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Structural analysis of potato starch transformation during high-energy ball-milling: Oxygen and humidity content effects

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Abstract

High Energy Ball-Milling (HEBM) modifies starchs' granule morphology, physicochemical properties, and chemical structure. However, understanding how the HEBM changes the starch chemical structure is necessary to control these modifications. Therefore, this study aimed to investigate the changes in potato starch's long- and short-range molecular order during HEBM at different environmental conditions such as oxygen (Air) and humidity content. Due to the correlation between the starch modification and the energy supplied (E_{supp}) by the HEBM, Burgio's equation was used to calculate this energy. The starch transformation was followed by X-ray diffraction, Fourier Transform-Infrared Spectroscopy, and Raman spectroscopy. A Principal Component Analysis (PCA) was conducted to reduce the HEBM variables. PAC analysis demonstrated that the different oxygen-humidity conditions do not affect the HEBM of potato starch. Based on the starch chemical structure transformation correlated with E_{supp} during HEBM, four stages were observed: orientation, modification, mechanolysis, and over-destruction. It was identified for the first time that at low milling energy (<1.5 kJ/g, orientation stage), the glycosidic rings change their orientation, and starch-water interaction increases while the starch's organization reduces. Ergo, the potato starch could be more susceptible to chemical modifications during the first two stages.