**Flat micro heat pipe-based shell and tube storage unit for indirect solar dryer: a pilot study**

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## Abstract

Poria cocos has been dried in an indirect solar drying system composed of a roughened solar air heater (RSAH), a shell and tube storage unit assisted with flat micro heat pipes fins, and a drying chamber. The main novelty in this study is using FMHPs as fins in shell and tube storage unit with paraffin wax and lack of investigations on Poria cocos solar drying as medicinal material used in Chinese medicine. First and second laws of thermodynamics are used to assess the performance of the system and the results indicated that the RSAH average thermal (η) and exergy efficiency ($\eta_{Ex}$) were 73.9% and 5.1%, respectively, with averaged incident solar radiation of 671 W/m2 under airflow rate of 0.0381 m3/s. Furthermore, the storing system showed 37.6% as averaged overall $\eta$ and 17.2% as averaged overall $\eta_{Ex}$, as well as, discharging prolonged to 4 h with effective drying temperature. The overall $\eta$ of the dryer was 27.6% with specific energy consumption (SEC) of 8.629 kWh/ kg moisture. The payback period of the system is 1.7 years.

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APPLICATION OF PHASE CHANGE MATERIALS IN SOLAR ENERGY SYSTEMS

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## Abstract
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**Keywords** Indirect solar dryer · Flat micro heat pipes (FMHPs) · Poria cocos · Paraffin wax · Efficiency

## Introduction

The utilization of solar drying technologies to preserve vegetables, fruits, and other crops in the agricultural community has revealed to be viable, inexpensive, and greener. Solar dehydration technology is universally used in several regions to dry crops. Since, this increases product quality, mitigates waste, and makes use of renewable energies (Prakash & Kumar 2013). Solar dryers could be categorized as direct, indirect, mixed-mode, and hybrid type (Gatea 2011; Patil & Gawande 2016). The indirect dryers are very recent method, but so far not vastly marketable; its configuration and forms are still based on practice rather than science (Belessiotis & Delyannis 2011). Despite the high capital costs, the indirect drying systems has magnificent advantages including (a) high drying rate, (b) drying process could be fully controlled, (c) climate changes and mass loss by humans, animals, and insects have no effect on the drying products, (d) this kind of dryers could be used commercially with a small area and massive production, and (e) availability and flexibility for drying similar corps across the whole seasons of the year (Belessiotis & Delyannis 2011). Indirect solar dryers mainly are classified to natural and forced air circulation types (Ayua et al. 2017). To enhance the efficiency in this type of dryers, some improvement technologies such as superior collectors, heat storing units, moisture absorbents, recirculation and frequent usage of air, photovoltaic cells, and supplementary heating sources have been implemented (Phadke et al. 2015). Providing this kind of dryers with a forced convection RSAH and storing units is highly recommended to accelerate the drying rate and ensure the dried material quality (Lingayat et al. 2020).

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