Title: Advancing high-protein snack production: Unlocking the potential of nitrogen gas-assisted extrusion with x-ray & high-speed imaging

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Abstract:

The production of high-protein extruded snacks has been constrained by challenges such as undesirable texture and high density, limiting their appeal as healthier food options. These issues, coupled with the complex extrusion process and limited understanding of expansion dynamics, have impeded the development of nutritionally optimized, sensory-appealing products. To address these challenges, this study explores nitrogen gas-assisted extrusion, an innovative technique with the potential to enhance both the nutrition and taste of extruded snacks.

This research represents the first comprehensive investigation into the effects of nitrogen gas injection across a wide range of protein contents (0-50% d.b.). Moreover, a high-speed thermal camera was employed to monitor the extrusion process, while x-ray tomography offered detailed visualization of extrudate microstructures, facilitating a deeper understanding of the expansion-microstructure-texture relationship, providing critical insights into optimizing nitrogen gas-assisted extrusion processes. Extrudates with 50% protein content, regardless of nitrogen gas injection pressure, exhibited the most distinct characteristics—high density, hardness, and low porosity—compared to those with lower protein levels (0-40%). These results highlight that the highest protein content (50%) is detrimental to extrudate physical quality. However, nitrogen gas injection at 300 kPa significantly improved expansion, reducing cell wall thickness and hardness, and resulted in extrudates with attributes closer to those with lower protein content, showcasing its potential to mitigate the adverse effects of high protein incorporation.

This study demonstrates the potential of nitrogen gas-assisted extrusion as a promising innovation for producing high-protein snacks with superior texture and quality. The findings advance both the scientific understanding of extrusion processes and the development of nutritionally rich, appealing plant-based snacks, contributing to ongoing efforts to improve food quality and human nutrition through innovative processing techniques.