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Synergistic effects of heat and shear during high-pressure homogenization on corn starch with different amylose contents: Multi-scale structural evolution to pasting properties

Fuhan Xie [a], Huabing Zhai [a], Yongmei Mo [a], Yaqi Zhong [a], Yifan Niu [a], Fengwei Xie [b], Pei Chen [a*],

* Corresponding author *E-mail address:* peichen@scau.edu.cn

[a] *Guangdong Provincial Key Laboratory of Food Quality and Safety, College of Food Science, South China Agricultural University, Guangzhou, Guangdong 510642, China*

[b] *Chongqing Key Laboratory of Speciality Food Co-Built by Sichuan and Chongqing, College of Food Science, Southwest University, Chongqing 400715, China*

Abstract

Starch is a vital biopolymer in food systems, serving as a crucial energy source in the human diet. Besides, due to its inherent properties such as gelatinization and gelation, starch serves as an important thickening and gelling agent in fluid foods like sauces, soups, and dairy product [1]. Mechanical shear is commonly used to regulate the viscosity, stability, and mouthfeel of fluid systems . This regulation is highly correlated with the evolution of starch's structure during shear processing [2]. To correlate the structural evolution of starch with its pasting properties under heat-shear, high-pressure homogenization (HPH) was applied near the gelatinization temperatures of three corn starches: waxy (WCS, 0:100), normal (NCS, 26:74), and high-amylose (HACS, 80:20). Structural analysis revealed a temperature-dependent degradation mechanism. Below gelatinization temperature, heat-shear follows a surface-to-core pattern, preserving the granule structure and the chain length distribution (CLD) of amylopectin. Within gelatinization temperature range, granule disintegration causes extensive chain scission, decreasing the weight-average molecular weight (M_w). The degradation pattern depends on the amylose/amylopectin ratio. In WCS (65 and 75 ℃), cleavage targets the amylopectin backbone and inter-cluster chains (B2/B3). In NCS (67 and 77 ℃) and HACS (71 and 91 ℃), amylose potentially correlates with minor CLD changes in amylopectin. Collectively, these structural transformations drive a rheological shift: the starch paste transitions from elasticity-dominated to viscosity-dominated flow, evidenced by decreasing consistency index (K) and storage modulus (G'). This transition results from the loss of granule and crystalline structures, and the entanglement network formed by long-chain molecules (amylose and B2/B3 chains). Heat-shear processing provides mechanistic insights into designing starch pasting properties.

References

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