World Academy of Science, Engineering and Technology
International Journal of Agricultural and Biosystems Engineering
Vol:12, No:02, 2018

Optimization of Process Parameters and Modeling of Mass Transport during Hybrid Solar Drying of Paddy

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Abstract : Drying is one of the most critical unit operations for prolonging the shelf-life of food grains in order to ensure global food security. Photovoltaic integrated solar dryers can be a sustainable solution for replacing energy intensive thermal dryers as it is capable of drying in off-sunshine hours and provide better control over drying conditions. But, performance and reliability of PV based solar dryers depend hugely on climatic conditions thereby, drastically affecting process parameters. Therefore, to ensure quality and prolonged shelf-life of paddy, optimization of process parameters for solar dryers is critical. Proper moisture distribution within the grains is most detrimental factor to enhance the shelf-life of paddy therefore; modeling of mass transport can help in providing a better insight of moisture migration. Hence, present work aims at optimizing the process parameters and to develop a 3D finite element model (FEM) for predicting moisture profile in paddy during solar drying. Optimization of process parameters (power level, air velocity and moisture content) was done using box Behnken model in Design expert software. Furthermore, COMSOL Multiphysics was employed to develop a 3D finite element model for predicting moisture profile. Optimized model for drying paddy was found to be 700W, 2.75 m/s and 13% wb with optimum temperature, milling yield and drying time of 42˚C, 62%, 86 min respectively, having desirability of 0.905. Furthermore, 3D finite element model (FEM) for predicting moisture migration in single kernel for every time step has been developed. The mean absolute error (MAE), mean relative error (MRE) and standard error (SE) were found to be 0.003, 0.0531 and 0.0007, respectively, indicating close agreement of model with experimental results. Above optimized conditions can be successfully used to dry paddy in PV integrated solar dryer in order to attain maximum uniformity, quality and yield of product to achieve global food and energy security

Keywords : finite element modeling, hybrid solar drying, mass transport, paddy, process optimization
Conference Title : ICFSN 2018 : International Conference on Food Security and Nutrition
Conference Location : Mumbai, India
Conference Dates : February 22-23, 2018