A review of solar food dryers with thermal energy storage

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Abstract

Food is the most essential need for both human and animal survival. During food production, and in high harvesting times, the food supply can be greater than food demand. This will result in more food wastage. The use of a solar dryer will reduce food wastage and preserve food for a longer time before consumption. Solar drying improves the quality of the dried products significantly, and also reduces crop losses when compared to the traditional method of open sun drying. A lot of recent work has been carried out on solar food drying for various agricultural products using different types of solar food dryers. The use of solar food drying can be disadvantageous since the sun is not available at night or during cloudy periods. Few studies have addressed this disadvantage by combining thermal energy storage (TES) with solar food dryers for superior thermal and economic performance leading to an increase in the drying capacity. Therefore, in this review paper, an attempt has been made to summarize the past and current research in the field of solar food drying combined with thermal energy storage. With the integration of the heat storage system, agricultural foods can be dried during late evenings or at night which cannot be done with a normal solar food dryer.

Objective

Presenting a brief literature review on different solar food dryers with thermal energy storage so as to evaluate their overall performance.

Literature Review

- **Bal et al (2010), reviewed a simple solar food dryer with thermal energy for drying agricultural products.**
- **A mixed mode solar food dryer.**

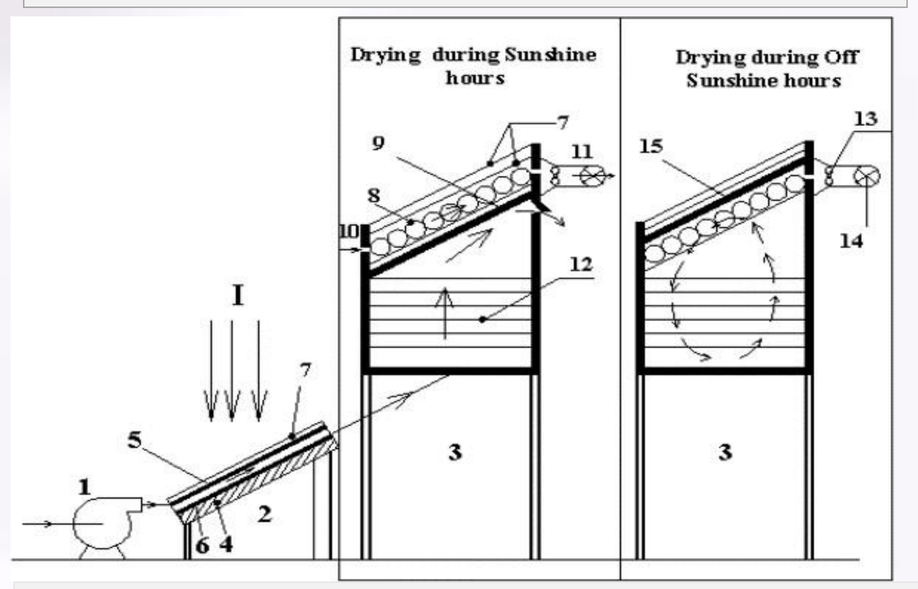

Figure 1: The schematic of the experimental setup .

- **The drying hours of peas and pineapple**

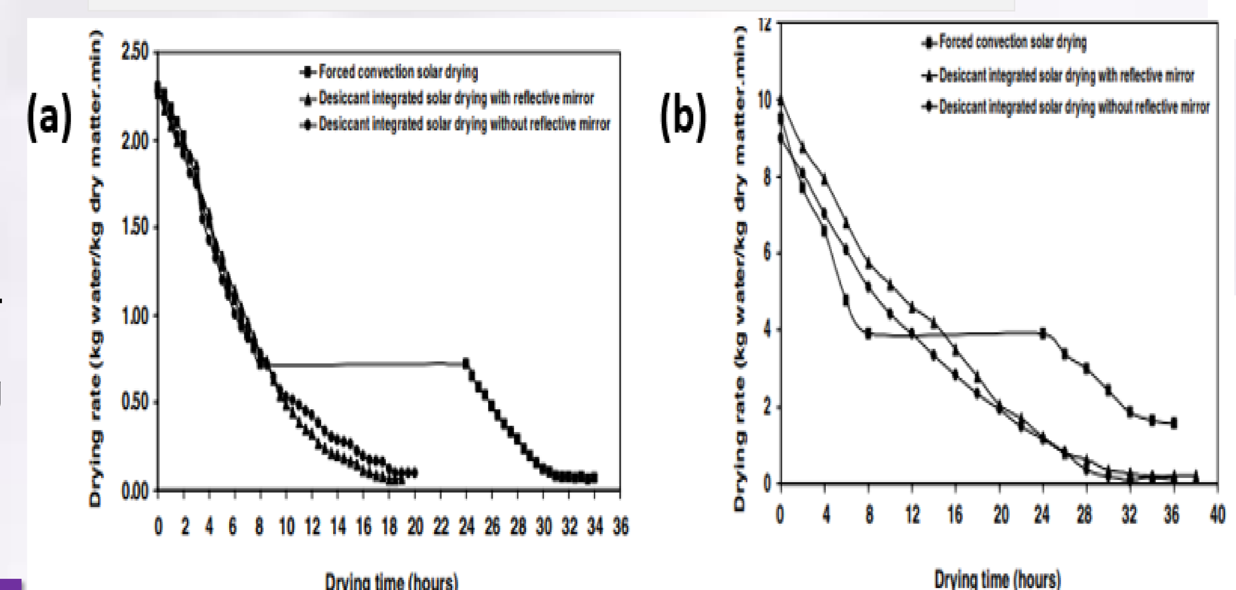

Figure 2. Variation of drying rate with moisture content at different drying conditions for (a)green peas, (b)Pineapple.

- **Esakkimuthu et al (2013) developed an indirect solar dryer which utilized phase change material (PCM) balls inside a storage tank as a thermal heat storage system.**
- **Indirect solar dryer**

Figure 3: A double pass V-corrugated solar air collector

- **Temperature variation during sunshine hours**

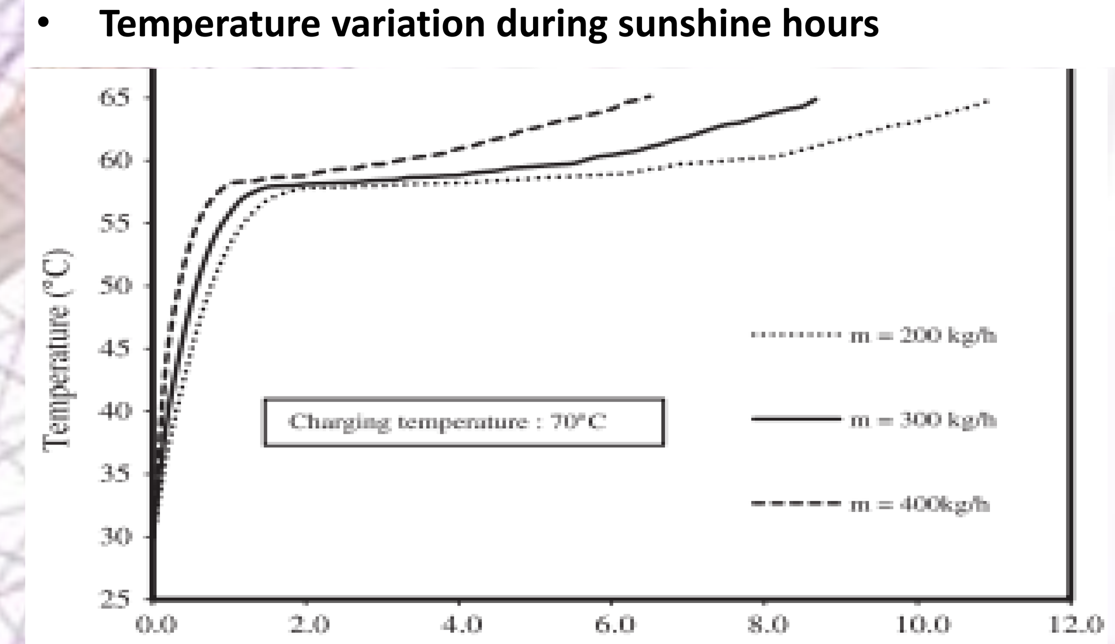

Figure 4: Temperature variation of air at the exit of the storage tank during the charging process(sunshine hours)

Literature Review Cont.

- **Baniasadi et al (2017) investigated the experimental performance of a multi tray mixed-mode solar dryer with thermal energy storage.**
- **Multi tray mixed mode solar dryer.**

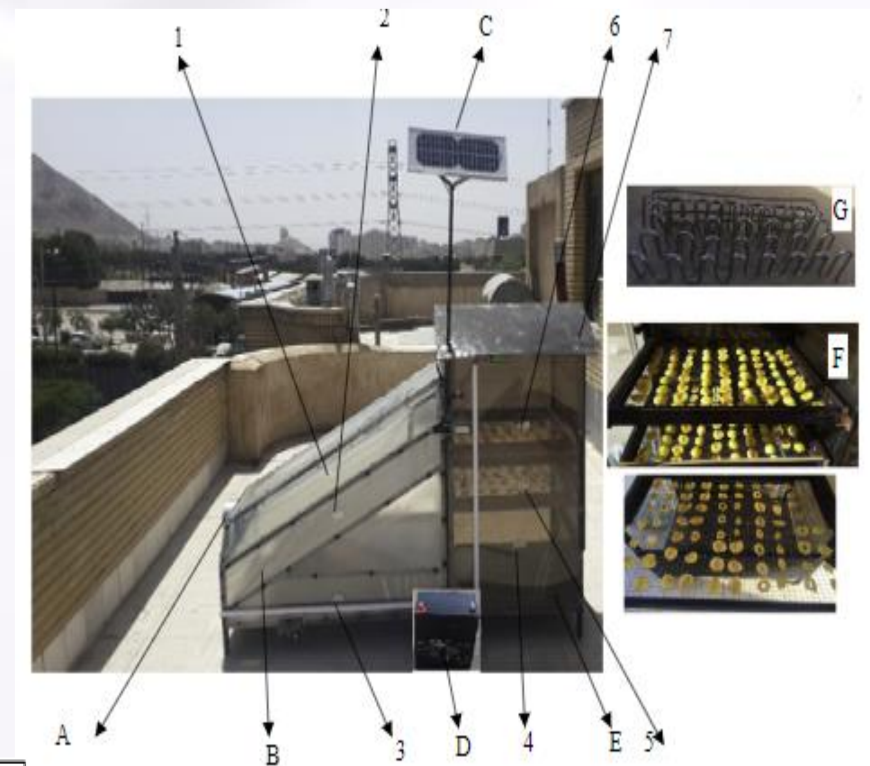

Figure 5: below shows the experimental setup and how the product was placed.

- **Temperature distribution graph**

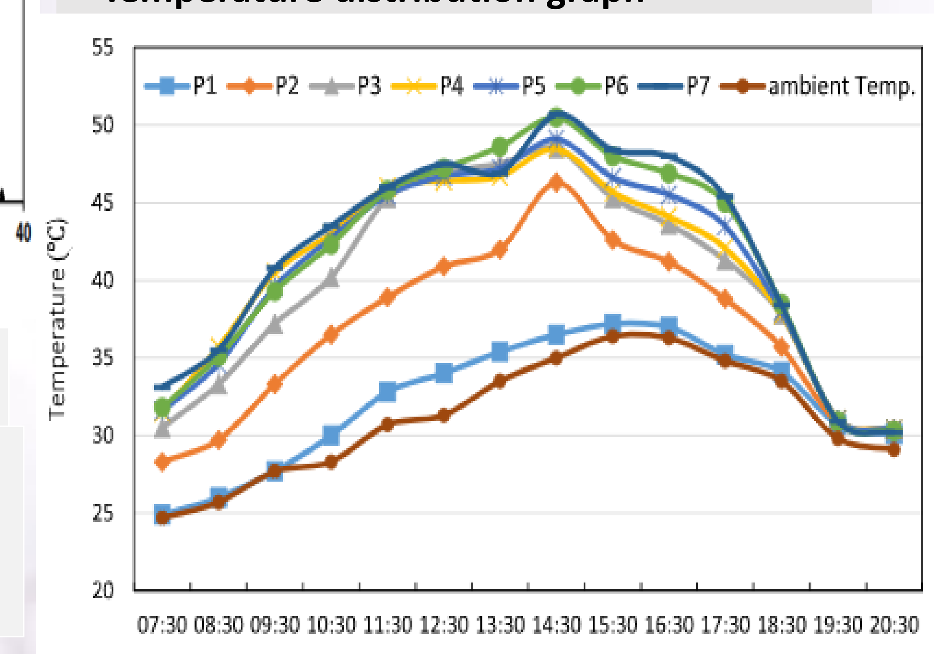

Figure 6: Temperature distribution inside dryer and ambient temperature during experiment.

- **Hadi et al (2018) investigated the drying process of tomato slice in a PV-assisted solar dryer using a sun tracking system.**
- **A pv-assisted solar dryer.**

Figure 7:The laboratory scale of the solar dryer

Literature Review Cont.

- **Variation of moisture ratio.**

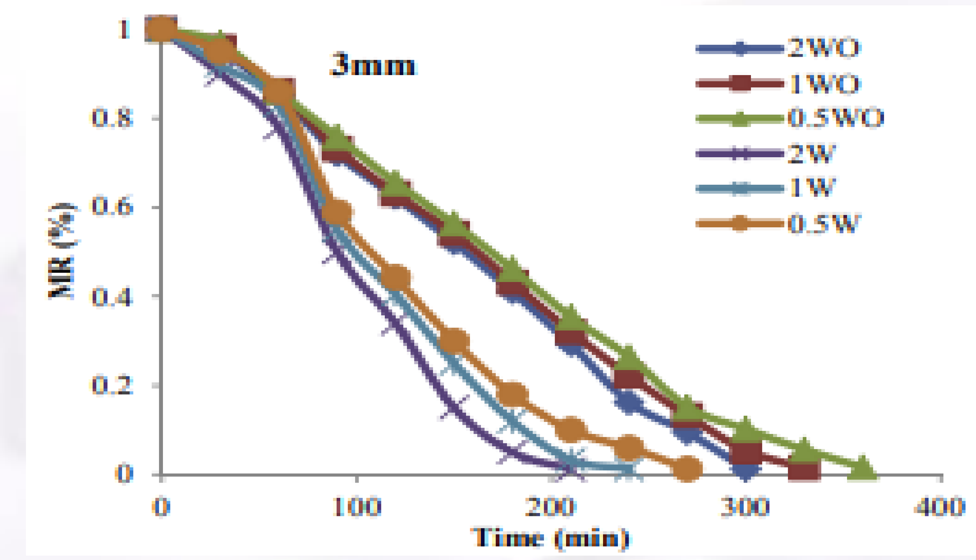

Figure 8: Variation of MR versus time consuming for drying of tomato slice thickness and three levels of air velocity for both solar dryer with (W) and without (WO) sun tracking system

- **Chaouch et al (2018) investigated the study of an active direct and indirect solar food dryer with sensible heat storage for camel meat drying in Saharan environments.**
- **An Indirect solar dryer with thermal energy storage.**

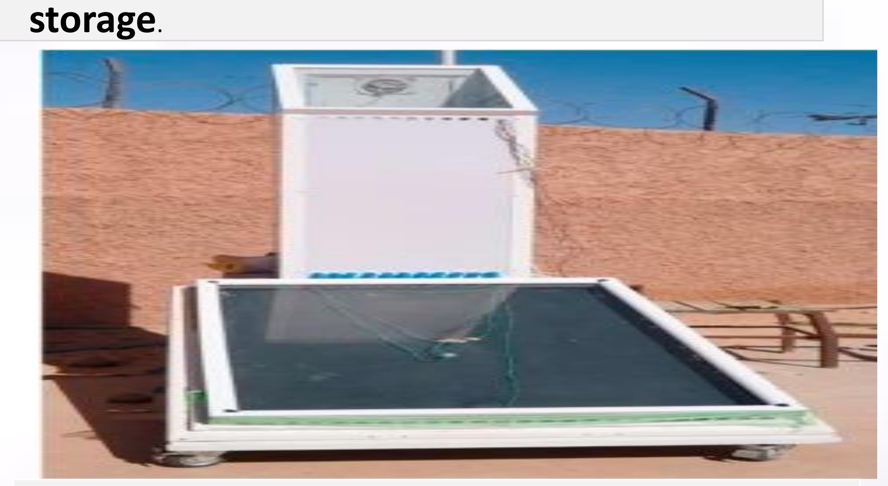

Figure 9: Experimental setup of an indirect solar cooker

- **Evolution of moisture content.**

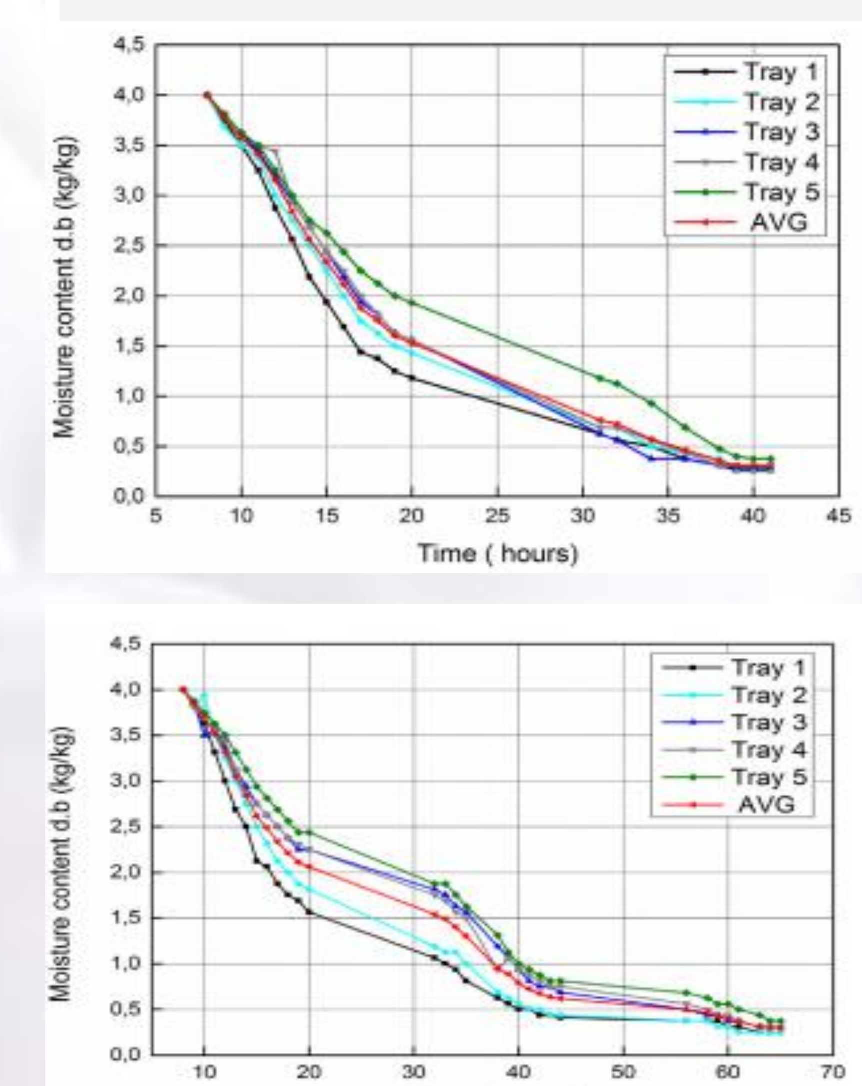

Figure 10: Evolution of moisture content at dry basis in the indirect drying chamber for each tray and their average: **(a)** July experiment, **(b)** November experiment respectively.

Conclusion

All the experiments mentioned and others not presented, resulted in better performance of solar dryer technology for agricultural food products.
The effective thermal energy storage technology in solar dryers for drying should be consolidated to better facilitate the end user in cost effective manner.
A PCM with a high latent heat of fusion and with a large surface area for heat transfer is an important factor in the drying process.
The overall use of solar food dryers is beneficial to humans as it prevents poverty.
Limited studies have been done on the performance of solar dryers with thermal energy storage on the collector to enhance drying.
The review will assist in experimental tests of a solar dryer with a TES collector which is currently being fabricated.

References

- Arun KR, Srinivas M, Saleel CA, Jayara S. Active ddrying of unriped bananas in aa multi-tray mixed –mode solar cabinet dryer with backup energy storage. Solar Energy 2019; 188:1002-1012.
- Aymen EK, Bouadila S, Kooil S, Farhat A, Guizan A. Thermal behavior of indirect solar dryer: Nocturnal usage of solar air collector with PCM. Journal of cleaner production 2017; 148:37-48.
- Bal LM, Satya S, Naik SN. Solar dryer with thermal energy storage systems for drying agricultural food products: A review. Renewable Sustainable Energy Reviews 2010; 14:2298-2314.
- Baniasadi E, Ranjbar S, Boostanipour O. experimental investigation of the performance of a mixed-mode solar dryer with thermal energy storage. Renewable Energy 2017; 112:143-150.
- Chaouch WB, Akhellaf A, Slimani MA, Loumani A, Hamid A. Experimental investigation of an active direct and indirect solar dryer with sensible heat storage for camel heat drying in Saharan environment. Solar Energy 2018; 174:328-341.
- Esakhimuthu S, Hassaboy AH, Palaniappan C, Spinnler M, Blumeberg J, Velraj R. Experimental investigation on phase change material based thermal storage system for solar air heating applications. Solar Energy 2013; 88:144-153.
- Hadi S, Akbar A. Accelerating drying process of tomato slices in a PV-assisted solar dryer using a sun tacking system. Renewable Energy 2018; 123:428-438.
- Khadraoui A, Hamdi I, Kooli S, Amenallah G.Dying of pepper slices in a solar greenhouse dryer and under open sun: Experimental and mathematical investigations. Renewable Energy 2019; 52:262-270.
- Shanmugan V, Natarajan E. Experimental study of regenerative desiccant integrated solar dryer with and without reflective mirror. Applied Thermal Engineering 2007; 27:1543-1551.
- Tomer V, Timari GN, Norton B. Solar dryers for tropical food preservation; thermodynamic of crops, system and components. Solar Energy 2017; 15:2-13.

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