Mango Sheet Drying by the Solar Dryer Combine with Electric Coil

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Abstract
This research was aimed to compare the duration of drying, energy consumption and yield of drying mango sheet between drying with solar energy and drying with the combination of solar energy and electric coil. The designed condition of the temperature divided into 3 ranges, i.e., 45-50°C, 55-60°C, and 65-70 °C, to find the optimal range of the temperature.

The result found that the optimum temperature for drying was 65 - 70°C which used the time less than the other conditions. The combined system was more efficiency than that of the solar energy because it could dry the product more than that of the solar system approximately 60%.

Keywords: Solar Dryer, Mango Sheet

Introduction

Chachoengsao province is the venue for the most favorite fruit in Thailand where mangoes are the major products, with the area of 34,400 Acre available for agriculture, which mangoes are grown mostly in Bang Khla and Plaeng Yao districts. The most popular cultivars of mango are Rad, Khaew Sawei, Chao Khun Thip, and Thongdam. The mango fruits season is in March, where the mango festival will be held annually for selling the mango fruits to tourists and local people. It has been shown that the mango fruits are oversupply during this period where the left over mangoes become ripe and lead to the lower price of mango due to the fruits become rotten during the shelf life. In order to reduce the economic lost of unsold mango fruits, there is a need to transform the mango fruits into the value added products such as the dried mango paste derived from the pulp of ripe mango fruits.

Drying process is the procedure that is defined as the removal process of water or moisture from the mango pulp. Food drying is also a process of food preservation that can help to keep fruits and vegetables last longer time by reducing the amount of water they contain from 80 - 90% to 10 - 20%. Therefore, drying can be defined as a process that reduces the amount of moisture in products to a level that they can be preserved against decay.

To date, the qualities of driers that commercially available are not quite satisfied in drying facilities they provided. Each method has some limitations and deficiencies in terms of power consumption, drying cost and quality variables in products. The current commercially available driers are designed to use one or a few methods such as contact drying, convective drying, drying with radiation, dielectric drying, and freeze drying, osmotic drying and vacuum drying. Among drying methods, the most commonly used one is the convective drying method carried out with the help of airflow. Various types of energy sources (electric, LPG, fuel oil) are still being used to heat the air in dryers in industry. Since the utilization of commercial power sources in heating air will increase the expenses of drying, this method is not suitable for use in drying fruits and vegetables in rural areas. For this reason, solar power dryers have been focused on the development of dryers based on solar energy in order to dry vegetables and fruits.

Drying method by means of solar power is divided into two major groups, i.e., passive and active method, according to air circulation technique in dryer. In passive dryers, air circulation is activated by means of thermal power (according to the "Principle of Convection"). In active dryers, air circulation is provided by means of an electric fan. Although active dryers facilitate a faster drying compared to passive dryers, they cannot be used in places where there is no electricity, which necessitates an additional cost. Active dryers should be preferred when product to be dried is in a large amount; and when the drying period is short. Solar power dryers are classified as direct, indirect, and combined types according to the forms of exposing to solar radiations (Ekechukwu and Norton, 1999). Many types of solar air heaters and dryers have been developed in the past for the efficient utilization of solar energy (Sami et al., 2011). Among stationary solar heaters, air flat-plate collectors (FPCs) have been widely used for energy management in an increasing number of installations. They are quite attractive for low-temperature solar energy technology, which requires air temperatures below 100 °C. In fact, solar air FPCs are extensively used over years because they are relatively simple with a minimal use of materials, easy to operate and have low capital costs (Duffie and Beckman, 2013; Kalogirou, 2004). Furthermore, it is established that the introduction of different geometries of artificial roughness, in the dynamic air vein of the FPC, increases the transfer rate and favors the creation of turbulences near the absorber plate (Karim and Hawlader, 2006).

The objective of this research was aimed to compare the temperature and time that effecting change color, where the moisture content of mango and stirring process during drying would base on using solar drying and solar energy in combination with the heater. The cost of drying under solar drying would be compared with that using solar energy in combination with the heater.

Method

Experiment setup

In this study, a solar air power cabin dryer collector was designed in order to dry mango sheets and used the electric power combine to the drying process for increasing the temperature or used when the solar radiation was low. The designed conditions of the temperature divided into 3 ranges, i.e., 45-50°C, 55-60°C, and 65-70 °C. in order to find the optimal temperature where the power consumption was considered as the major factor.

Solar dryers combined with electrical coils shown in Figure 1 (a) a solar collector panel, which used to generate hot air for drying. The product tray was placed with clear glass the heat of solar could pass through the glass for drying the products that could be dried by direct sunlight (b). An electric coil heater was used to generate heat to raise the temperature when the solar heat was not sufficient (c).

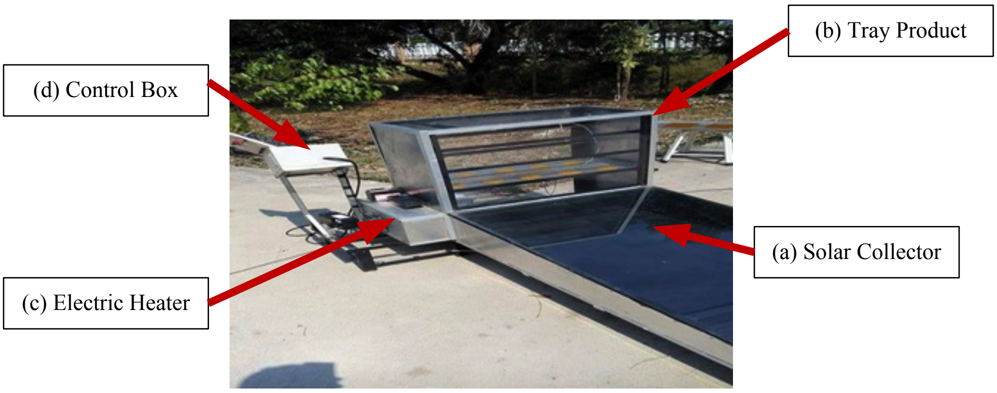


Figure 1. Solar dryer combine with electric coil

Data reduction

This study was to analyze the results to know the time to change the color of mango and stir in water each hour. To find the optimal conditions for drying mango stir and comparison between drying using solar drying using solar heater with temperature 45-50 ° c, 55-60 ° c and 65-70 ° c with the following steps

Prepare the product the mango cooked taken through the process of stirring until dry and can be made up of 5 kg.

Figure 2. Mango stir

Record the weight of mangoes sheet and arrange on the product tray. Then, dried with a solar dryer with the electric coil. Record the inside and outside temperature of the solar dryer. Record the weight of the product and compare color of the mango sheet with the standard color every 1 hour and read the electric power consumption, too.

Once the data has been completed the data were analyzed. It is possible to calculate the moisture content of crop being dried at any t time as follows:

$$\text{Moisture content} = \frac{M_t - M_e}{M_e}$$

(1)

In the term of M_t is the mass of the drying product at a time t (kg) and M_e dry mass of product (kg)

In drying process, dimensionless moisture ratio (MR) is one of the most important parameters while examining drying and dryer parameters. While calculating dimensionless moisture ratio, measurement time, moisture content, initial moisture content and balance moisture content are taken into consideration.

$$MR = \frac{M_t - M_e}{M_i - M_e}$$

(2)

Term M_i is initial of product's mass.

Moisture content wet basis ($\%MC_{wb}$) is compare the weight of the total weight of the product. Can be written as an equation.

$$\%MC_{wb} = \frac{M_w}{M_w - M_s} x100$$

(3)

When, M_w is the mass moisture in the product and M_s is the mass of the dry product.

Results and Discussion

Dried mango stir with a combined process which compared between drying by using the solar power alone and in combination with solar heaters. Setting the temperature inside the dryer at 45-50 ° C, 55-60 ° C and 65-70 ° C to find the right time and the drying mango stir colorful appetizing compared to the market. With the change of the temperature outside and inside the dryer every one hour the temperature changes, humidity and the weight.

Temperature and Drying time

Experiment setting for drying mango sheet in 4 cases that are drying with solar power only, solar power combine with electric coil and setting the temperature at 45-50 ° C, 55-60 ° C and 65-70 ° C. The result shown in figure 3-6.

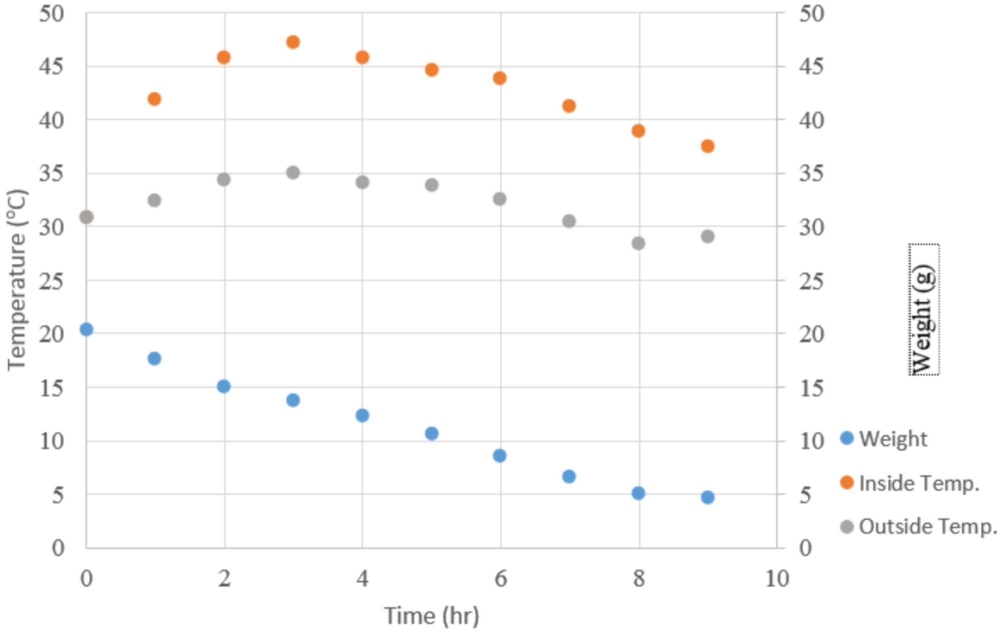
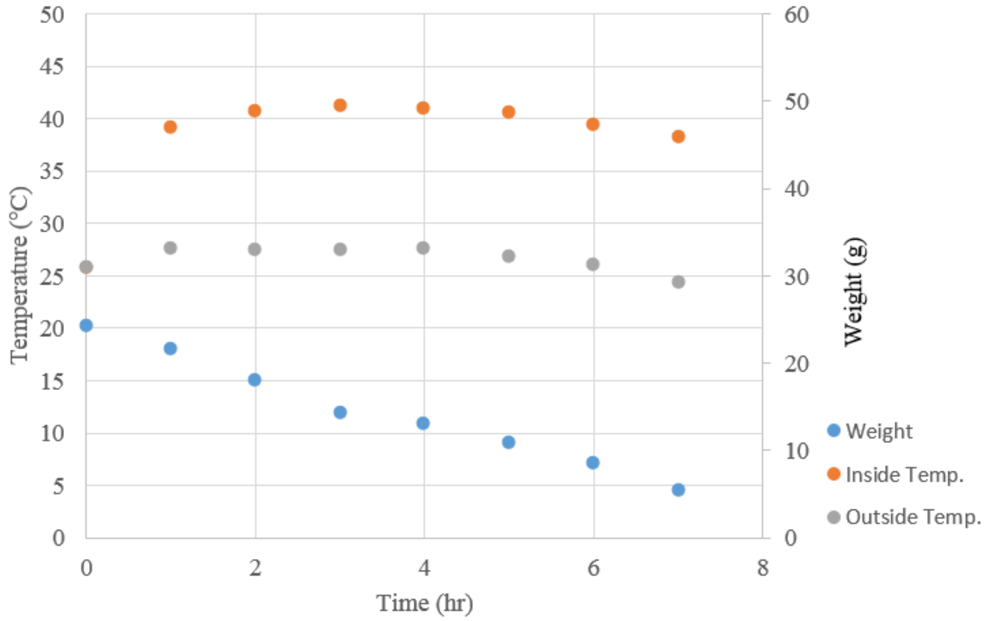


Figure 3. Drying with solar power



. **Figure 4.** Solar drying with electric coil (45-50 °C)

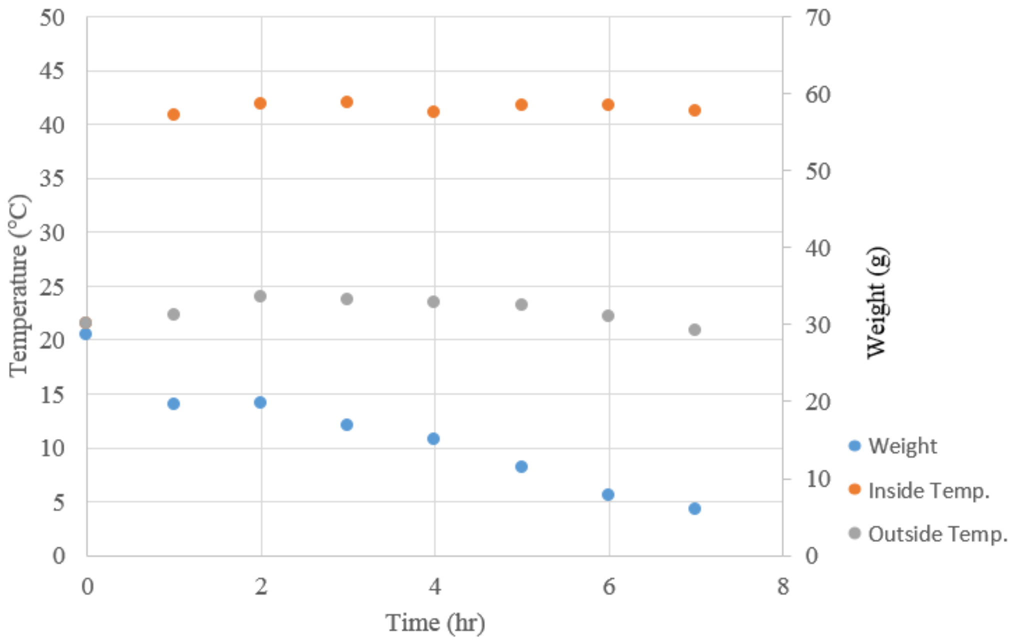


Figure 5. Solar drying with electric coil (55-60 °C)

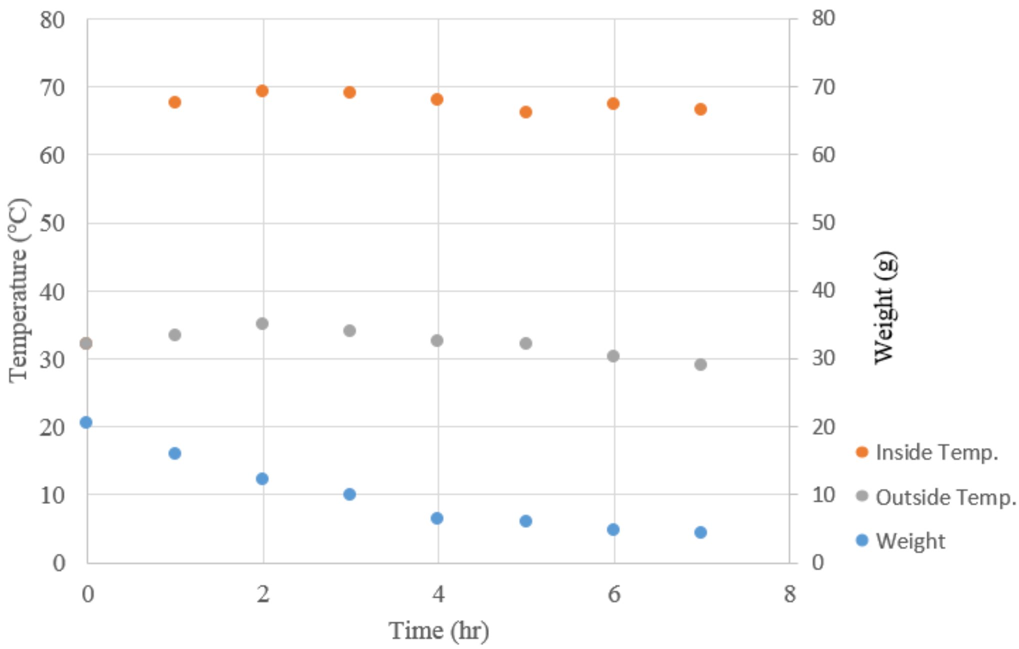


Figure 6. Solar drying with electric coil (65-70 °C)

In Figure 3. Shown mango sheet drying with solar power only, the maximum temperature is 51 °C and the time to use for drying is 8-9 hours (compare with the standard color). Figure 4-6 Shown a mango sheet drying with solar power combine of the electric coil. The temperature setting to 45-50 °C, 55-60 °C and 65-70 °C, respectively. The result shown the maximum temperature in each case are 50 °C, 60 °C and 70 °C and the time to use for drying are 7, 6 and 5 hours, respectively.

Moisture content of the mango sheet

Moisture content in drying process shown in figure 7. It can be seen that the temperature at 65-70 °C with the evaporation of the water dropped quickly, within a period of five hours to get the color of mango stir compliant reference. The temperature of 45-50 °C and 55-60 °C for a period of up to 6 hours and 7 respectively. In the case of solar power only it takes 8 hours to calculate the moisture content of 3-5%, which is close to the base wet mango agitation used as the reference standard.

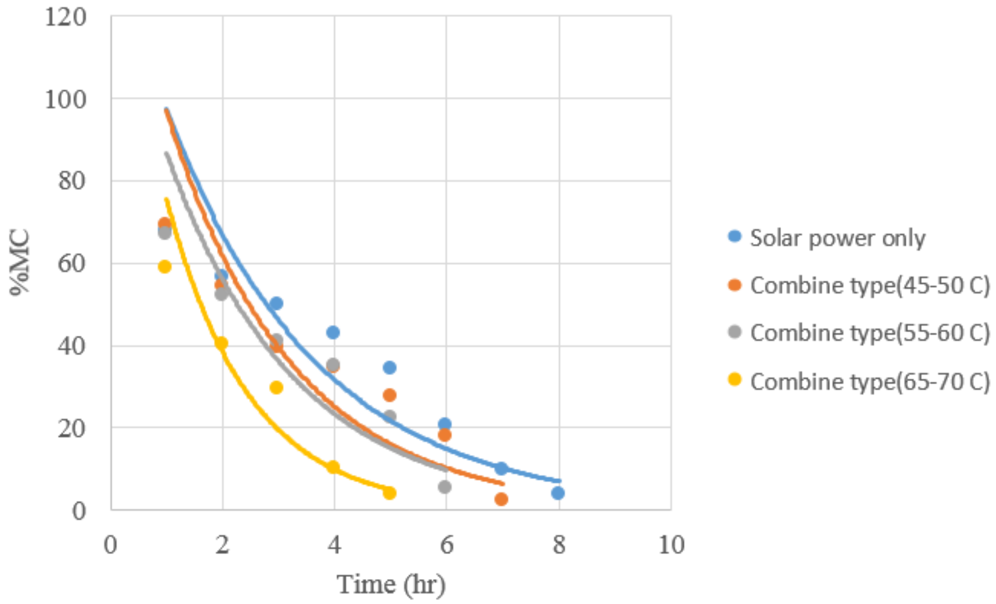


Figure 7. Moisture content of drying mango sheet

Power consumption

Information from the electric power meter drying. Solar electric fans are used alone. The power consumption is minimal the temperature at 45-50 °C with the operation of the heater periodically. Due to the change in solar the use of more electricity. The temperature range of 55-65 °C, 65-70 °C heat energy from the sun is not hot enough. The temperature inside a low heater work more. The use of energy more time. The power consumption shown in figure 8.

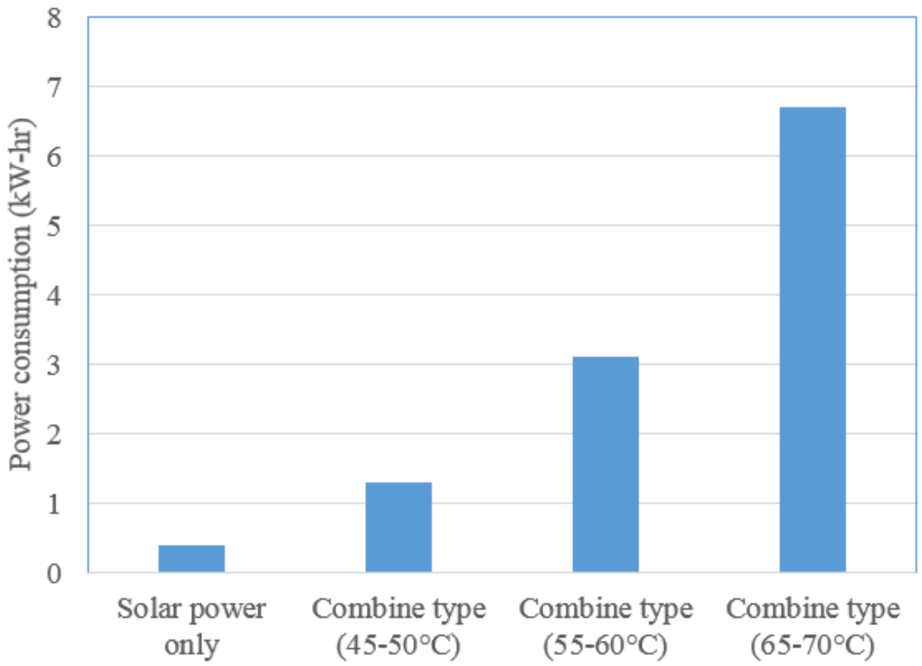


Figure 8. Power consumption in drying process

The ability to stir the mango drying up of solar dryers. Drying can be stirred mango 150 sheet/time period of drying, using solar power criteria for the extrapolation. Drying temperature is 45-50 °C, 55-60 °C and 65-70 °C oven can stir the mango pieces of 171.4, 200 and 240, respectively, revenues from the sale of mangoes found much less electricity. 65-70 °C temperature drying period, drying more quickly than it can be dried mango quantities. The net income for the most power.

Conclusion

The experiments compare the drying mango sheet process. By using a solar power and solar drying with the heater. It is seen that the dried mango stir using solar drying takes eight hours until the color that meets the needs of the market. Unlike drying using solar heater with temperature 45-50 °C, 55-60 °C and 65-70 °C takes the drying 7 hours, 6 hours and 5 hours reduced accordingly. Due to the higher temperatures result in a discoloration of mango stir quickly. But there will be electricity consumption increases. The heater requires more work as well. The drying temperature is 65-70 °C use the power is 6.7 kWh, temperature 55-60 °C use the power is 3.1 kWh electricity consumption and the drying temperature 45-50 °C use the power 1.3 kWh. The drying temperature is 65-70 °C drying rate was over. Despite the high electricity consumption. But it can be much more than dried mango, dried using solar energy and drying at temperatures of 45-50 °C and 55-60 °C compared to the same period of drying off.

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