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Effect of Waste Heat Recovery on Drying Characteristics of Sliced Ginger in a Natural Convection Dryer

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Abstract

In the present work, quality drying characteristics of sliced ginger were studied utilizing the concept of waste heat recovery in a biomass operated natural convection dryer with sensible heat storage material (SHSM) and phase change material (PCM). Ginger slices (2 and 4 mm thick) were dried from initial moisture content (MC) 88-90 % (w.b.) to final moisture content 11-12% (w.b.) with hot air maintained at temperature 60^0C, air velocity 0.2 m/sec, atmospheric average relative humidity 74% and ambient temperature 25^0C. It was observed that the biomass consumption and melting time of PCM were significantly reduced due to the use of waste heat. The optimum drying time was found to be 5.5 h for 2 mm thick ginger slices. Color, texture and aroma were found better in treated sample.

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Keywords: Waste heat recovery; Natural convection dryer; Phase change material; Quality drying

1. Introduction

Ginger is one of the important tropical commercial spices and herbs used extensively in food and medicines [1]. It is used for extensively due to its fragrance and texture in the preparation of wide variety of dishes [2]. Ginger produced in North–East (NE) region of India is found to excellent in fragrance and texture. So it is considered as one of the major cash crop [3]. Ginger production from 7000 tonne during the year 1997-98 is now likely to increase to 702 MT making an impact in the world market [4, 5]. However, increase in production of ginger demands for high

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cost in transportation and storage [6]. Most of the ginger growing areas are hot and humid rendering deterioration in quality of ginger during storage. For preservation, drying, canning and freezing have been found suitable. But, drying by hot air is considered to be simple and economical among these processes [7].

Open sun drying process can't be entertained due to the drawbacks like slowness of the process, the exposure of the product to the environment and the products get contaminated due to dust and insects. Hence an effective and quality drying technique is essential for drying of such good quality ginger all around the year which can be affordable and easily handled by the rural farmers. There are different drying techniques employed to dry different products. Each technique has its own advantage and limitation. So, choosing the right drying technique is crucial in the process of drying of these perishable products like ginger.

Drying is energy intensive process mainly in case of post harvesting [8] ,because the raw products with 80-90% moisture content have to bring down to equilibrium moisture content (EMC) by utilizing lot of heat energy. Drying through natural convection grain dryer is an important alternative for rural farmers [9]. Waste heat can be a source to be utilized in dryers to save energy as well as to reduce environmental impact. Many attempts have been made by the researchers to utilize waste heat in drying process. No extra cost of drying is required by utilizing exhaust gas of diesel engine for drying of paddy grains [10]. Waste heat of a pump used in irrigation purpose can be utilized to minimize post harvesting losses and effectively utilize the available energy resources for rural farmers [11]. A biomass operated natural convection dryer can be utilized to dry perishable products like ginger [12]. Utilization of part of the exhaust heat of the flue gas through thermal coupling by a heat exchanger is the subject of present work. Present work involves utilization of waste heat of a natural convection dryer to improve its performance by reducing the energy consumption and time required for drying of ginger slices. Detailed description of the natural convection drier along with the process of experiments and the results for the optimized condition of drying are drawn and discussed in the present paper.

2. Materials and Methods

In present study, freshly harvested ginger (Zingiber officinale) was collected from the agricultural field. Rhizomes were washed properly in running water and sliced into almost uniform thickness of 2 mm. The slices were subsequently boiled in hot water at 90^0C for 15 minutes. The boiled samples were then spread upon a perforated container to drain the water from the samples for a period of 15 minutes. Similar method was followed for ginger samples with 4 mm thickness.

2.1 Pre drying treatment

2.1.1 Untreated samples

One kg from each of the boiled samples are measured in a strain gauge based weighing machine (Mettler-Telodo India Pvt. Ltd.) and soaked separately in water for 1 h followed by draining.

2.1.2 Treated samples

One kg from each of the boiled samples (2mm and 4mm thick ginger slices) are soaked in 2% (m/v) concentrated calcium hydroxide ($Ca(OH)_2$) solution for 1 h to avoid attack of insect and to provide better color and texture to the dried ginger rhizome [13]. The treated samples are then placed in a perforated container to let the water drain out. Initial moisture content of all the samples is measured by muffle furnace (Lab tech International Ltd).

2.2 Description of the natural convection drier

At the core of the dryer a conical furnace fabricated with MS sheet was placed centrally 22 cm above the bottom of the dryer. The furnace was placed over a base plate made of GI sheet with 1700 holes each of 5 mm in diameter to