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Operational Improvement of A Convective Coffee Dryer by Numerical Methods and Computational Fluid Dynamics

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Abstract

Considering that the coffee harvest peaks in Colombia coincide with the rainy seasons, the coffee growers face many complications when attempting to sun dry their coffee due to the high cloudiness and low direct sun radiation; deriving in post-harvest processes delays or incomplete grain dryness, risking the quality, innocuousness and safety of the product. That is why local workshops started to fabricate low capacity mechanical dryers simulating the industrial coffee drying equipment's working principles. One of the most commercialised units is a triple tray rectangular-shaped convective dryer with a net drying capacity of 31.25 kg of dry parchment coffee per 21-hour batch, providing an acceptable solution to the drying concerns. However, the process seemed improvable, focusing mainly on the dryer's geometry, air inlet and coffee bed thickness, seeking to enhance the airflow inside the unit, and reducing the product's drying time. Hence, a new dryer design was proposed displaying a circular shape, a lower grain bed thickness and a vertical air inlet accompanied by a diffusive tray. Based on the Thompson and Michigan State University mathematical models for grain drying, both units were simulated to obtain their theoretical drying time. A computational fluid dynamics simulation was also conducted to observe the drying air's behaviour inside the units; the circular drying unit presented a notable theoretical reduction in the drying time. It also displayed a more homogeneous and uniform air distribution, optimising the dryer's performance, deriving into improving the grower's profitability, dynamising the post-harvest processes to avoid product spoilage and reducing the electrical and gas consumption.

Keywords: CFD Simulation, coffee drying, Parchment coffee, Porous bed

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