

Microstructural, textural and rheological properties of edible bigels designed for 3D food printing

Three-dimensional (3D) food printing is an emerging technology in food processing, offering high flexibility and customization to meet the growing demand for personalized nutrition and innovative product designs. Bigels, semi-solid systems composed of a hydrogel and an oleogel, present a promising approach as edible inks for extrusion-based 3D food printing due to their structural and functional properties.

This study aimed to develop and characterize edible bigel inks with optimized properties for 3D food printing applications. Bigels were prepared by blending beeswax (6%)–monoglycerides (4%) sunflower oil oleogels with gelatin (4%)–guar gum (1%) hydrogels at varying ratios (0–50%). Their microstructural, textural, and rheological characteristics were evaluated to assess printability and structural integrity.

Polarized light microscopy revealed distinct microstructures with increasing oleogel content, shifting from oleogel-in-hydrogel systems to bicontinuous networks. Textural analysis using a forward extrusion test demonstrated that oleogel content significantly influenced firmness and extrusion force, key parameters for 3D printing performance. Rheological analyses, including flow curve assessments, amplitude and frequency sweep tests, confirmed that all formulations exhibited pronounced shear-thinning behavior and predominantly elastic properties ($G' > G''$). These features are critical for smooth extrusion and maintaining structural stability post-printing. Furthermore, the 3-Interval Thixotropy Test (3ITT) evaluated structural recovery under shear, showing improved recovery percentages at higher oleogel concentrations.

These findings highlight the potential of bigels as functional and customizable inks for 3D food printing, enabling the development of novel food products with tailored textural and nutritional attributes.