# Investigation of Medical Herbs Moisture in Solar Drying

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*Abstract*: This paper studies the moisture content changes of dried medical herbs (ginger, lemon grass, onion and turmeric) using solar drying. The experiment of drying investigates different mass flow rate. In first chamber, drying of medical herbs is carried out at mass flow rate of 0.12 kg/s with an average temperature of 44 º C and humidity chamber of 27%. Meanwhile, in second chamber, the same procedure is carried out at mass flow rate of 0.06 kg/s with an average temperature of 54 º C and humidity chamber of 21%. The result shows that for turmeric, ginger and lemon grass, the initial content wet basis are 83 %, 89%, and 65% which takes 3.5 h, 4 h and 4.5 h to dry and reach to 8 % moisture. For onions, the time period of 4.5 h is required to reduce the moisture content of 78 % to 10 % at 44 °C with air relative humidity of 27 %.

*Keywords*: Solar drying; moisture content; herbs; ginger; turmeric; onion; lemon grass

## 1. Introduction

Ginger, lemon grass, onion and turmeric are some vegetables that take the fancy of majority of Malaysian people as part of their main meals.. Those are main ingredients in all cooking, while has high nutritional value. The use of ginger, lemon grass, onion and turmeric is not only for adding food palatability, but also is beneficial for human health.

Traditionally, herbs were dried using the direct sun. Direct sun drying requires large open space area, long drying times and depends on the availability of sunshine. Moreover, it is susceptible to contamination. However, drying procedure exterminates insects and fungi, which thrive in moist conditions. Another problem of traditional drying is the out come is relatively low quality dried products.

By and large, agricultural commodities require drying process to preserve their vitamins. The quality of the dried products depends on many factors including the drying temperature and duration of drying time [1].

As an alternative to open sun drying, solar drying system is evolved. It is an environmentally friendly technology, which economically viable in the most developing countries. There are numerous reports on the benefits of drying kinetics of agricultural fruits and vegetables. Thin-layer drying models have also been used for analysis of drying of various agricultural products [2-5]. Fudholi et al. [6,7] studied effects of drying air temperature on the drying kinetics of marine products. They reported that moisture content of seaweed (*Gracilaria changii*) and brown seaweed (*Eucheuma cottonii*) is about 95% and 92%.

Various solar drying for agricultural and marine products have been reviewed by Fudholi et al. [8-1011]. They analyzed the moisture content of agricultural products. For instance, onions should be dried until its moisture content reaches to 6 to 10% with initial moisture content of 80 to 85% (see Table 1).

For the ginger and turmeric, those numbers are 80% and 10% (see Table 1). Therefore, the present study is a comparison of moisture content changes of ginger, lemon grass, onion and turmeric in solar drying.

## 2. Material and Methods

The solar drying experiment was constructed at the Green Energy Technology Innovation Park, UKM Malaysia in 2010 (see Fig 2). The drying is classified as a forced convection indirect type (see Fig 1). The solar drying consists of auxiliary heater, blower, drying chamber and double-pass solar

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collector with finned absorber. The collector width and length are1.2 m and 4.8 m respectively. The solar collector array consists of 4 solar collectors. The upper channel depth is 3.5 cm, and the lower depth is 7 cm. The bottom and sides of the collector have been insulated with 2.5cm thick fiber glass to minimize heat losses. The collector consists of the glass cover, the insulated and a black painted aluminum absorber. The size of the collector is 1.2 m wide and 4.8 cm long. In this type of collector, the air initially enters through the first channel formed by the glass covering the absorber plate and then through the second channel formed by the back plate and the finned absorber plate. This drier was capacity of drying 75 kg. The size of the chamber is 2.4 m in length, 1 m width and 0.6 m in height.

Table 1. Moisture content of various agricultural produces [11]

| Product | Moisture content | |
|---|---|---|
| | Initial (%) | Final (%) |
| Onions | 85 | 6 |
| Onion flakes | 80 | 10 |
| Onion rings | 80 | 10 |
| Tomatoes | 95 | 7 |
| Green peas | 80 | 5 |
| Grapes | 80 | 15-20 |
| Applies | 82 | 11-14 |
| Bananas | 80 | 15 |
| Cassava | 62 | 17 |
| Copra | 30 | 5 |
| Tobacco | 90 | 10 |
| Coffee | 65 | 11 |
| Garlic flakes | 80 | 4 |
| Chilies | 80 | 5 |
| Ginger | 80 | 10 |
| Cabbage | 80 | 4 |
| Tea | 80 | 3 |
| Pepper | 71 | 13 |
| Turmeric | 80 | 10 |
| Potato chips | 75 | 13 |
| Paddy, raw | 22-24 | 11 |
| Paddy, parboiled | 30-35 | 13 |
| Maize | 35 | 15 |
| Wheat | 20 | 16 |
| Millet | 21 | 4 |
| Corn | 24 | 14 |
| Cauliflower | 80 | 6 |
| Carrots | 70 | 5 |
| Green beans | 70 | 5 |
| Garlic | 80 | 4 |
| Cabbage | 80 | 4 |
| Sweet potato | 75 | 7 |
| Red lauan | 90 | 20 |
| Potatoes | 75 | 13 |
| Spinach | 80 | 10 |
| Prunes | 85 | 15 |
| Apricots | 85 | 18 |
| Peaches | 85 | 18 |
| Guavas | 80 | 7 |
| Mulberries | 80 | 10 |
| Okra | 80 | 20 |
| Pineapple | 80 | 10 |
| Yams | 80 | 10 |
| Nutmeg | 80 | 20 |
| Sorrel | 80 | 20 |
| Coffee beans | 55 | 12 |
| Cocoa beans | 50 | 7 |
| French bean | 70 | 5 |
| Groundnuts | 40 | 9 |
| Figs | 70 | 20 |

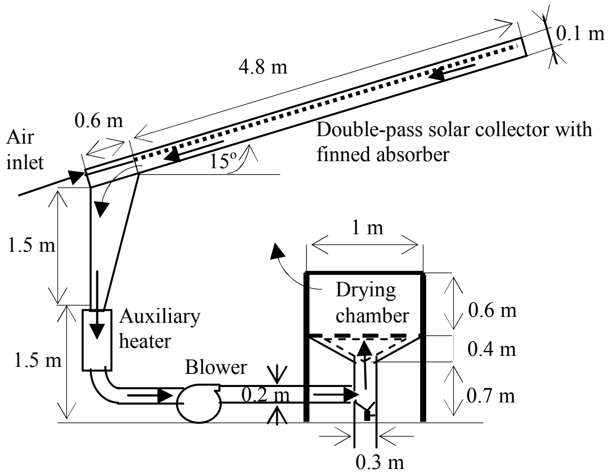


Fig. 1. The schematic of the solar drying

Fig. 2. Photograph of the solar drying

Experiment was done between 9:00 A.M to 5:00 P.M. To determine the moisture loss of drying medical herbs during experiment, medical herbs were placed in the tray inside two chambers. The moisture loss of medical herbs was determined by means of digital electronic balances. The data including air temperature (ambient temperature and chamber temperature), radiation intensity and air velocity were measured. The relative humidity sensors were installed in inlet, middle and outlets of drying chamber. Air temperature was measured by T-type thermocouple, and the intensity of solar radiation measured by pyranometer. During the drying process, the temperature and relative humidity in solar drier were recorded at 1 minute intervals during experiments by the ADAM Data Acquisition System connected to a computer. Data was averaged for 30 minutes prior to the period.

The moisture content of materials (M) is calculated by two methods on the basis of either wet or dry basis using the following equations. The moisture content wet basis

$$M = \frac{w(t) - d}{w} \times 100\% \qquad (1)$$

The moisture content dry basis

$$M = \frac{w(t) - d}{d} \qquad (2)$$

where,
w(t) = mass of wet materials at instant t
d = mass of dry materials

## 3. Results and Discussion

Fig. 3 shows the experimental results of drying with mass flow rate of 0.12 kg/s, which obtained from drying chamber. The drying chamber temperature ranges from 29 °C to 50 °C, and an average of about 44 °C. Furthermore, relative humidity of drying chamber was recorded around 14 % to 68 % with an average of 27 %.

Fig. 4 shows the experimental result of drying with mass flow rate of 0.06 kg/s, obtained from drying chamber with temperature range around 31 °C to 66 °C and average of 54 °C. In addition, relative humidity of drying chamber was recorded around 12 % to 48 % with average of 21 %.

Fig. 5 and Fig. 6 shows an decrease in moisture content wet basis and dry basis of drying at 27% RH and mass flow rate of 0.12 kg/s, respectively.

For mass flow rate of 0.06 kg/s and average humidity of 21%, decrease in moisture content wet basis and dry basis are illustrated in Fig. 7 and Fig 8. Decrease in moisture content wet basis of drying time at different mass flow rate is shown in Fig. 9 to Fig. 11 respectively.

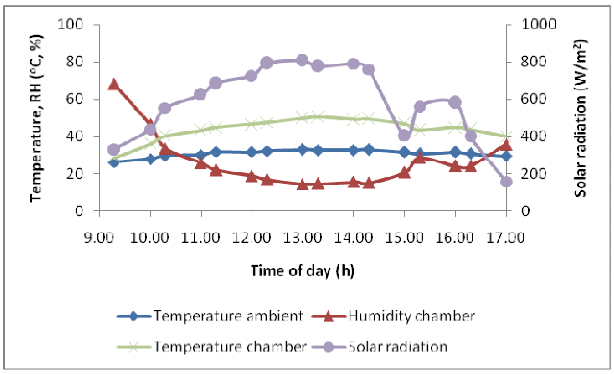


Fig. 3. Air temperature and relative humidity of drying chamber at mass flow rate 0.12 kg/s

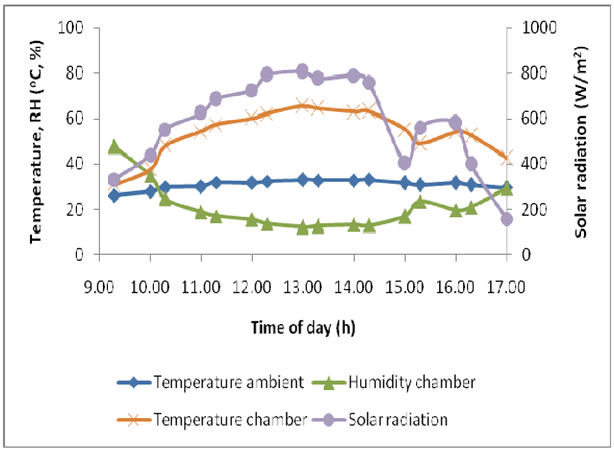


Fig. 4. Air temperature and relative humidity of drying chamber at mass flow rate 0.06 kg/s

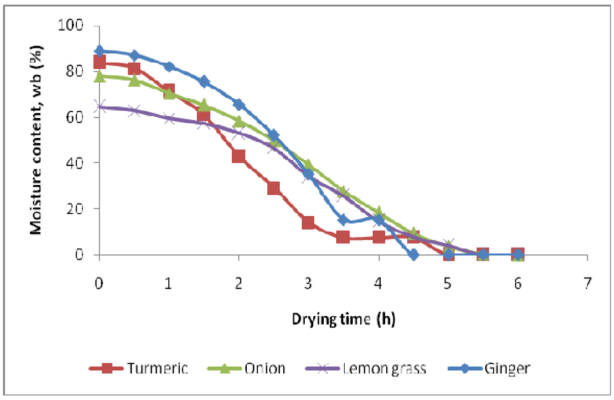


Fig.5. Drying curve: wet basis moisture content versus drying time at 27% RH and mass flow rate of 0.12 kg/s

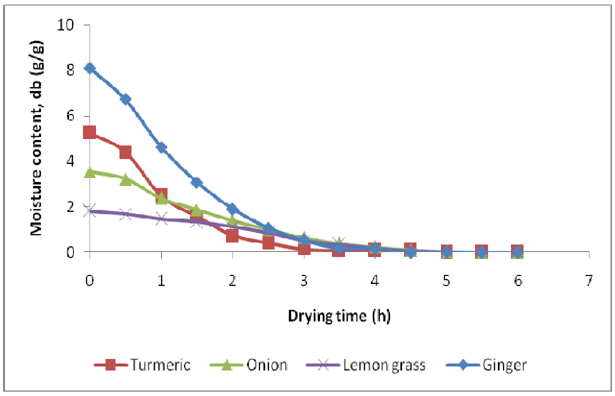


Fig. 6. Drying curve: dry basis moisture content versus drying time at at 27% RH and mass flow rate of 0.12 kg/s

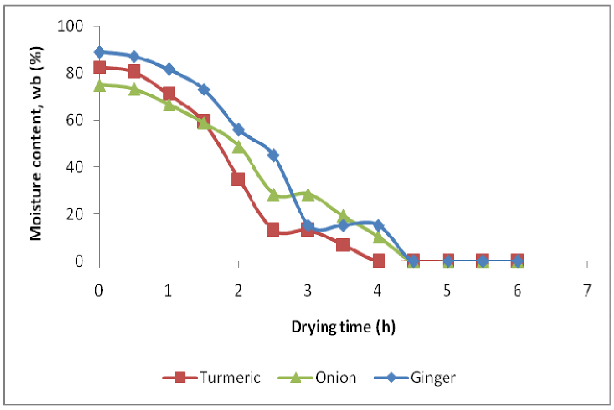


Fig.7. Drying curve: wet basis moisture content versus drying time at 21% RH and mass flow rate of 0.06 kg/s

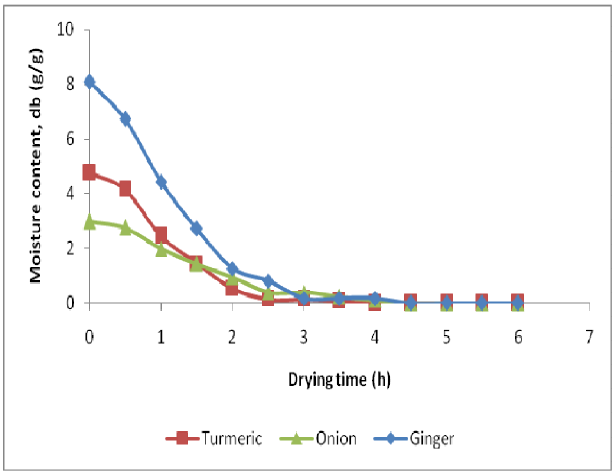


Fig. 8. Drying curve: dry basis moisture content versus drying time at at 21% RH and mass flow rate of 0.06 kg/s

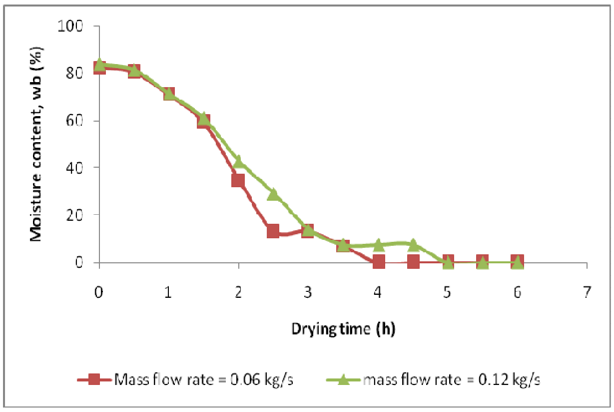


Fig.9. Drying curve: wet basis moisture content versus drying time for turmeric at different mass flow rate

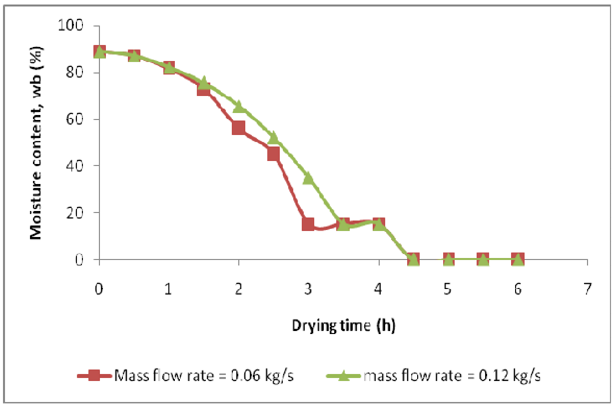


Fig.10. Drying curve: wet basis moisture content versus drying time for ginger at different mass flow rate

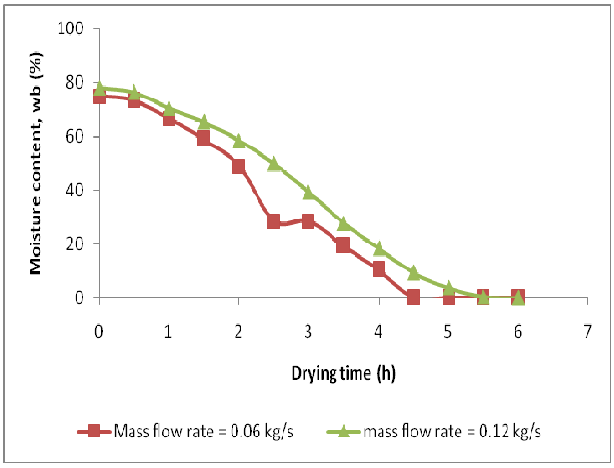


Fig.11. Drying curve: wet basis moisture content versus drying time for onion at different mass flow rate.

## 4. Conclusion

This paper presents the moisture content changes of dried medical herbs (ginger, lemon grass, onion and turmeric) in solar drying. The turmeric, ginger and lemon grass were dried from moisture content of 83 %, 89%, and 65% (wet basis) to final moisture content about 8 % (wet basis) with drying time of 3.5 h, 4 h and 4.5 h, respectively. For drying of onion from moisture content of 78 % to moisture content of about 10 % with a drying time of 4.5 h. From the comparison of the experimental results, it shows that the process of drying at 54 °C with 21% air relative humidity is the faster dry for drying of medical herbs (ginger, lemon grass, onion and turmeric).

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