MATHEMATICAL MODELLING AND IMPROVEMENT OF OPERATING PRACTICES OF SUN DRYING OF RICE

PYSETH MEAS

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MATHEMATICAL MODELLING AND IMPROVEMENT OF OPERATING PRACTICES OF SUN DRYING OF RICE

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To my mother (Kân Lun)

ព្រមទាំង វិញ្ញាណក្ខន្ធលោកឪពុក មាស សៀង

& spirit of my father (Sieng Meas),

This humble manuscript is lovingly dedicated

ABSTRACT

In Cambodia, sun drying of rice has always been of great importance for preserving rice. The main goal of this study was to find the conditions for sun drying that maximise the throughput while minimising quality loss.

A whole-bed approach was taken to investigate the conditions of the grain and the air at different layers during the drying process. Seven sets of sun-drying experiments were conducted in Cambodia using a range of methods practiced by rice farmers. These methods included drying with different bed depths (2 to 6 cm), with the bed on different pads (water-proof tarpaulin, mat, net, polystyrene or rice husk), and with different bed tempering methods (stirring regularly or shading and/or covering the bed around midday) for four Cambodian rice varieties (Pka Knhey, CAR11, Masary and IR66).

The grain temperature was found to be more affected by the solar intensity than the temperature of the ambient air. Fastest drying was achieved when the bed was thin, less compacted, stirred regularly but not shaded or covered around midday, dried on a pad which allows some air and moisture movement and with high or strong solar intensity.

Only the mechanical impact (MI) and milling tests of the rice quality provided useful results. Higher quality was found for grain that was dried in thin beds, stirred regularly, shaded with or without covering around midday and dried on pads with less air circulation.

Among the methods used to determine the glass transition temperature of the grain, only the Differential Scanning Calorimetry method gave meaningful results. The glass transition temperature data were highly variable but generally decreased with increasing moisture content and compared quite well with the published glass transition temperatures for other varieties of rice.

To provide additional detail on the local conditions within the bed, to better understand the drying process and the interactions between variables and to predict alternative parameters that might be used to correlate with the head rice yields (HRYs), a mathematical model for heat and moisture transport within the bed was developed. The model covered all the drying methods/conditions studied experimentally. A lumped parameter approach to energy and mass transfer in individual kernels was used in the bed model.

The model was validated against experimental data. The predicted drying time, temperatures, moisture contents and water activities (relative humidity of the air within the bed) were found to compare very well with the experimental data except when a polystyrene pad was used. The model proved to be a very good mechanistic tool with advantages of simplicity and practical accuracy in the design and management of the sun drying system.

A number of parameters related to postulated grain damage mechanisms were derived from the predicted conditions within the bed during drying. The best predictors of the grain quality were found to be rewetting the kernels when the grain is bulked (especially when the kernels are partly below and partly above critical moisture content) grain temperature and distance from the glass transition temperature line.

It was concluded that in order to get the fastest drying conditions rice should be sun dried with thin bed, stirring, not shaded or covered around midday and dried on a pad with air circulation. For the highest quality grain, that is grain which would have the least breakage during milling, rice should be sun dried with a thin bed, stirring, shaded or covered around midday and dried on a pad with less air circulation. The optimal drying conditions to get the best quality combined with the fastest practical drying rate, the drying conditions should be drying with 2 cm bed depth, stirring the grain bed every hour, shading or covering the bed around midday and using a tarpaulin or net pad placed directly on the ground.

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Like most of my compatriots, I have suffered intolerable pain and misery through the conflicts in Cambodia. I lost my loving father in my childhood and have had to almost totally rely on my mother, brother and some relatives. Due to the fighting, shelling and many wild fighters, I have had many relocations and my mum was always scared to let me be away or out of her reach. During this, I had a lot of time to observe what she was doing. One of her businesses was to buy paddy grain, get it milled and graded and sell it to make a small profit.

What I saw was that the grain is produced in a very hard way with a high percentage of broken grains in the milled rice. Farmers in the country still do not have many chances to ease their hard work by the means of improved machinery or technology and rely almost totally on the weather for drying. In the end, they do not have good grain for their own consumption and my mother and Cambodian rice farmers can not sell the rice they have produced for a good price due to its low quality. As a result, Cambodia still remains one of the poorest nations. This led me into choosing to look at the effects of sun drying of rice on the quality of milled grain as the subject of my PhD.

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