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Thin-layer drying of litchi (*Litchi chinensis* Sonn.)

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ABSTRACT

This article presents the thin-layer drying of peeled litchi, which was conducted under controlled conditions of temperature and relative humidity. It was observed that the drying temperature has some influence on the drying rates of peeled litchi, so that the higher the temperature the less the drying time. Eight different thin-layer models were fitted to the experimental data of peeled litchi. The drying parameters of peeled litchi were found to be a function of drying air temperature and relative humidity. The Page model was revealed to be the best and it was followed by the logarithmic models. The agreement between the predicted and experimental values for the Page model is excellent, so that this can be used to provide design data and for simulation and optimisation of the dryer for efficient operation. The colour of the dried litchi was light golden brown and it remained almost unchanged for drying at 50 °C, 60 °C and 70 °C. Therefore, the quality change of the dried litchi in terms of colour change was not significant for drying in the temperature range of 50–70 °C.

Keywords: Litchi; Thin-layer drying; Drying model; Colour change

1. Introduction

Litchi (*Litchi chinensis* Sonn.) is a tropical fruit with high commercial value in the international market (Holcroft and Mitcham, 1996) and it is also one of the major fruits in Thailand. The mature litchi is a small spherical fruit and is dark red in colour. Peeled litchi fruits are welcomed by restaurants and consumers for convenience of service and consumption. However, peeled litchi fruits are highly perishable (Dong et al., 2004). The novel alternative practice for preservation of peeled litchi fruits is drying. Again, litchi is a seasonal fruit and drying of the peeled litchi during harvesting season ensures the year-round availability and taste of litchi. Furthermore, the demands for dried litchi are increasing in the international markets because of its taste and flavour. For proper understanding of transfer processes during drying and production of quality dried litchi products, it is essential to know the thin-layer drying characteristics and the quality of the dried products.

Many studies have been reported on thin-layer drying of agricultural products and food materials (Hossain and Bala, 2002; Akpinar et al., 2003; Barrozo et al., 2004; Ertekin and Yaldiz, 2004; Baini and Langrish, 2006; Shiby and Mishra, 2007; Doymaz, 2009; Hacihafizoglu et al., 2008; Nourhene et al., 2008; Usab et al., in press). A considerable number of studies have been reported on the drying of fruits (Hassan and Hobani, 2000; Ahmed et al., 2001; Yaldiz and Ertekin, 2001; Baini and Langrish, 2006).

Precoppe et al. (2008) reported the guidelines for the optimisation of the current litchi drying systems via inventory and comparative analysis of drying facilities in the Chiang Mai area of Thailand. No study has been reported on the thin-layer drying of peeled litchi. This study aims to evaluate thin-layer drying characteristics of the litchi fruit and the

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Nomenclature

a	parameter in thin-layer drying models
a^*	parameter in the colour measurements
a_w	water activity
b	parameter in thin-layer drying models
b^*	parameter in the colour measurements
C^*	parameter in the colour measurements
c	parameter in thin-layer drying models
g	parameter in thin-layer drying models
h	parameter in the colour measurements
k	parameter in thin-layer drying models
L^*	parameter in the colour measurements
M	moisture content of longan fruit (%, db)
M_e	equilibrium moisture contents of longan (%, db)
M_i	initial moisture content of longan (%, db)
M_{obs}	observed moisture content (%, db)
M_{pre}	predicted moisture content (%, db)
p	parameter in thin-layer drying models
R^2	coefficient of determination
RMSE	root mean square error (%)
rh	relative humidity (%)
T	temperature (°C)
t	time (h)

quality of peeled, dried litchi in terms of colour and vitamin C content.

2. Materials and methods

2.1. *Drying experiments*

The litchi fruits used in this investigation had an initial moisture content about 528–569% (db), and they were stored at 5 °C and then left at room temperature before starting the experiments. The litchi fruits were peeled and de-stoned. They were placed on a tray in a thin-layer in a laboratory dryer and dried under controlled conditions of temperature and relative humidity (rh). The laboratory dryer used here is similar to that described by Guarte (1996). A schematic diagram of this laboratory dryer is shown in Fig. 1. The laboratory dryer consists of a ceramic packed bed for producing saturated air at a given temperature, an electrical heater, a blower, a drying section, measurement sensors and a data recording and controlling system with a personal computer. In this laboratory dryer, the blower forces ambient air through a humid ceramic packed bed. The air absorbs moisture while it passes through the packed bed. At the top of the packed bed, this air leaves in a humidified condition. Then, this saturated air is heated by the air heater and passed across the product placed in the tray. Users can choose the through-flow drying mode or over-flow drying mode by closing or opening the air valves to control the flow direction. The rh and temperature of the drying air are controlled by adjusting the power supply to the air heater and the water heater using a psychometric chart as a guideline.

Prior to an experiment, the laboratory dryer was allowed to run for 30 min to obtain a steady temperature. For each experiment, about 500 g of peeled litchi was placed in the drying tray. All the drying experiments were carried out at an air velocity of 0.5 m s^{-1}. The drying air temperatures were monitored using a thermocouple (K type) connected to a personal computer using an interface at an interval of 5 min and the weights of peeled litchi were recorded by an electronic balance (accuracy ±0.01 g) at an interval of 1 h. The thin-layer drying tests were conducted in the temperature range of 50–70 °C and the rh of the drying air from 10% to 25%. Three sets of experiments were conducted for the peeled litchi fruit.

2.2. *Mathematical modelling*

There are three approaches to the modelling of thin-layer drying of agricultural products (Bala, 1998). These approaches are: (a) theoretical approach, (b) semi-theoretical approach and (c) empirical approach. A theoretical equation gives a better understanding of the transport processes but an empirical equation gives a better fit to the experimental data without any understanding of the transport processes involved. The semi-theoretical equation gives some understanding of the transport processes.

Thin-layer drying models of experimental data of peeled litchi are expressed in the form of moisture content ratio of samples during drying, and it is expressed as:

$$MR = \frac{M - M_e}{M_0 - M_e} \quad (1)$$

where MR is the dimensionless moisture content ratio; and M, M_0 and M_e are the moisture content at any given time, the initial moisture content and the equilibrium moisture content, respectively.

To select a suitable model for describing the drying process of peeled litchi, eight different thin-layer drying models were selected to fit the thin-layer experimental data of peeled litchi. The selected thin-layer drying models are presented in Table 1. The models were fitted to the experimental data by direct least square. The coefficient of determination (R^2) was one of the

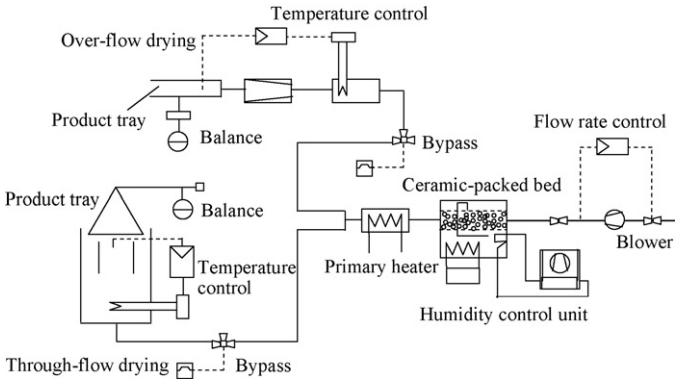

Fig. 1 – Schematic diagram of the laboratory dryer.