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The Development of Drying System by Using Parabolic Collector Technique for SMEs

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Abstract

Drying is one of the most methods used to preserve food products for longer periods. The majority of farmers nowadays used the open sun drying method for drying agricultural products. It is the oldest preservation technique of agricultural products and sun drying is widely practiced in the tropics and subtropics. It usually takes long time periods and will not be completed on time when the lack of sunlight or on the raining season. Moreover, by using an ancient model such as open sun drying, this very simple technique leaves the crop susceptible to rain, contamination by dirt and animals and also usually takes a much longer time to dry resulting in a final produce with very poor quality. Thus, this research has been used the application of solar energy for a dryer to solve the problems. The dryer concept is divided into two main parts; first is a solar collector for sun solar collection using parabolic technique. The heat produced from solar energy on this system is used to provide 50 % of heat source for the dryer process. Second system is a solar greenhouse chamber and the temperature controller; the parabolic panels can be adjusted from 1-50 degrees. The dryer system can produce heat up to 80° C in the greatest sunny days [1]. However, this season the drying system can produce the temperature up to 63°C in the chamber dryer to dry fresh chilli.

The experimental results of proposed dryer system are compared to the ancient model of open sun drying, the result shown that by using the applied of parabolic collector technique and solar greenhouse chamber can reduced the moisture content of Jinda chili from 86 % wb (wet basic) to 8% wb within 3 days, while using open sun drying meet the moisture content of 67 % wb (wet basic) within the same period. The Development of Drying System by Using Parabolic Collector Technique for SMEs is presented an effective of used such as natural energy for the drying process. It can improve the quality of products and reduce drying time and costs drying operations for farmers.

Keywords: Solar energy, Parabolic, Hot air, Dryer

1 Introduction

Thailand is an agricultural country, and its products range from world famous jasmine rice to various vegetables, fruits and herbs. Most of the products need some kind of preservation to enhance their shelf life since the production usually exceeds market demand at the harvest season. Drying is one of the most used methods for product preservation, and as a result, it adds higher value to the products. A dryer can achieve this purpose by supplying more heat which in turn increases the vapor pressure of the moisture in the product, reduces relative humidity of the air, then increases its moisture loading capacity and ensures sufficiently low equilibrium moisture content. Solar energy can be used as an important and environmental compatible source of renewable energy. The use of solar energy for drying effectively reduces the problems arising from generating energy by convention method. This is because the use of the conventional energy source for drying purposes is costly and hazardous to environment [2]. "Clean, economical and unlimited use" all of these are the definition of solar energy. In general, it is well known for its use in the production of electricity through the solar cell panel. In the past majority of famers mostly used open sun drying method for drying agricultural products to preserve or keep the quality of products. It usually takes long time and will not be done by time when the lack of sunlight or on the raining season. Moreover, by using an old fashion such as open sun drying, it will cause the products not achieved the demand target; contaminated of the dust and this would be reduced the quality of the products. Nowadays even though there are increasing in development of dryers such as Microwave, electric infrared, electric heater, gas burner, fuel diesel, fuel gasoline, etc. Those methods mentioned above use high capital, high power consumption and also affects the environment. Nowadays, solar energy is widely used in the world [1].

Therefore, this research has been used the application of parabolic solar collector technique for a dryer to make benefit. This energy is clean energy and no capital and it can be used as tha main heat source.

2 Materials, Methods and Theories

2.1 *Experimental Setup*

The drying system type of parabolic collector technique was installed at Rajamangala University of Technology Thanyaburi, Pathum Thani Province, Thailand. The dryer consists of a parabolic roof structure made from polycarbonate sheets on a concrete floor. The system has a width of 6.0 m, length of 8.0 m and height 2.5 m. Four DC fans operated by one 50-Watt solar cell modules were installed in the wall outlet side and other one in the inlet side to ventilate the dryer. Parabolic solar collector has a width of 0.825 m, length of 2.40 m. depth of 0.45m with eight panels were installed at the rear side of the dryer. The basic concept behind the parabolic solar dryer is to explore the possibility of using the parabolic trough collector systems such as those used in the line focus point and combining it with the glazing collector system to increase the efficiency of the solar dryer. It is made of zinc which transforms the heat through the reflection to the tube absorbing the heat to the drying chamber properly. The pictorial view of the whole designs of the solar drying system in this study is shown in Fig.1.

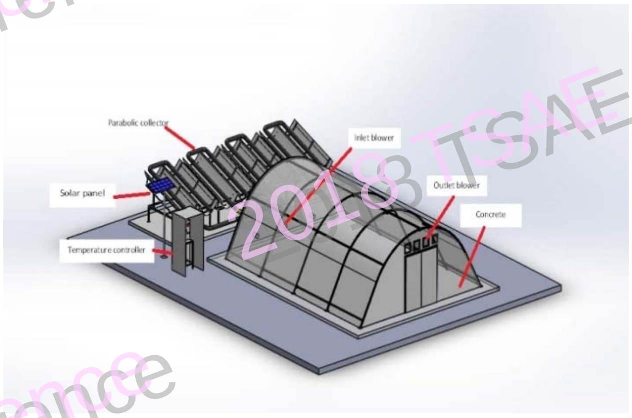

Fig.1. Whole designs of the solar drying system

Solar radiation passing through the polycarbonate roof heats the air and the products inside the dryer as well as the concrete floor. The hot air from the parabolic collector is ventilated through a small hole at the bottom of the behind side of the dryer was absorbed by one DC fan, which the air inside the chamber heated by the concret floor and the products exposed to solar radiation. The heated air while passing through and over the products absorbs moisture from the products. Direct exposure to solar radiation of the products and the heated drying air enhance the drying rate of the products. Most air is sucked from the dryer by three PV-fans at the top of the outlet side of the dryer. The pictorial view of the solar drying system with parabolic collector technique is shown in Fig.2.

Fig.2.The pictorial view of the solar drying system with parabolic collector technique

2.2 *Experimental procedure*

The experimental were carried out 50kg for Jinda Chilli during the period of February, 2018. The chilli was weighed and spread out over the tray in a thin layer in the solar chamber dryer. Seven control samples of Jinda Chilli were placed on the tray inside the chamber at different position as shown in Fig.3 and another one sample was also placed on a tray outside the chamber in the open sun drying. Drying was started after completion of the loading, usually at 9:00 and discontinued at 17:00. About 20g of each sample was weighed from the samples in the chamber dryer. Weight loss of both the samples in the solar chamber dryer and the control samples in the open sun drying were measured during the drying period at 1 h interval with digital scales (Model SF-400, accuracy ±1g). In the afternoon, after 17:00, the samples in the solar chamber dryer were kept in the dryer and the control samples were kept in a room at ambient conditions. These control samples were again put out in the sun next morning usually at 9:00 a.m. Then both the solar and sun drying samples were subjected to dry under the same weather conditions.

A K-type thermocouple (Daiichi-TH207) was used to measure the drying air temperature inside the chamber, inlet and outlet. A solar meter (Model IR G-22, accuracy ±1.5%) was used to measure the solar radiation at the position of the PV module. Relative humidity and temperature of the ambient air were measured with a digital humidity/temperature meter (Model ThermoPro TP 50: accuracy ±1%). Velocity of drying air was measured with a vane type anemometer (Model CFM/CMM Thermo - Anemometer: accuracy ±.01 m/s) at the inlet and outlet of the dryer. The ambient temperature, ambient relative humidity, temperature inside the chamber dryer, relative humidity at the inlet and outlet of the dryer, air flow rate at the inlet, outlet of the dryer, solar radiation, were recorded at 1h intervals during the solar drying of chilli. The moisture content of the chilli samples were measured at the starting and end of each run of the experiment by drying the samples in an air ventilated oven at 105 °C for 24 h as shown in Fig.4 [3]. After completion of drying, the dried chilli was collected, cooled in a shade to the ambient temperature and then sealed it in the plastic bags.

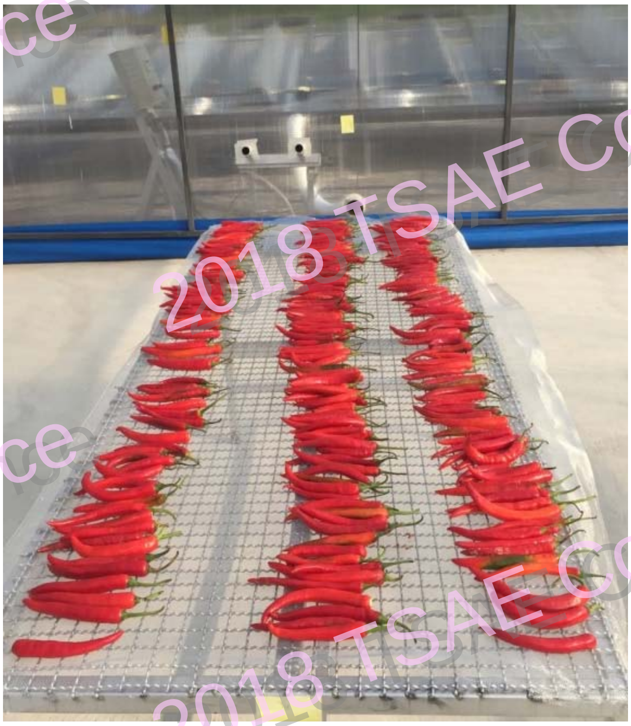

Fig.3. Pictorial view of the Jinda Chilli inside the chamber dryer

Fig.4. Pictorial view of the moisture content experiments using air ventilates the oven dryer

2.3 *Experimental theories*

The focus point of the parabolic collector system can be determined as the equation below [4]:

$$f = \frac{D^2}{16h} \quad (1)$$

Where:

F focus point of the parabolic collector
D width of the product
H depth of product

Moisture content can be determined on the wet or dry basis as indicated in the equations below [4]:

$$\text{Moisture Content(dry basis)} = \frac{(Wi-Wf)\times 100}{Wf} \quad (2)$$

$$\text{Moisture Content(wet basis)} = \frac{(Wi-Wf)\times 100}{Wi} \quad (3)$$

The final mass of water lost can then be determined by:

$$Mw = \frac{(MCwi-MCwf)\times Wi}{1-MCwf} \quad (4)$$

Where:

MCwi	Initial moisture content on a wet basis before drying (%)
MCwf	Final moisture content on a wet basis after drying (%)
MCd	Moisture content on dry basis (%)
MCw	Moisture content on wet basis (%)
Wi	Initial mass before drying (g)
Wf	Final mass after drying (g)

3 Results and discussion

Fig.5 shows the variations of solar radiation during the typical experimental runs of solar drying of Jinda Chili in the solar chamber dryer.The three experiments were carried out during 13th-15th Febraury, 2018. In each experiment of drying the weather was clear sky day with the maximum solar radiation of 481W/m^2. During the drying of Jinda Chili, solar radiation increased sharply from 9 am to noon but it considerably decreased in the afternoon. There was also a slight random fluctuation in solar radiation. However, the overall cyclic patterns of the solar radiation were similar during these three days.

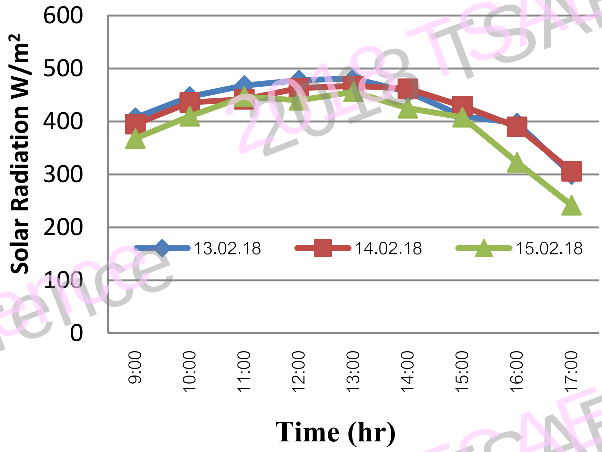

Fig.5. Variations of solar radiation with time of the days for a typical experimental run during drying of Jinda Chilli

At the middle of the dryer, the drying air temperatures inside the chamber on the top of the tray were found to varried in the range of 39 - 63 °C during 9:00 .– 17:00. Temperature air inlet, air outlet and inside the chmaber of solar collector were compared with the ambient temperature and shown in Fig. 6.

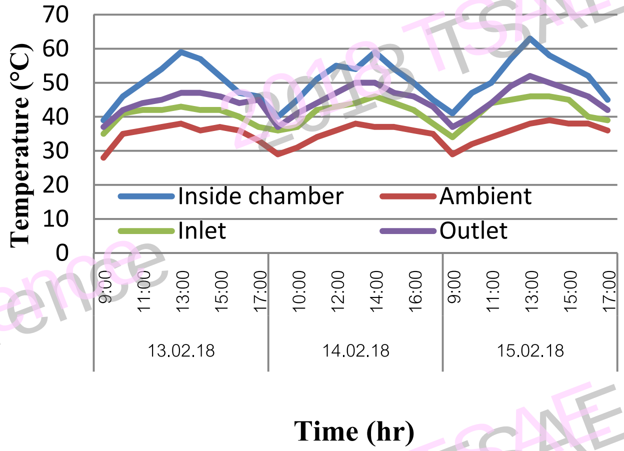

Fig.6. Variations of the ambient temperature and temperature of the inlet air, outlet air and inside the chamber dryer

Fig.7. shows relative humidity inside the chamber dryer for typical experimental runs during solar drying of Jinda Chili. Relative humidity decreases with time inside the dryer during the first half of the day. This is caused by decreasing relative humidity of the ambient air and increased water holding capacity of the drying air due to temperature increase, whereas the opposite is true for the latter half of the day. The relative humidity of the air inside the dryer is always lower than the ambient air and the lowest humidity is in the middle of the day which persists for about 5 hours. Thus, the time of day with the most potential for solar dying is between 9:00 and 16:00.

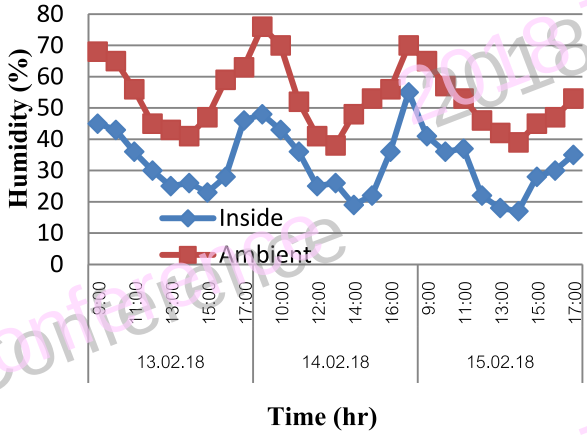

Fig.7. Variations of ambient relative humidity and relative humidity inside the chamber dryer with time of the day for a typical experimental run during drying of Jinda Chili

Fig.8. shows the variations moisture content of Jinda Chili samples in the chamber dryer for typical experimental runs compared to the control samples dried in the open sun drying. The moisture content of Jinda Chili in the solar dryer was reduced from the initial value of 86 % (wb) to a final value of 8 % (wb) within 3 days whereas the moisture content of the open sun drying sample was reduced to 67 % (wb) within the same period.Thus, drying in the solar chamber dryer results in a reduced drying time. About 5 kg of fresh Jinda chillies were dried to about 0.8kg as shown in Fig.9.

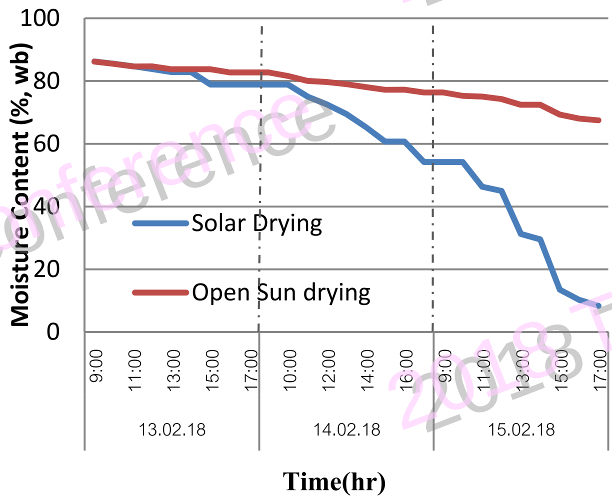

Fig.8. Comparison of the moisture contents of Jinda Chili inside the chamber dryer with the open sun drying method

Fig.9. Remains weight of Jinda Chilli from 5kg to about 0.8kg after 3 days of the drying process

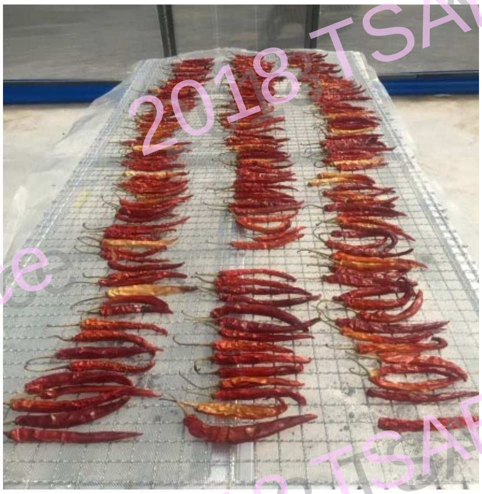

Fig.10. Pictorial view of the Jinda Chili after 3 days of drying process

4 Conclusions

This research is applied parabolic collector technique with heat from solar energy inside the chamber greenhouse for drying agricultural products. Solar energy is based on the principle of the parabola in lighting. The dryer system can produced heat up to 63 °C and a daily average was 51 °C the results presented that; it can reduced the moisture content of Jinda Chilli from 86% wb (wet basic) to 8% wb within 3days, while using open sun drying meet the moisture content of 67% wb (wet basic) within the same period, which is not suitable for market moisture requirement. The Development of Drying System by Using Parabolic Collector Technique for SMEs is presented an effective of used such as natural energy for the drying process. It can improve the quality of products and reduce drying time and costs drying operations for farmers.

5 Acknowledgements

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