Chapter 1

Introduction

1.1 General

Drying offers a multitude of advantages which includes reduction in volume, easy handling and transportation, less chance of pest and microbial attack during storage for almost all agricultural products. It is a dual process of heat transfer to the product from the heating source and mass transfer of moisture from the interior of the product to its surface and from the surface to the surrounding air. Under ambient conditions, the drying process is slow, and in environments of high relative humidity, the equilibrium moisture content is insufficiently low for safe storage (Ekechukwu, 1987; McLean, 1980). The traditional open sun drying utilized widely by rural farmers has inherent limitations. For this to be feasible, the ambient relative humidity during the harvest period must be low enough to ensure that the crop, when dried to its equilibrium moisture content, can be stored safely. Meteorological data, even for the ‘most favoured’ areas, show that this is not always feasible (McLean, 1980). The basic essence of drying is to reduce the moisture content of the product to a level that prevents deterioration within a certain period of time, normally regarded as the ‘safe storage period’ (Ekechukwu, 1987). In hot and humid climates, crop deterioration is obviously worse, as both warmth and high moisture contents promote the growth of fungi, bacteria, mites and insects in crops. High crop loss also occurs from inadequate drying, fungal attacks, insects, birds, rodents, unexpected rain and other weathering effects. The objective of a dryer is to supply the product with more heat than is available under ambient conditions, thereby increasing sufficiently the vapour pressure of the moisture held within the crop and decreasing significantly the relative humidity of the drying air and thereby increasing its moisture carrying capacity and ensuring a sufficiently low equilibrium moisture content (Arslan and Ozcan, 2008; Akpınar, 2004; Ekechukwu, 1987).

Theoretical investigations have also been initiated in recent times to utilise solar energy in various thermal applications with the aim of reducing CO\textsubscript{2} emissions to the environment through decreased dependence on carbon-based fuels. In a detailed theoretical
study (Purohit and Michaelowa, 2008) related to CO₂ mitigation potential for solar water heater usage across various states in India, it was found that the State of Maharashtra has the highest annual CO₂ emissions reduction potential (4.3 million tonnes) followed by Tamil Nadu (3.2 million tonnes). On the other hand, in an estimation in India (Chaurey and Kandpal, 2009) on the impact of carbon finance on the effective cost to the users for SHSs (solar house systems), it was reported that, the effective burden of SHS to the user could be reduced by 19%, if carbon prices were $10/t CO₂. A macro-level assessment of SHSs (Purohit, 2009) was conducted to estimate the CO₂ emissions’ mitigation potential of 23 million tonnes based on computed number of 97 million SHSs in India. Assuming some basic input data to estimate CO₂ emissions mitigation for India during drying of various crops other than potato using indirect type solar dryer, a theoretical approach was attempted (Kumar and Kandpal, 2005). Another study (Piacentini and Mujumdar, 2009) estimated annual CO₂ emissions of 14.77 tonnes for drying system, considering electricity consumption of 100 kWh/day for the UK conditions. Thus, these climatic conditions dictate the need for more effective drying methods. In such conditions, solar-energy crop dryers appear increasingly to be attractive as commercial propositions.

In many rural locations of most developing countries, grid-connected electricity and supplies of other non-renewable sources of energy are either unavailable, unreliable or, for many farmers, too expensive. Thus, in such areas, crop drying systems that employ motorized fans and electrical heating are inappropriate. The large initial and running costs of fossil fuel powered dryers present such barriers that they are rarely adopted by small scale farmers. Drying also represents one of the most energy intensive unit operations used in the food processing industry and energy constitutes a major portion of the operating costs. In particular, in industrialized countries, between 7% and 15% of the industrial energy is used in drying (Keey, 1992). It is therefore imperative that, major emphasis in the food industry should continue to be placed on energy conservation. The best alternative to overcome the disadvantages of traditional open sun drying and the use of fossil fuels, is the development of solar crop dryers. In addition to mitigation of fossil fuel use, the quality of the dried crops is also higher and the loss of dried products is considerably reduced.

Among the spices, ginger (Zingiber officinale) is grown over a wide area of the tropic although; the major areas of production are Southern and Eastern Asia. India
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produced about 50% of the world ginger (Purohit and Michaelowa, 2008) till 2008. India produced 3.07 Lakh MT during 2004-05 which was 50% of the world ginger and to this, contribution of N-E region as a whole was 2.09 Lakh MT (Jha and Deka, 2008). India ranks first in the production of dry ginger which is produced mainly in Kerala (Purohit, 2009). World production of dry ginger during 1994 was 5,29,700 MT of which, 2,10,000 MT was produced in India (Chaurey and Kandpal, 2009). The region as a whole produces over 207,000 MT of raw ginger every year (Ferreira et al., 2008). Fresh gingers contain about 88.88% to 90.91% moisture (wb) and are extremely perishable. Volatile oil content of dry ginger may be in the range of 0.5 to 4.4% whereas oleoresin may be in between 3.5 to 10% (Sharma et al., 1999). As per Spices Board of India report (Anonymous, 2006), production of turmeric (Curcuma longa L.) in the North East region of India was 20360 MT which is quite significant and have high intrinsic values. Dried ginger is used directly as a spice and also for the preparation of its extractives, ginger oleoresin and ginger oil. The major use of ground dried ginger on a world-wide basis is for domestic culinary purposes while in the industrialized nations it also finds use in the flavouring of processed foods, especially in the bakery products and desserts (Purohit and Michaelowa, 2008). Turmeric, a derivative of the plant, curcuma longa, a member of the ginger family, is a spice commonly used in Middle Eastern countries and other regions of Asia. Traditionally turmeric is used in various cuisines for flavour as well as a colouring agent for foods such as rice, yogurt, and chicken. Turmeric may also be used by itself or in combination with other mixed spices. Curry powder is a mixed spice with turmeric as one of the principal ingredients. It also has a long history of use in herbal remedies, particularly in China, India, and Indonesia. Curcumin, an active component of turmeric, is a yellow pigment that has been isolated from the ground rhizome part of the curcuma plant species, zingiberaceae (Ireson et al., 2002; Chen et al., 1997).

Driers in general can be easily classified into different types, depending on mode of heat supply, design case, operating pressure, handling of the feed stock etc (Ekechukwu and Norton, 1999). Leis et al. (1999) used a biomass burner for air heating and running blower through electricity corresponds to a thermal output of 112 kW. The limitation of this drier is that it cannot be used in the areas where electricity is not available. However, the brace type solar drier is one of the few designs that have achieved some level of
acceptance (Brett et al., 1996). The design is suitable for small-scale industries because it is easy and inexpensive to construct, simple to run and can produce a good quality of products under favourable climatic conditions. One significant disadvantages of this drier is that it works in the sunlight only. For commercial producers, this factor limits its ability to dry a produce when there is not adequate solar radiation. Drying time also extends as drying takes place during daytime only. Review of literature indicates that there have been a few attempts made to overcome this limitation in simple natural convection solar driers. Industrial scale driers are operated on electricity. Choosing the right drying technique is thus important in the process of drying produce, especially in the humid region where some agricultural produce are collected and harvested during winter or rainy season.

Solar and biomass are the two main renewable sources of energy that is used for drying of agricultural produce. Appropriate use of these sources in drying provide reduction of drying time and specific improvement of the product quality in terms of colour, taste and texture in comparison to open sun drying. In open sun drying, products are spread on ground in thin layer where they are exposed to direct sunlight and wind carrying dust. Considerable losses occur during this drying process because of influences such as rodents, birds, insects, rain and microorganisms. This causes degradation in produce quality and the product not to be marketable in domestic and international market (Lutz et al., 1978).

Hence a suitable dryer of small scale for drying ginger rhizomes and other high valued crops in the production catchment shall be the most appropriate technological intervention for value addition, postharvest loss reduction and for economic benefits of stake holders. To reduce the cost of drying by harnessing solar radiation when it is available followed by a bio-waste fired heat generation system completely devoid of grid electricity dependency would be highly beneficial for the stake holders. The idea of an energy efficient drying system which would partly run on solar energy and partly on bio-waste energy with natural draft mechanism for induced air flow has been conceived. However, there is not much work about the integration of solar and biomass drying system for the spices and its effect on drying characteristics, quality attributes. Therefore, the present study emphasized on development of a solar-biomass integrated drying system;
optimization of drying processes and also the effect of drying characteristics, quality attributes of the ginger and turmeric rhizome.

1.2 Objectives

Keeping the aforementioned issues in view, the present study has addressed the following objectives:

1) To design and develop an integrated drying system.
2) To study the drying characteristics of ginger and turmeric in the developed integrated drying system.
3) To optimize the drying process based on quality attributes