ISSN: 2773-7055
Proceedings of 4th International Research Conference
Institute of Technology, University of Moratuwa
October 9, 2025

DETERMINATION OF MOISTURE DIFFUSIVITY OF KOHILA DRYING IN A CONVECTION TRAY DRYER

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ABSTRACT: Kohila (*Lasia spinosa*), a widely used ethnobotanical herb in Sri Lanka, is recognized for its therapeutic properties and potential in functional food development. This study investigates the drying kinetics of Kohila rhizome slices using a convection tray dryer at temperatures of 60°C, 65°C, and 68°C, with the aim of developing value-added, shelf-stable products. Sliced rhizomes (5 mm thick) were dried under controlled conditions, and moisture loss was recorded over time. Results indicate effective moisture diffusivity increasing with temperature. Estimated D_{eff} values ranged from 2.83×10^{-7} to 7.50×10^{-6} m^2/s. The activation energy for moisture diffusion was determined to be 8.52 kJ/mol, and the diffusivity coefficient was 6.75×10^{-9} m^2/s. These findings provide essential insights for optimizing drying conditions and support the commercial utilization of Kohila rhizomes in dried or powdered form.

Keywords: drying kinetics, convection tray dryer, Kohila, diffusivity

1 INTRODUCTION

Kohila (*Lasia spinosa*), a widely distributed ethnobotanical herb in Sri Lanka, is traditionally valued in Ayurvedic medicine. Both Its young leaves and rhizomes are known for their therapeutic properties and are commonly used in the treatment of digestive disorders, piles, rheumatism, and colic. The thick underground rhizomes, which are swollen horizontal stems, are recognized for their blood-purifying effects and have been utilized to manage rheumatoid arthritis, constipation, and other chronic ailments. Given its broad therapeutic potential, the development of value-added products from Kohila rhizomes such as dried powder, chips, or Kohila powder-infused bakery items can provide health-conscious consumers with convenient, functional food options while also creating new market opportunities for local producers (Adikari et al., 2022). For preservation and commercial utilization, Kohila (*Lasia spinosa*) rhizome slices must be dried to a final moisture content of 8–10%, a range that effectively inhibits mold growth and microbial spoilage (Shefana & Ekanayake, 2009). While sun drying is a traditional method, it presents several drawbacks, including dependency on weather conditions, risk of contamination, and uneven drying. Therefore, alternative drying techniques, such as convection drying, are necessary to achieve safe, hygienic, and consistent drying outcomes. Drying is a fundamental unit operation in food and chemical processing industries, where the primary objective is to reduce moisture content without compromising product quality. To optimize the drying process for Kohila rhizomes, it is essential to investigate critical parameters such as drying kinetics, effective moisture diffusivity, diffusion coefficient, and specific energy consumption (Sousa et al., 2024). Among these, moisture diffusivity plays a central role in governing mass transfer during drying and is influenced by factors such as slice geometry, drying temperature, and initial moisture content. While several studies have explored these parameters for herbs like black pepper and cinnamon, there is limited literature available on the effective moisture diffusivity of Kohila rhizomes, highlighting the need for targeted research in this area (Amarasinghe et al., 2025).

Low-cost drying methods such as packed bed dryers, fluidized bed dryers, and convection tray dryers are commonly employed in the agricultural sector due to their affordability and ease of operation (Jayatunga & Amarasinghe, 2014; Dryer & Sunderland, 1968). In contrast, novel drying technologies like freeze drying and microwave drying offer superior quality retention, particularly for heat-sensitive bioactive compounds, but are often limited by their high capital and operational costs. As an initial step toward developing value-added products from Kohila (*Lasia spinosa*), this study investigates the effect of varying drying temperatures on the drying kinetics of Kohila slices using a convection tray dryer. Furthermore, the study aims to evaluate the effective moisture diffusivity and diffusion coefficient of Kohila rhizomes during the drying process.

2 METHODOLOGY

Kohila rhizomes were purchased from a local vendor in Homagama. The rhizomes were thoroughly washed with clean water and sliced into discs approximately 5 mm thick to ensure uniform drying by avoiding over-drying of thinner slices or incomplete drying of thicker ones. The average diameter of the rhizomes ranged from 3.0 to 3.5 cm.

Drying experiments were conducted using a laboratory-scale convection tray dryer (*GUNT CE 130*). The air velocity was maintained at 2.8 m/s, which was sufficient to ensure proper airflow across the samples but not high enough to cause fluidization in the tray dryer. Experiments were carried out at three different temperatures: 60°C, 65°C, and 68°C. The desired drying air temperature was attained by the electric heater and the temperature control unit. In all experiments, the fluctuation of temperature was maintained within ±0.5°C. The sliced Kohila rhizomes were evenly distributed on the trays, stacked one over the other, allowing uniform airflow across the slices.

Drying temperatures were selected in the range of 60–68°C, as most agricultural crops are typically dried between 60 and 70°C to minimize the decomposition of heat-sensitive compounds (Jayatunga & Amarasinghe, 2019).

The weight reduction of the slices during drying was recorded at regular intervals using the auxiliary instruments provided with the dryer. Room temperature and relative humidity were monitored using an EXTECH EasyView™ Digital Hygro-Thermometer (Model EA20), while the airflow velocity from the blower was measured using an EXTECH Vane Thermo-Anemometer (Model SDL300).

3 RESULTS AND DISCUSSION

As shown in Figure 1, the drying rates were high at the beginning of the drying process, probably due to evaporation of moisture from the surface of the Kohila slices, and later decreased with decreasing moisture content, for all the drying conditions, proving that the mechanism of moisture movement is governed by a diffusion phenomenon as stated by Fick's law. Effective moisture diffusivities of Kohila slices were estimated from a plot of ln(MR) versus drying time for different drying conditions, as shown in Figure 2 and listed in Table 1 together with corresponding values of determination coefficient (R2) and relative mean square error (RMSE).

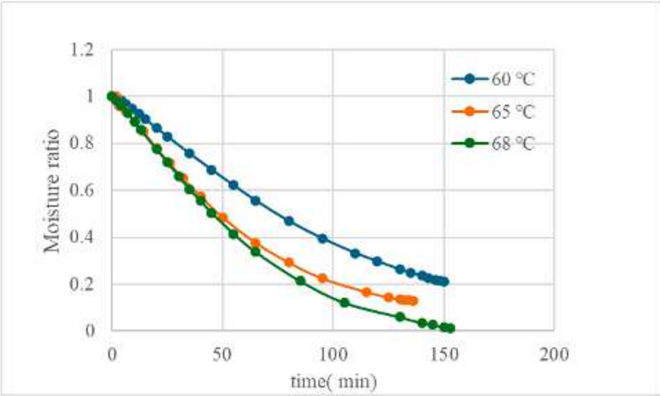

Figure 1. Moisture ratio vs time for drying Kohila slices in a convection tray dryer (bed weight = 400 g, air velocity 2.8 m/s)

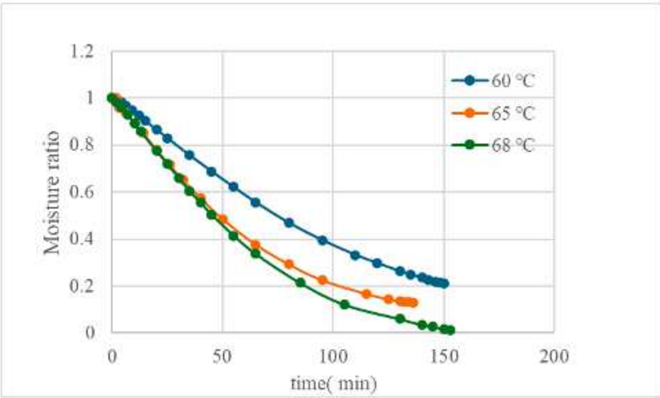

Figure 2. Ln(Moisture ratio) vs time of Kohila drying in a convection tray dryer

Table 1. Effective moisture diffusivity of Kohila slices dried in a convection tray dryer at different drying temperatures

Drying temperature T (°C)	Effective diffusivity D_{eff} (m^2/s) wdt	R^2	RMSE
60	2.83×10^{-7}	0.99	0.05944
65	4.1×10^{-7}	0.99	0.09781
68	7.5×10^{-6}	0.96	0.2149

According to the results, the effective diffusivity of Kohila slices depends on the drying temperature and increases with increasing temperature. The diffusivity coefficient was found to be 6.75×10^{-9} m^2/s, while the activation energy was 8.52 kJ/mol. It is worth mentioning that the effective diffusivity of barley was reported as $3.94{\times}10^{-11}$ m^2/s at 55 °C (Markowski et al., 2010), wheat as 8.33×10^{-14} m^2/s at 30 °C (Panagiotou et al., 2004), and malt as 1.11×10^{-8} m^2/s at 20 °C in the literature.

4 CONCLUSION

This study investigated the drying kinetics of Kohila (*Lasia spinosa*) rhizome slices in a convection tray dryer at temperatures ranging from 60°C to 68°C and an air velocity of 2.8 m/s. The effective moisture diffusivity values were found to increase with temperature, ranging from 2.83×10^{-7} m^2/s to 7.50×10^{-6} m^2/s. The activation energy for the drying process was estimated as 8.52 kJ/mol, and the corresponding pre-exponential factor was also determined. These results confirm that moisture migration during drying follows a diffusion-controlled mechanism governed by Fick's law. The increasing trend of effective diffusivity with temperature, along with a relatively low activation energy, suggests favorable drying characteristics compared to other agricultural materials. These findings lay a strong foundation for scaling up Kohila drying operations and incorporating dried rhizomes into value-added food and nutraceutical products, thereby contributing to rural livelihoods and the functional food industry in Sri Lanka.

5 ACKNOWLEDGEMENT

The authors gratefully acknowledge the Division of Polymer and Chemical Engineering Technology, Institute of Technology, University of Moratuwa (ITUM), for the support provided during this study.

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