COMPARISON OF DRYING TIME OF MICROWAVE AND HYBRID DRYER

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ABSTRACT

In this study, black radish slice at thickness of 8 mm were dried using a microwave conveyor dryer and hybrid dryer (hot air and microwave). The effect of microwave power (0.7 kW, 1 kW, 1.05 kW, 1.4 kW, 1.5 kW and 2.1 kW) and conveyor speed (0.245 m/min) on drying time of black radish was investigated. The hot air produced with the usage of a collector which is designed in the shape of a hemisphere by the purpose of getting high efficiency from solar energy, was transported to a conveyorized drying chamber operating with microwave energy at the speed of 0.245 m/min. As a result of this study, the drying times of these two dryers were compared.

Keywords: *Microwave, dryer, hybrid, conveyor, hot air*

INTRODUCTION

Today, drying is a necessary practice in many areas. Sometimes drying is necessary for easy transport. Some products can be sold after the amount of moisture they contain has been reduced to a certain level. Some products are dried for easy storage and not to require cooling equipment during transit.

Microwave processing of materials has emerged as one of the prominent and efficient methods. Microwaves find applications in food processing, telecommunication, radar system, material processing. Microwave heating takes place due to the polarization effect of electromagnetic radiation at frequencies between 300 MHz and 300 GHz. Microwaves are a form of electromagnetic energy associated with electric and magnetic fields [1]. Microwave ovens are one of the great discoveries of the 20th century and are widely used. Compared to the ovens, microwave ovens produced only for heating food can do heating in a very short time. In this way, it allows saving both time and electricity. In industrial drying applications, microwave heating is a very suitable system for industrial application, since it is desired to remove the moisture quickly through the material. The major advantages of using microwaves for industrial processing are rapid heat transfer, volumetric and selective heating, compactness of equipment, speed of switching on and off and pollution-free environment as there are no products of combustion.

Several types of dryers and drying methods have to be developed and adapted for each specific situation, and to be commercially applicable. There are several types of drying methods that can be divided according to many factors, such as pressure (atmospheric), subatmospheric), type of unit operation (continuous, batch, semi continuous) temperature (freeze drying, hot air convective) and many others [2].

Characteristic nature of microwave processing that makes it as one of the most attractive processing techniques is the inside-out heating due to interaction with materials at molecular level. Microwaves penetrate in to materials and generate heat at molecular level, while the conventional heating takes place from outside to inside nature of the material. This nature of conventional heating results in temperature differences between layers of the material, causing energy and material losses. Heat transfer in microwave and conventional processing methods is schematically shown in Fig. 1 [1].

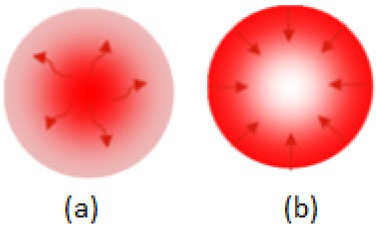


Fig. 1 *Heat transfer in (a) microwave processing (b) conventional processing*

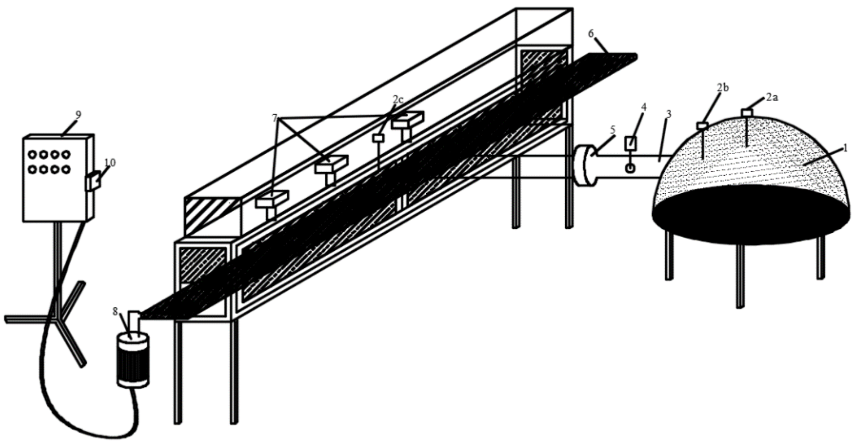
In this study; microwave solar combination dryer and microwave energy band dryers were compared and the optimum dryer type and microwave power were determined. A new drying technology can shorten drying times, reduce drying defects, increase the potential for product innovation and provide a seamless integration into automated manufacturing systems.

MATERYAL VE METOD

Fresh black radishes with approximately 85% (w.b.) were bought from a local market where they had been stored at 4°C (Tekirdağ/Turkey). The black radishes were placed in the drier by being sliced in 8 mm without being subject to any pretreatment,

The experimental set up is shown in Fig. 2. Fresh carrots were obtained from the store of a local market (Tekirdağ, Turkey). The microwave cavity was a rectangular shape with a cross-sectional area of 500 mm x 400 mm x 3500 mm (width x height x depth). The microwave power was generated by means of three magnetrons of 700W each at 2.45GHz. During the drying process, the conveyor belt speed was to regulate and could be set at the potentiometer of control unit. The drying system consists of stainless steel conveyor, teflon belt, electric motor, control panel, temperature and air velocity measurement devices, fan (35 W), hot air conveying channel (1,5m, Ø0,01m) and spherical collector (Ø1,5 m) made of acrylic material. The speed and direction of rotation of the band can be adjusted with an inverter that controls the electric motor and is located in the control panel. The hot air produced in the collector is moved to conveyor by the help of the fan on the cylindrical dryer channel.

Throughout the drying process, the weight of the product was determined in every three minutes for microwave dryer and in every five minutes for hybrid dryer. The moisture losses that occurred throughout the experiments were measured by Presca XB 620M (±0.001g), (Switzerland) brand precision scale.



Sıra No	Adı
1	Acrylic collector for heating the air with solar energy
2a	The in-collector temperature measurement probe is used for measuring the inside temperature of the collector
2b	The in-collector temperature measurement probe is used to measure the temperature of the air transported from the collector
2c	Oven temperature measuring probe
3	Galvanized pipe carrying air heated in collector
4	The prop is a measure of the temperature and velocity of the air in the galvanized pipe.
5	Fan carrying the air in the galvanized pipe
6	Teflon tape
7	Microwave group (Magnetron, Transformer, Fan, etc.)
8	The electric motor that drives the tape
9	Control board
10	Electric meter

Fig 2. *A schematic diagram of hybrid dryer*

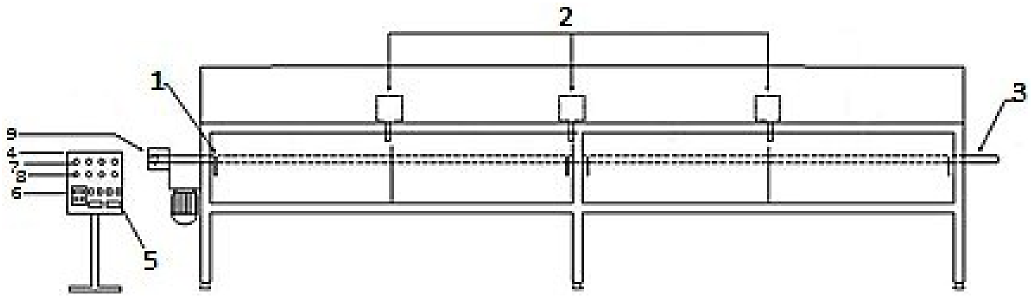


Fig.3. *A schematic diagram of microwave conveyor dryer (1. Drying chamber, 2. Magnetron, 3. Conveyor belt, 4. Control panel, 5. Main swtich, 6. Speed control, 7. Power (on/off), 8. Microwave power control, 9. Electric motor)*

In order to determine the moisture content, the black radishes were initially dried in an oven at 105°C for 24 h and the dried mass was measured. The moisture content of the black radishes with respect to the wet base was 85±0.5%.

In the belt drier, the radish slice has been placed at a certain height in order to make it easier to remove the moisture from the product and to provide a more homogeneous surface contact. The experiments were conducted at 0.7 kW, 1 kW and 1.4 kW power levels for hybrid drying at 1.05 kW, 1.5 kW and 2.1 kW power levels for microwave drying. The belt speed was set at 0.245 m / min during the test. The hot air produced in the collector for hybrid drying was expected to reach a constant value until 11:00 am to 13:00 pm. Then the experiment was started and the generated hot air was transferred at constant speed. In the hybrid dryer experiments, the weight of the product was measured every five minutes with a precision scale. In the microwave dryer experiments the weight of the product was measured every three minutes. The microwave power was applied until the weight of the sample reduced to a level corresponding to moisture content of about 12±0.5% on wet basis. Three different drying trials were conducted for each microwave power and the values obtained from these trials were averaged. The power of the microwave energy and conveyor speed were adjusted from control panel.

The moisture content of the dried products on wet base is calculated using equation 1. Equilibrium moisture content in the microwave oven is assumed to be zero [3].

$$MR = m / m_o \qquad (1)$$

RESULTS AND DISCUSSION

As a result of drying with these systems, the variation of drying times and the color changes on the products have attracted attention (seen Fig. 4). In this work drying operation for microvave dryer lasted 72-92 minutes, for hybrid dryer lasted 65-82 minutes.

Partial burning was observed in the products dried in the microwave dryer. Homogeneous drying occurred in the hybrid system. In terms of drying times, the most suitable drying system was found suitable for 1400 W in the hybrid dryer. The irregularity of the drying curves is due to energy losses and non-homogeneity of the product.

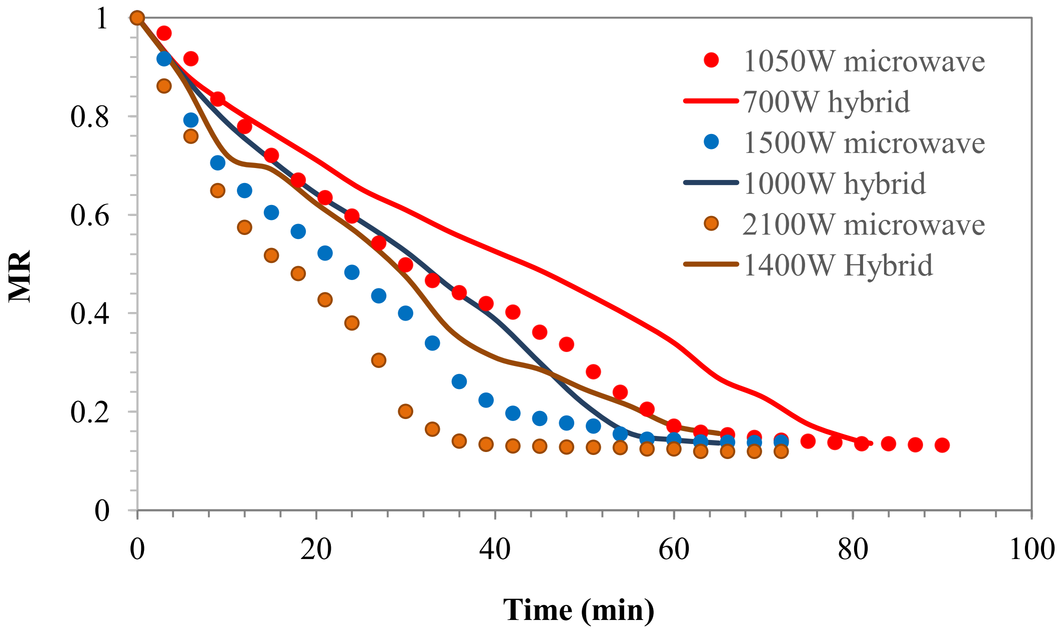


Fig.4. *Drying curves for different microwave powers*

Despite lower energy usage, both microwave and hybrid drying systems have reached the moisture levels that are desired to be reached at about the same time. In this case, energy was saved because it was dried with lower energy in the same time. In the hybrid drying system, it can be said that energy and time saving can be done by selecting power in the energy levels used in microwave drying.

As a result, in the drying implementations with microwave conveyor dryer it can be said that working with the lowest speed band possible is more beneficial for quality criterias. Also it can be said that these methods are more feasible for drying of the fruits and vegetables where commercial issues, conservation of colour and the other quality parameters are so important. It is suggested that hybrid dryers are appropriate in terms of their time usage in the agricultural products sector.

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