EVALUATION OF SOLAR DRYER DESIGNS FOR FODDER DRYING

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ABSTRACT. A solar dryer was designed and constructed to dry fodder for livestock. The objectives of this project were to design and construct solar dryer systems for fodder drying and to evaluate the performance of the systems developed so that farmers can compare and choose an appropriate drying system to dry fodder. Two types of solar driers were designed in this study named as a) prototype solar dryer and b) greenhouse solar dryer. The performances of both systems were evaluated by observing their ability to achieve and maintain an optimum temperature of 60°C for a perfect drying process. In 2011, the prototype solar dryer was constructed at the Malaysia Veterinary Institute; however the results obtained were not as expected as the highest temperature achieved with the system was 44.9°C. Therefore, in 2012, the greenhouse solar dryer was constructed to replace the prototype model and the system has the ability to achieve the temperature up to 72.7°C.

Keywords: prototype solar dryer, greenhouse solar dryer, design, construction, fodder drying

INTRODUCTION

Fodder that is not fed fresh requires drying to reduce its moisture content to prevent damage during storage (Augustus *et al.*, 2009). Fodder is generally dried under the sun drying due to its simplicity and can be used at zero cost (Hossain *et al.*, 2011). Even though solar energy is available at no cost, there are a few disadvantages, especially in terms of product quality, contamination of product and the loss of certain product desirable characteristics when exposed too long in the direct sunlight. It has also been postulated that this conventional method is tedious, time consuming with low hygienic conditions (El-Amin *et al.*). Therefore, various indirect drying methods utilizing solar energy have been designed and developed as an alternative technique to dry products to overcome all these problems. The aim of this research was to design, construct and evaluate the performance of two solar drying units namely a) prototype solar dryer and b) greenhouse solar dryer to determine which system is more effective and able to achieve an optimum temperature of 60^{o}C to dry fodder. The prototype solar dryer was constructed in 2011 at the Malaysia Veterinary Institute, Kluang and the system was tested to determine its performance. The basic equipment to develop the prototype solar dryer was solar panels, charge controller, solar rechargeable batteries, inverter, blower and heater. However, the system failed to operate properly and the results obtained were not as expected. Therefore, a new design called the greenhouse solar dryer was constructed in 2012 to replace the older model. The greenhouse solar dryer was designed in a way that the drying process can be done continuously throughout the night and during both cloudy and rainy conditions.

DESCRIPTION OF THE SYSTEM

The dimension of the prototype solar dryer was 3.0 m × 2.5 m × 2.5 m as shown in Figure 1, built of metal deck and insulated by single layer plywood and three-layer plywood for walls and floor respectively. There was a single drying bed measuring 1.0 m × 0.6 m × 0.8 m inside the drying chamber with a loading capacity of 3kg of fodder per batch (Figure 2). This design consists of 4 units of 24VDC/100W solar panels where sunlight is used to make direct current (DC) electricity for powering the 220VAC/200W of heater to provide heat and 220VAC/20W of blower that was used as force ventilation to remove moisture. The solar panels were connected to the charge

Figure 1: The prototype solar dryer

Figure 2: Drying bed of the prototype solar dryer

Figure 3: The greenhouse solar dryer

Figure 4: Drying bed with heater and blower of the greenhouse solar dryer

Figure 5: Drying bed without heater and blower of the greenhouse solar dryer

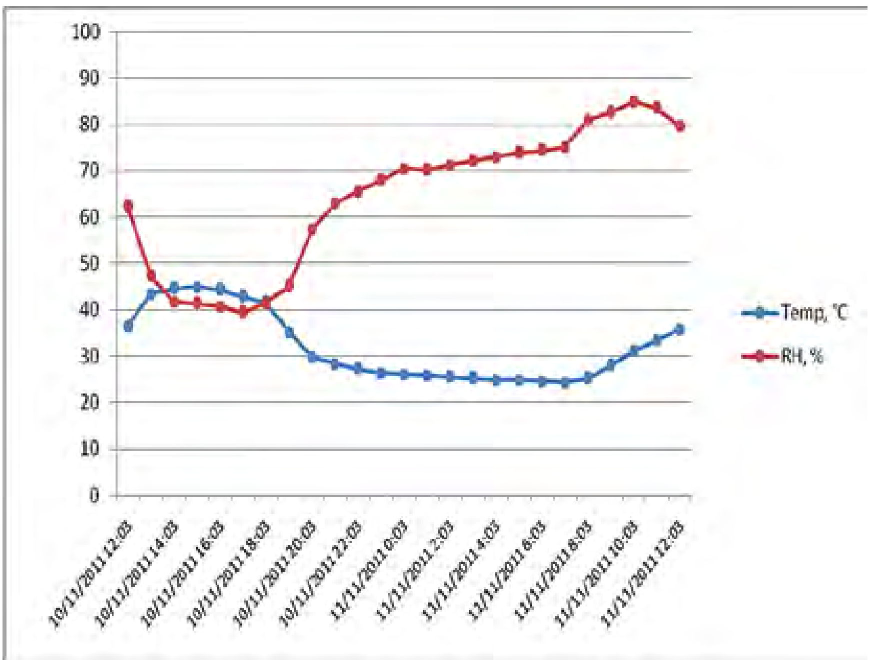

Figure 6: Temperature and relative humidity inside the drying bed of the prototype solar dryer

controller, 2 units of 12VDC/100AH solar rechargeable batteries connected in series and power inverter that used to convert 24VDC into 220VAC since both heater and blower use alternating current (AC) electricity to operate. A charge controller was installed to protect the batteries from overcharging or undercharging to prevent permanently battery damage. The function of the solar rechargeable batteries is to store energy for use by the system at night or during bad weather condition.

The dimension of the greenhouse solar dryer was 3.7 m × 3.0 m × 3.0 m as shown in Figure 3, built of polycarbonate plates as walls with a concrete floor [Chamnong, Poonsuk and Serm, 2005]. The transparent nature of the drying chamber walls allow most of the solar radiation to pass through the drying chamber so that the drying during the day can be done naturally without any additional heating [Kamaruddin, 2010]. This system was equipped with two drying beds, with and without heater as shown in Figure 4 and Figure 5 respectively. It is also equipped with 10 units of 24VDC/100W solar panels, 6 units of 12VDC/100AH solar rechargeable batteries, charge controller, inverter, 220VAC/300W heater and 220VAC/24W blower. An exhaust fan and 2 units of energy saving fluorescent light bulbs were installed to ventilate and illuminate the drying chamber respectively. Excess moisture will be forced out of the drying chamber by the exhaust fan. Meanwhile, the blower was installed inside the drying bed to disperse the hot air throughout the drying bed to accelerate the drying period. The greenhouse solar dryer should be operated at a constant 60°C throughout the day. The heater and blower would operate automatically when the internal temperature drops below 60°C.

MATERIALS AND METHOD

In this study, the performances of both systems were evaluated by drying Napier (*Pennisetum purpureum*). Three kilograms and five kilograms of Napier used at each batch of experiment by using the prototype solar dryer and greenhouse solar dryer respectively. Data loggers were placed inside the drying chamber and drying bed to record the temperature and relative humidity. The desired temperature to dry fodder is at 60°C and this was controlled by a thermostat. In the prototype solar dryer, the system depends on the heater and blower to undertake the drying process at all time. Both appliances will stop automatically when the temperature reaches the desired point. It would restart after 2 minutes and the process is repeated. In the greenhouse solar dryer, the Napier was dried by the greenhouse effect during the day. The heater and blower would operate when the temperature inside the drying chamber drops below than 60°C. The temperature and relative humidity inside the drying chamber and drying bed were recorded at one-hour interval using the data logger.

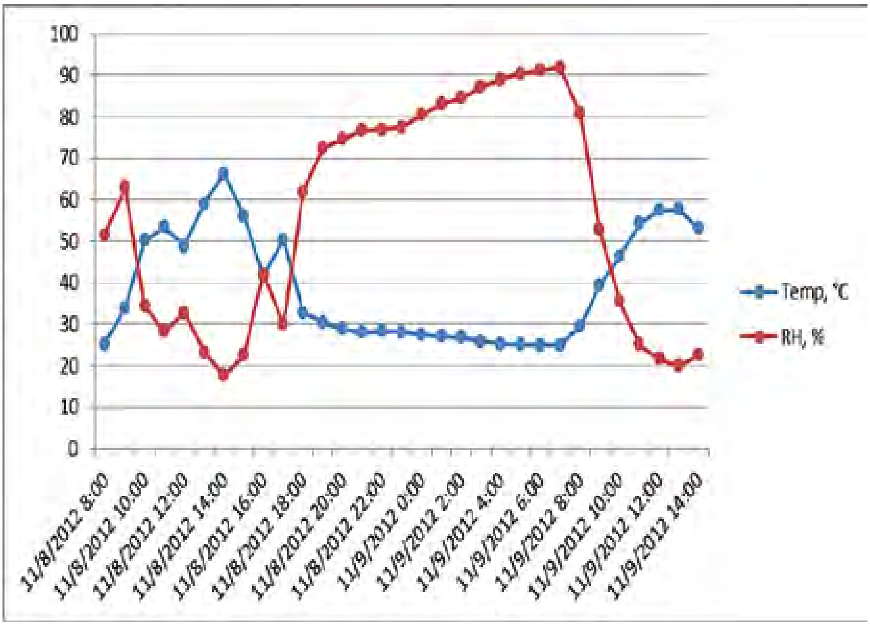

Figure 7: Temperature and relative humidity inside the drying chamber of the greenhouse solar dryer

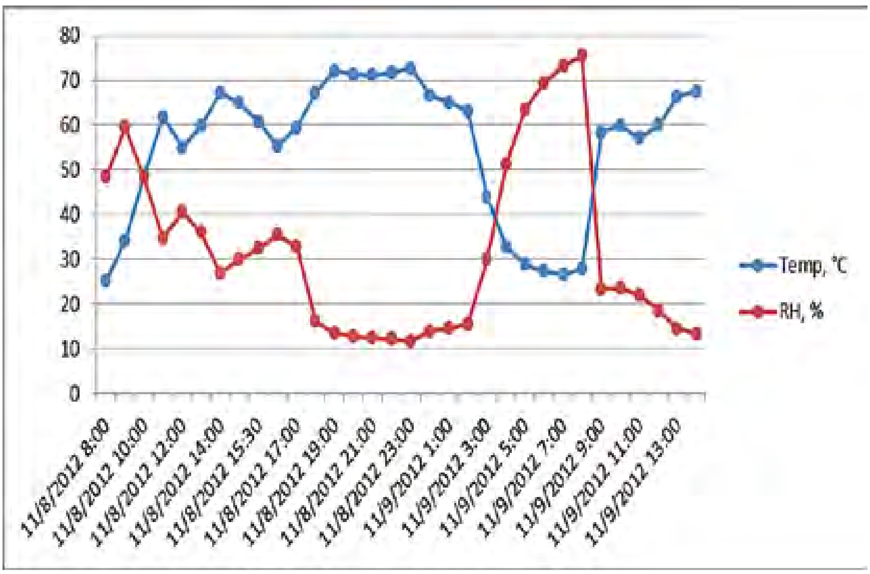

Figure 8: Temperature and relative humidity inside the drying bed of the greenhouse solar dryer

RESULTS AND DISCUSSION

The drying experiment using the prototype solar dryer was carried out in November 2011. Based on the results obtained as shown in Figure 6, the highest temperature recorded was 44.9°C with a relative humidity of 41.4%. However, this is insufficient to dry Napier in a short period. This lower temperature was attributed to the openings at the base of the drying bed. The drying bed was supposedly to be confined to make sure that the hot air out will be released through the drying tray to dry Napier, not through the opening base. In addition, the system was experiencing a problem where the heater tripped several times since it can only be operated not more than 3 hours. This system failed to reach the desired temperature of 60°C and thus, the greenhouse solar dryer was developed to replace the prototype model since the older system is totally broken.

In November 2012, two batches of experiments were carried out using the greenhouse solar dryer. The data recorded for the temperature and relative humidity inside the drying chamber and drying bed are shown in Figure 7 and Figure 8 respectively. Based on the results obtained, it shows that the highest temperature inside the drying chamber and drying bed were 66.3°C and 72.7°C with relative humidity of 17.6% and 13.4% respectively. The highest temperature inside the drying bed of greenhouse solar dryer was above the required temperature of 60°C compared to the reading of prototype design at 44.9°C.

CONCLUSION

The prototype solar dryer and greenhouse solar dryer have been designed and erected as alternative techniques to dry fodder instead of conventional method that has a lot of disadvantages in various aspects. During the test run period, it shows that the greenhouse solar dryer is more effective and has the ability to achieve the optimum temperature required to dry Napier. The combination of greenhouse concept and additional heating system such as heater and blower help to assured that the Napier will not get wet in rainy days and still undergo drying process from the hot air released by the heater.

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