

Experimental Investigation of Drying Kinetics for Dragon Fruit Using Microwave Drying Method.

Sanket R. Choudhari¹, Dr. Pramod B. Lanjewar²

¹Research scholar, Department of Mechanical Engineering, St. Vincent Pallotti college of Engineering and Technology

²Professor, Department of Mechanical Engineering, St. Vincent Pallotti college of Engineering and Technology

Abstract

Drying is an extensively used method of preservation in that it minimizes post-harvest damage and extends storage life of horticultural products. Dragon fruit (*Hylocereus undatus*) is identified as one of the tropical fruits with high antioxidant, betalains, and vitamin C values that receive global attention; nonetheless, its water content (>85%) makes it a perishable commodity. In this research, drying kinetics for dragon fruit pieces were explored experimentally in a household-scaled microwave oven at three power levels (200, 400 and 600 W). Moisture ratio (MR), Drying rate (DR), were evaluated. Various mathematical and drying models were used to explain the kinetic data. It has been observed that instead of other drying technique microwave drying is the highly efficient technique to process in dragon fruit utilization.

Keywords: Dragon fruit, microwave drying, drying kinetics,

1. Introduction

Drying is the technique to preserve various agricultural products to enhance their storage life in that technique they use the principal of heat and mass transfer at a time to increase the performance of moisture removal rate that inhibits microbial growth and enzymatic activity there by maintaining product stability during storage [1]. Among various drying methods microwave drying has earned significant concentration to its high performance shorter processing time and potential to retain product standard [2]. Microwave drying operates by subjecting the product to electromagnetic waves, typically at a frequency of 2.45 GHz, which cause dipolar rotation and ionic conduction in water molecules. This results in the combination of internal heating and moisture evaporation from the surface of the product [3].

Expect traditional drying methods which lay on surface heat conduction microwave drying provides volumetric heating leading to faster drying rate and reduced thermal damage [4]. Dragon fruit was a

tropical and subtropical fruit valued for its special appearance different colour and rich nutritional value. It contains significant amounts of vitamins (Thiamine, riboflavin, niacin) minerals (calcium, Phosphorus, iron) and bioactive compounds such as polyphenols, and anthocyanin's which contribute to its antioxidant properties [5]. Whenever its moisture content is very high up to 85% makes its highly perishable and necessitating efficient drying methods to preserve and prevent their quality [6]. Various studies have explored the application of microwave drying of pitaya fruit. Altay [7] investigated the drying kinetics of pitaya fruit at variable microwave power levels (350-700 W) and reported that higher power levels significantly increased the effective moisture diffusivity (5.93×10^{-8} to 1.16×10^{-7} m²/s) and improved powder flow ability. Cetin.et.al [8] studied the effects of various pre-treatment such as ultrasound gum Arabic and sucrose before microwave drying at 300 W.

2. Materials and Methods



Figure 1: Microwave drying setup

Fig shows the diagram of microwave set up (stove kraft limited, Karnataka India) located in the laboratory of research center having power range up to 650W applied during the experiment (Duygu et.al, 2012). In this digital oven having a facility for select the temperature range from 0°C to 230°C and set up the time limit for maximum 60 min. The microwave oven having a maximum capacity of 9 liter having an inside dimension is 34.4 cm x 26.1 cm x 21.4 cm, with voltage supply 220-240 Volt (weikang Guo et.al, 2025). As compared to the traditional drying techniques vacuum drying or microwave drying is best way for improved the moisture removal rate and food quality also (Wang et al., 2013). In this process, water is removed from the pitaya fruit slices at ambient Temperature which reduces unfavorable chemical properties in the dry product. This technique helps to maintain quality parameter such as vitamins, flavors and colour in the dried products. The pitaya fruit pieces treated in ascorbic acid before drying the microwave power level varies from 100 watt to 600 watt at the vacuum level (2-10 K Pa).[2]

Sample preparation



Figure 2: Dragon fruit slices

For this experiment collect the sample of dragon fruit from the seloo market, wardha. The sample is sorted and separate out carefully fresh and healthy dragon food samples will be selected and peeling their outer cover and cut to uniform slices of wearing thicknesses 5 mm, 10 mm and 15 mm. These pieces will then be dried in a microwave oven under different temperature and time combination. During each trial observation will be recorded for changes in weight colour and moisture contain at fixed time interval. Based on the collected data important drying parameters such as drying efficiency, moisture reduction rate, and quality characteristics will be analyzed.

Research Methodology

In this experimental study a microwave oven with a rated power of 650 watt is used to investigate the drying behaviors of dragon fruit. During all experiments the microwave power is kept constant to maintain uniform heating conditions throughout the process. The first priority of this experiment is analyses effects of different drying temperature and slice thickness for moisture removal rate and drying efficiency of dragon fruit. [7] There are some distinct temperatures levels 50°C, 60°C, 70°C, 80°C, and 90°C are selected for the experiments. The reason for choosing this temperature is that the drying temperature must always be higher than the ambient temperature to ensure moisture evaporation. The cleaned fruits are peeled and sliced into three different thickness 5 mm, 10 mm, and 15 mm [4] using a stainless steel cutter to ensure uniformity. Each slice is weighted before drying with the help of digital weighing balance with an accuracy of ± 0.01 g. [11] the slices is placed on a glass tray inside the microwave cavity with adequate spacing to ensure uniform exposure to microwave radiation. After placing the samples in the microwave the drying process begins and weight measurements are recorded every 30 minutes to monitor the drying performance (Duygu et.al, 2012).

3. Mathematical Models for drying curves.

Thin layer mathematical modeling is important for studied the drying curves of dragon fruit. In this experiment microwave drying data is valuated by using different equations of mathematical models having shown in table (Gibson et.al. 2020) (Wang et.al 2007). [18]

Table 1 Mathematical models used by various researchers

Sr. No.	Model Name	Model	References
1	Lewis	$MR = \exp(-kt)$	Wang et.al 2007
2	Page	$MR = \exp(-ktn)$	Wang et.al 2007
3	Modified Page	$MR = \exp(-kt) n$	Wang et.al 2007
4	Henderson and Pabis	$MR = a \exp(-kt)$	Wang et.al 2007
5	Wang and singh	$MR = 1 + at + bt^2$	Wang et.al 2007

4. Result and conclusion

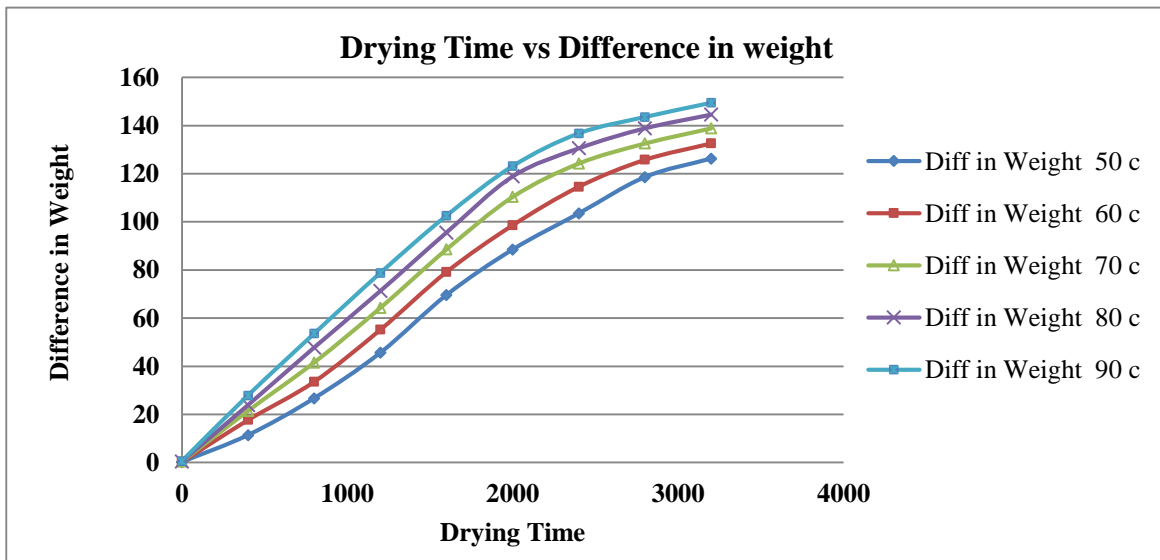


Figure 1: curve of weight difference vs time at different temperatures.

Fig shows that how to variation at occurs when we used different temperature for different drying time the graph is continues increase from initial value to equilibrium state. As increase the temperature variation in weight also occurs it clearly shows in figure.

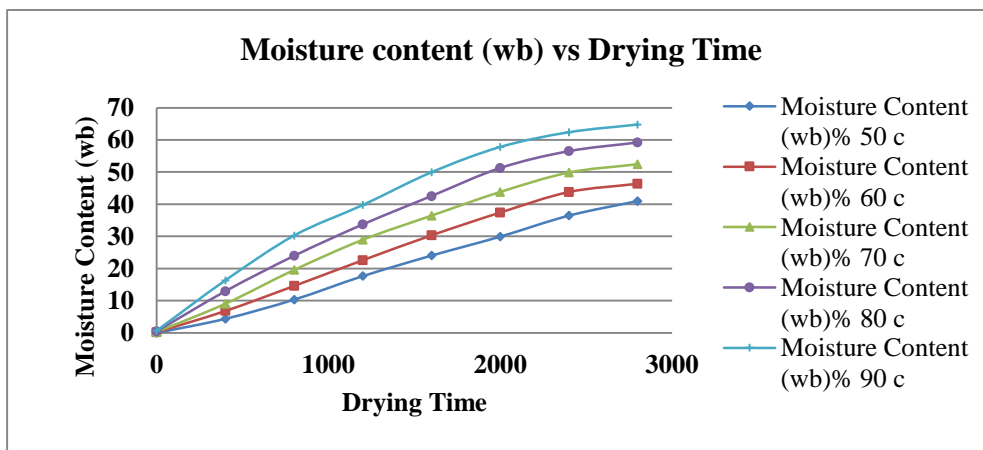


Figure 2: curve of moisture content (wb %) vs time at different temperature

The graph shows that moisture content is increases with the temperature higher drying temperature shows the higher moisture content value and its improve the removal of moisture content from fruit within the drying period.

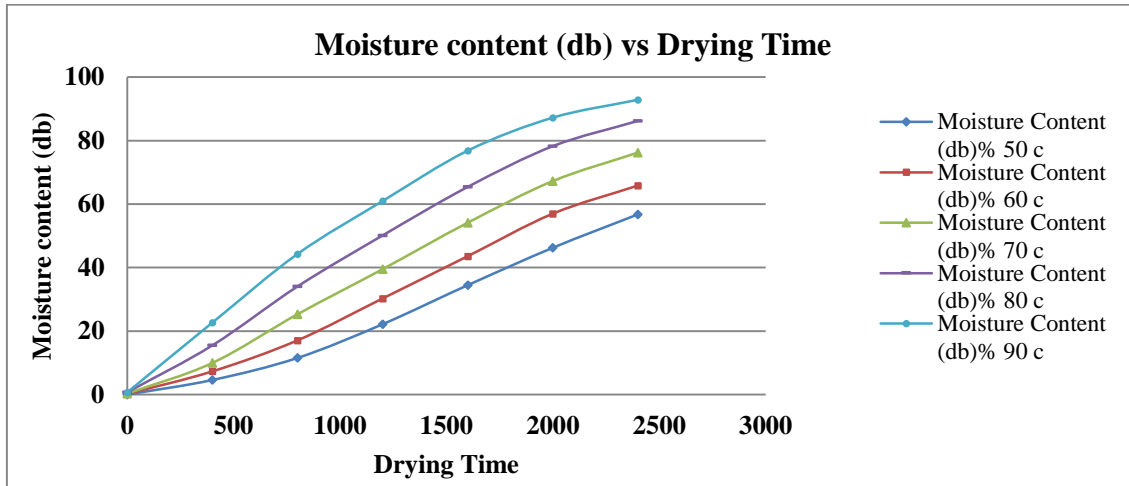


Figure 3: curve of moisture content (db %) vs time at different temperature

This graph shows that the moisture content in dry basis is increase with the increasing of drying temperature for a particular drying period and it give result in the removal of moisture rate .

5. Conclusion

The graph shows that the difference in weight increases frequently with respect to time for all temperatures, with higher temperature causing a faster and rapid change. At lower Temperatures 50°c, 60°c the rate of change is moderate, while at higher temperature 80°c, 90°c the difference in weight rises neatly and reaches equilibrium more rapidly. Beyond around 2800 seconds all curves tend to level off, indicating saturation or equilibrium overall the results confirm that the process is strongly temperature dependent with higher temperatures accelerating the rate of weight change.

References:

1. Chahbani, A., El Feki, A., Chachand, N., et al., Microwave drying effects on drying kinetics, bioactive compounds and colour of green peas, *Journal of Food Engineering*, Vol 238, 2018. <https://doi.org/10.1007/s00231-019-02633-x>
2. Ramírez, C., H. Núñez, R. Vallejos, K. Belmonte, S. Almonacid, and F. Marra. "Simultaneous application of refractance window and microwave drying: A novel hybrid technique for fruit dehydration to reducing drying time and improve bioactive compound retention." *Future Foods* 12 (2025): 100709. <https://doi.org/10.1016/j.fufo.2025.100709>
3. Noui, Yassine, Adel Lekbir, Hamza Moussa, Maamar Haffas, Abla Bousselma, Samir Hameurlaine, Hichem Tahraoui et al. "Effects of microwave drying on physicochemical characteristics, microstructure and antioxidant activities of date fruit powders: Y. Noui et al." *Journal of Food Measurement and Characterization* (2025): 1-18. <https://doi.org/10.1007/s11694-025-03336-0>
4. Dehghannya, Jalal, and Mahdi Habibi-Ghods. "Microwave Drying of Food Materials: Principles, Hybrid Techniques, Modeling Approaches, and Emerging Innovations." *Comprehensive Reviews in Food Science and Food Safety* 24, no. 6 (2025): e70312. <https://doi.org/10.1111/1541-4337.70312>
5. Layeghinia, Narges, Safoora Karimi, Habib Abbasi, and Khadije Silavi. "Effect of osmotic dehydration on qualitative and nutritional characteristics and kinetics of microwave drying of Iranian Quince slices." *Journal of Agriculture and Food Research* 20 (2025): 101749. <https://doi.org/10.1016/j.icheatmasstransfer.2025.109664>
6. Zeng, Chenlu, Rui Li, Yaxuan Liao, Hao Dong, Yuxing Liu, Yun Jing, Lingling Li, Shaobo Cheng, and Guogang Chen. "Effect of vacuum microwave drying pretreatment on the production, characteristics, and quality of jujube powder." *Lwt* 222 (2025): 117674. <https://doi.org/10.1016/j.lwt.2025.117674>
7. Li, Qianxin, Juan Chai, Shenghui Deng, Jucai Xu, Yanxian Feng, Ruili Yang, and Wu Li. "The Comparison of the Profile of Phenolic Compounds in Noni (*Morinda citrifolia* L.) Fruit by Different Drying Methods." *Foods* 14, no. 8 (2025): 1398. <https://doi.org/10.3390/foods14081398>
8. Arkain, Begüm, and Ilknur Alibas. "Effect of different drying methods on bioactive potential and nutrients of medlar fruit." *Scientific Reports* 15, no. 1 (2025): 10202. <https://doi.org/10.1038/s41598-025-86955-3>
9. Xing, Yage, Tingting Zhang, Tianyi Yue, Rumeng Yi, Qinglian Xu, and Li He. "Effect of vacuum microwave drying pretreatment on the quality characteristics and textural structure of new paocai raw materials." *Sustainable Food Technology* (2025).
10. Pashazadeh, Hojjat, Ali Ali Redha, Joel B. Johnson, Ilkay Koca, and Mustafa Fatih Ertugay. "Microwave drying of black rosehip (*Rosa pimpinellifolia* L.) fruit: Optimization for enhanced anthocyanin content and analysis of physicochemical properties and bioaccessibility." *Journal of Food Composition and Analysis* 132 (2024): 106316. <https://doi.org/10.1016/j.jfca.2024.106316>
11. Hou, Wenyi, Zhenhua Duan, Yi Yi, and Xiaoxian Tang. "Differences in monophenolic content and composition of persimmon fruit slices from different regions under fresh and microwave drying." *Food Bioscience* 59 (2024): 103853.

12. <https://doi.org/10.1016/j.fbio.2024.103853>
13. Zahoor, Insha, Tanveer Ahmad Mir, Wani Suhana Ayoub, Salma Farooq, and Tariq Ahmad Ganaie. "Recent applications of microwave technology as novel drying of food–
14. review." *Food and Humanity* 1 (2023): 92-103.
15. <https://doi.org/10.1016/j.foohum.2023.05.001>
16. Abbasi, Habib, Narges Layeghinia, Solayman Mohammadi, and Safoora Karimi. "Effect of fruit thickness on microwave drying characteristics of *Myrtus communis* L." *Iran. J. Chem. Chem. Eng. Research Article* Vol 42, no. 1 (2023).
17. Zhu, Rui, Juan Shen, Chung Lim Law, Xiaoxuan Ma, Dandan Li, Yongbin Han, Hossein Kiani, Sivakumar Manickam, and Yang Tao. "Combined calcium pretreatment and ultrasonic/microwave drying to dehydrate black chokeberry: Novel mass transfer modeling and metabolic pathways of polyphenols." *Innovative Food Science & Emerging Technologies* 83 (2023): 103215. <https://doi.org/10.1016/j.ifset.2022.103215>
18. Chatzilia, Theodora, Kyriakos Kaderides, and Athanasia M. Goula. "Drying of peaches by a combination of convective and microwave methods." *Journal of Food Process Engineering* 46, no. 4 (2023): e14296. <https://doi.org/10.1111/jfpe.14296>
19. Borah, Mriganka Shekhar, GVS Bhagya Raj, Ajita Tiwari, and Kshirod Kumar Dash. "Effect of intermittent microwave convective drying on quality characteristics of persimmon fruit." *Journal of Agriculture and Food Research* 14 (2023): 100816.
20. <https://doi.org/10.1016/j.jafr.2023.100816>
21. Soproni, Vasile Darie, Livia Bandici, Alin Cristian Teusdea, Francisc Ioan Hathazi, Mircea Nicolae Arion, Carmen Otilia Molnar, Teodor Leuca, Claudia Andrada Dalea, and Simona Ioana Vicas. "Phenolic content, antioxidant capacity, and browning impact of apple slices during microwave drying: A chemo metric approach." *Processes* 11, no. 6 (2023): 1601. <https://doi.org/10.3390/pr11061>
22. Wang, Zhengfu, Junhong Sun, Fang Chen, Xiaojun Liao, and Xiaosong Hu. "Mathematical modelling on thin layer microwave drying of apple pomace with and without hot air pre-drying." *Journal of Food Engineering* 80, no. 2 (2007): 536-544. <https://doi.org/10.1016/j.jfoodeng.2006>.