Spray-chilled oleogel particles enabling hierarchical oleogel-in-oleogel structures

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The food industry relies heavily on saturated fats because they solidify at room temperature and form crystalline structures, which serve as delivery and protective mechanisms while providing unique sensory properties. However, excessive intake of these fats can lead to obesity and increase the risk of cardiovascular disease, metabolic syndrome, and type 2 diabetes. Replacing saturated fats with oils rich in polyunsaturated fatty acids offers a promising strategy to improve health outcomes and potentially reduce healthcare costs. Structured lipid systems, such as oleogels, which immobilize liquid oils within three-dimensional networks, have garnered interest due to their versatility and potential to mimic the textural and functional properties of conventional solid fats while delivering essential fatty acids. Despite their advantages, achieving simultaneous control of structure, oxidative stability, and digestibility remains a major challenge, and their high caloric content limits unrestricted consumption.

Building upon our first-generation ethylcellulose-based oleogel-in-oleogel (OG/OG) system [1], which leverages the kinetic confinement properties of the ethylcellulose network to slow lipid digestion, this study introduces a second-generation OG/OG architecture using a mixture of β-sitosterol and γ-oryzanol (BSGO), gelators with recognized health benefits and a lower crystallization temperature, facilitating its handling. The BSGO combination forms tubular crystalline networks that entangle into fibre-like structures, contributing to controlled digestibility and potential cholesterol-lowering effects. A spray chilling approach enables the formation of coated, micron-scale BSGO oleogel particles, which act as internal fillers within an outer oleogel matrix, creating a hierarchical OG/OG structure. The spray-chilled BSGO particles offer a smaller, more uniform architecture compared to the larger first-generation ethylcellulose beads obtained by prilling, a technology that inherently limits particle size reduction. This smaller and more uniform structure facilitates incorporation into the outer oleogel. The resulting composite OG/OG system displays uniform morphology, structural integrity, controllable digestibility and compatibility with various continuous oleogel matrices, demonstrating potential for incorporation into more complex food products [2]. This work advances the design of hierarchical oleogel architectures by integrating spray-chilled particle formation, particle coating, kinetic confinement, and lipid physical state control, providing a versatile strategy for engineering next-generation functional oleogels with tailored digestibility and improved applicability.

Keywords:
oleogel, oleogel-in-oleogel, spray chilling, fat replacement, lipids

References:

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