DRYING CHARACTERISTICS OF PAPAYA (*Carica papaya* L.) DURING MICROWAVE-VACUUM TREATMENT

Ida Idayu Muhamad, Nurul Asyikin Md Zaki *, Liza Md. Salleh, Nozieana Khairuddin
Bioprocess Engineering Department, Faculty of Chemical and Natural Resources Engineering,
Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia.
Email: nursyique@gmail.com

ABSTRACT

Microwave-vacuum drying is of increased interest among food researchers. The microwave power and system pressure plays an important part to ensure that the product quality is improved. The aim of this project is to study the effect of power intensities and system pressures during microwave-vacuum treatment on drying characteristics of Carica papaya L. Samples of papaya were treated in microwave-vacuum drying equipment at different power levels (110, 380 and 750 W) and pressures (200, 450 and 700 mmHg) to achieve 90% reduction of moisture content. The drying rate increased with increasing power intensity, while system pressure showed no significant effect to the reduction of moisture content. Higher microwave power level resulted in shorter drying time of papaya. The entire drying process for the samples occurred in the range of falling rate period.

***Keywords**: microwave-vacuum, drying characteristics, moisture content, papaya.*

INTRODUCTION

Papaya (*Carica papaya* L.) is grown extensively in all tropical and sub-tropical parts of the world. Papaya has been regarded as one of the most valuable tropical fruits that contains beta carotene, protein, carbohydrate, vitamins and minerals. Hence, processing and preservation of papaya is important to retain the product quality and its nutritional value. Dehydration is one of the important preservation methods employed for storage of fruits besides its application in product processing. Dehydration method and various processing parameters have huge effects on the quality of dried fruits and thus selection of proper drying techniques and conditions is necessary to optimize the drying performance and retain the quality of the dehydrated products.

Hot air drying often degrades the product quality, provides low energy efficiency and lengthy drying time during the falling rate period [1] It has been reported that hot-air drying of food materials, involving their prolonged exposure to elevated drying temperatures, results in substantial deterioration of such quality attributes as color, nutrient concentration, flavor and texture [2], [3], [4]. The desire to eliminate this problem, prevent significant quality loss and achieve fast and effective thermal processing has resulted in the increasing use of microwaves for food drying. Microwave drying has offered an alternative way to improve the quality of the dehydrated products. It is rapid, more uniform and energy efficient. Microwave drying is of increased interest among food researchers because of its energy saving possibilities it might represent.

Major advantages of microwave drying of foods are higher drying rate, energy saving and uniform temperature distribution giving a better product quality [5]. The microwave energy can penetrates directly into the material, causes volumetric heating from the inside out of the material and provides fast and uniform heating throughout the entire product. It enables to shorten dehydration time and to control undesirable biological transformations. The quick energy absorption by water molecules causes rapid evaporation of water, resulting in higher drying rate of the food and creating an outward flux of rapidly escaping vapor. Because the removal of moisture is accelerated, the heat transfer to the solid is slowed down significantly due to the absence of convection [6]. The increased drying rate and lower heat transfer provides energy saving of microwave drying. However, microwave drying is known to result in a poor quality product when applied improperly [4].

In recent years, microwave-vacuum drying has been investigated as a novel alternative method of drying to obtain products of acceptable quality including fruits, vegetables and grains. Microwave-vacuum drying combines the advantages of both microwave heating and vacuum drying. In vacuum drying, removal of moisture from food products takes place under low pressure. The lower pressure allows reduction of drying temperature and furthermore provides higher quality products [7]. Vacuum expands air and water vapor present in the food products and creates a frothy or puffed structure [8]. The low temperature and fast mass transfer conferred by vacuum incorporated with rapid energy transfer by microwave heating generates very rapid, low temperature drying [9] and thus it has the potential to improve energy efficiency and product quality. Furthermore, it permits a shorter drying time and a substantial improvement in the quality of dried materials, in relation to those dried with hot air and microwaves drying methods [10].

Some fruits and grains have been successfully treated with microwave-vacuum drying techniques [3-4], [9-15]. Despite those investigations, there is scanty information available on the drying characteristics of papaya undergoing microwave-vacuum drying technique. Therefore, the aim of this project is to study the effect of microwave power intensities on drying characteristic of *Carica papaya* L.

MATERIALS AND METHODS

The experimental setup used for the microwave-vacuum drying of the samples is depicted in Figure 1, which consists of a microwave oven (Sharp R-4A53) of rated capacity of 800W. The microwave oven was modified to incorporate vacuum to the system. A glass container containing the material to be dried was placed inside the microwave cavity and a vacuum pump was connected to the container to maintain the desired vacuum pressure levels inside. Vacuum in the container was monitored by using a vacuum gauge and a pressure regulating valve to maintain the pressure at the desired levels. Samples of papaya from the Hawaiian type supplied by MARDI Pontian were hand-peeled and cut into cubes of 2 cm. The samples were treated in the microwave-vacuum apparatus at different levels of power intensity (110, 380, 750 W) and system pressure (200, 450, 700 mmHg) until the moisture content was reduced to 10% (d.b.). Sample weight was determined by the digital balance weight. The weight of the samples was recorded at every 2 minutes intervals by switching off the microwave oven and after releasing the vacuum.

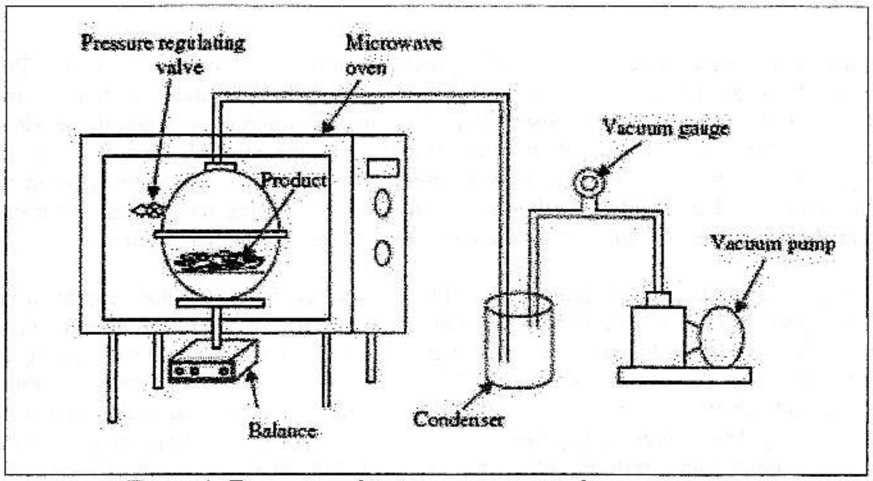

Figure 1: Experimental microwave-vacuum drying apparatus

The moisture content was expressed on a dry basis as kg of water per kg of free-moisture solid or kg H_2O/kg dry matter. It was determined by an oven method, slightly modified from Funebo et al. (2000) [16]. Cubes of papaya were placed in an oven (Memmert) at 100°C for 24 hours to obtain the dry weight. Time-dependent moisture content of the samples was calculated as follows:

$$MoistureContent = \frac{Wetweight - dryweight}{dryweight}$$

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RESULTS AND DISCUSSIONS

The drying curves for drying of papaya cubes under microwave-vacuum drying are shown in Figure 2 - 4, where the moisture content of the samples at various time intervals and for varying microwave power level and system pressure is recorded. The time required to reduce the moisture content to any given level in microwave-vacuum drying was dependent on the power level, being the highest at 110W and lowest at 750W. It has been observed that the processing time reduced with increased in power intensity. Papaya having 82% initial moisture content dried to a range of final moisture content below 10% within 30 and 8 min at microwave power level of 110 and 750W, respectively, at pressure level of 200, 450 and 700 mmHg. Consequently, the microwave-vacuum drying times at microwave power level of 750 W was around 75% and 60% shorter than the times required to remove moisture to the desired moisture content at 110 and 380 W, respectively.

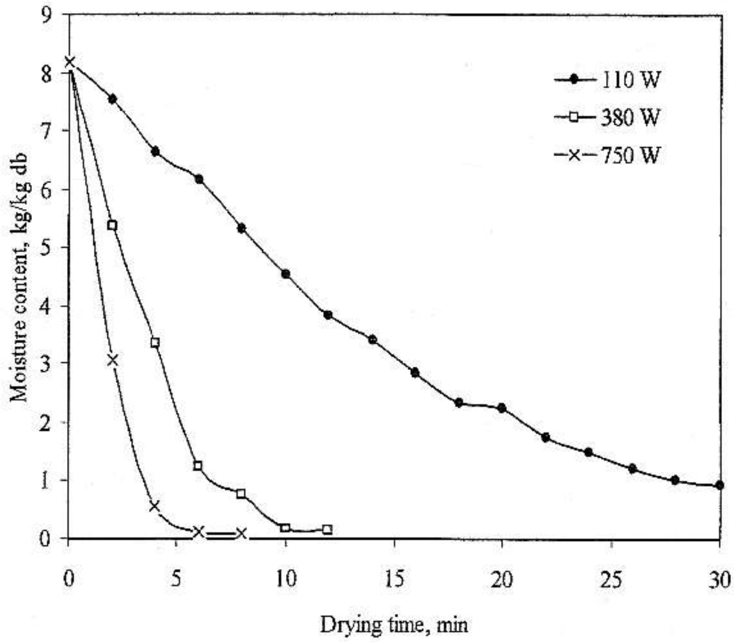

Figure 2: Drying curves of microwave-vacuum dried papaya at 200 mmHg system pressure

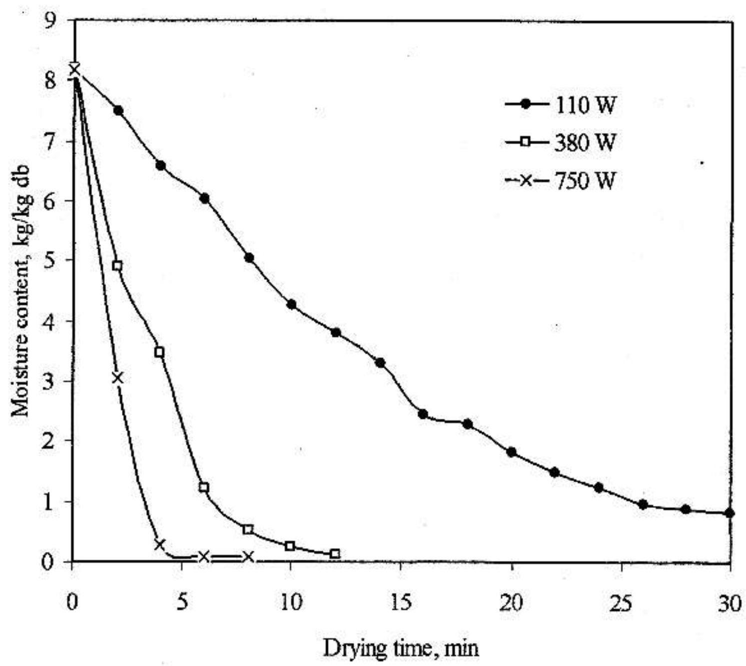

Figure 3. Drying curves of microwave-vacuum dried papaya at 450 mmHg system pressure

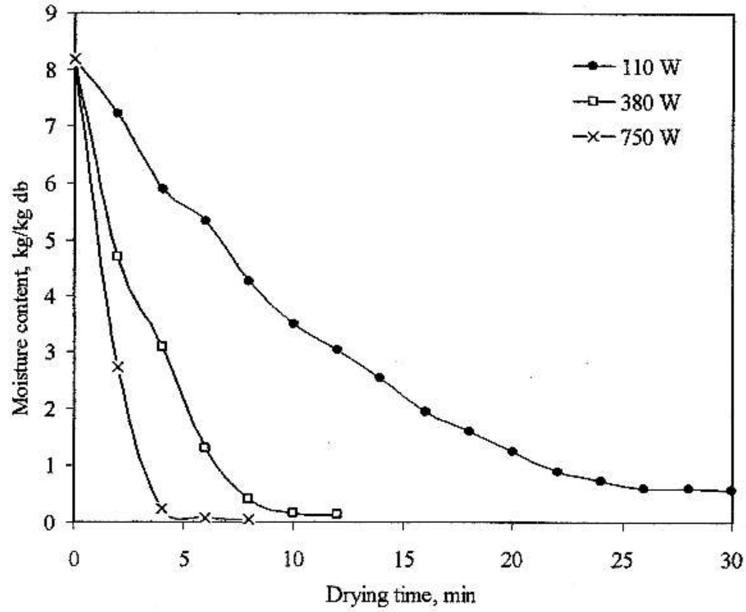

Figure 4. Drying curves of microwave-vacuum dried papaya at 700 mmHg system pressure

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Figure 5 further shows the effect of changing the process variables, namely system pressure on the drying time during microwave-vacuum drying of papaya. When microwave power intensity remains constant, the drying rate at higher vacuum level was slightly greater. However, the effect of system pressure on drying time was not as significant as that of microwave power. The hypothesis was observed on the microwave-vacuum drying of mushroom slices [9], as well. Higher vacuum level normally would give rise to glow discharges or electrical arcing in the cavity and may cause local overheating and irreversible damages to the product [17]. Therefore, relatively higher vacuum level should not be used in order to preserve the product quality.

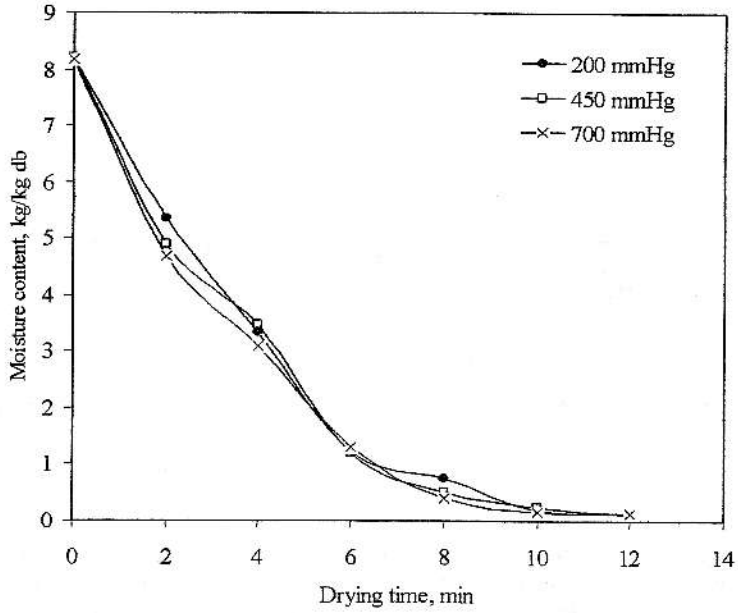

Figure 5. Effect of pressure levels on the drying time for microwave-vacuum dried papaya at 380 W microwave power

The influence of microwave power on the drying rate is illustrated in Figure 6. There were no constant rates drying under any of the test conditions. Although papaya has high moisture content, an expected constant rate period was not observed in the present study, probably because of the layer arrangement and too rapid heating by microwaves, providing instant drying. The results indicated that mass transfer is rapid during larger microwave power heating because more heat was generated within the samples, creating a larger vapor pressure differential between the centre and the surface of products [15]. As expected, higher drying rates were obtained with higher microwave power. It was clearly seen from the figure that drying rates were higher during higher moisture content and decreased with decreasing moisture content. At moisture content of less than 1.0 kg/kg d.b. there is no difference in the drying rates among different power intensities, indicating the significance of internal resistance to mass transfer at low water content in the material. The amount of microwave energy absorbed by the material depends upon its dielectric properties and the electric field strength [9]. As the values of dielectric constant and loss factors are higher at higher moisture content of the material, obviously the material absorbs more microwave power and heating is faster at high moisture content. As drying progressed, the loss of moisture in the product decreases the absorption of microwave power and resulted in a fall in the drying [18]. It is obvious that the entire drying process for the samples occurred in the range of falling rate period.

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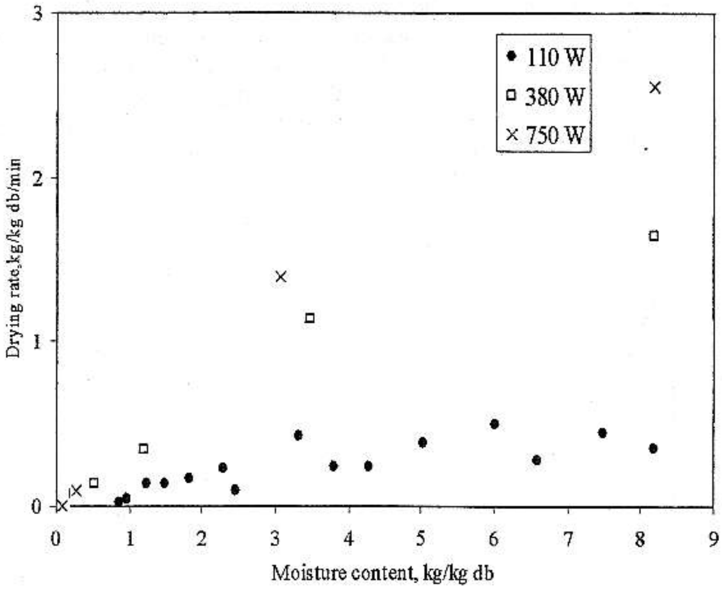

Figure 6. Drying rate for microwave-vacuum drying of papaya at 450 mmHg system pressure

CONCLUSIONS

From the study, it was concluded that microwave power intensity influenced the drying characteristics of papaya fruit. As microwave power increased, the drying rate increased. As to achieve final moisture content of 10% and below during microwave-vacuum drying of papaya, increase in power intensity resulted in shorter drying time. Meanwhile, the effect of system pressure on the drying time was not as significant as that of microwave power level. It is obvious that the entire drying process for the samples occurred in the range of falling rate period.

ACKNOWLEDGEMENT

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