Innovative Food Science and Emerging Technologies 36 (2016) 59–67

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

Mathematical modeling and performance analysis of thin layer drying of bitter gourd in sensible storage based indirect solar dryer

S. Vijayan [a,*], T.V. Arjunan [a], Anil Kumar [b,c]

[a] Department of Mechanical Engineering, Coimbatore Institute of Engineering and Technology, Coimbatore 641 109, India
[b] Energy Technology Research Center, Department of Mechanical Engineering, Faculty of Engineering, Prince of Songkla University, 15 Karnjanavanich Rd., Hat Yai, Songkhla 90110, Thailand
[c] Department of Energy (Energy Centre), Maulana Azad National Institute of Technology, Bhopal 462051, India

ARTICLE INFO

Article history:
Received 17 March 2016
Received in revised form 24 April 2016
Accepted 28 May 2016
Available online 31 May 2016

Keywords:
Solar drying
Bitter gourd
Mass flow rate
Sensible heat storage
Porous bed
Thin layer drying

ABSTRACT

An indirect forced convection solar dryer integrated with porous sensible heat storage medium was developed. The effect of porous thermal storage and mass flow rate of air on the performance of the system for drying bitter gourd was studied. The experimental setup consists of a blower, solar flat plate collector with corrugated absorber plate (2 m^2) and a drying chamber. The thermal storage medium (pebble) is placed below the corrugated absorber plate, in the air passage as a porous medium. The experiments have been carried out with various mass flow rates of air and different drying models have been used for explaining the drying behaviour of sliced bitter gourd. The result shows that, (i) the initial moisture content 92% (w.b) of bitter gourd was reduced to 9% (w.b) in 7 h in the proposed drying system, while it was 10 h for open sun drying, (ii) the maximum specific moisture extraction rate was observed as 0.215 kg/kWh at the mass flow rate of 0.0636 kg/s and the corresponding specific energy consumption was 4.44 kWh/kg, (iii) the collector and drying efficiency of the system were 22% and 19% respectively. The two term model and Midilli–Kucuk model are most suitable for indirect solar dryer and open sun drying in terms of statistical parameter respectively. The drying inside sensible heat storage based indirect dryer was more consistent and produced better quality product as compared to open sun drying.

Industrial relevance:

- Every year post harvest losses are increasing rapidly due to the lack of storage facilities.
- Solar dryers are the most suitable technology that can be easily availed at low cost and in small scale and it can be used as an income generation option for farmers and women in rural areas.
- The role of solar dryers in food processing industries is significant especially in developing countries in the following areas

  - o For preserving fruits and vegetables
  - o Dairy industries
  - o Agricultural crop drying
  - o Timber drying
  - o Industrial waste drying

- The utilization of thermal storage medium in the solar dryers is being focused much for the reasons of extending the availability of the system for operation and to achieve better quality of the products.

1. Introduction

Bitter gourd (*Momordica charantia*) is a herbaceous tropical and subtropical vine that belongs to the member of *Cucurbitaceae* family. It is mostly cultivated and consumed in Asian countries (especially China, India, Japan, and Malaysia), East Africa, the Caribbean, the Amazon, and also some parts of South America (Ahmed, Lakhani, Gillett, John, & Raza, 2001). Bitter gourd has many medicinal values; it is mainly used for the treatment of diabetes and also for dysmenorrhea, eczema, emmenagogue, galactagogue, gout, jaundice, kidney (stone), leprosy, leucorrhea, piles, pneumonia, psoriasis, rheumatism, and scabies. Bitter

* Corresponding author.
E-mail address: vijayandakshinya@gmail.com (S. Vijayan).

http://dx.doi.org/10.1016/j.ifset.2016.05.014
1466-8564/

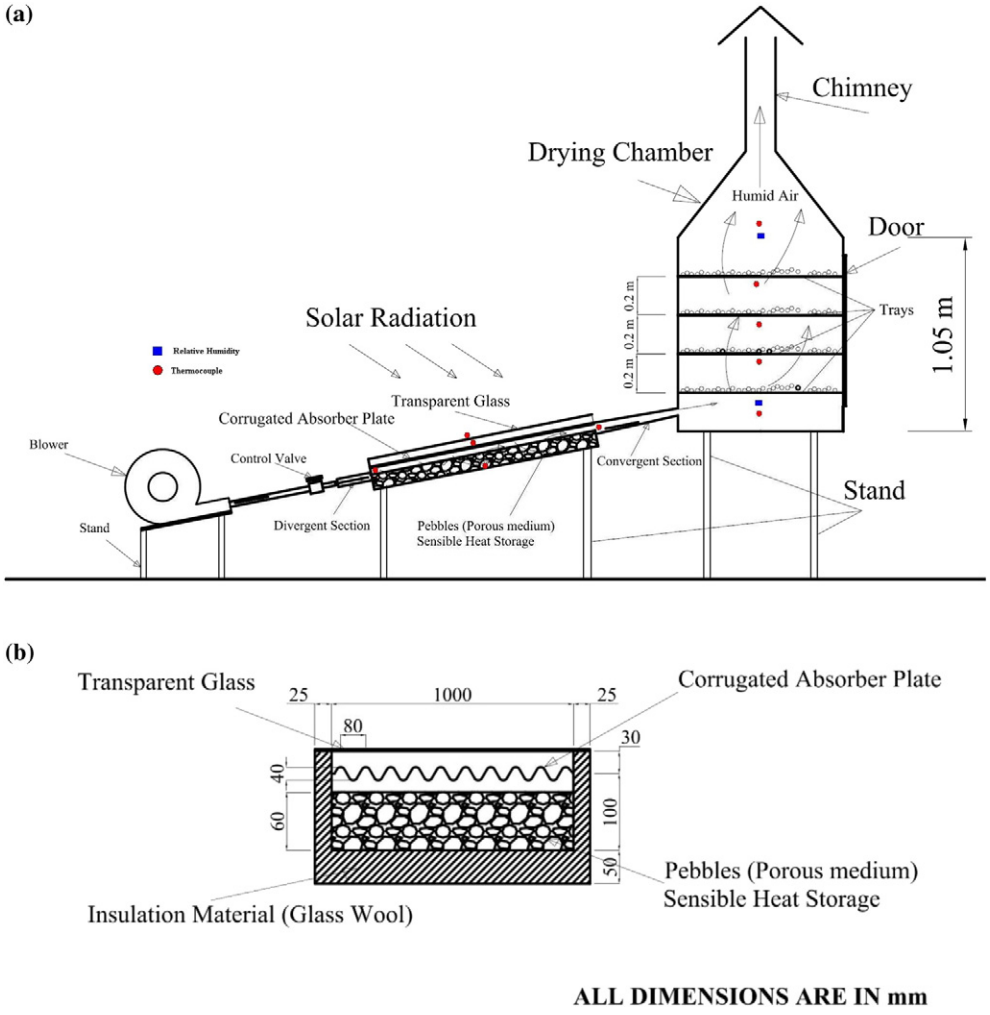

Fig. 1. (a) Schematic diagram of the experimental setup. (b) Cross-sectional view of the solar collector.

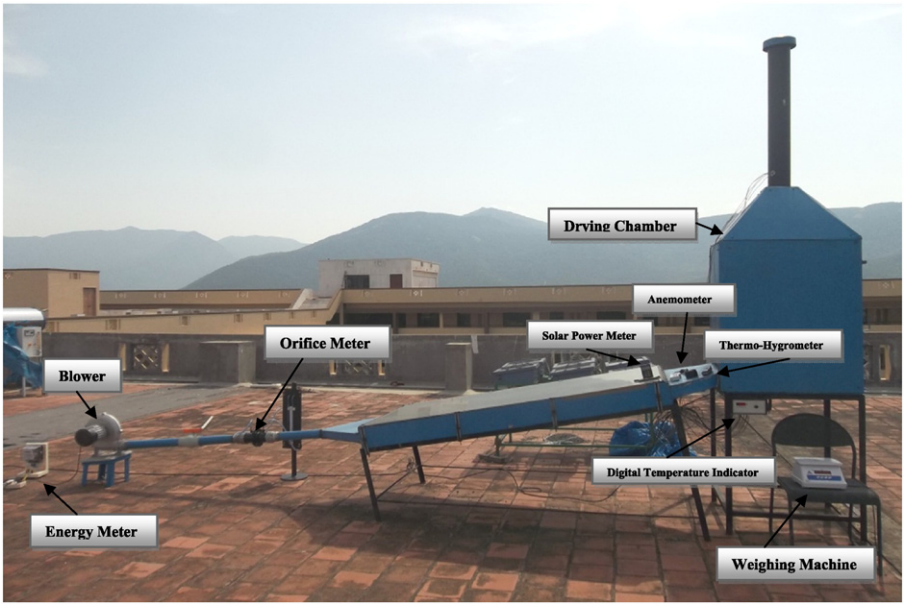

Fig. 2. Pictorial view of the experimental setup.