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Computer Simulation Approach in the 3D Printing Operations of Surimi Paste

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Abstract : Simulation technology is being adopted in many industries, with research focusing on the development of new ways in which technology becomes embedded within production, services, and society in general. 3D printing (3DP) technology is fast developing in the food industry. However, the limited processability of high-performance material restricts the robustness of the process in some cases. Significantly, the printability of materials becomes the foundation for extrusion-based 3DP, with residual stress being a major challenge in the printing of complex geometry. In many situations, the trial-a-error method is being used to determine the optimum printing condition, which results in time and resource wastage. In this report, the analysis of 3 moisture levels for surimi paste was investigated for an optimum 3DP material and printing conditions by probing its rheology, flow characteristics in the nozzle, and post-deposition process using the finite element method (FEM) model. Rheological tests revealed that surimi pastes with 82% moisture are suitable for 3DP. According to the FEM model, decreasing the nozzle diameter from 1.2 mm to 0.6 mm, increased the die swell from 9.8% to 14.1%. The die swell ratio increased due to an increase in the pressure gradient (1.15107 Pa to 7.80107 Pa) at the nozzle exit. The nozzle diameter influenced the fluid properties, i.e., the shear rate, velocity, and pressure in the flow field, as well as the residual stress and the deformation of the printed sample, according to FEM simulation. The post-printing stability of the model was investigated using the additive layer manufacturing (ALM) model. The ALM simulation revealed that the residual stress and total deformation of the sample were dependent on the nozzle diameter. A small nozzle diameter (0.6 mm) resulted in a greater total deformation (0.023), particularly at the top part of the model, which eventually resulted in the sample collapsing. As the nozzle diameter increased, the accuracy of the model improved until the optimum nozzle size (1.0 mm). Validation with 3D-printed surimi products confirmed that the nozzle diameter was a key parameter affecting the geometry accuracy of 3DP of surimi paste.

Keywords : 3D printing, deformation analysis, die swell, numerical simulation, surimi paste
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