Application of Microwave Technology for Home Industry

Nor Hisham Haji Khamis, Shakirah Ramli, Tan Chew Ean, and Wan Zaimatul Azrul Wan Bakar

Radar Laboratory
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
81310 UTM Skudai

Abstract - Conventional methods have been used to dehydrated fruits and vegetables for the purpose of preservation and to extend the storage life of flowers, fruits and vegetables. However, these conventional methods have low drying efficiency, long drying time and the quality of the dried flowers, fruits and vegetable are rather poor.

The application of microwave in flowers, fruits and vegetables dehydration is studied to verify the effectiveness of microwave dehydration, and to maintain the quality of dried flowers, fruits and vegetables as compared to conventional methods. Microwave dehydration provides volumetric heating effect where heat is generated within the product itself and heats the entire volume at a faster rate. The parameters to be controlled during microwave dehydration had been identified to give better quality output, higher drying efficiency and shorter drying time. A simple microwave dehydration system had been build to understand better the architecture of microwave dehydration system.

Microwave dehydration had decreased the dehydration time of flowers, fruits and vegetables with higher energy and drying efficiency. In this study, the microwave dehydration process was able to dry flowers that have better color and texture. It was also able to dry the moisture content of carrot that is 4 to 8 times faster than hot air dehydration. This study has shown the potential of the application of microwave technology for the benefit of home industry.

1. Introduction

Microwave drying is widely used, ranging from fundamental scientific research to development and implementation of applications in industry [1]. The research activities concentrated on developing non-traditional manufacturing processes for industrial applications that demanded competitive productivity rates and quality standards. Meanwhile, factories have applied microwave technology in the processing of food in order to improve productivity and the quality of food. Examples of the application of microwave technology in food processing are heating and sterilizing of fast food, mass cooked-meals, cake and pastries; drying of meat floss, seafood, cereals and grains, instant food, rock sugar, bread crumbs, animal feeds, prawn/fish crackers, tobaccos and tea leaves, herbs and spices, snack and biscuits; sterilization and pasteurization of flour, dairy products, soy, chilly, tomato and various types of sauces, pre-cooked poultry and seafood.

Microwave food drying has advantages when compared to conventional food drying method, such as high drying velocity, high quality food, energy saving and can also be environmentally friendly.

For home industry, the advantage of microwave dehydration is that dehydrated food can be stored for a longer period of time, easier to pack or transported to another destination since the weight of dried fruits and vegetables is relatively light. This will cut down the packaging and transportation cost.

2. Microwave Heating Mechanism

Microwave energy is more easily directed, controlled, and concentrated than low frequency EM waves. The main mechanism for microwave heating is bipolar polarizations where molecules already permanently polarized due to their chemical bonds are realigned in the fluctuating field. This realignment occurs millions of times each second, causing a heating effect within the whole volume of the material [2]. Microwaves radiation penetrates deep into the object heated. Within the heated material, the electromagnetic energy is transformed into heat by means of several complex conversion mechanisms such as dipole rotation and stretching of large molecules, interface polarization and ionic conduction. Ionic polarization occurs when ions in a solution move in response to an electric field. Heat is thus generated in a distributed manner inside of the material to be heated, allowing for a more uniform and faster heating. The surface, which is in contact with the cold surrounding air, remains cooler. Little heat is lost to the environment. The surface itself may still be heated, if desired, by insulating it from the surrounding air. As a result, microwaves heat the whole volume of the object being heated.

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3. Experimental Set-up

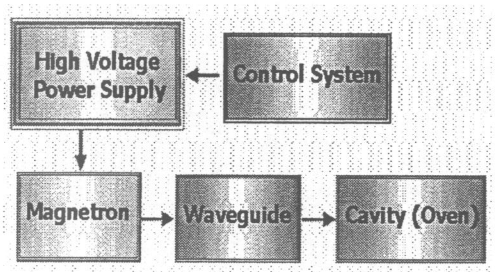

Figure 1: Block Diagram of Microwave Dehydration System.

Figure 1 shows the experimental set-up for this study. Most components were sourced from a conventional microwave oven. The control system consists of a microcontroller to control the operations of the dehydration system. The high voltage power supply is interfaced with the magnetron input terminals to provide power for filaments and oscillation of the magnetron. System control circuits and magnetron fault protection are typically incorporated into this unit. The magnetron is a low-cost, efficient and cross-field microwave oscillator. It generates the microwave energy when provided with high voltage at its terminals. The waveguide controls the propagation of microwave so that the wave is forced to follow a path that is defined by the physical structure of the guide. The material that is to be dehydrated is placed inside the cavity.

4. Experimental Parameters

Experimental parameters are the parameters that need to be monitored and controlled during the dehydration process.

The first parameter that needs to be monitored and controlled is the power level. Power level determines how much microwave energy is needed to dry a typical kind of fruits or vegetables with a predetermined size from a moisture content level to another moisture content level in a period of time.

The second important parameter in this experiment is the moisture content. Moisture content at wet basis is the percentage of the initial weight of water in a material to the initial weight of the material. And, initial moisture content at dry basis is the percentage of the initial weight of water to the weight of dry solid material. The formulas to calculate moisture contents are given below.

Moisture content (wet basis) =

$$\frac{\text{mass of moisture}}{\text{Initial mass of the product}}$$

Moisture content (dry basis) =

$$\frac{\text{mass of moisture}}{\text{(mass of wet product - mass of moisture)}}$$

OR $\quad$ mass of dry matter

The target moisture content to be achieved is 20% at wet basis where this moisture content may slow down the growth of spoilage microorganism[3, 4].

5. Experimental Results

The materials chosen in this study are flowers and carrot. These materials are easily available at reasonably inexpensive price.

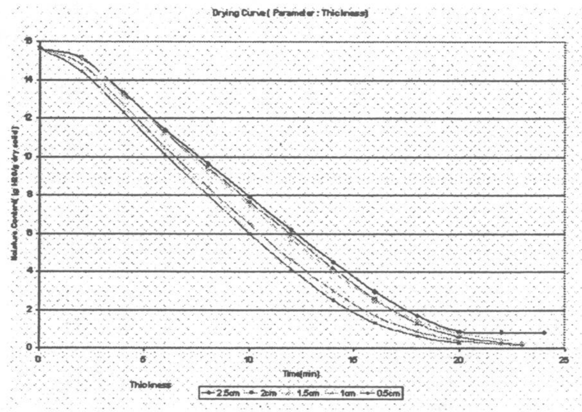

Figure 2: Drying curves of carrot at different thickness.

The samples with different thickness (which are 0.5cm, 1cm, 1.5cm, 2cm and 2.5cm) are dehydrating use high power level (800 watt). The diameters of samples are in the range of 3 cm to 3.5 cm. And the amount of every batch is fixed at 200g. From the drying rate curves and drying curve, the different in thickness do not show slightly different in the efficiency. From the result of experiment, 0.5cm thickness has efficiency a bit better than others. So, thickness at 0.5 cm is chosen as the optimum thickness.

Figure 3 shows the drying curves of carrot at different diameters. The samples with different diameter (which are 1cm, 3cm, 3.5cm, 4cm and not uniform shape) are dehydrating use high power level (800 watt). The thickness of samples is fixed at 0.5cm. And the amount of every batch is fixed at 200g. From the drying curves, the different in diameter do show differences in the efficiency and drying time. From the result of experiment, the efficiency is increased when the diameter of samples is increased. Bigger diameter offers higher efficiency and shorter drying time.

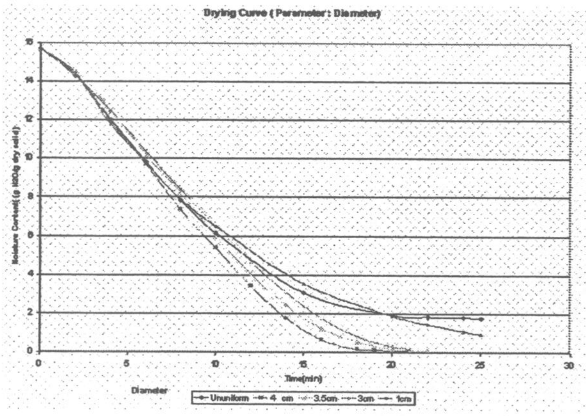

Figure 3: Drying curves of carrot at different diameters.

The diameter is limited by the original size of the carrot. Although 4 cm diameter offers higher efficiency but the amount of carrot with diameter 4cm is limited. So, the optimum diameter range is 3 cm to 4 cm, which offer acceptable efficiency, drying time, and majority amount of the carrot has this diameter.

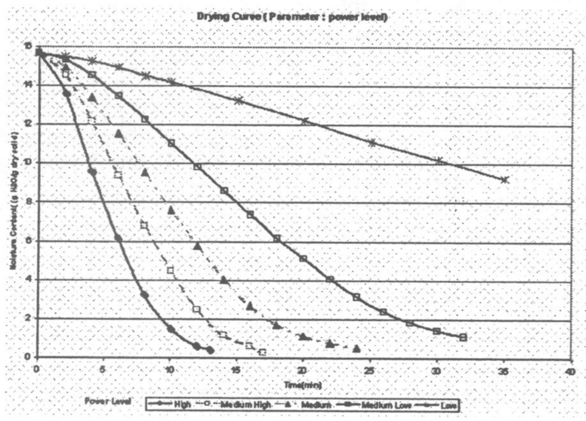

Figure 4: Drying curves for different power levels.

Figure 4 shows the drying curves for different power levels. The carrot samples were dehydrated using 5 different power levels, which are high (800 watt), medium high (560 watt), medium (400 watt), medium low (240 watt) and low (80 watt). The power level, which provides highest efficiency, will be chosen as the optimum power level.

The drying rate curves and drying curves plotted using data collected from experiments shows that higher power level may provide better drying efficiency and faster drying rate. But through observation during the experiment, the quality of sample for medium high power level is better than high power level when they achieved moisture content around 30% at wet basis. The drying time is very long for low power level. The drying time is almost 8 to 10 times longer than medium high power level to achieve moisture content 0.6 (g H_2O/g dry solid) at dry basis(db). Thus, low power level will not be chosen as optimum power level. Medium high power level been chosen as optimum power level since it provide higher drying efficiency and drying time compare to other lower power level and faster better quality of sample compare to high power level. Observations during the experiments showed that the sample would start to be burnt (or carbonized) when the moisture content is around 3 (g H_2O/g dry solid) for all power level except for low power level. This may be caused by the unevenly distributed of microwave energy. From the observation during experiment, the part of sample, which “faces” to the plate, will start to be burnt first. This may be to the fact that most of the moisture is concentrated at the lower part of sample and the microwave energy is focused at the high moisture content part of the samples.

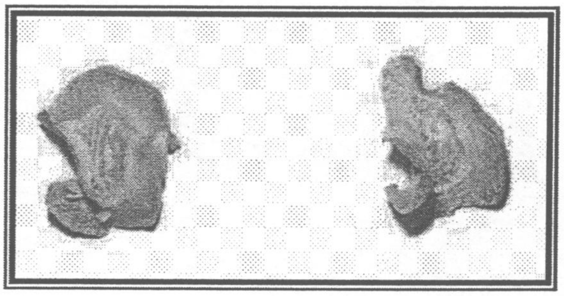

Figure 5: Carrots Dehydrated Using Hot Air.

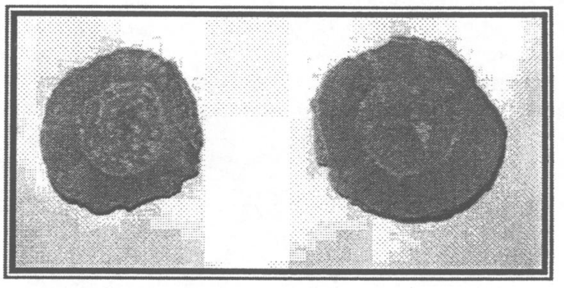

Figure 6: Carrots Dehydrated Using Microwave.

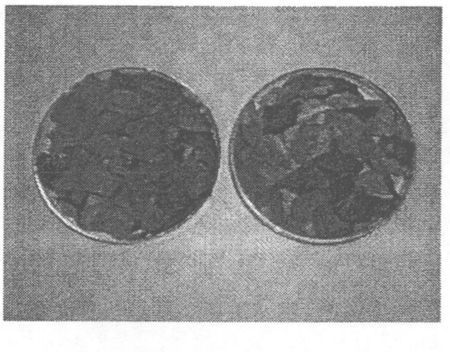

Figure 7: Comparison of rose petals.

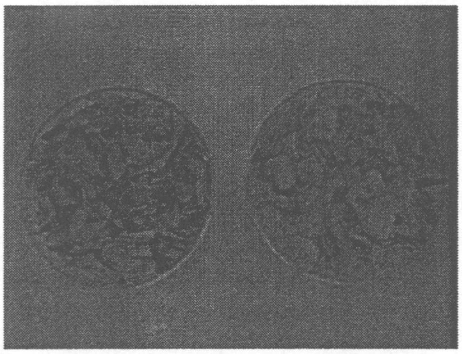

Figure 8: Comparison of orchids.

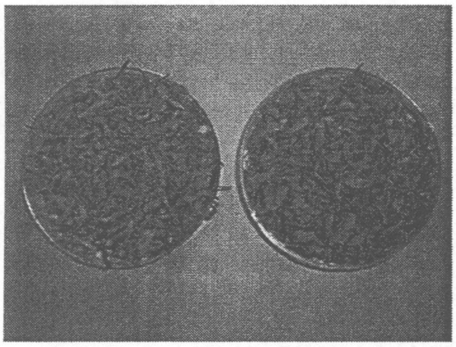

Figure 9: Comparison of chrysanthemums.

Figure 5 shows the result of carrot dehydration using hot air while Figure 6 shows the result of dehydration using microwave energy. As can be seen from the figures, carrot dehydrated using microwave have better texture and color. Figures 7, 8, and 9 show the differences in the result of flower dehydration using conventional oven and microwave oven. Again, the differences in texture and color are quite apparent.

6. Conclusion

This study has shown the potential of using microwave technology for home industry. The benefits of using microwave technology are very good. Microwave dehydration had decreased the dehydration time of fruits and vegetables with higher energy and drying efficiency. Microwave dehydration is also able to maintain good quality of the carrot slices such as smell, color, texture, shapes and size. Thus, microwave dehydration is an excellent method to dehydrate fruits and vegetables so that the storage life extended. Microwave dehydration enables the production of dried fruits and vegetables with good quality and the dehydration process is rapid and mild.

References

[1] A. C. Metaxas & R. J. Meredith (1988). "Industrial Microwave Heating" 2nd. Ed. England: Peter Peregrinus Ltd.

[2] www.petrieltd.com

[3] Tein M. Lin, Timothy D., and Christine H. (1998). "Characterization of vacuum microwave, air and freeze dried carrots slices." *Journal of Food Engineering*. 31(2):111-117.

[4] S. Litvin, C. H. Mannheim and J. Miltz. (1998). "Dehydration of Carrots by a Combination of Freeze Drying, Microwave Heating and Air or Vacuum Drying." *Journal of Food Engineering* 36:103-111.