Abstract

The primary objective of this study was to optimise the formulation and spray-drying parameters for encapsulating the enzyme alliinase and its natural substrate, alliin, within inhalable microcarriers. This approach enables the *in situ* formation of unstable but highly potent allicin, recognised for its broad-spectrum antimicrobial activity. The spray drying robot (Büchi Mini Spray Dryer S-300 equipped with a custom accessory) was employed for time-effective preparation of multiple formulations using two types of atomisers: two-fluid (2F) and three-fluid (3F) kinetic nozzles. This setup allowed production of two distinct carrier types: *i*) matrix-type particles containing only enzyme or substrate (2F particles) and *ii*) a core-shell type configuration where both enzyme and alliin are co-encapsulated within a single microcarrier (3F particles).

Early investigations identified maltodextrin as the optimal carrier material based on particle size distribution (PSD), the aerodynamic properties of the resulting powders, and its exceptional ability to maintain high alliinase activity over an extended period. The study further explored the effect of selected additives (ammonium carbonate – porogen, leucine – surface property modifier), the concentration of maltodextrin in the atomised solution, as well as key processing parameters (inlet drying temperature, atomising gas flow rate, and nozzle type geometry) on aerosolisation performance. The most promising formulations (2F and 3F) were rigorously evaluated for storage stability under accelerated conditions, antibacterial efficacy, and cytotoxicity. This work pioneers the development of bioinspired microparticles tailored for deep lung delivery of allicin's precursors, opening new possibilities for utilising one of the most bioactive compounds found in nature.