Single-stage chili milling for improved energy efficiency through brittleness enhancement

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This study evaluated the potential of single-stage chili milling (SSCM) as a significantly more energy-efficient alternative than the conventional multistage milling method. The research specifically investigated the impact of reducing the chili moisture content to enhance milling efficiency by increasing material brittleness. Initial chili moisture content, ranging from 12% to 13% w.b. during storage, was effectively reduced to 3.5-4% w.b. by allowing the chili to reach equilibrium moisture content in a controlled environment of 20% relative humidity and 37°C, created using heat pump air dehumidifiers. SSCM trials were performed using a pulverizer, and the energy consumption was rigorously analyzed using classical grinding laws, including Bond, Rittinger, and Kick's laws. The results demonstrated a remarkable reduction in energy consumption for SSCM (266 kJ kg^{-1}) compared to the conventional multistage chili milling process (1116 kJ kg^{-1}). This substantial decrease is further highlighted by the significantly lower specific energy (88.65 kJ kg^{-1} for SSCM compared to 611 kJ kg^{-1}) and Bond Work Index (BWI) (8.82 kWh t^{-1} for SSCM compared to 255 kWh t^{-1}) observed with the single- stage method. The calculated constants for Kick's, Rittinger's, and Bond's laws consistently indicated the superior energy performance of SSCM. This study unequivocally demonstrates that controlled dehumidification as a pre-treatment significantly enhances the energy efficiency of chili milling, and the adoption of SSCM offers a compelling strategy for substantial energy savings in chili processing.

Keywords: *Chili milling, Dehumidification, Energy efficiency, Grinding laws, Moisture content, Single-stage milling*