Heat Pump Drying for Turmeric: A Preview

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Abstract: Turmeric (Curcuma domestica VAL) is a rhizome plant that is very popular as a spice and as a medicinal ingredient. The form of turmeric that can be used is in the form of fresh turmeric, dried turmeric, or turmeric powder. Turmeric drying produces dry turmeric, which has a longer shelf life and makes packaging easier. One of the dryers that can be used to dry turmeric is a heat pump dryer. In this study, the water content of the turmeric simplicial product was tested at various heating times, i.e., 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7 hours, and 8 hours with a constant temperature of 400C. The final water content of the dry turmeric product reached 7.53%.

1 INTRODUCTION

One of the medicinal plants that is frequently utilized as a raw material in Indonesia's herbal and pharmaceutical industries is turmeric (Curcuma domestica Val.). The anti-inflammatory, antioxidant, and blood-clotting properties of turmeric help to reduce pain and hasten wound healing. One of the many active components found in turmeric is an antioxidant. Curcuminoids are the most significant main antioxidant present in turmeric.

One of the earliest methods of food preservation is drying. Hot air drying is currently one of the most developed drying techniques out of the many that have been created. This drying method provides advantages in terms of drying time, but it also has certain drawbacks, such as changes in color and flavor, a reduction in nutritional content, and a loss of the product's functional characteristics (Ozkan, 2007). This promotes efforts to create new drying techniques, one of which is heat pump drying that integrates the refrigeration system.

In order to increase shelf life and avoid food spoiling owing to chemical processes and biological degradation due to the growth of microorganisms, it is crucial to remove some of the water from the matrix of agricultural or industrial products during the drying process (Moradi, 2020). The process of removing moisture uses two simultaneous mechanisms: the first involves applying heat to the product to cause evaporation, and the second involves mass-transferring moisture from the product surface to the atmosphere. Heat and mass transfer refers to this simultaneous process.

Convection, where hot air or gas is blown over the surface of the product and heat is transferred to the product, provides the energy required for evaporation of the moisture present in the food in this process. This heat raises the temperature of the product, causing moisture to evaporate as water vapour and raising the vapor pressure of the product. The vapor pressure of the product is greater than the vapor pressure of the surrounding air in this condition. This pressure difference causes moisture to evaporate from the product's surface into the air. This pressure gradient acts as a driving force in the drying process, removing moisture from the product as it exits the air. The moisture on the product's surface is evaporated until it reaches equilibrium conditions.

Drying is one of the most energy-intensive operating equipment, accounting for up to 10-20% of total industrial energy utilization, and most of the energy in many industrial drying processes is wasted in the environment (Ogura H, 2005). Batch dryers were used for small and medium-sized production

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runs and relatively thin products such as fruits or vegetables or sliced spice products in research using heat pump drying methods and equipment in (Kerr, 2013. Cuynet, 2020. Erbay, 2017. Chapchaimoh, 2016. Haonan, 2020. Ta L, 2018). Food is loaded onto trays in cabinets and left to dry until it is completely dry. Cabinet dryers typically have low turnover rates due to their simple design, and the drying process is not uniform throughout the drying chamber.

Drying with heat pumps is becoming more popular in industry due to its low energy consumption and high drying efficiency (Deng Y, 2015). Energy-saving heat pump drying is based on the reverse Carnot cycle principle; it can recover energy from used drying air heat and reuse it in the drying process, as well as control the temperature and humidity of the air independently (Chua K J, 2007).

1.1 Experimental Apparatus and Method

A local market in Denpasar, Bali, Indonesia, provided fresh turmeric. Before beginning each experiment, a 25 mm and 2 mm diameter turmeric was peeled and sliced transversely into 2 mm-thick slices using a cutting machine. The turmeric used in this study was fresh turmeric, up to 2100 g, that had been sorted. In this study, turmeric was sorted, weighed, and placed on a drying tray, with each tray weighing 350 g. The drying process was carried out using a heat pump dryer, with drying times varying from 1 hour to 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7 hours, and 8 hours at a temperature of 40ºC. The remaining turmeric weight was measured at the end of the test and used to calculate the water content. A psychrometric analysis of the hot air circulating in the system will also be performed as part of this study. Figure 1 depicts the equipment used in this study, which is a heat pump drying unit.

Controlling the time for the heating process is the point of comparison in this experiment. The fan blows hot air into the drying cabin at an average speed of 1.8 m/s. The main refrigeration components are listed below.

Figure 1: Heat pump drying machine.

Table 1: Main component.

No	Component	Specification
1	Compressor unit	Hermetic, Rotary 0.25 HP, R134a refrigerant
2	Condenser unit	Fin and tube with air cooled system.
3	Expansion device unit	Thermostatic expansion valve
4	Evaporator unit	Fin and tube exchanger with air cooled system.

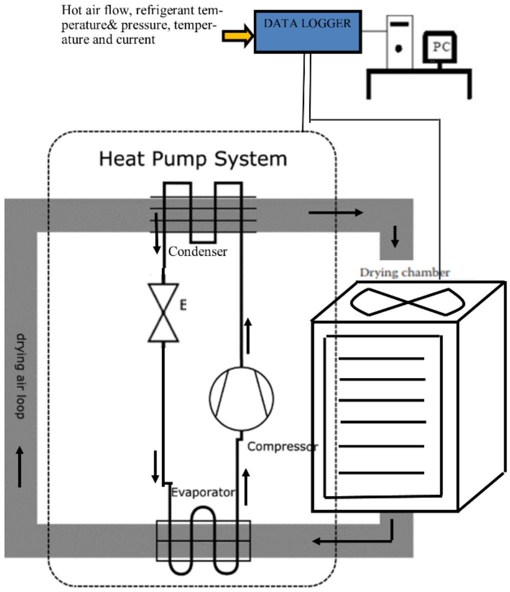

Figure 2: Schematic heat pump drying machine.

The measurement instruments used in this investigation were a K-type thermocouple, hygrometer, low and high-pressure gauges, anemometer, and stopwatch. Using k-type thermocouples, the temperatures of the refrigerant R-134a and the air circuit at the inlet/outlet of the air ducting system were measured. The sensors are either attached to the outside of the copper tubing that transports the refrigerant or are built into the thermal insulation. In the meantime, the electrical system uses a thermostat unit with a detecting light to regulate the refrigerant flow's on/off cycles. All data were logged with a data logger set to 1 Hz and stored in external memory.

2 RESULT AND DISCUSSION

Turmeric drying was performed using a heat pump drying device at 40°C with varying drying times of 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7 hours, and 8 hours respectively. The turmeric drying method used in this study is a thin layer drying method in which the turmeric is directly exposed to the hot air flow from the condenser. Figure 3 depicts the changes in turmeric weight at the beginning and end of the drying process.

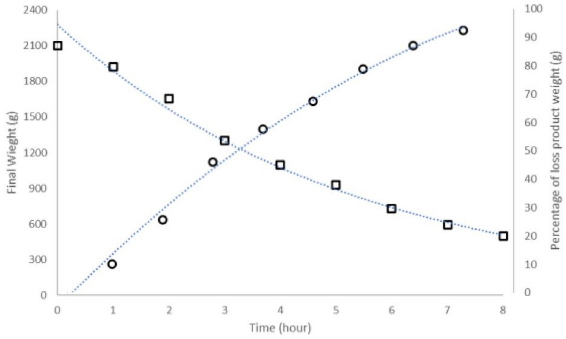

Figure 3: Weight and water content of turmeric.

This section discusses the performance of the heat pump drying from the standpoint of the product's water content. The water content of the product is one indicator of heat pump drying performance; their time series data indicate heat pump drying performance and are discussed below.

According to Figure 3, drying 2100 grams of turmeric for 8 hours resulted in a residual weight of 498 grams with a remaining water content of 7.53 percent. Data from time series graphs show that the greater the amount of water evaporated, the longer the drying time. However, more research is required to optimize the drying time. The slope of the graph appears steep before 4 hours at a constant drying temperature of 40°C. The maximum slope value obtained for the final weight is -353, and the percentage of remaining water in the product is 20.43. The maximum slope phenomenon occurs between the second and third hours. Then it drops slightly in the third and fourth hours. There is a decrease in slope for times greater than 4 hours. This phenomenon occurs because the water content is deep in the product, requiring more time to evaporate at a constant holding temperature. This also demonstrates that the rate of reduction of the product's water vapor content occurs optimally over a period of 2-4 hours, as shown in Figure 3.

3 CONCLUSIONS

To describe preliminary drying characteristics, an experimental investigation into the water content of products dried by a heat pump dryer was carried out. The heat pump drying method is effective at decreasing the water content of the product by 7.53 percent after eight hours of drying, with the most effective drying phenomenon occurring in the second to third hour.

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