

Parchment Coffee Drying Using Microwave Combined with Hot Air

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Abstract. We studied the kinetics of parchment coffee dried by microwave combined with hot air and assessed the coffee quality. Coffee beans with initial moisture content of 55% wet basis were dried to a moisture content of 10% wet basis. Drying temperatures between 60°C and 80°C and microwave powers from 600 to 800 W were examined. Coffee quality was assessed by the electric conductivity test: increase in both temperature and microwave power led to increasing electric conductivity. Drying at 60°C with 600W microwave power had the lowest electric conductivity of 276 micro cement per centimeter per gram. Drying at 60°C combined with 800W microwave power showed the lowest energy consumption of 18.7 kW-hours for a 98 minute drying time. The highest energy consumption was 26.6 kilowatt-hours at 60°C and 600W microwave power for a 145 minute drying time. Thus, considering both energy consumption and quality, drying at 60°C combined with 800W microwave power is recommended.

Keywords:

parchment coffee, microwave-hot air combination drying, quality

1. Introduction

Coffea arabica (Arabica coffee) is more superior to the other coffee species due to its sensory properties [1]. It is mainly grown in the cooler highland areas of the northern part of Thailand and regularly processed through the wet method where red mature coffee cherries of consistent maturity are hand-picked and mechanically depulped to remove the exocarp and mesocarp. Subsequently, the thin mucilaginous layer surrounding the coffee seeds are removed via a fermentation process of approximately 24-48 hrs. Finally, the processed coffee beans are then mechanically dried with a stream of hot air at 65–85 °C or sun-dried to a moisture content of 11–12% wet basis for safe storage of parchment coffee before exporting, roasting and brewing [2],[3].

Drying is one of the most important steps in the processing of Arabica coffee. It has impact on the quality of coffee. Over-dried coffee will become brittle and produces too many broken beans during hulling which considered being defective beans. Coffee that is not dried sufficiently will be too moist and prone to rapid deterioration caused by the attack of fungi and bacteria [4]. In the terms of the effect of drying on the physicochemical properties, there were studies claiming about the negative effects of high temperature to the final cup quality of coffee [5]-[7].

Microwave radiation is the one of alternative drying methods implemented to overcome these disadvantages due to its high energy efficiency and uniform heat distribution in the material [8]-[10].

As mentioned above, we aim to study the effects of microwave powers combined with drying temperatures on drying kinetics and energy consumption of parchment coffee drying. Also, the electrical conductivity was implied to be as a quality indicator of coffee drying.

2. Materials and Methods

2.1 Parchment Coffee Samples

Wet parchment coffee from Arabica coffee cherries (*Coffea arabica* L. cv. Catimor) that planted in Chiang Rai province, the northern area of Thailand, were transported to Faculty of Engineering, Mahasarakham University by keeping in foam box with ice to prevent the mold growth. Then, samples were removed to keep in freezer at -19 °C.

Before conducting the experiment, coffee was rinsed with water to imitate as parchment coffee after soaking. The moisture content of coffee was determined by oven drying at 105°C for 24 hr. The initial moisture content was about 55% wet basis.

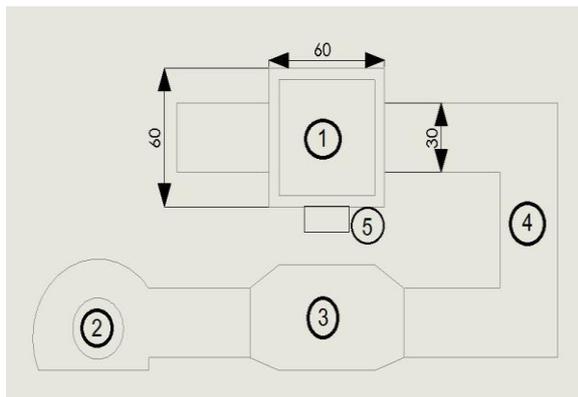
2.2 Microwave-hot Air Combination Drying

A microwave-hot air combination dryer was constructed at the Faculty of Engineering, Mahasarakham University, Thailand. The dryer is shown in Fig. 1.

Two domestic microwave ovens with a maximum power of 800 Watts were adapted by connecting it with a hot air drying system. A scheme of the experimental system is shown in Fig. 2.



Fig. 1: The microwave-hot air combination dryer used in the Experiment



- (1) Microwave oven (3) Heater 20 kW
- (2) Blower 1 hp. (4) Air duct
- (5) Control motor Gear box

Fig. 2: Drawing of microwave oven with hot air (cm)

2.3 Drying Conditions

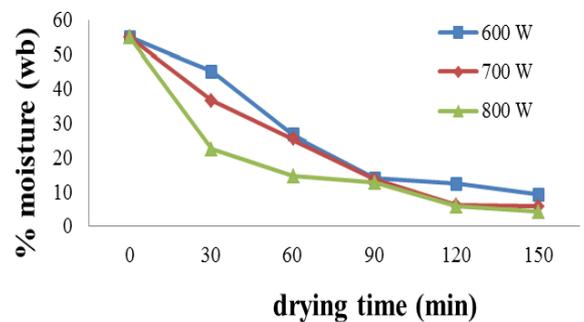
The drying conditions were drying temperatures of 60 and 80 °C combined with microwave powers of 600, 700 and 800 watts. The air velocity was fixed at 0.23 m/s. To study the drying kinetic, 100 g of wet parchment coffee was dried in batch at different times of 30, 60, 90, 120 and 150 minutes. Then, bean was determined the moisture content using oven method. The moisture content versus drying time was plotted to study the drying behavior. The energy consumption of each condition was determined using an electric meter (Model number: DD28, China) with 15 Amp.

2.4 Electrical Conductivity Measurement

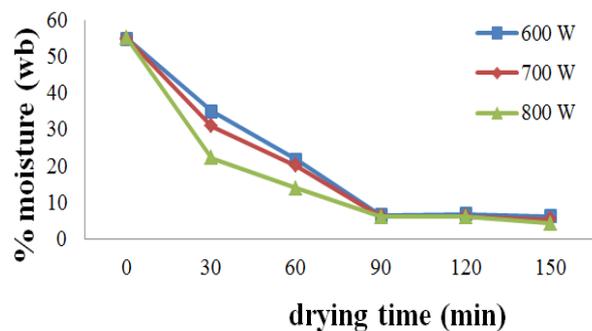
For the electrical conductivity measurement, sample was dried until the final closed to 10% wet basis before analyzing. The electrical conductivity of the raw beans was determined by adapting the methodology conducted by Coradi et al. [6]. Fifty beans with no visible defects from each sample were used. The beans were weighed and immersed in 75 mL of deionized water inside beaker with a capacity of 250 mL and placed in ambient temperature for 24 hours. The solution’s electric conductivity was measured by the Electro Conductivity Meter model Sension 5. From the results obtained, electric conductivity was calculated and the results were expressed in $\mu\text{Scm}^{-1}\text{g}^{-1}$ of sample.

3. Results and Discussion

Parchment coffee was drying by combination of different microwave powers and drying temperatures. The drying kinetic was plotted between moisture content and drying time. To compare the effect of microwave power at given drying temperature, graph is presented the drying behavior when the drying temperature is fixed as shown in Fig.3. Also, to compare the effect of drying temperature at specific microwave power, graph is shown the drying behavior at each microwave power as demonstrated in Fig.4

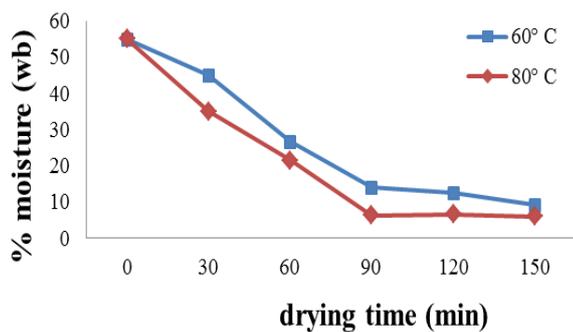


(a)

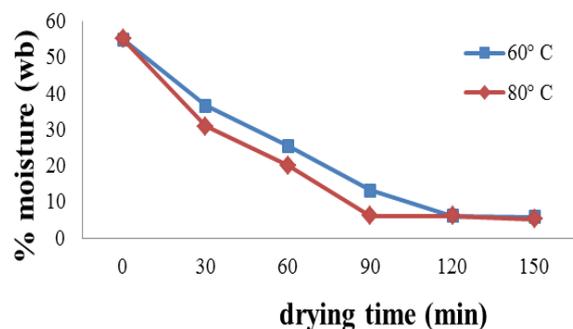


(b)

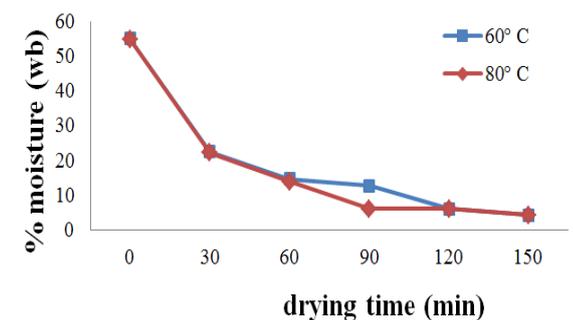
Fig. 3 : Moisture content of parchment coffee during drying under different microwave powers at specific drying temperatures at (a) 60 °C and (b) 80 °C



(a)



(b)



(c)

Fig. 4 : Moisture content of parchment coffee during drying under different drying temperatures drying at specific microwave power levels of (a) 600 watts, (b) 700 watts and (c) 800 watts

After drying, parchment coffee was taken the photograph. The pictures of samples from different drying conditions are shown in Fig 5. By visual assessment, it can be seen that the bean appearance were similar.

To access the quality of coffee, the electrical conductivity was used to be the criteria of coffee quality. The solution of parchment coffee soaking is shown in Fig. 6. The darker color is obviously increased when the drying temperature increased. This implied that the coffee bean is more undesirable. The coffee's deterioration and quality loss is directly related to the higher electrical conductivity. The values are presented in Table 1. It can be seen that the electrical conductivity is positively affected by drying temperature microwave power.

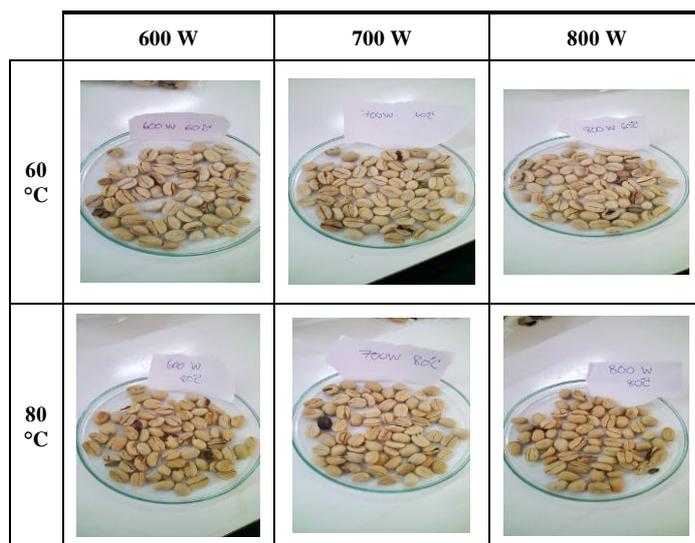


Fig. 5: Dried parchment coffee from different drying conditions

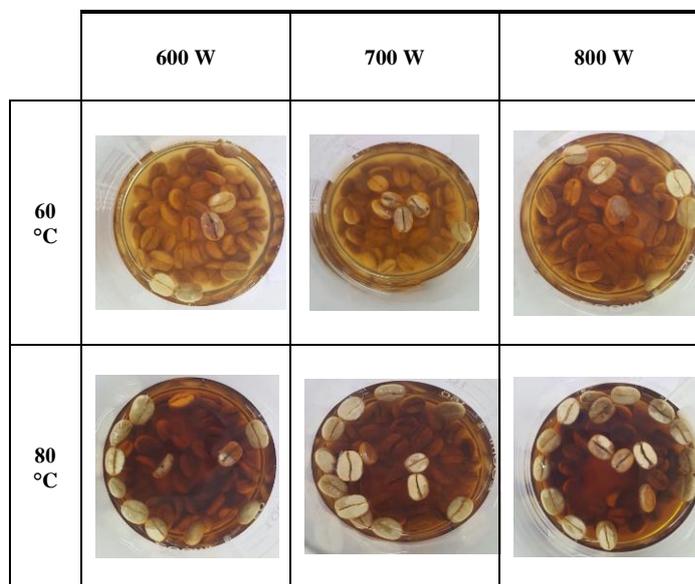


Fig. 6: Soaking's solution of coffee bean from different drying conditions

Table 1: Mean electric conductivity values ($\mu\text{Scm}^{-1}\text{g}^{-1}$) of each drying condition

Drying temp (°C)	Microwave Power (W)	Conductivity ($\mu\text{S/cm.g}$)
60	600	276.04 ± 7.16 ^c
	700	308.69 ± 6.24 ^d
	800	329.78 ± 8.92 ^c
80	600	346.71 ± 1.44 ^b
	700	373.14 ± 1.71 ^a
	800	338.73 ± 5.31 ^{bc}

Means with the same letter within a column are not significantly different ($P < 0.05$) by DMRT

Energy consumption of parchment coffee drying until the final moisture content was down to about 10% wet basis as shown in Table 2. The result found that the longer drying time resulted in the higher energy consumption. By considering at the specific microwave power, the increase in drying temperature consumed electrical energy more than increase in microwave power.

Table 2 : Drying time and energy consumption of each drying condition

Drying temp (°C)	Power (W)	Drying time (hr)	E_{Fan} (kW·h)	E_{Heater} (kW·h)	$E_{micro.}$ (kW·h)	E_{total} (kW·h)
60	600	2.41	1.44	21.93	3.21	26.58
	700	1.73	1.03	15.77	2.69	19.49
	800	1.63	0.97	14.83	2.89	18.69
80	600	1.45	0.86	22.01	1.93	24.80
	700	1.36	0.81	20.62	2.11	23.54
	800	1.25	0.74	18.96	2.22	21.92

4. Conclusions

Wet parchment coffee was dried under different conditions of drying temperature and microwave power. The experimental results can be drawn as the following:

- Microwave power and drying temperature had effect on moisture reduction.
- The increase in temperature and microwave power resulted in the increasing of electric conductivity of coffee.
- Energy consumption depended on the drying time, the shorter drying time the lower energy consumption.
- The drying at 60 °C combined with microwave power of 800 watts was recommended when considering in electrical conductivity and energy consumption.

However, this work focused only on drying characteristic and appearance of the dried beans. The quality in other aspects apart from electrical conductivity should be taken into consideration when optimization is needed for further study.

Acknowledgements

Financial support from the Faculty of Engineering, Mahasarakham University, Thailand, under the fiscal year 2014 incoming budget was gratefully acknowledged. Also, we wish to thank Mr. Dusit Ketwon and Mr. Witsarut Chuenchom for hard working on this research.

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Biography



Lamul Wiset received her Ph.D in Food Science and Technology from University of New South Wales, Sydney, Australia in year 2007. At present, she is a lecturer in biological engineering in Mahasarakham University, Thailand. Her research interests include drying technology in particular quality of agricultural products such as rice, herbs, fruit and nut.



Nattapol Poomsa-ad has been working as a lecturer in biological and mechanical engineering in Mahasarakham University, Thailand since year 2002. He graduated B.Eng, M.Eng and Ph.D. from King Mongkut's University of Technology Thonburi, Bangkok, Thailand. His Ph.D. degree was energy technology. His research interest includes thermal processing for food and agricultural product drying technology and energy conservation and management.