Simulation of the Temperature Profile of Coffee Beans Roasted Under Far-Infrared Radiation

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Coffee is the most consumed beverage in the world besides water and the most traded agricultural commodity. Roasting is the most important step in coffee processing. Rotating in batch roasters using convective heating is popular in the industry. But the use of convective heating consumes more time and energy. The gradual heating of coffee beans under a low temperature gradient with convective heating causes excessive caramelization and deterioration of organoleptic properties in roasted coffee. Far-infrared (FIR) radiation causes rapid heating of coffee beans which eliminates the above problems. The temperature profile of coffee beans roasted under far-infrared radiation has been studied in this study to optimize the FIR coffee roasting. The temperature profile inside coffee beans and the surface temperature of the beans exposed to far-infrared radiation was simulated using COMSOL Multiphysics. Coffea arabica beans were singularly roasted in an experimental setup and the temperature-time curves were plotted to validate the model. Sets of 12 coffee beans in each batch were roasted for five time intervals (20 s, 25 s, 30s , 35 s and 45 s) to determine the roasting degrees of coffee roasted under FIR. A good agreement between the simulated data from the model and experimented data was observed (RMSE of 25.3°C at the 25% duty cycle, 35.6°C at the 17.5% duty cycle, 37.2°C at the 10% duty cycle). It can be concluded that FIR can be effectively used for coffee roasting and the roasting is much faster (internal temperature reach 300°C in 44s) than the traditional convective heating. All three roasting degrees; light roast, medium roast and dark roast can be obtained by roasting with FIR.

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