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Investigating the Impact of Microwave Drying on Papaya Slice Quality and Drying Attributes

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***Abstract:** Impact of microwave power and thickness of papaya slices were studied on the product quality and drying attributes of dehydrated papaya slices. Power (20, 40, 60 and 80W), thickness (3, 6 and 9mm), Moisture content, Vitamin'C' and Iron content were determined and found i.e.M.c 24.23 to 13.25% w.b., Vitamin 'C' 45.55 – 45.38 mg/100g, Iron content 4 - 3.98 mg/100g. The quality and sensory attributes were determined, and it was found that the sample with the thickness of 3mm with 60W power was found highest score in overall acceptability with minimum loss of vitamin C and iron content. Drying rate, Rehydration Ratio, Ash Content were determined and found i.e., Drying Rate 0.0002 – 0.00025 g/s, Rehydration Ratio 1.85 – 1.08, Ash Content 1.80 – 1.02 %. In color parameters the product achieved dark color [L-22.48]at higher microwave power before acceptable dehydration. Where, as the sample dehydrated at slice thickness 3mm and microwave power 60 W scored acceptable color and sensory score as well as L (39.46), a (8.45) &b (15.23. The samples processed at 60 W microwaves drying had higher porosity than fresh samples analyzed by using SEM.Based on the criteria for thin-layer drying kinetics, the results reveal that, in comparison to the Henderson and Pabis, Lewis and Page model, the Singh and Wang model achieved the best values for the coefficient of determination (R2), chi-square (χ2), and reduced root-mean-square error approximation (0.01341).*

***Keywords:** Microwave Drying, Slices thickness, Power.*

I. INTRODUCTION

India contributed 43% of the global papaya supply in 2020. Global fruit output is predicted to reach 6 million tons per year. With an annual output of over 3 million tons, India is the global leader in papaya production. Reports indicate that fruit loss ranges from forty percent to one hundred percent of total annual yield, even though there is a lot of land dedicated to papaya. Inadequate product penetration of microwave radiation, uneven heating, and potential textural damage are some of the main problems with microwave drying on its own. To get around these problems, you can mix different drying methods. Inadequate product penetration of microwave radiation, uneven heating, and potential textural damage are some of the main problems with microwave drying on its own. To get around these problems, you can mix different drying methods.

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Combination spouted bed drying, for instance, can greatly reduce the uneven heating of single microwave drying—specifically, for particle materials that can be spouted (Feng and Tang, 1998, [2]). The degree to which the microwave field penetrates the items is another important disadvantage. While 915 MHz microwaves do a better job of penetrating than 2450 MHz, they still can't compare to the 10-300 MHz radio frequency heating that's used for large-scale drying applications (Wang et al., 2003, [10] [13]). Pastry, sweets, ice cream, frozen desserts, yogurt, and a host of other culinary compositions sometimes include dried fruits. One of the most important ingredients in a wide variety of foods is dried papaya (Mandala et al., 2006, [4]). The polar water molecules are directly heated by the microwave's interaction with them. According to Schiffman (1992, [8][16]), the drying time is greatly reduced while using a microwave.

II. MATERIALS AND METHODS

A. Procurement of Raw Material

The materials such as Semi Ripe papaya, sugar, distilled water, tissues, and bowl were procured from the local market of Prayagraj.

B. Pre-Treatment Process for Papaya

After washing, the papaya was sliced into 3,6,9 mm pieces and kept in a sugar syrup with a pH of 70 and a fruit-to-sugar ratio of 2:1 at ambient temperature (23±1°c) for 18 hours in order to dehydrate it through osmosis. The papaya slices were rinsed with warm water to remove any clinging solution after osmotic dehydration, and then gently dried using absorbent tissue paper.

C. Microwave Drying

The pretreated papaya slices were dried in microwave oven. Drying was carried out at different at different temperature settings of microwave ranged atup to 80ºc. The papaya was dried, in order to ensure uniform drying conditions. Different physicochemical properties of sliced dried papayas were analysed for further treatments.

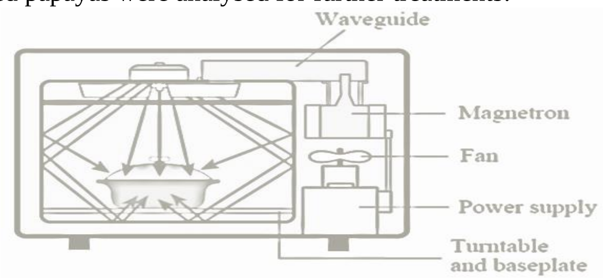

Fig. 1 Schematic Diagram of Microwave Oven

Microwaves function directly to dry material from the inside out, as opposed to applying energy just to the exterior of the product. This is the reason why this characteristic is observed. The moisture on the surface of the papaya is removed very rapidly using this method. When the papaya is placed inside the microwave, the moisture that is contained within the slices of papaya is expelled in the form of a vapor, like steam, which was exhausted from the microwave with the help of a fan fitted inside. Microwave drying preserve the fruits' qualities, including their aroma, color, and texture, the overalldrying process using microwave is a quick and efficeint.

Fig. 2 Microwave Dehydrated Papaya Slices.

a. Analysis of Moisture Content.

In order to determine the amount of moisture that is contained in papaya slices, a standardized process developed by AOAC (1980) was utilized. A set of equations was utilized in order to determine the amount of moisture that was present in the sample.

$$\text{Moisture content (wet basis)} = \frac{M1-M2}{M1} \times 100 \quad \text{... [Eq.1]}$$

$$\text{Rate of drying} = \frac{\text{Moisture content loss}}{\text{Time difference}} \quad \text{.... [Eq.2]}$$

The weight of the sample before it was dried in the oven is denoted by M1 (g), the weight of the sample after it was dried in the oven is denoted by M2 (g), and the moisture content of the sample is denoted by MMC (% w.b).

b. Evaluating the Moisture Content of Papaya Slices.

As the drying process progressed, the moisture content was determined using mass balance. In order to accomplish this, the weight of the sample was recorded at regular intervals throughout the drying process. A digital weighing balance was utilized in order to determine the weight of the samples. The following formula was used to calculate the moisture content:

$$\mathbf{M.C} = \frac{\textbf{wt of sample at desired time} - \textbf{wt of bone dry material}}{\textbf{wt of sample at any time}} \times \mathbf{100} \quad \text{...[Eq.3]}$$

$$\textbf{Wt. Of Bone Dry Material} = \frac{\textbf{Initial Wt Of Sample} \times \textbf{100} - \textbf{Initial Moisture Content}}{\textbf{100}} \quad \text{... [Eq.4]}$$

D. Physio-Chemical Evaluation

a. Identification of Ascorbic Acid in Papaya.

Mix a little amount of distilled water with 21 milligrams of sodium bicarbonate. To make 100 milliliters, dissolve 26 milligrams of 2,4-dichlorophenol indophenol in it. Add sliced papaya and fill the rest with purified water. The dye starts off as a blue compound, but by the time it reaches its final destination, it looks pink. Dye turns pink due to the presence of acidiccontent.

b. Iron Content

Iron content in dried papaya slices were determined by complexing it with xylenol orangeusing spectrophotometer.

c. Rehydration Ratio.

After dehydrating the sample, five grams were put to a small container with 120 milliliters of distilled water. The mixture was then brought to a boil and left covered for fifteen minutes under a watch glass. Covering a white dish with filter paper allowed the sample to absorb any excess water. The weight of the sample was recorded, and the rehydration ratio was calculated using theformula mentioned below:

Rehydration ratio = B/A

Where,

B is the weight of sample (g) after rehydration and

A is weight of sample (g) before rehydration.

d. Drying Rate.

$$\text{Drying Rate (g/s)} = \frac{\textbf{Moisture content lost}}{\textbf{Time Diffrence}} \quad \text{... [Eq.5]}$$

e. Ash Content.

The ash content will be estimate according to the method described by AOAC.

$$\textbf{\%Ash content} = \frac{\textbf{wt. after ashing}}{\textbf{wt. before ashing}} \times \mathbf{100} \quad \text{... [Eq.6]}$$

f. Color Determination.

Because of the uniform distribution of colors, the color of the fruit was determined through direct reading using the L*a*b* color space. In addition, a Hunter Lab colorimeter was used to measure the L*a*b* color values, which are yellowness/blueness, a* (redness/greenness), and L *(brightness/darkness), since the L*a*b* color space is extremely similar to how humans perceive color. Each measurement was averaged from a set of fresh fruits that were selected at random.

g. Scanning Electron Microscopy

Using a scanning electron microscope (SEM) (DSM 940, Zeiss and Oberkochen, Germany), the internal structures of dried papaya slices were characterized. After the samples were sliced using a razor blade, an aluminum stub was utilized to attach them using double-sided carbon tape. The customer was subsequently shown the samples. Then, while the samples were maintained in a vacuum, a coating of palladium and gold was applied to each cross-sectional sample (Udomkun et al., 2018, [11]). An accelerating voltage of 15 kV was used to acquire photographs of the coated samples using the scanning electron microscope (SEM).

III. DRYING MODELS

Many fruits and vegetables' drying kinetics have been quantified using simplified drying models. Based on the results provided in Table.1, the exponential thin layer drying models were used to fit the experimental drying data of guava using non-linear regression analysis. We used Microsoft Excel 2007 to conduct our regression analysis.

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Table. 1 Thin Layer Drying Models

Model name	Model
Page	$MR = \exp(-kt^N)$
Lewis	$MR = \exp(-kt)$
Henderson and Pabis	$MR = a \exp(-kt)$
Singh and Wang	$MR = 1 + at + bt^2$

The moisture ratio (MR) can be calculated as

$$MR = \frac{\text{Moisture Content at any Time (t)}}{\text{IntialMoistureContent}}$$

Evaluation of each model's goodness of fit was done using chi-square (χ2) and root mean square error (RMSE). In order to compare the experimental and projected moisture ratios, the following equations were used:

$$RMSE = [\frac{1}{N}\sum_{i=1}^{n}(MRexp,i - MRpredt,i)] \quad \text{...[Eq.7]}$$

$$X^2 = \frac{1}{N-n}\sum_{i=0}^{n}(MRexp,i - MRpredt,i)^2 \quad \text{...[Eq.8]}$$

IV. RESULTS AND DISCUSSION

A. Effect of Microwave Power and Thickness of Papayas on Drying Rate of Papaya Slices

After osmotic dehydration, about 45% of the moisture in fresh papaya is lost, leaving about 34.76% of moisture in the slices. Research was conducted to determine the impact of microwave drying on various drying parameters, including rehydration ratio, drying rate, and moisture content. The moisture content of the samples was reduced from 24.23% to 13.25% when they were microwave dried at power levels ranging from 20 to 80W. According to Pandaya et al. (2014, [6][17][18]), microwave energy is more effective in removing moisture than the conventional hot air drier. With an increase in microwave power from 20 to 80W, the drying rate of the samples went from 0.0002g/s to 0.00025g/s when drying in the microwave. As the microwave power was increased from 20 to 80W, the rehydration ratio decreased from 1.85 to 1.08 when the samples were dried in the microwave. Due to the fact that holes enable water to infiltrate the cells, a high rehydration ratio suggests that the dried material is of excellent quality [Okpala LC and Ekechi CA, 2014, [5]].

B. Microwave Drying and its Impact on Papaya Slice Quality

Researchers looked at how microwave drying affected several quality indicators, including color, sensory value, iron content, ash content, vitamin C content, and iron content.

a. Vitamin C Content

Papaya slices retain most of their vitamin C content when heated in a microwave. The vitamin C concentration decreased from 45.56 to 45.48 mg/100g when the drying power increased from 20 to 80W (P> 0.05). Vitamin C level in papaya samples is impacted by a wider range of microwave powers. Because they are dried at a lower temperature than when they are wet, dried fruits have a lower vitamin C concentration. A correlation exists between the amount of vitamin C and the degree of structural collapse. Collapse of structures can impact the rate of vitamin C degradation due to the increase in material density. (Forni et al., 1997, [3]).

b. Iron Content

The Microwave powers significantly affect retention of iron content in papaya slices. When the samples dried in MW for 20 to 80 W, iron content was reduced from 4.0 to 3.980 mg/100g,(P> 0.05)**(Ela et al., 2015,** [1][14][15]**).**

c. Ash Content

When the samples dried in microwave, ash contents were reduced from 1.80% to 1.02% as microwave power was increased from 20 to 80W, (P> 0.05) **(Ela et al., 2015).**

d. Color Determination

Food products, particularly fruits, are evaluated first and foremost by their color changes, which indicate how well consumers receive them. A significant difference in color parameters (L* - lightness, a*-redness, and b*-yellowness) among the osmotically dehydrated samples was observed in this study, as shown in Fig.9. The highest L* value papaya slices was 48.75[at 20 W &3 mm] and lowest highest L* value papaya slices was 22.58[at80W&3mm]. Microwave drying caused changes to the color parameters (L*, a*, and b*) as determined by the color analysis of papaya slices. Microwave drying reduced the luminosity (L* value) of papaya slices while increasing the value of a* with increasing sample thickness. The value of b* increased as thickness increased sample and decreased as power increased compare to fresh papaya. This is possibly due to the variation in slice thickness and microwave power which affects the water loss from the sample, Sharma et al., (2017, [7]).

C. Effect on Microstructure

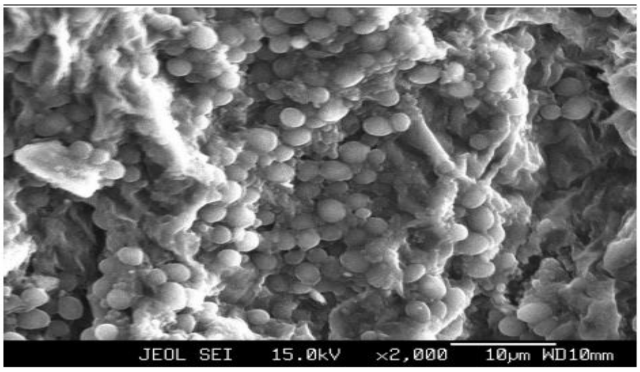

Fig. 3 SEM Images of Fresh Papaya Slice

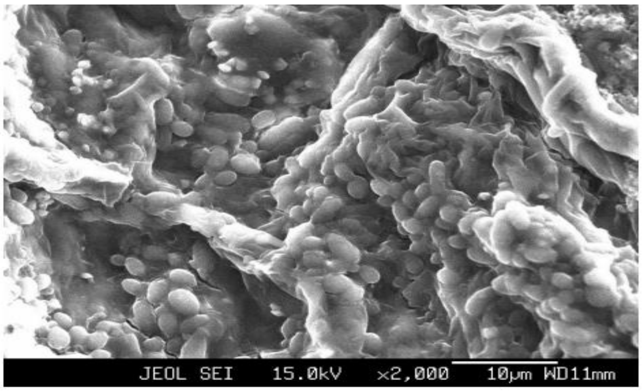

Fig. 4 SEM Images of Microwave 60 W Dried Papaya Slice

Fig.3 and Fig.4 shows the scanning electron microscopy images of fresh papaya and microwave 60 W dried papaya samples. According to the micrographs, the structure of both fresh papaya and slices dried in a microwave at 60 W looked remarkably similar, with the former having a very smooth structure and the latter having very few pores. In cases when a crispier product, like papaya chips, is sought, a smoother surface is not ideal because it could indicate a leatherier texture. Due to their greater porosity, samples dried in 60 W microwaves were deemed superior to their fresh counterparts. Pretreated papaya slices may have a higher overall phenolic preservation rate because microwave drying pretreatment creates a crusty surface layer and establishes a compact microstructure of the sample.

D. Goodness of the Fit of Different Papaya Slices Model.

Table 3.5 shows the results of fitting four separate moisture ratio equations to the experimental data in order to obtain drying curves. According to Ozdemir &Devres (1999), Sarsavadia et al. (1999), and Yaldiz (2001, [12]), the principal criteria for choosing the optimal equation to explain the differences in the drying curves of the dried samples were the chi-square (χ2), the coefficient of determination (R2), and root mean square error (RMSE).

Table. 2 Assessment of the Page Model's Predictive Power and Empirical Constant

TREATMENTS	K	N	R^Z	χ2	RMSE
T1	1.0914	0.604	0.9692	0.00463	0.39578
T2	1.1055	0.621	0.968	0.00653	0.38415
T3	1.1265	0.6677	0.958	0.00861	0.38281
T4	1.1084	6475	0.9639	0.01144	0.37118
T5	1.0871	0.5828	0.9711	0.01537	0.36358
T6	1.0717	0.5679	0.9725	0.01964	0.3524
T7	1.0584	0.553	0.9761	0.02462	0.34122
T8	1.0422	0.5425	0.9757	0.02979	0.33004
T9	1.0386	0.5174	0.9823	0.03837	0.32512
T10	1.0167	0.5156	0.9753	0.04358	0.3126
T11	1.0064	0.5017	0.979	0.05199	0.30634
T12	0.9945	0.483	0.9732	0.06417	0.30008

Table. 3 Evaluation of the Lewis Model with Respect to the Empirical Constant and Model Predictions

TREATMENTS	K	N	R^Z	χ2	RMSE
T1	1.0914	0.604	0.9692	0.00463	0.39578
T2	1.1055	0.621	0.968	0.00653	0.38415
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T8	1.0422	0.5425	0.9757	0.02979	0.33004
T9	1.0386	0.5174	0.9823	0.03837	0.32512
T10	1.0167	0.5156	0.9753	0.04358	0.3126
T11	1.0064	0.5017	0.979	0.05199	0.30634
T12	0.9945	0.483	0.9732	0.06417	0.30008

Table. 4 Assessment of the Henderson and Pabis Model's Predictive Power and Empirical Constant

TREATMENTS	K	R^Z	A	χ2	RMSE
T1	0.1857	0.9801	1.1114	0.01696	0.13416
T2	0.1792	0.9767	1.0986	0.02456	0.12521
T3	0.1714	0.9758	1.09867	0.03501	0.11627
T4	0.1665	0.974	1.09862	0.04512	0.1118
T5	0.1603	0.9721	1.0862	0.05865	0.10285
T6	0.156	0.9707	1.0838	0.07231	0.09838
T7	0.1514	0.9677	1.0698	0.08865	0.08944
T8	0.1484	0.9656	1.0592	0.10218	0.08945
T9	0.1408	0.9619	1.0436	0.13215	0.07602
T10	0.1411	0.9657	1.0446	0.14006	0.08049
T11	0.1371	0.9668	1.0173	0.16316	0.08032
T12	0.1327	0.9713	1.0081	0.19325	0.07965

Table. 5 The Singh and Wang model's Empirical Constant and its Predictive Power

TREATMENTS	A	B	R^Z	χ2	RMSE
T1	0.2245	0.0326	0.9849	0.99965	0.01341
T2	0.2312	0.0268	0.986	0.99975	0.02683
T3	0.2378	0.0215	0.9888	0.99987	0.0313
T4	0.2296	0.0191	0.988	0.99987	0.03577
T5	0.2278	0.0161	0.9879	0.99988	0.04024
T6	0.2188	0.0144	0.9877	0.99989	0.04472
T7	0.2152	0.0121	0.988	0.9999	0.04919
T8	0.2023	0.0117	0.9853	0.99987	0.05366
T9	0.2076	0.0077	0.9879	0.99991	0.05813
T10	0.1777	0.0106	0.9848	0.99989	0.05366
T11	0.1757	0.0087	0.9875	0.99992	0.05813
T12	0.1523	0.0055	0.9867	0.9992	0.04919

In comparison to the Henderson and Pabis model, the Lewis and Page model, the Singh and Wang model achieved the highest values for the coefficient of determination (R^2) at 0.9888, the chi-square (χ2) at 0.9992, and the lowest value for the reduced root mean square error (RMSE) at 0.01341. This was discovered through the analysis of the thin layer drying using kinetics criteria. **Salunkae et. al., (2019, [9]).**

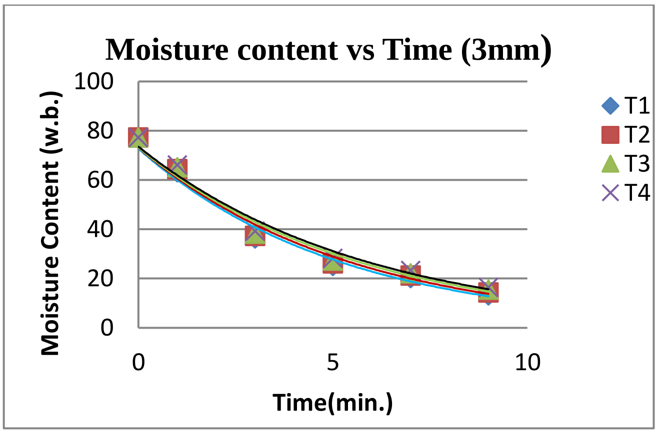

Fig. 5 Moisture Content of Pre-Treated Papaya Slices of 3mm thickness at 20, 40, 60 & 80W Powers

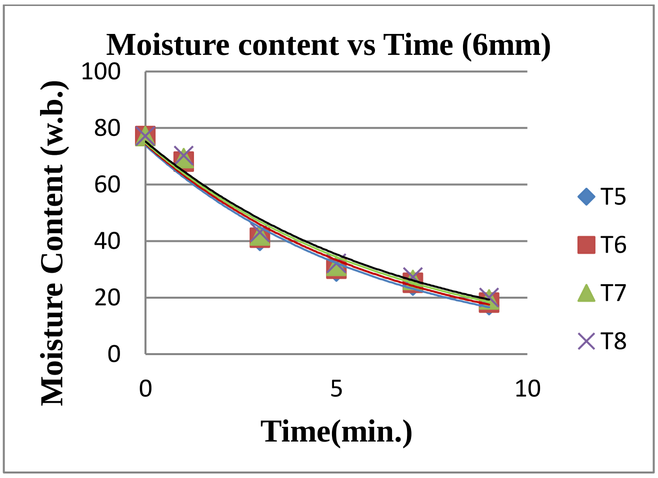

Fig. 6 Moisture Content of Pre-Treated Papaya Slices of 6mm thickness at 20, 40, 60 & 80W Powers

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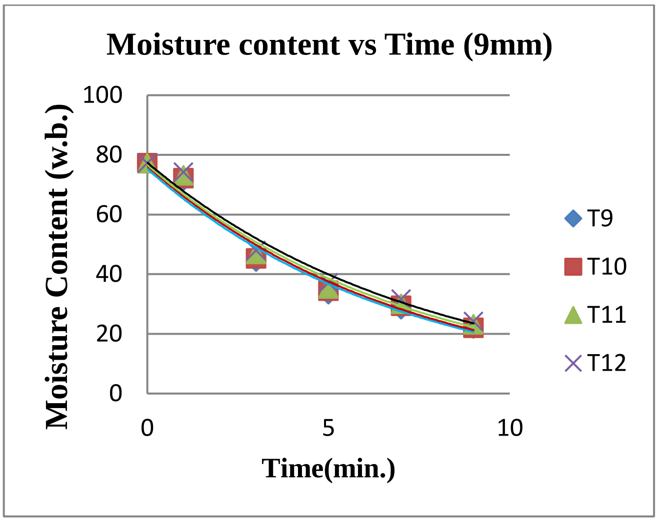

Fig. 7 Moisture Content of Pre-Treated Papaya Slices of 9mm thickness at 20, 40, 60 & 80W Powers

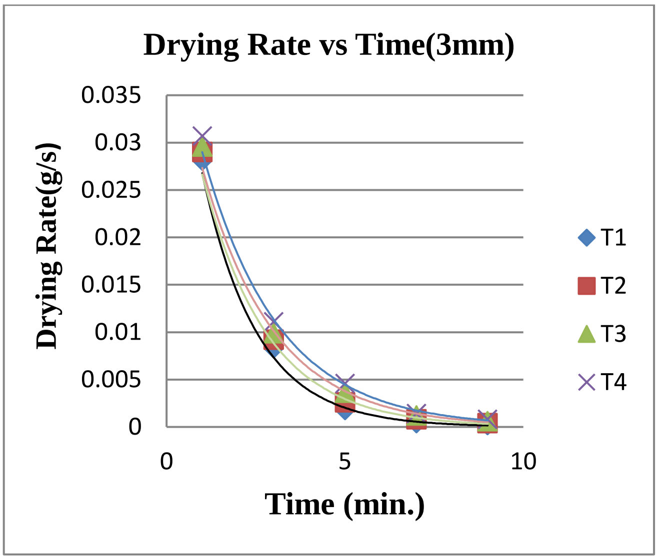

Fig. 8 Microwave Drying Rate of Papaya Slices of 3mm thickness at 20, 40, 60 & 80 W Powers

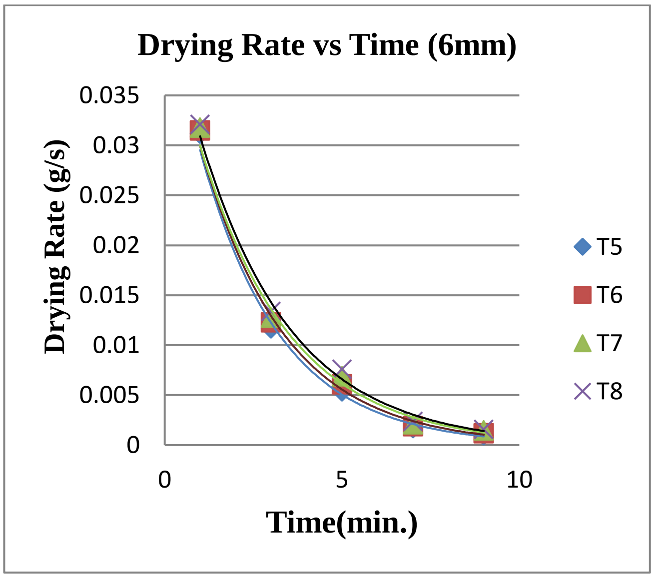

Fig. 9 Microwave Drying Rate of Papaya Slices of 6mm thickness at 20, 40, 60 & 80 W Powers

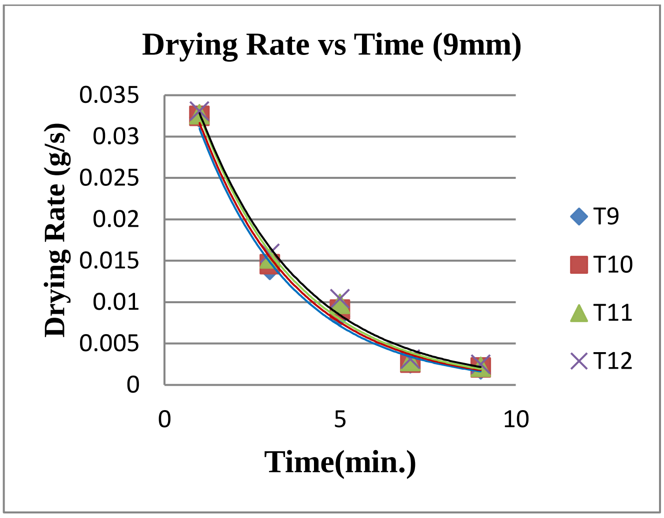

Fig. 10 Microwave Drying Rate of Papaya Slices of 9mm thickness at 20, 40, 60 & 80 W Powers

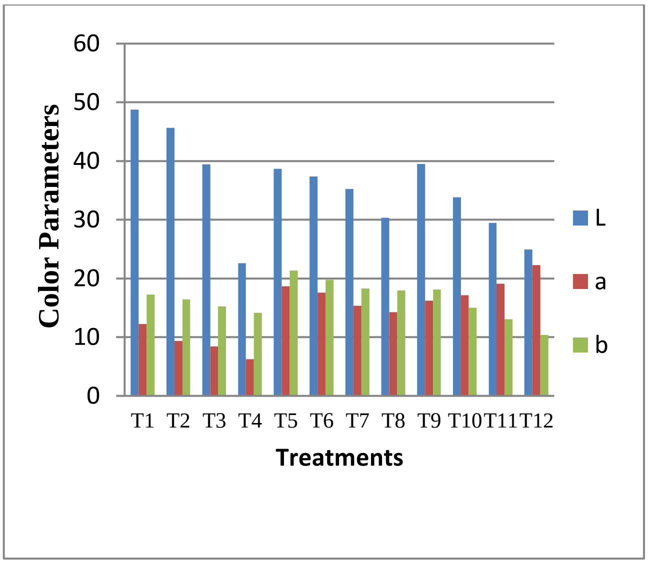

Fig. 11 Color Parameter of Microwave Dried Papaya Slices

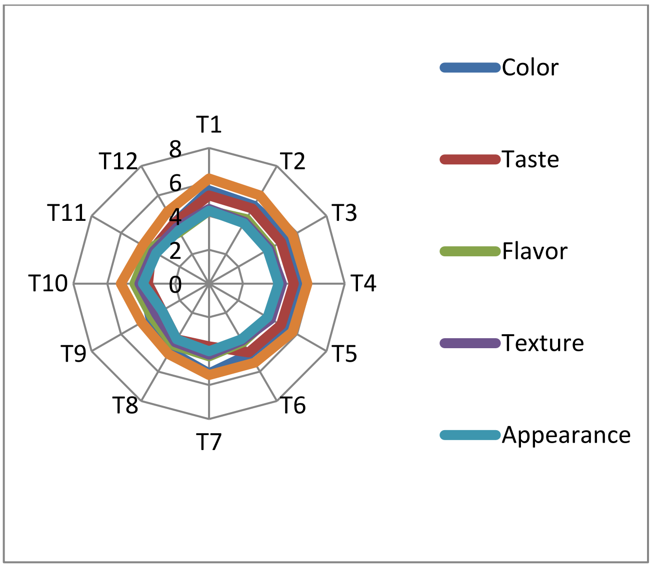

Fig. 12 Sensory Analyses of Papaya Slices Samples

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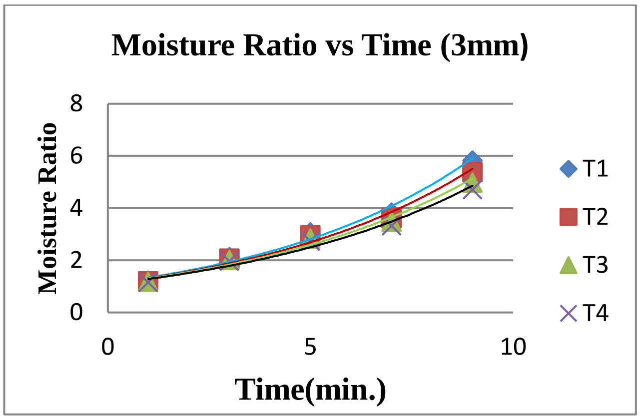

Fig. 13 Moisture Ratio of Papaya Slices of 3mm thickness at 20, 40, 60 & 80 W Powers

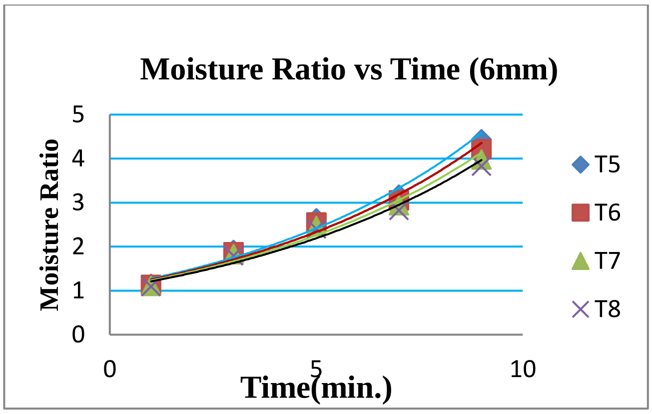

Fig. 14 Moisture Ratio of Papaya Slices of 6mm thickness at 20, 40, 60 & 80 W Powers

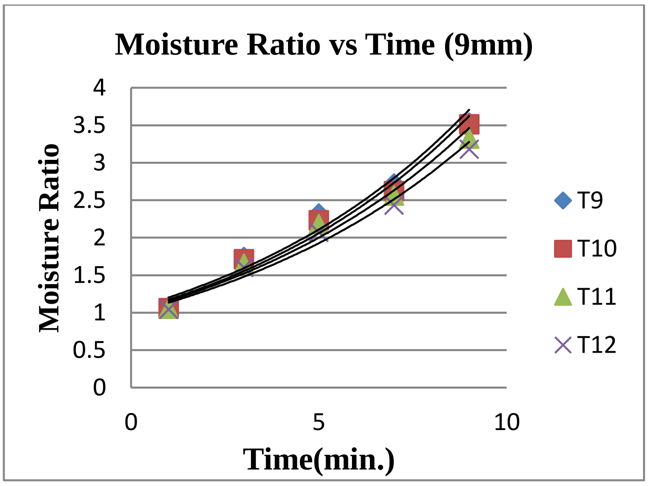

Fig. 15 Moisture Ratio of Papaya Slices of 9mm Thickness at 20, 40, 60 & 80 W Powers

V. CONCLUSION

The drying of papaya slices was found to be satisfactory in T3 (3mm & 60w) in all the aspects. Such as rehydration ratio, drying rate, moisture content and sensory attributes such as color, taste, flavor, texture, appearance and overall acceptability vitamin C and iron content. As the thickness decreases drying time also decreases compared to the high thickness slices and but sample with high thickness causes burns, but compared to the other drying methods Microwave takes less drying time to dry the product. Due to MW drying there is not much loss in vitamin C & iron content. The samples processed at 60 W microwaves drying had higher porosity than fresh samples by using SEM micrographs and were therefore found to be more desirable. When comparing the mathematical models used to predict the drying characteristics of papaya slices, the one developed by Singh and Wang outperformed the others. Specifically, their model achieved the highest values for the coefficient of determination (R2) of T6, 0.9992 for T11, and 0.01341 for T1, the lowest value for the reduced RMSE.

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not required.
Authors Contributions	All authors have equal participation in this article.

REFERENCES

1. Ela Singh, B.KalyaniB.Shasank Reddy. Osmatic Dehydration of papaya slices. [JOSR-J ESTFT]PP (2015). 72-95.
2. Feng,H and Tang J.Microwave finish drying of diced apple in spouted bed.Journal of Food Science. (1998),63(4):679-683 https://doi.org/10.1111/j.1365-2621.1998.tb15811.x
3. Forni E, Sormani A, Scalise S, Torreggiani D. The influence of sugar composition on the colour stability of osmodehydrofrozen intermediate moisture apricots. Food Res Int. (1997);30(2):87-94. https://doi.org/10.1016/S0963-9969(97)00038-0
4. Mandala I.G, E.F.Anagnostars and C.K. Influence of osmatic dehydration conditions on papaya air drying kinectics and their quality characterstics. Journal of Food Engineering, (2006).69, 306–317. https://doi.org/10.1016/j.jfoodeng.2004.08.021
5. Okpala LC, Ekechi CA. Rehydration characteristics of dehydrated West African pepper (Piper guineense) leaves. Food Sci Nutr. (2014); 2(6):664-8. https://doi.org/10.1002/fsn3.149
6. Pandya, Rushikesh & Chandra Yadav, Kailash. Study on Effect of Pretreatments and Microwave Drying On Banana Chips. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS) (2014). e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 7, Issue 7 Ver. IV (July. 2014), PP 04-10 https://doi.org/10.9790/2380-07740410
7. Sharma, Ragini & Chandra Yadav, Kailash. Study on Effect of Microwave Drying on Drying and Quality Characteristics of Guava (Psidiumguajava). International Journal of Scientific Engineering and Technology.(2017). 6. 150. 10.5958/2277-1581.2017.00007.9. https://doi.org/10.5958/2277-1581.2017.00007.9
8. Schiffman. Combined Hot Air, Microwave, and Infrared Drying of Hawthorn Fruit: Effects of Ultrasonic Pretreatment on Drying Time, Energy, Qualitative, and Bioactive Compounds' Properties. (1992)
9. Shivam Salunke, Kailash Chandra Yadav and ShahajiKadam. Effect of microwave drying on drying and quality characteristics of banana chips. ournal of Pharmacognosy and Phytochemistry; (2019) 8(2): 2031-2036
10. Wang, J., and Y. Chao. Drying characteristics of irradiated papaya slices. Journal of Food Engineering, (2003). 52(1),83–88. https://doi.org/10.1016/S0260-8774(01)00090-5

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11. Udomkun P, Argyropoulos D, Nagle M, Mahayothee B, Oladeji AE, Müller J. Changes in microstructure and functional properties of papaya as affected by osmotic pre-treatment combined with freeze-drying. J Food Meas Charact. (2018).;12:1028–37 https://doi.org/10.1007/s11694-018-9718-3
12. Yaldız, O., & Ertekin, C. Thin layer solar drying of some different vegetables. Drying Technology, (2001).19(3), 583–596 https://doi.org/10.1081/DRT-100103936
13. Zhang and Xu (2003). Mathematical modeling on thin layer microwave drying of papaya pomace with and without hot air pre-drying. Journal of Food engineering .doi:10.1016/j.jfoodeng.(2006).06.019.
14. Stephen, S. E. A., & E, V. Kumar. (2020). Optimization of Osmo-Dehydration Process of Honey Ginger Candy by using Response Surface Methodology. In International Journal of Engineering and Advanced Technology (Vol. 9, Issue 4, pp. 984–986). https://doi.org/10.35940/ijeat.c5353.049420
15. Optimizing Dehydration Conditions of Cow's and Goat Milk Yogurt Powder. (2020). In International Journal of Innovative Technology and Exploring Engineering (Vol. 9, Issue 3S, pp. 68–71). https://doi.org/10.35940/ijitee.c1015.0193s20
16. Mittal, S., & R, V. (2022). Microwave Photonics Advancements in Radar Application. In International Journal of Recent Technology and Engineering (IJRTE) (Vol. 11, Issue 3, pp. 35–40). https://doi.org/10.35940/ijrte.c7227.0911322
17. Yadav, Dr. K. C., Karhale, H. B., & Singh, Prof. (Dr.) M. (2023). Food Extrusion: A Highly Popular Technology to Process. In Indian Journal of Food Engineering (Vol. 2, Issue 3, pp. 1–8). https://doi.org/10.54105/ijfe.c1005.062323
18. P S, S., & V.A, Dr. H. (2023). Agriculture Distress and Farmers' Suicide in Kerala in the Globalization Era. In Indian Journal of Agriculture Engineering (Vol. 3, Issue 2, pp. 1–7). https://doi.org/10.54105/ijae.b1510.113223

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