As. J. Energy Env. **2005**, 6(02), 133-139

Asian Journal on Energy and Environment
ISSN 1513-4121
Available online at www.asian-energy-journal.info

Performance of a PV-ventilated Greenhouse Dryer for Drying Bananas

Serm Janjai*, Chamnong Chaichoet and Poonsuk Intawee

Solar Energy Research Laboratory, Department of Physics , Faculty of Science, Silpakorn University, Nakhon Pathom 73000, Thailand

*Author to whom correspondence should be addressed, email: serm@su.ac.th

Abstract: The performance of a greenhouse solar dryer was investigated. The greenhouse dryer has a concrete floor with the area of 5.5×8.0 m^2. It is covered with transparent polycabonate plates. When solar radiation transmits through the polycabonate plate, the greenhouse effect is occurred in the dryer. Three fans powered by a 50-watt solar cell module was used to ventilate the dryer. To investigate its performance, the dryer was used to dry two batches of bananas. Results from the investigation showed that 50 kg of fresh bananas with the initial moisture content of 70 % can be dried in 3 days. With the same weather conditions, natural sun drying required 5 days of drying time. The air temperature inside the dryer at noon time of a clear day was 60-70 ^{o}C.

Keywords: Solar Energy, Solar Drying, Greenhouse Dryer.

Introduction

Dried bananas are one of the most popular snack items in Thailand. They are generally produced from "Namwa variety" which are mainly grown in the central part of Thailand. A production of dried bananas is concentrated in the province of Pitsanulok. A natural sun drying method is commonly used to dry bananas. According to this method, bananas are spread on bamboo mats and exposed to solar radiation without any covers. They are usually contaminated by dusts, insects and animals. In the rainy season, dried bananas are often rewetted by rains. Therefore, an appropriate dryer is needed to overcome this problem. As Thailand receives relatively high solar radiation [1] the use of a solar dryer is considered to be an alternative solution to this problem. Although many solar dryers have been developed during the last 20 years [2-8] applications of these dryers are very few. In this work, a multi- purpose greenhouse solar dryer developed at Silpakorn University was tested to dry bananas. Its performance is presented in this paper

Description of The Dryer

The greenhouse dryer used in this study was built on a concrete floor.It has a parabolic cross-section. The greenhouse is covered with polycabonate plates with the transmittance of 0.82. The floor of the greenhouse has the area of 5.5×8.0 m^2.The air ventilation is done by three fans powered by a 50-watt solar cell module intalled on top of the greenhouse. Iron shelves with aluminium trays are used to place products to be dried. The dryer was built at Silpakorn University, Nakhon Pathom (13.82 ^{O}N, 100.04 ^{O}E). It is oriented in the north-south direction. The structure of the greenhouse is shown in Fig. 1.

Fig. 1 The greenhouse solar dryer.

Materials and Method

This greenhouse dryer was designed for a multi-purpose drying. In this study, its performance for drying bananas was investigated. To investigate the influence of parameters effecting the performance, various measuring devices were installed. A pyranometer (Kipp&Zonen, model CM3) was used to measure incident solar radiation on top of the roof of the greenhouse. Type K thermocouples were used to measure air temperatures in the dryer and ambient air. The outlet air speed from the dryer was monitored by a hot wire anemometer (Airflow, model TA5). To measure the relative humidity of the air, a hygrometer (Detensor, model) was employed. The electrical signal from the thermocouples and the pyranometer was recorded with a 20-channel data logger (Yokogawa, model DC100). The air speed and the weight of bananas samples were manually recorded. Bananas of Namwa variety from a local market were used as materials for the drying experiments. These bananas had an initial moisture content of about 70% (wb). They were dried to the final moisture content of 30 % (wb). Two experiments were conducted. Fifty kilogram of bananas were used for each experiment. In the experiments, ripe bananas were peeled and spread on the trays in the dryer. There are three levels of the trays namely, upper trays, middle trays and lower trays. The treatments. The drying started at about 8:00 a.m. and stopped at about 6:00 p.m. Samples of bananas in the dryer were weighted at 3-hour interval for the determination of the moisture. Afterward, the bananas were collected and kept in air-tight plastic boxes to induce fermentation and uniform moisture distribution in bananas fruits. They were spread again on the trays in the next morning and the process was repeated until the final moisture content was reached.

Results and Discussion

Two experiments were undertaken in March, 2004. This month is at the beginning of the summer with a lot of cloudless days. During these experiments, the sky was clear with the maximum global radiation of 800-900 W/m^2. A typical result is shown in Fig.2.

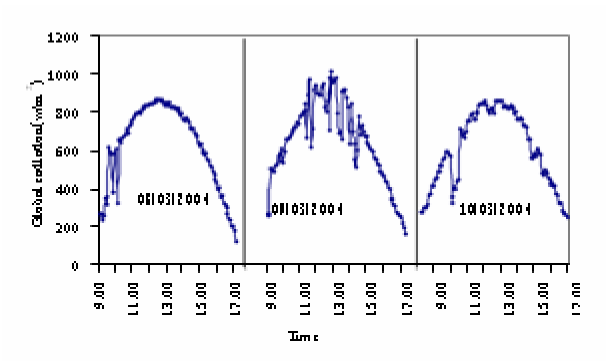

Fig. 2 Variation of global radiation.

For the drying air temperatures at the middle of the dryer for different levels of the trays, they varied in the range of 35 - 70 ^{o}C during 9:00 a.m.–5:00 p.m. as shown in Fig.3. A slight difference of drying air temperature was observed. This range of temperature helps to accelerate a drying rate of bananas without damaging the products being dried.

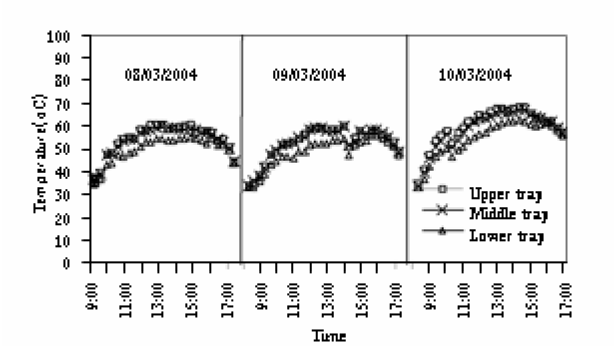

Fig. 3 Variation of drying temperature at the middle of the dryer for different levels of the trays.

For the relative humidity of the drying air at the different levels of the trays, its values are nearly the same, as shown in Fig.4. This relative humidity is much lower than that of the ambient air for most time of a day. Therefore, the air in the dryer has significantly higher drying potentials than the ambient air.

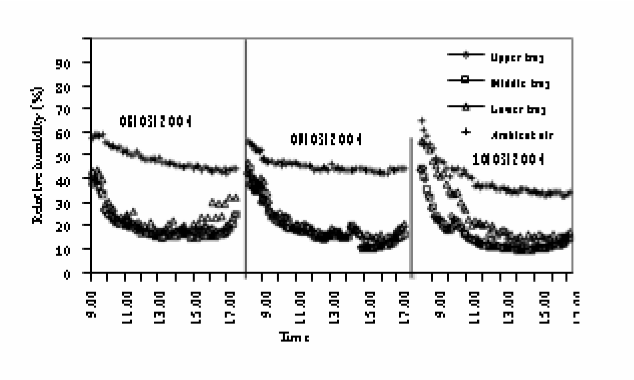

Fig. 4 Relative humidity of the drying air at the middle of the dryer.

As the fans were powered by a solar cell module, the air flow varied with solar radiation, as depicted in Fig.5.

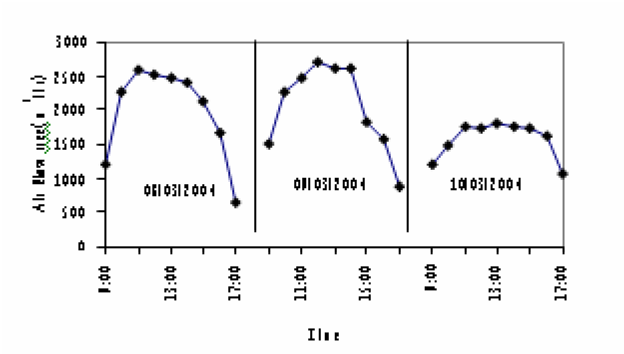

Fig. 5 Variation of the air flow rate.

It was observed that the air flow rate varied in the range of 1,000-2,500 m^3/hr during 8:00 a.m. – 5:00 p.m. This flow rate help to control the drying air temperature in the dryer. This is due to the fact that when solar radiation is high, the air flow rate is also high, causing the drying air temperature not high. Inversely, when the radiation is low, the air flow rate is low, making the drying air temperature not too low.

In terms of the drying rate, the variation of the moisture content of the bananas in different levels of trays, compared with that of bananas dried with the natural sun drying is showed in Fig.6.

It is noticed that there is only slight difference in drying rate of bananas in the different levels of the trays, owning to a uniform drying air temperature in dryer. The drying rate of bananas in the dryer is significantly higher than that of the natural sun dryer. The drying time required for drying bananas is approximately three days, or two days shorter than that of the natural sun drying. In this dryer, the drying process continue until 6 p.m. due to heat storage in the concrete floor.

The quality of dried bananas in terms of colour, texture and taste is as good as high quality dried bananas in markets.

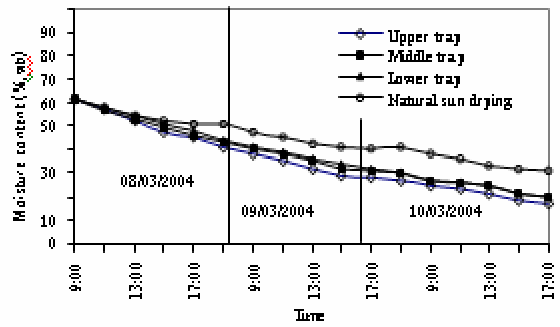

Fig. 6 Drying curves of bananas.

Conclusion

The performance of a greenhouse solar for drying bananas has been investigated. Two experiments were carried out. Fifty kilograms of bananas can be dried in 3 days. The PV- ventilated system effectively helped to regulate the drying air temperature. The drying process continued until 6 p.m. due to heat stored in the concrete floor. The problem of losses due to a contamination by insect and animal and rewetting by rain was overcome. The dried products of high quality were obtained.

Acknowledgements

The authors would like to thanks the Department of Alternative Energy Development and Efficiency for partially supporting this research work. The authors would also thanks Mr. Vasana Kumwongsa and Mr. Worawut Makjaroen for their assistance in conducting the experiments.

References

[1] Janjai S., Laksanaboonsong J.,Nunez M.and Thongsathitya A. (2005), Development of a method for generating operational solar radiation maps from satellite data for a tropical environment, *Solar Energy* ; (in press).

[2] Bala B. K., Mondol M. R. A., Biswas B. K., Chowdury B.L., Janjai S. (2003), Solar drying of pineapple using solar tunnel drier, *Renewable Energ,y* 28 , pp. 183-190.

[3] Schirmer P., Janjai S., Esper A., Smitabhindu R., Muhlbauer W. (1996), Experimental investigation of the performance of the solar tunnel dryer for drying bananas, *Renewable Energy*, 7(2), pp. 119-129.

[4] Soponronnarit S.,Assayo M.,Rakwichian W. (1991),Performance of a solar banana dryer, *RERIC International Energy Journal* , 13, pp. 71-79.

[5] Sudha M.S.,Bansal N.K., Kumar A.,Bansal P.K.,Malik M.A.S.,(1987), *Solar Crop Drying*. Vol 1, CRC Press, Florida.

[6] Boon-Long P., Hirun A., Siratanapanta T. Siriplapla P.,Sitthipong N., Sucharitakul P., Therdtoon P., Rerkkringkrai P, (1984), Solar-assisted tobacco curing, *Proceedings of the Regional Seminar on Solar Drying*, Yogyakarta, Indonesia , pp. 85-95.

[7] Wibulsawas P. and Thaina S., (1980),Comparative performance of a solar cabinet dryer. *Proceeding of a Workshop on Fuel and Power*, Universite de Bordeaux, France, pp..1- 14.

[8] Exell R. H. B., Kornsakoo S., (1976), A low cost solar rice dryer. *Appropriate Technology* ,5,pp. 23-25.