Macadamia Drying by Microwave Dryer combined with Hot Air

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บทคัดย่อ

วัตถุประสงค์ของงานวิจัยนี้เพื่อศึกษาจลนพลศาสตร์ของการอบแห้งแมคคาเดเมียด้วยไมโครเวฟร่วมกับลมร้อน ในการทดลองจะใช้แมคคาเดเมียทั้งกะลา ซึ่งมีความชื้นเริ่มต้นอยู่ในช่วงร้อยละ16-19 มาตรฐานแห้ง อบแห้งจนเหลือความชื้นสุดท้ายต่ำกว่าร้อยละ 4 มาตรฐานแห้ง การอบแห้งดำเนินการที่สภาวะแตกต่างกัน เพื่อศึกษาอิทธิพลของลมร้อน (40 50 และ 60 องศาเซลเซียส) และกำลังไมโครเวฟ (300 450 และ 600 วัตต์) ต่อลักษณะปรากฏของแมคคาเดเมียและความสิ้นเปลืองพลังงาน ผลการทดลองแสดงให้เห็นว่า การเพิ่มขึ้นของกำลังไมโครเวฟสามารถลดความชื้นของแมคคาเดเมียได้มากกว่าการเพิ่มขึ้นของอุณหภูมิการอบแห้ง หลังการอบแห้งและกะเทาะเปลือกพบว่าที่กำลังไมโครเวฟ 300 วัตต์ ในทุกๆ อุณหภูมิ เนื้อในของแมคคาเดเมียมีสีสม่ำเสมอกันมากที่สุด เมื่อพิจารณาในแง่พลังงาน พบว่า การทดลองที่อุณหภูมิ 40 องศาเซลเซียส กำลังไมโครเวฟที่ 450 วัตต์ ใช้พลังงานต่ำสุด 0.17 กิโลวัตต์ชั่วโมง

คำสำคัญ: แมคคาเดเมีย ไมโครเวฟ การอบแห้ง

Abstract

The purpose of this research was to study the kinetics of macadamia drying by a microwave dryer combined with hot air. Macadamia nuts with shells were used in the experiment. The initial moisture content of the nut with shells in the range of 16-19% dry basis was dried until the final moisture content was less than 4% dry basis. Drying was done under different conditions to study the influences of hot air temperature (40, 50 and 60 degrees Celsius) and microwave power (300, 450 and 600 watts) on the appearance of the macadamias and energy consumption. The result indicated that the increase in microwave power could reduce moisture content of the macadamias more than the increase in the drying temperature. After drying and shelling, the microwave power of 300 watts at every temperature resulted in the most uniform color of the kernels. Considered in terms of energy consumption, the drying at 40 degrees Celsius combined with microwave power of 600 watts had the lowest energy consumption at 0.15 kW-h.

Keywords: Macadamia: Microwave: Drying

Introduction

Macadamia nuts (*Macadamia integrifolia*) are a healthy food which has the potential to play an important role in human diet. They contain unsaturated fatty acid which can help to decrease cholesterol and triglyceride levels [1]. Macadamia nuts with high moisture content need to be dried to minimize quality deterioration. The shell of the

macadamia nut is hard and brittle, reasonably isotropic, and uniform. To crack the shell and maintain the quality, macadamia nuts need to be dried until the final moisture content is reduced to the appropriate level of 1.5% dry basis of kernel [2].

The macadamia nut drying process is very long if using natural air for drying [3]. However, a few drying techniques have been reported using artificial drying to reduce the moisture content, such as microwave drying and hybrid drying [2], [4] Energy consumption is another issue in the selection of the process for drying of agricultural products. The use of microwave energy for drying has been shown to use low energy consumption [4], [5]. This work studied the effects of microwave powers combined with drying temperatures on drying kinetics and energy consumption.

Materials and Methods

Raw material

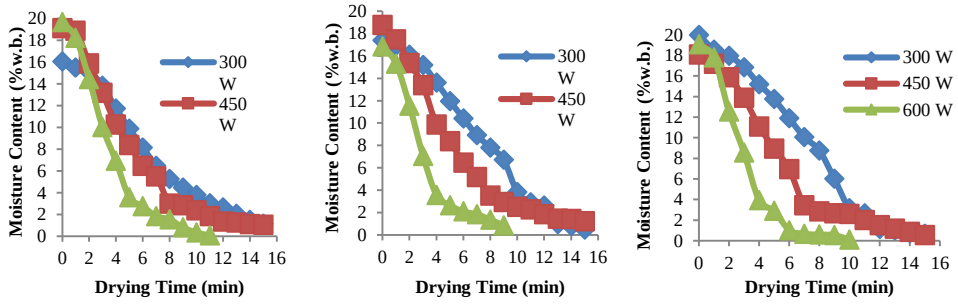
Macadamia nuts were purchased from a farmer in Loei province in the northeastern part of Thailand. The raw material used in this research was hulled with a moisture content of 16-19 % dry basis. The moisture content of macadamia nuts was determined by the vacuum oven drying method. Kernel nuts were ground into small pieces of about 7–8 g and put into an aluminum dish and placed in a vacuum oven (model EV018) at 100°C with 21 kPa for 7 hours.

Drying methods

The macadamias were dried by microwave-assisted hot air dying at different hot air temperatures of 40, 50 and 60 degrees Celsius and microwave powers of 300, 450 and 600 watts. The air velocity was fixed at 1.2 m/s. The sample was dried and its weight was recorded every minute until a constant weight was reached. After that, the drying curve was plotted between the moisture content and drying time. Samples with the moisture content lower than 4% dry basis was shelled and the kernels collected for the taking of a picture. The energy consumption of each condition was determined using an electric meter (Model number: DD28, China) with 15 Amp.

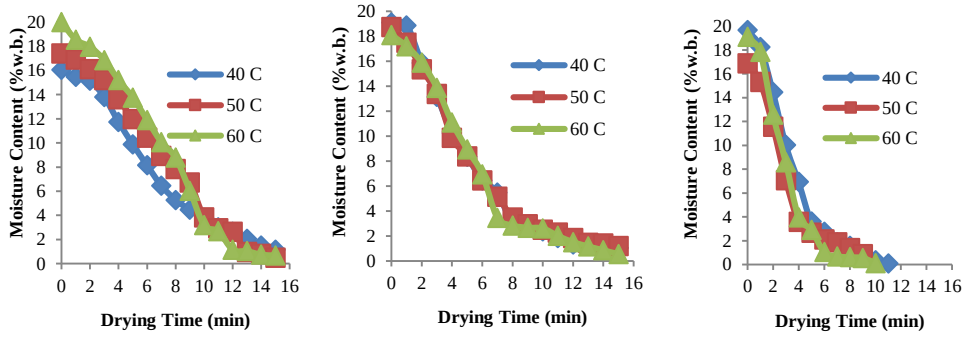
Results and Discussion

Macadamia nuts were dried by a combination of different microwave powers and drying temperatures. The drying kinetic was plotted between moisture content and drying time. The effects of microwave power at a given drying temperature are presented in Figure 1. The effects of drying temperature at a specific microwave power are shown in Figure 2.



a) 40°C b) 50°C c) 60°C

Figure 1 Moisture contents of macadamias during drying under different microwave powers



a) 300 W b) 450W c) 600 W

Figure 2 Moisture contents of macadamias during drying under different hot air temperatures

Table 1 Energy consumption of macadamias drying under different conditions

Drying temperature (°C)	Microwave power (Watts)	Drying time (min)	Energy consumption (kW-h)
40	300	11.00	0.22
	450	8.34	0.17
	600	5.15	0.15
50	300	10.31	0.52
	450	8.13	0.41
	600	4.51	0.27
60	300	10.07	0.70
	450	7.50	0.53
	600	4.21	0.34

Figure 3 Macadamias after drying with different hot air temperatures and microwave powers

Table 1: Energy consumption of macadamias drying until the final moisture content was down to about 4% dry basis. The result found that longer drying time resulted in the higher energy consumption. For a specific microwave power, the increase in drying temperature consumed more electrical energy than the increase in microwave power. From drying kinetics in Figures 1 and 2, the moisture reduction was more affected by the increase in microwave power than by drying temperature. Therefore, the increase in microwave power resulted in shorter drying time and less energy consumption than increase in drying temperature.

After drying, macadamia nuts in the shell were cracked and shelled to get the kernel and photographs were taken. The pictures of the kernel obtained from different drying conditions are

shown in Figure 3. By visual assessment, it can be seen that the increase in microwave power caused the dark brown color which is an undesirable characteristic. The microwave power of 300 watts at every temperature resulted in the most uniform color of kernels.

Conclusions

The result indicated that the increase in microwave power can reduce moisture content of macadamias more than the increase of drying temperature. Visually, kernels dried at 300 watts showed the least amount of browning. In term of energy consumption, the drying at 40 degrees Celsius combined with microwave power of 600 watts had the lowest energy consumption at 0.15 kW-h.

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