ABSTRACT

The vibration-aided infrared (IR) heating of high moisture paddy had been studied to develop a faster and uniform parboiling-cum-drying system. A laboratory set-up, capable of modulating both frequency and amplitude of vibration of the grain bed was used to ensure proper mixing of grains. The parameters for the mixing were vibration amplitude, frequency and mixing time, varied respectively from 2 to 10 mm, 10 to 50 Hz and 5 to 120s for all three varieties of paddy (short bold, medium slender and long slender) with different length-breadth ratio (slenderness ratio of 2.70, 4.48 and 5.77). The range of frequency between 20-22 Hz and amplitude between 8-9 mm of vibration were found to be optimum for three bed depths i.e., 25, 12 and 6 mm for uniform mixing. Irrespective of grain bed depth, all three different types of paddy showed maximum value of mixing indices after 60 seconds of mixing. The hot water soaked paddy with initial moisture content of $43 \pm 2\%$ (db) were irradiated by IR source at five levels of radiation intensity (1509, 2520, 3510, 4520, and 5514 W/m^2) for four different grain bed depths (single kernel thickness of 3 mm, 6, 12 and 25 mm) under optimized vibration conditions. Drying rate was found significantly dependent on radiation intensity. Two distinct drying rate periods were observed namely, an initial heating-up period and falling rate period. Drying took place almost under falling rate period. The Page model fitted best for describing the IR drying characteristics of high moisture paddy. Average effective moisture diffusivity values were found to vary between 7.78×10^{-09} and 3.88×10^{-10} m^2/s for different drying treatments. The quality of the dried grains was evaluated in terms of percent head yield, colour (yellowness index), percent gelatinized kernel and specific energy consumption. Both the grain bed depth and the radiation intensity showed their effect on the quality and specific energy consumption either at 1% or 5 % levels of significance. The optimum range of radiation intensity and grain bed depth were found to vary between 3100-4290 W/m^2 and 12-16 mm respectively, in maximizing the head yield (67.87 to 69.66%), percent gelatinized kernel (87.06 to 91.08%), and minimizing the colour (34.28 to 37.09) and specific energy consumption (16.06 to 18.94 MJ/kg). A batch type vibratory infrared dryer was designed, developed and tested for drying characteristics of paddy under optimum

range of radiation intensity and grain bed depth. The drying characteristics were found to be consistent with the observations obtained from the earlier experiments. The experimental values of the quality attributes i.e. head yield, percent-gelatinized kernel and colour were almost close to the predicted values obtained under optimized conditions. The theoretical model developed using finite difference method was used to predict the moisture and the temperature distribution in an individual paddy kernel. A higher rate of decrease in the moisture content (15% per min) at the surface of paddy was observed as compared to that at the center (10% per min). At any specific time of exposure, the temperature was always found to be higher at surface than at the center. Approximately after 2 minutes of infrared exposure, a maximum difference of 24°C was observed between the temperature at kernel surface and center.

Key Words: *Infrared (IR) heating, Drying, Effective moisture diffusivity, Mixing index, Paddy, Parboiling, Quality of Paddy, Vibratory dryer*