the algal species was made using morphological characteristics and molecular barcoding using *ITS* primers. Algal polysaccharides were extracted using the hot alkaline extraction method. Carrageenan was extracted from the red alga *K. alvarezii* with a high yield of 51.78%. Alginate was extracted from the brown algae with a yield weight of 42.65% and 42.59% from the two *Sargassum* spp. and *T. conoides* respectively. The chemical composition of the polysaccharide extracts was confirmed by fourier transform infrared (FTIR) spectroscopy, revealing characteristic sulphate ester peaks in carrageenan and guluronic and mannuronic acids in alginate. Optimization studies were conducted to enhance the properties of hydrogel formation. Parameters relevant to gelation properties were evaluated including solubility, gelation capacity and time, calcium chloride concentration, pH stability, swelling ratio, turbidity and melting and freezing temperatures. Optimum hydrogel formulations were achieved with 1.0 M $CaCl_2$ in carrageenan 2% (w/v) and with 0.5 M $CaCl_2$ in alginate 1% (w/v). The optimized hydrogel formulation combined high gel strength, low turbidity, stable swelling behaviour, and thermal stability suitable for physiological conditions. The materials produced in this study present a promising, sustainable, and biocompatible platform for future applications in biomedical engineering and advanced three-dimensional cell culture systems.

Keywords: *Algal hydrogels, Carrageenan, Alginate, Three-dimensional cell culture, Biomaterial*