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Experimental studies on drying of *Zingiber officinale*, *Curcuma longa l.* and *Tinospora cordifolia* in solar-biomass hybrid drier

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Abstract

An integral type natural convection solar drier has been fabricated and coupled with a biomass stove. Experiments have been conducted to test the performance of the drier by drying of *Zingiber officinale* (ginger), *Curcuma longa l.* (turmeric) and *Tinospora cordifolia* (guduchi) during the summer climate in Delhi. It was found that, during the load test for ginger, 18 kg of fresh product with an initial moisture content of 319.74(db)% was dried to a final moisture content of 11.8(db)% within 33 h. Similarly, moisture content of turmeric and guduchi were reduced from 358.96 to 8.8 and 257.45 to 9.67(db)% during 36 and 48 h of drying, respectively. The drying of these products has also been studied under 'solar-only' and open sun in the same climatic conditions and the results indicate that for all the products, drying is faster, and is within 33–48 h in hybrid drier, against 72–120 h in 'solar-only' operation of the same drier and 192–288 h in open sun. Efficiency of the drier during its two mode (solar and biomass separately) of operation has been estimated and quality evaluation of under-studied products showed that developed drier is suitable for the drying of these products. The developed drier is a simple system, which can be manufactured locally and can be used for drying of other agricultural products.

Keywords: Hybrid; Drying; *Zingiber officinale*; *Curcuma longa l.*; *Tinospora cordifolia*

1. Introduction

Zingiber officinale (ginger), *Curcuma longa l.* (turmeric) and *Tinospora cordifolia* (guduchi) are the important spices and herb, which are used extensively in Indian system of

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medicine. Ginger and turmeric are widely grown in different regions of India and are commercially important edible spices, which are used for their characteristic aroma and texture in the preparation of wide variety of dishes [1]. Guduchi, as a drug plant, has bulk demand in the market ranging from 300 to 500 tonnes of dry woody stems annually [2]. All these three products required careful drying before producing them to the market.

Various drying techniques are employed to dry different food products. Each technique has its own advantages and limitations. Choosing the right drying techniques is thus important in the process of drying of these perishable products. The Brace type solar drier is one of the few designs that has achieved some level of acceptance [3,4]. One significant disadvantage of this drier is that it is normally not used with any form of back-up heating. To reduce its dependence on solar radiation for operation and to improve the quality of drying, a biomass stove was incorporated with solar drier. It has extended the period of drying beyond sunshine hours, and perhaps during night as well, while drying high-value products.

This paper evaluates the performance of the solar-biomass hybrid drier against 'solar-only' and open sun conditions.

2. Materials and method

2.1. Description of the solar-biomass hybrid drier

A complete picture of solar-biomass hybrid drier and its schematic presentation are shown in Fig. 1(a,b). Hybrid drier is having two parts: (i) Solar drier, (ii) Biomass stove.

2.1.1. Solar drier

The sectional view of solar drier is shown in Fig. 1c. The design consists of single glazing (2 mm thickness) having an inclination of 28.5° according to the Delhi latitude, to maximize the capture of solar radiation during the test period (April–June 2004). The drier has three drying trays of perforated wire mesh base and drying area covered by each tray is 0.991 m^2. Three adjustable vents, measuring $0.16\times0.05\ m^2$, are located at the top of the drier.

2.1.2. Biomass stove

The sectional view of biomass stove is shown in Fig. 1d. The design of the biomass system is based on the following points:

(1) The heating is indirect, i.e. flue gases from the chimney and the drying air could not be mixed. This is protecting the product from contamination by smoke, soot and ash of the flue gases.
(2) Temperature of the drying air could be controlled, by maintaining the combustion in the stove, with opening or closing of the primary air supply gate.
(3) Biomass burning could be carried out for extended periods of time, unattended. The biomass stove is having a dimension of $0.65\ m\times0.60\ m\times0.55\ m$ surrounded by brick walls ($1.45\ m\times1.17\ m\times0.9\ m$). A burner grate with a perforated tray is provided inside the stove. The exhaust gases exit via a 7.5 cm diameter and 60 cm long chimney located at one side of the stove. In order to lengthen the flow path of exhaust gases