

## DRYING CHARACTERISTICS OF PAPAYA (*CARICA PAPAYA* L.) DURING MICROWAVE-VACUUM TREATMENT

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### 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 some 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 significant 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 [2-4]. 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 dehydrated products. It is rapid, more uniform and energy efficient. Microwave drying is of increased interest among food researchers because of the 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 penetrate directly into the material, releases volumetric heating out of the material and provides fast and uniform heating throughout the entire product. This helps to shorten the dehydration time and 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 increase in drying rate and decrease of heat transfer provide 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 studied as an alternative method of drying to obtain high quality products 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 low pressure allows reduction of drying temperature and furthermore provides high quality products [7]. Vacuum expands the air and water vapor present in the food products and creates a frothy or puffed structure [8]. The low temperature and rapid mass transfer conferred by vacuum incorporated with quick energy transfer by microwave heating generate very rapid but low temperature drying [9]. Thus

microwave-vacuum drying 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 comparison 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 characteristics 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 having 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% (dry basis). Sample weight was determined by the digital balance. The weight of the samples was recorded at every 2 minutes intervals after switching off the microwave oven and after releasing the vacuum.

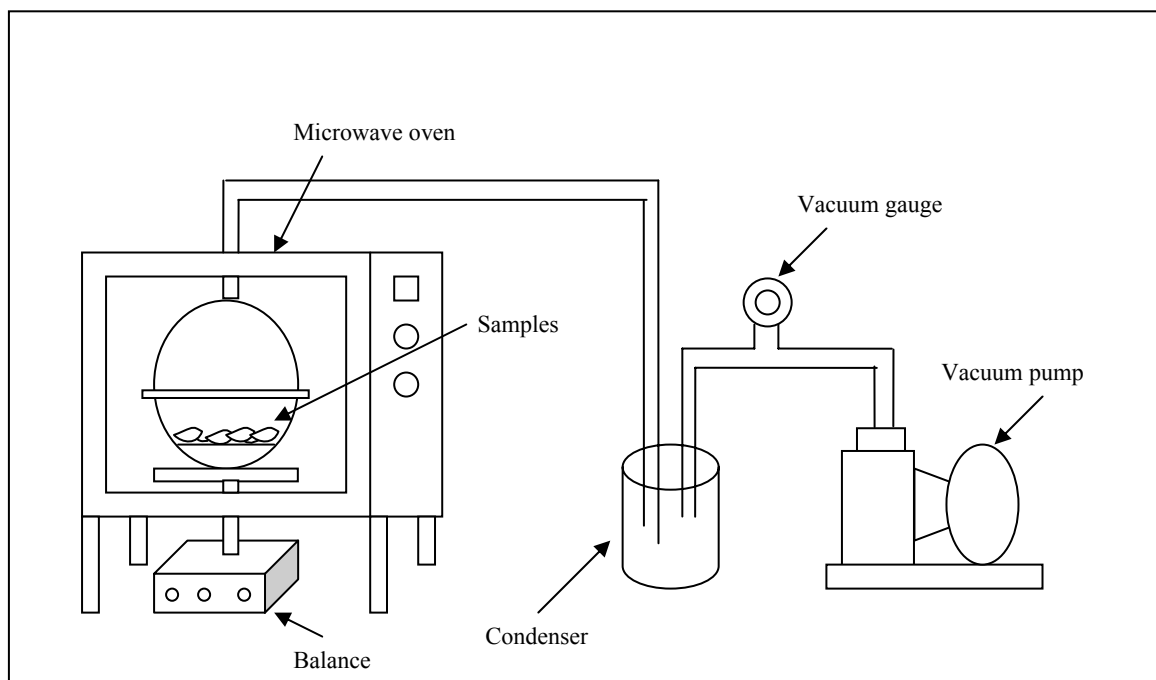


Figure 1: Experimental microwave-vacuum drying apparatus

The moisture content was expressed on a dry basis as kg of water per kg of free-moisture solid. It was determined by an oven method, slightly modified from Funebo et al. [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 was then calculated based on the sample weight.

## RESULTS AND DISCUSSIONS

The drying curves for drying of papaya cubes under microwave-vacuum drying are shown in Figures 2 - 4, where the moisture contents of the samples were recorded at various time intervals and for varying microwave power levels and system pressures. 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 was dried to a range of final moisture content below 10%. Drying was carried out 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% shorter than the times required to remove moisture to the desired percentages at 110 W whereas it was 60% shorter than that at 380 W.

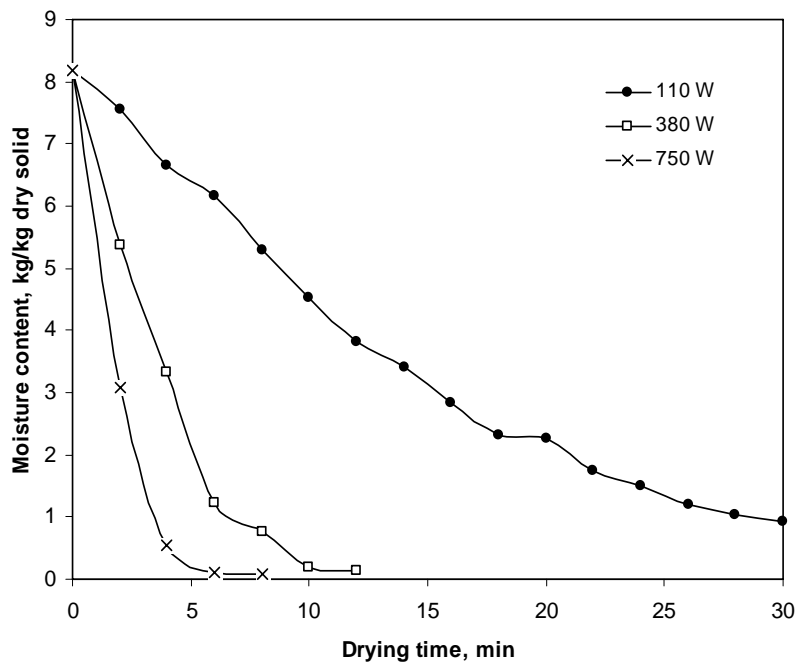


Figure 2: Drying curves of microwave-vacuum dried papaya at 200 mmHg system pressure

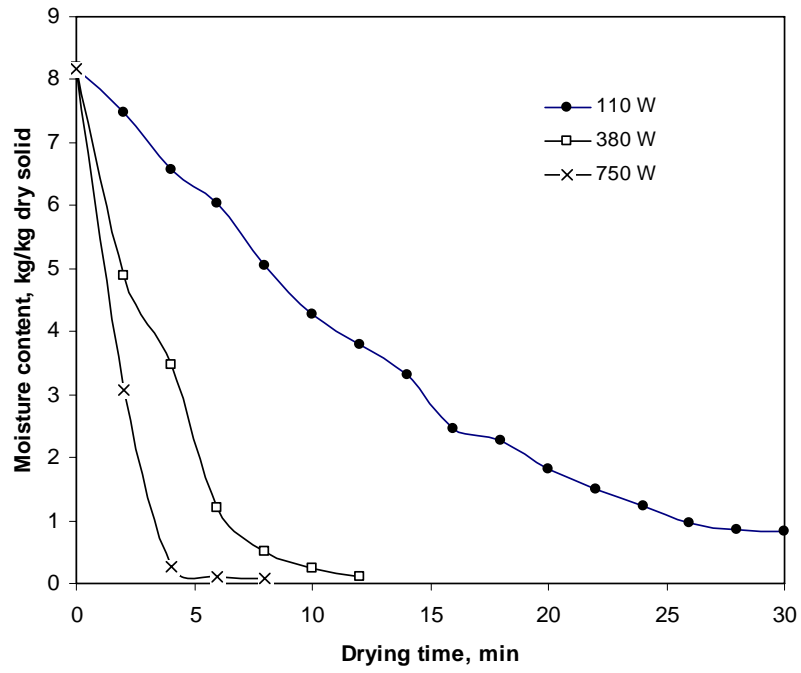


Figure 3. Drying curves of microwave-vacuum dried papaya at 450 mmHg system pressure

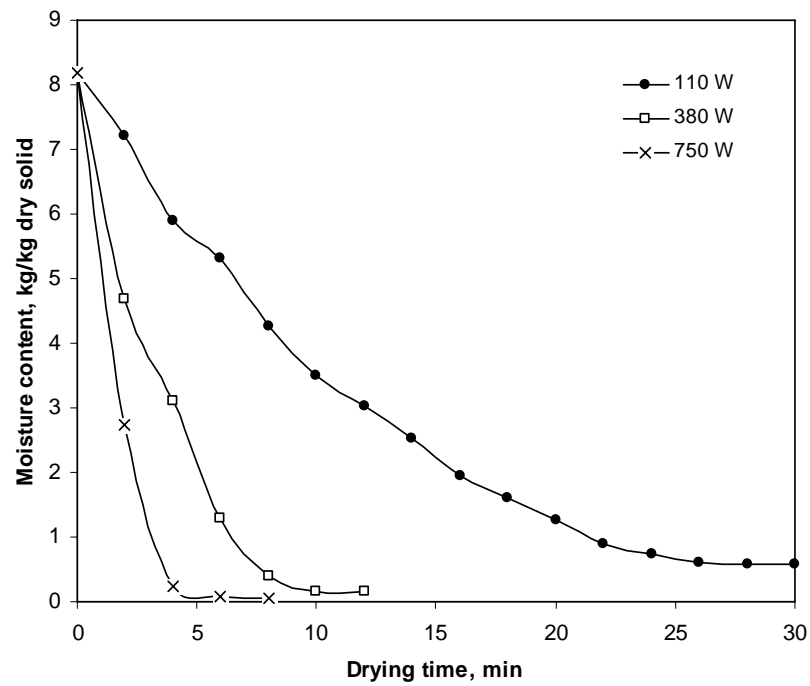


Figure 4. Drying curves of microwave-vacuum dried papaya at 700 mmHg system pressure

Figure 5 shows further the effect of changing the process variables, namely system pressure on the drying time during microwave-vacuum drying of papaya. When microwave power intensity remained 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 might 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.

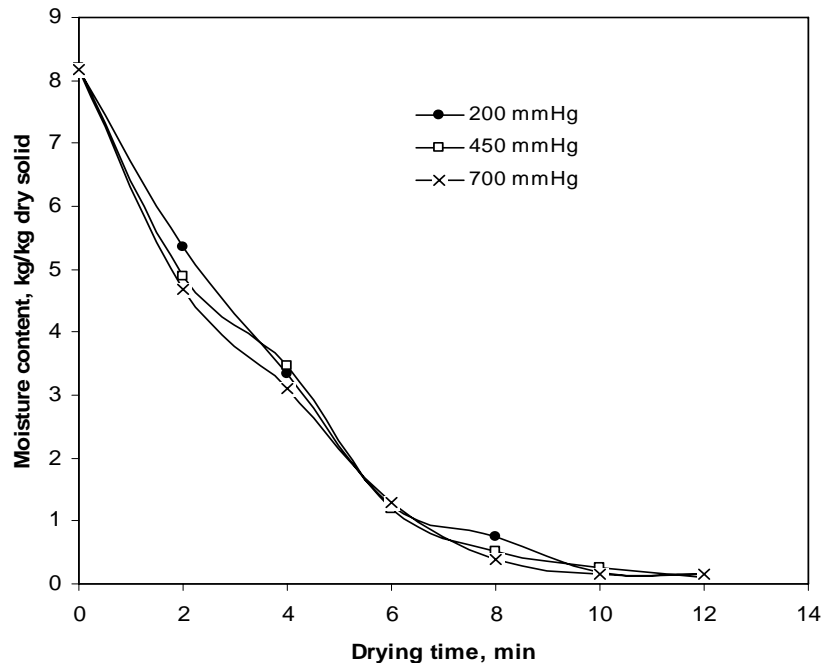


Figure 5. Effect of pressure levels on the drying time for microwave-vacuum dried papaya at 380 W microwave power

The influence of microwave power on the drying rate is illustrated in Figure 6. There were no constant rate drying under any of the test conditions. This proves the conclusion made by Giri *et al.* [9] that drying by microwave-vacuum occurred only in the range of falling rate period. Several researches on microwave and microwave-vacuum drying also stated that the constant rate drying was not observed throughout the drying process of papaya [18], banana [1], peach [5], mushrooms [9] and apples [19]. 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 reduced the absorption of microwave power and resulted in a fall in the drying [20]. It is obvious that the entire drying process for the samples occurred in the range of falling rate period.

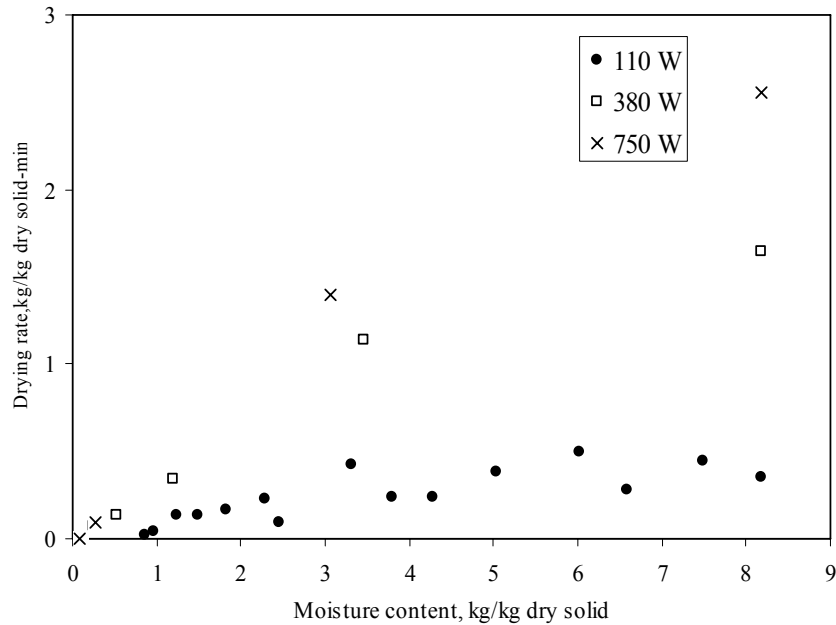


Figure 6. Drying rate for microwave-vacuum drying of papaya at 450 mmHg system pressure

## 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 below 10% 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.

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