

Development of alginate-montmorillonite-starch with encapsulated *Trichoderma harzianum* and evaluation of conidia shelf life

ABSTRACT

Biological control agents, such as *Trichoderma harzianum*, are widely used in sustainable agriculture. However, commercialisation and mass production of biocontrol products have remained a challenge, especially in viability and efficiency in field application. The encapsulation method has emerged as a sophisticated technique to develop the formulation of *T. harzianum*. Hence, encapsulation through extrusion was used to prepare *T. harzianum* beads. The physical characteristics comprising weight, diameter, and swelling ability of the beads were significantly improved when the starch percentage was increased. Alginate-montmorillonite-starch (10%) revealed the lowest shrinkage and the highest swelling ability. The interaction within the functional groups of alginate, montmorillonite, and starch was confirmed by the Fourier-transform infrared spectroscopic (FTIR) study. Furthermore, scanning electron microscopic analysis exposed compatible scattering of montmorillonite particles and starch granules over the alginate linkages. Meanwhile, the X-ray diffraction analysis confirmed the exfoliation between starch and montmorillonite. Storage of *T. harzianum* beads at 5°C was more suitable than storage at 28°C. At low temperature, the encapsulated *T. harzianum* beads maintained their viability at 6.59 ± 0.12 log CFU g⁻¹ for an effective threshold value for up to seven months. The current findings indicated that the combination of alginate, montmorillonite, and starch is the best formulation of encapsulated *T. harzianum* with improved conidia shelf life.

Keyword: Alginate-montmorillonite-starch; Biological control agents; Encapsulation; Extrusion; Shelf life; *Trichoderma harzianum*