Synthesis and characterization of postbiotics from *Bacillus* spp.: study of functional properties and applications

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ABSTRACT

Despite their widespread use, the clinical efficacy of probiotics is highly variable and often inconsistent. Their functionality, in fact, is often impaired by limited survival, reduced engraftment and decreased metabolic activity during transit through the gastrointestinal tract. This hinders their capacity to exert sustained and biologically meaningful effects within the host. These limitations significantly impair their ability to colonise or transiently integrate into the resident microbiota, thereby restricting stable host–microbe interactions. Consequently, the anticipated health benefits are frequently diminished, transient, or absent, giving rise to significant concerns regarding their reliability as therapeutic interventions. In this context, postbiotics — defined as non-viable microbial cells, their components, or metabolites that confer health benefits — are emerging as a promising alternative. Unlike probiotics, postbiotics do not rely on microbial viability, thereby overcoming challenges related to stability, storage, and gastrointestinal survival. Furthermore, they offer greater safety, standardisation and mechanistic clarity, making them more suitable for precise and reproducible therapeutic applications. These features position postbiotics as a next-generation strategy for microbiome-based interventions. In this study, we focus on *Bacillus*-based postbiotic production using alternative carbon sources, particularly prebiotic substrates such as inulin and fructooligosaccharides. These are not digested by the human host, but can be metabolised by microorganisms, thereby enhancing the production of beneficial metabolites. This combined approach is a promising strategy for overcoming the current limitations of probiotics and supporting the development of applications for gut and skin microbiota.