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Determination of effective moisture diffusivity, energy consumption and active ingredient concentration variation in *Inula racemosa* rhizomes during drying

Vasudha Agnihotri*, Arvind Jantwal, Rajesh Joshi

G.B. Pant National Institute of Himalayan Environment and Sustainable Development, Kosi-Katarmal, Almora, India

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ABSTRACT

Influence of drying temperature (30 °C–60 °C) and relative humidity (30%–80%) on moisture diffusivity, energy requirement and quality of Inula racemosa rhizomes, in terms of alantolactone and isoalantolactone, were analyzed. The rhizomes were dried in climate control chamber with constant values of temperature and relative humidity. At low relative humidity condition temperature was found as major controlling factor for drying rate but at high relative humidity conditions, it control drying rates in comparison to temperature. Effective diffusion coefficient (Deff) was found to decrease with increase in relative humidity of drying air. Energy requirement increases with increase in relative humidity and temperature. Concentration of alantolactone and iso-alantolactone was found to increase during drying in comparison to that in fresh *I. racemosa* rhizomes.

1. Introduction

Inula racemosa, commonly known as Pushkarmool, belongs to family Asteraceae. It is a traditional herb used as drug in Ayurvedic and Chinese system of medicines. The rhizome has medicinal properties and considered a specific for cough, dyspnea, asthma, pleurisy, tuberculosis and chest pain especially pre cordial pain. The aqueous extract of the fresh or dry roots is given orally in rheumatic pains and liver problems. Externally a paste or liniment is used for relieving pain. The root forms an important ingredient of several polyherbal fomulations for heart diseases and inflammatory conditions of spleen and liver (The Ayurvedic Formulary of India, 1978). Along with *Commiphora mukul*, the drug combination called 'pushkar guggulu' is a popular anti obesity, hypolipidemic indicated in cardiac ailments. Root powder is reportedly hypoglycemic and hypocholesterolemic in human subjects (Tripathy et al., 1979). Use of *I. racemosa* rhizomes is reported in drug preparation of asthama as part of ayurvedic drug *Respiton–850 mg* (Vermula et al., 2011). It is also used in the treatment of ailments like skin allergies, cough and cardiac diseases. Along with these properties, plant rhizomes are also having antifungal, anthelmintic, antimicrobial & hypolipidemic properties. As a traditional Chinese medicine, the rhizomes of *I. racemosa* usually were used to invigorate the spleen, regulate the function of the stomach, relieve the depression of the liver Qi, alleviate pain especially between the neck and the shoulders and to prevent abortion (Jiangsu College of New Medicine, 1977; Tsarong, 1994). Alantolactone (ALT) and isoalantolactone (IALT) are two important sesquiterpene lactones present in *I. racemosa* (Arora et al., 1980). These compounds are used as active principle of antiulcer drug Alanton (Milman, 1990). ALT and IALT are reported as antifeedant to granary pests (Streibl et al., 1983). These compound are anti-inflammatory (Dalvi and McGowan, 1982), antimicrobial, anthelmintic (Wordenbag et al., 1986) properties. Being such an important plant, it had been selected for the drying study.

After harvesting of medicinal plants, plant material had to gone through various post harvest processing steps such as cleaning, drying for storage, packaging for transportation etc. It is estimated that as high as 30% of the raw material reaching the manufacturers is of low quality and hence is likely to be rejected. Therefore, improving quality, reducing losses and subsequent value addition would increase profitability. Among the various above mentioned steps, drying is the most common and fundamental step required for post harvest preservation of medicinal plants because it allows quick protection of medicinal qualities of the plant material in an uncomplicated manner (Muller and Heidnl, 2006). In order to optimize practices for thermal processing and drying of biological mate-

* Corresponding author.
E-mail address: vasudha@gbpihed.nic.in (V. Agnihotri).

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rials, extensive research has been carried out around the world on various drying methods. There are three major types of drying procedures; (i) shade drying (Khorshidi et al., 2009; Verma and Chauhan, 2011; Annamalai et al., 2011) (ii) sun drying (Asekun et al., 2006) and (iii) drying using artificial methods such as freeze drying (Koller, 1995), heating (Radunz et al., 2001; Braga et al., 2005; Venskutonis, 1997; Buggle et al., 1999; Omidbaigi et al., 2004), microwave drying (Soysal et al., 2009), drying using climate chamber (Reynolds, 1998) etc. Different types of drying methods have been used to optimize the drying of target materials where not all types of drying processes are suitable for all the biological materials (Sadykov et al., 1997). The quality of medicinally important biological materials is so specific that drying of each product should be studied on an individual basis (Dillard and German, 2000).

The method of drying must be experimentally determined for each plant/plant part used as drug. The slow drying may cause harmful changes, by the action of enzymes, fungi and bacteria, before the process is completed. A very quick drying hardens the superficial layer of the cells and prevents the evaporation of water inside the organ, which also results in the action of enzymes (Bonazzi and Dumoulin, 2011). So drying process needs to be standardize which can reduce the loss of medicinally important compounds present in medicinal plants. This investigation aims to determine effective moisture diffusivity and energy required during drying of rhizomes, and to analyze the variation in alantolactone and iso-alantolactone content in *Inula racemosa* rhizomes dried at different drying conditions.

2. Material and methods

2.1. Drying equipment

Drying was performed in Climate chamber (Jeio Tech, Korea; model: TH-PE-100) equipped with controllers for temperature and relative humidity (Fig. 1). A balance (make: Citizen) was placed outside the dryer and used for measurement of weight variations of sample during definite time intervals.

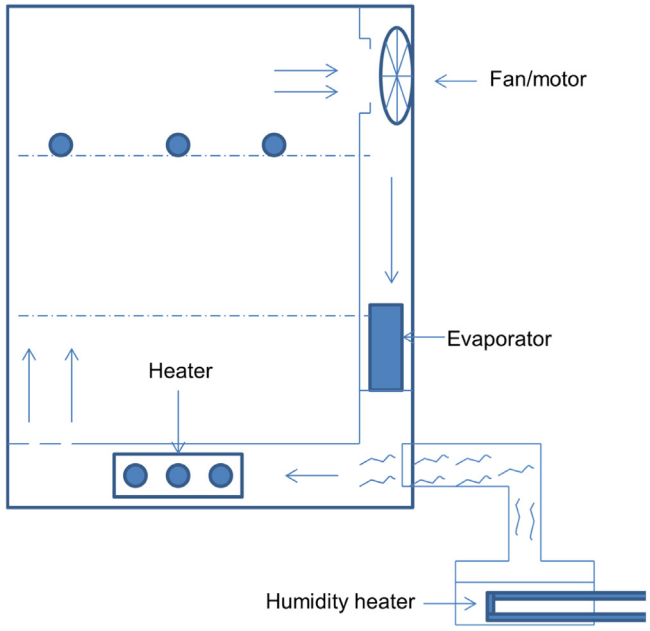

Fig. 1. Climate chamber set up used for drying experiments.

2.2. Plant material and chemicals

Two-year-old freshly harvested *Inula racemosa* rhizomes were purchased from Shansha villege, Lahul, Himachal Pradesh (2868.2 amsl; 32°36′52.64”N, 76°54′05.31”E). After harvest, the material was immediately transported to laboratory, washed with water to remove soil particles and surface dried. Subsequently moisture content was determined and then kept in a refrigerator (4 °C) until used. HPLC grade and analytical grade solvents were purchased from Rankem, India. Alantolactone (lot number: 00001511-305) and isoalantolactone (lot number: 00009175-203) standards were purchased from Chromadex, CA, USA.

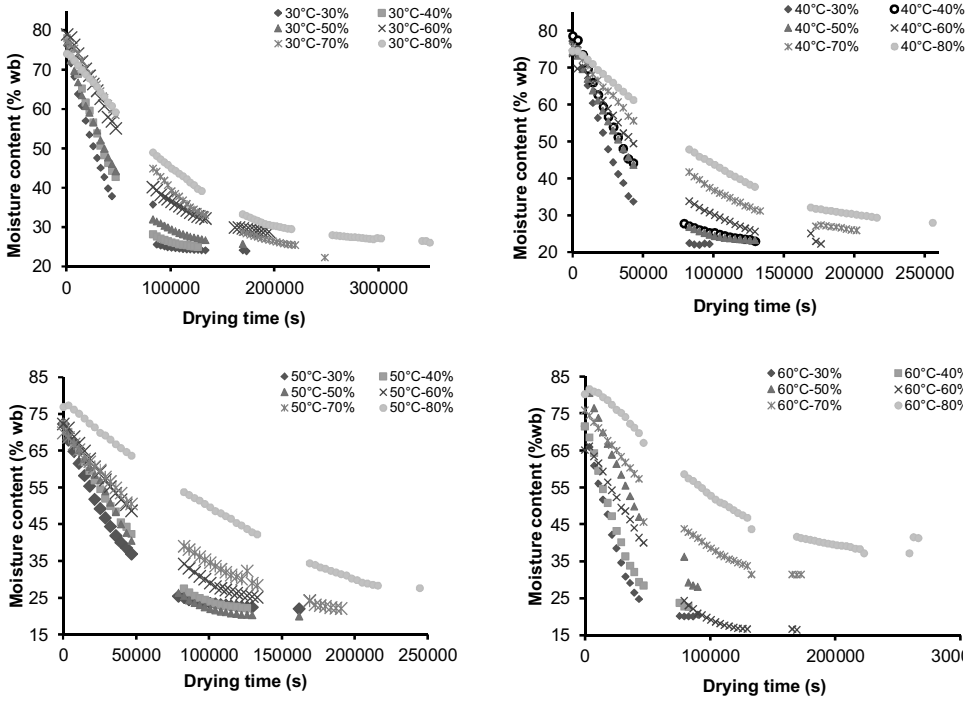

Fig. 2. Drying curves of *I. racemosa* rhizomes at different temperature (°C) and relative humidity (%) conditions.

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