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Analysis of current practices of litchi drying in small scale industries in Northern Thailand

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Introduction

Litchi (*Litchi chinensis* Sonn.) is a tropical highland crop originating from Southeast Asia (JIANG and LI 2003). It is mainly cultivated in Southern China, Thailand, India, South Africa, Australia, and Florida (HUANG et al. 2005). The Asia-Pacific region accounts for more than 95% of world production (MENZEL 2002). Litchi is one of the most perishable subtropical fruits (JIANG et al. 2001). Pericarp browning and pathological decay are the main post-harvest problems (JIANG and LI 2003).

In Thailand litchi is one of the most economically important fruit crops (MITRA 2002). More than 80% of the production originates from the upper northern provinces (HUANG et al. 2005). The majority of growers are smallholders (SETHPAKDEE 2002). Lately they have been converting their land use systems, mainly to annual crops, due to fresh litchi price decline (MENZEL 2002) and middlemen controlled markets (SETHPAKDEE 2002). Domestic and export markets are limited by the litchi perishable nature (JIANG *et al.* 2006; SETHPAKDEE 2002). Consequently, litchi canning and litchi drying have been developed (SETHPAKDEE 2002; SUBHADRABANDHU and YAPWATTANAPHUN 2001). Litchi drying is an energy-intensive process and convection dryers are the most common equipment used (ACHARIYAVIRIYA and PUTTAKARN 2003).

This study aims to characterize the litchi drying sector in Northern Thailand and analyze the on-site drying behavior of a litchi bulk. This is the first fundamental step necessary towards development of small-scale litchi drying technology in Northern Thailand.

Material and Methods

Characterization of the litchi drying sector

A survey of litchi drying facilities in Northern Thailand was conducted from April to June 2008. Drying facilities were identified, contacted and visited. Semi-structured questionnaires were applied at the drying facilities. The questionnaire evaluated the facilities in terms of age, equipment, operational procedures, energy, labor and costs.

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Analysis of litchi bulk drying behavior

From the 14th to 28th of May, 2008 four litchi drying experiments were conducted. The study site was a commercial litchi drying facility located in Mae Sa Noi village, Chiang Mai, Thailand. The facility used a convection cabinet-type tray dryer manufactured by Likhitchewan in 2007 (Model D001). The dimensions of the dryer are 1.75 m × 1.28 m × 1.22 m. The walls are made of 1.7 mm steel sheet metal. The loading capacity is about 200 kg of fresh litchi per batch. There are 17 square trays sized 0.63 m^2 each. The trays are positioned atop one another in a tray rack distanced 9 cm from each other. The rack turns on an axis making the trays rotate horizontally at 6 rpm. Heat is provided by a liquefied petroleum gas (LPG) burner which is controlled by a thermostat.

The experiments followed the facility's usual drying operation. Air temperature was controlled by the operator manually adjusting the thermostat. The operator monitored air temperature using a bimetal thermometer with the probe passing through the dryer door into the bulk. It was a stepwise drying process: in the first two hours, the target air temperature was 70 °C, then it was lowered to 65 °C and lowered again to 60 °C after six hours where it was maintained until the end of the process.

Air temperature and relative humidity in the bulk were recorded using 25 miniature logger Sugar Cube Clima (Meilhaus Electronic, Puchheim, Germany) distributed over the bulk. Measurements were synchronized and logged at 30-second intervals.

Results and Discussion

Characterization of the litchi drying sector

A total of 13 litchi drying facilities were interviewed. Local cooperatives were the most common operating structures found in the sector. However, it varied widely from small-scale farms managed by a single family drying only their own harvest, to large-scale drying operations where several megagrams were dried daily, which were commonly supplied by traders. The stated yearly output ranged from 200 kg to 10,000 kg of dried litchi.

Litchis were dried without seed and pericarp. The majority of the facilities performed a stepwise drying process with three stages: starting at 70 °C and decreasing to 65 °C and then to 60 °C over 10 to 20 hours. The common pretreatments included soaking in citric acid ($C_6H_8O_7$ 0.03%), soaking in potassium metabisulfite ($K_2S_2O_5$ 0.05%) and boiling in sugar syrup. Producers in general tried to engage the dryer year-round by also drying others fruits, most commonly longan.

Various types of cabinet tray dryers heated either with LPG or firewood were found. Dryer capacity varied from 80 kg to 3000 kg. Equipments were clustered in 3 groups according to their capacity for fresh litchi: high (≥800 kg), medium (800 kg to 100 kg) and low (≤100 kg). The high capacity dryers were LPG- or wood-fueled. The medium and low capacity dryers were only LPG-fueled. The high-capacity wood-fueled dryers delivered a product of a darker color and with a smoky aroma. This was mainly due to limited possibilities to control drying temperature and discontinuities in the burner exhaust, which released smoke into the drying chamber. A high-capacity LPG dryer was found only at one facility named Bankwae. The temperature control in this dryer allowed for achieving golden yellow litchi, appreciated by consumers. They are able to achieve homogeneous batch without having to change the tray's position. The dryer was developed by the Thai Department of Agriculture, but there is no company producing it. Therefore, the technology is not readily available. Nevertheless, it requires greater organizational structure as a large amount of raw material must be prepared in a short time to meet its capacity. In Phayao province, a cooperative of litchi producers has been drying litchi since 2004 with a dryer manufactured by Dry Magic Co., located in Chang Rai. The dryer is fueled by LPG and can hold up to 80 kg of fresh litchi. The control of temperature allowed for achieving a final product with optimum color. However, uneven heat distribution between trays obliged the user to shift the trays' position during the drying process. Additionally, its cost of €1,900 in relation to its capacity can be perceived as disadvantageous compared to other available equipments. The Mae Sa Noi Lychee Farmers Cooperative, in Mae Rim; the Ban Pabong House Wife Farmers Group, in Fang; and the Small and Micro Community Enterprise Baan Ton Phunt, in Lamphun use a dryer manufactured by Likhitchewan Co, Ltd. It is a LPG-fueled cabinet-type tray dryer with a capacity of 200 kg of fresh litchi. The users mentioned its convenient operation, good temperature control and cost-capacity ratio as its main advantages. The high fuel consumption and non-uniformity of the drying batch were consistently regarded as drawbacks of this dryer.

Analysis of litchi bulk drying behavior

The average air temperatures for experiments 1, 2, 3 & 4 were 65.8, 64.6, 62.0 and 61.8 °C, respectively (Table 1). Figure 1 shows the drying air temperature over time.

Table 1: Average air temperature with standard deviation and average relative humidity per experiment. Phase I refers to the first 2 hours of drying. Phase II between 2 hours and 8 hours of drying and Phase III the remaining period until the end of the process.

	Temperature (°C)			Relative humidity
Experiment	Phase I	Phase II	Phase III	(%)
1	68.2 ± 4.7	67.9 ± 3.6	65.0 ± 3.7	23.7
2	70.1 ± 3.7	68.4 ± 3.6	62.0 ± 6.7	25.8
3	64.2 ± 4.3	62.0 ± 3.5	61.5 ± 1.9	23.3
4	61.4 ± 4.8	61.5 ± 5.6	62.0 ± 3.1	27.7

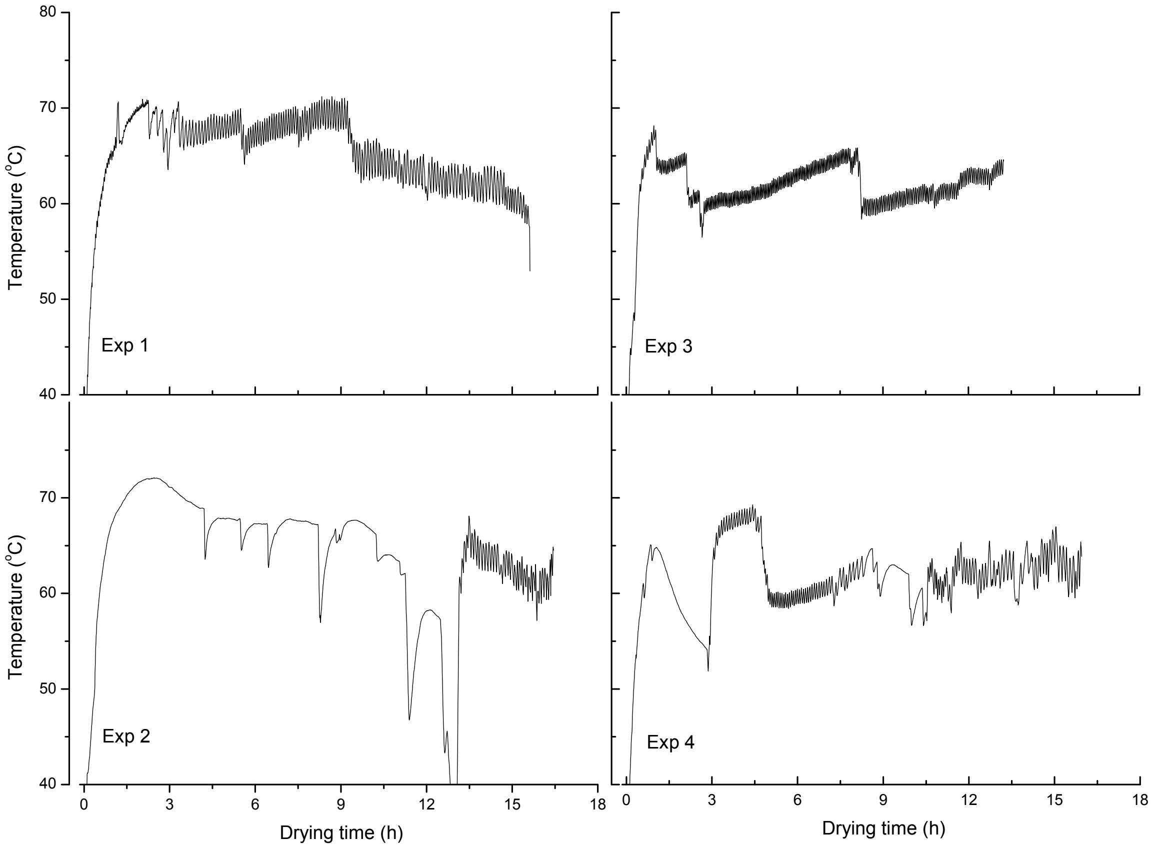

Figure 1: Average air temperature inside the bulk during the experiments.

The observed air temperature fluctuation is due the burner system which is either “on” or “off”. When “on” the temperature at the bulk is on average 7 °C higher than when it is “off”. Aware of this fluctuation and afraid to expose the fruits to higher temperature the operator used the upper limit of the variation to adjust the thermostat what makes the bulk average temperature lower than the targeted stepwise process.

However, in experiment 2, during the first 12.5 h this fluctuation was not observed. This was because the internal pressure of the LPG tank was respectively low and, consequently, the power of the burner was reduced. It remained ignited until the LPG finished after 12.5 h.

Conclusions

From the equipments available in Northern Thailand, the Likhitchewan cabinet dryer was observed as affordable and simple to operate. It has the potential to deliver a final product of high quality and seems suitable for litchi producers.

However, when analyzing the litchi bulk drying behavior at the Likhitchewan dryer deviations from the target stepwise drying process (70, 65, and 60 °C) and the average bulk air temperatures were observed. This divergence was mainly caused by the operator’s thermostat adjustments. It was also observed that the LPG tank pressure influences the temperature control. Therefore it is believed that this problem could be overcome if the equipment would be delivered with an operation manual instructing the user how to adjust the thermostat and recommending using high pressure LPG tank.

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