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A novel method for the production of core-shell microparticles by inverse gelation optimized with artificial intelligent tools

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ABSTRACT

Numerous studies have been focused on hydrophobic compounds encapsulation as oils. In fact, oils can provide numerous health benefits as synergic ingredient combined with other hydrophobic active ingredients. However, stable microparticles for pharmaceutical purposes are difficult to achieve when commonly techniques are used. In this work, sunflower oil was encapsulated in calcium-alginate capsules by prilling technique in co-axial configuration. Core-shell beads were produced by inverse gelation directly at the nozzle using a w/o emulsion containing aqueous calcium chloride solution in sunflower oil pumped through the inner nozzle while an aqueous alginate solution, coming out from the annular nozzle, produced the beads shell. To optimize process parameters artificial intelligence tools were proposed to optimize the numerous prilling process variables. Homogeneous and spherical microcapsules with narrow size distribution and a thin alginate shell were obtained when the parameters as w/o constituents, polymer concentrations, flow rates and frequency of vibration were optimized by two commercial software, FormRules® and INForm®, which implement neurofuzzy logic and Artificial Neural Networks together with genetic algorithms, respectively. This technique constitutes an innovative approach for hydrophobic compounds microencapsulation.

1. Introduction

Microencapsulation of hydrophobic compounds into a hydrophilic matrix is a useful approach to protect and deliver bioactive substances susceptible to degradation in presence of light, low pH or oxidative environmental conditions (Fang and Bhandari, 2010; Leong et al., 2016; Madene et al., 2006). Moreover, different techniques and specific polymeric excipients allow the encapsulation of active pharmaceutical ingredients (APIs) with a poor bioavailability, undesired taste or volatile while enabling the controlled release of the API leading to its compartment-specific distribution (Freiberg and Zhu, 2004; Xu et al., 2007). Oils are very hydrophobic compounds widely employed in the alimentary, pharmaceutical, agricultural and cosmetic fields, needing encapsulation for their controlled delivery or masking-off of taste and colors. Oils have numerous health benefits and functional properties including antioxidant, anti-inflammatory, anti-vasoconstrictive, anti-arrhythmic, antithrombotic, anticancer, antidiabetic, antidepressant (Bakry et al., 2016). Nevertheless, oils can be also used as synergic ingredient in combination with other hydrophobic active ingredients (Bakry et al., 2016; Owusu et al., 1992). Among the different encapsulation techniques, coacervation and spray drying are the most commonly used methods to encapsulate oils, despite the fact that in some cases such techniques do not assure high stability of the produced particles (Chan, 2011; Drusch and Berg, 2008). Polysaccharides are usually used as coating material for microparticles due to its biocompatibility, non-toxicity, stability and gel-forming capacities. Particularly, alginates crosslinked by calcium chloride have been used to perform particles loaded with both hydrophilic and hydrophobic active ingredients (Aquino et al., 2012; Cerciello et al., 2017; Hambleton et al., 2009). In the last few years an innovative approach referred as inverse gelation of alginate has been proposed for the encapsulation of oils in alginate capsules with desired size and morphology as well as with proper membrane thickness (Abang et al., 2012; Tsai et al., 2017; Wu et al., 2017). In these studies, an emulsion of calcium chloride solution in oil was added dropwise in an alginate solution to produce Ca-alginate capsules. The methodology requires the application of an

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