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Nutritional values and drying kinetics of *Carica papaya*

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Abstract
Papaya, often called Carica papaya, is a tropical fruit well-known for its flavor and several health advantages. In order to protect the fruit's vital nutrients and create an effective drying method, this study looked into the nutritional makeup and drying kinetics of papaya. A thorough examination of the fresh papaya's nutritional profile, including its macronutrients (carbohydrates, proteins, and fats), essential vitamins (like vitamin C, vitamin A, and vitamin E), minerals (calcium, potassium, and magnesium), and bioactive substances like carotenoids and antioxidants, served as the foundation for the research. The kinetics of papaya drying were then evaluated using a variety of drying techniques, such as sun drying, hot-air drying, refractive window drying and freeze-drying. In order to determine the best drying technique to maintain the fruit's nutritional value, the refractive window drying procedure entailed tracking variations in moisture content over time. According to the research, papaya has a comprehensive nutritional profile with considerable amounts of vitamins, minerals, and bioactive substances, making it a desirable dietary source. Notably, fresh papaya was shown to be particularly rich in carotenoids and vitamin C. However, due to the use of high temperatures during the drying process, several nutrients that are sensitive to heat, such vitamin C, experienced minor losses.

Keywords: Papaya, refractive window drying, drying kinetics, nutritional analysis

Introduction

Papaya is a succulent herbaceous plant with self-supporting stems. Papaya is a big perennial herb that grows quickly. The plants have a short lifespan, but they can bear fruit for up to 20 years. The papaya's reproductive system is highly convoluted. Male, hermaphrodite, or female plants exist. Male trees are rare, but they do occasionally appear when homeowners collect their own seeds. Commercially, hermaphrodite trees (flowers with male and female components) produce a pear- shaped fruit. These plants pollinate themselves. Natural chemicals (Annonaceous acetogenins) produced by *Carica papaya* plants in leaf bark and twig tissues have anti-tumor and insecticide activities.

It is frequently used to cure malaria, diabetes, and other ailments as a daily green vegetable or herb. It's high in three potent antioxidants (vitamin C, vitamin A, and vitamin E), minerals (magnesium and potassium), B vitamins (pantothenic acid), folate, and fiber are all important nutrients. Papaya leaves are high in vitamins and minerals, low in calories, and contain an enzyme that aids in the tenderization of meat and the treatment of dyspepsia.

Various parts of plants like fruits, juice, seed, root, leaves, and bark constitute of many nutrients as explained now. Fruits constitute of protein, fat, fiber, carbohydrates, minerals, calcium, phosphorous, iron, vitamin c, thiamine, riboflavin, niacin and caroxene, amino acid, citric acids and molic acid (green fruits), volatile compounds- linalool, benzylisothicynate, cis and trans 2,6- dimethyl-3,6 exposy-7 octen-2-ol and for isomeric melonated benzyl- B-D glucosides. Nutrients in juice are- N- butyric, n-hexanoic acid, lipid; myristic, palmitic, stearic, linoleic, linolenic acids- vaccenic acids and oelic acids. Now for seeds are fatty acids, crude protexylitolins, crude fiber, papaya oil, carpaine, benzyl isothiocynate, benzylglucosinolate, glucotropaeolin, benzylthiourea, bark nutrients are B-sitosterol, glucose, fructose, sucrose, galactose and xylitol. At last nutrients in latex are proteolytic enzymes, papain and chemopapain, glutamine, cyclotransferase, chymopapain A, B and C, peptidase A and B and lysozymes. (Rajasekhar Pinnamaneni *et al*. 2017) [15]

Need of processing

There is need of processing of papaya because there is loss of papaya in case of color, flavor, and taste. During the first month of storage changes in the carotenoids were seen and color changes resulted in the product of non- enzymatic browning. However losses in amino acid content was also seen in small and large amount depending upon the time of storage. (Chan Jr. and Cavaletto, 1982) [5]. The diseases associated after post harvesting of papaya are Rhizopus. Anthracnose, Stem End Rot, Black Spot, Parasitic diseases, Physiological Disorders, Mechanical Damage, Chilling Injury Scald and overweight fruit also due to less calcium in the fruit. All these diseases becomes severe when the fruit yellows up to 25% or more and these diseases goes on increasing as the time span increases up to 4 weeks at storage temperature 100 °C.

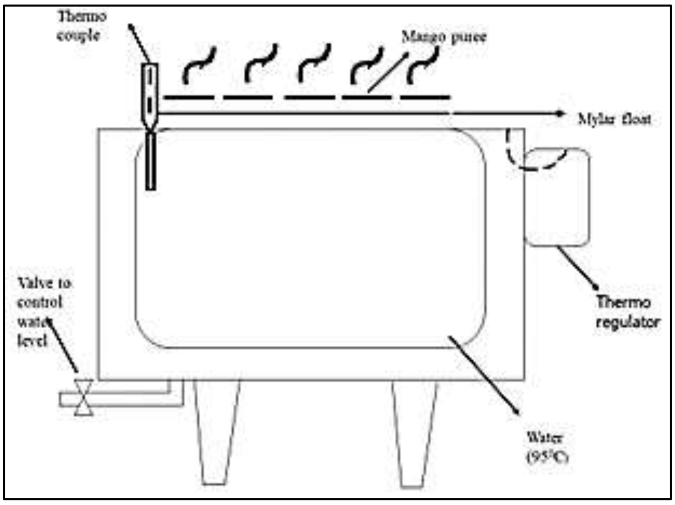
Refractive window drying

The ideal version of this device has a "window" through which mass and heat can be transferred. Through this window, infrared light can flow through any moist material applied to the plastic membrane's surface. The meal spread across the film only receives about half of the total heat radiation. Product temperatures, which are mostly influenced by moisture content, bed thickness, and product consistency, can reach up to 74 °C (but typically only reach a maximum of 39 °C to 47 °C). Heat is directly transferred to the water molecules. With an increase in refractive index, which causes thermal radiation to be reflected back into water, the drying "window" closes as the product loses moisture and "refracts" back into the heated water source. Infrared emissions from the hot water account for just around 3% of the total heat given to the product throughout the constant rate drying period, according to analysis of heat transfer fluxes during the Refractive Window Drying process. Up until the product reaches a crucial moisture level, conduction effects continue to assist moisture evaporation. The accompanying evaporative cooling effects that explain why the product's temperature is always lower than the water's temperature at any stage of drying take place during the later stages of drying.

In this method, we need to dry purees and liquids that are placed over a thin transparent layer that is done through the window. The temperatures are kept low, and drying happens in three different modes of heat transfer. Through this method, we need aromatic and pigment components for sensory and nutritive qualities. It is a non-thermal technique for drying goods like puree that is heat-sensitive. This process offers powders and flakes of exceptional quality at reasonably quick turnaround times and minimal operational expenses. (Raghavi *et al.* 2018) [14]

Mechanism of refractive window drying

The components which are included in the machine of refractive window drying are stainless steel hood, plastic conveyor belt, exhaust, hot water pump, water tank and heating unit



(Shende and Datta, 2019)

In the initial process of drying moisture is reduced and electromagnetic radiations are absorbed by wavelengths ranging from 3.0 to 15.3 um (Pavan, 2010) [26]. After placing a thin layer of surface on the conveyor belt and the humidity in the material produces infrared radiation. This infrared window radiation closes as soon as the moisture decreases from the product and conduction starts as a mode of heat transfer. (Karadbhajne *et al*., 2019) [27] and due to this small quantities of heat are transferred to dried materials and we get the reduced chance of overheating then thin drying processes.

Due to the convective cooling the product temperature becomes relatively low in refractive window drying and moist air is exhausted out of the dryer. And at the end the temperature is lowered so that the conveyor belt moves over the colder section (Karadbhajne *et al*., 2019) [27]. The main advantage of RWD is the product temperature is limited below 70 degree Celsius even though the water temperature is in its boiling phase. As drying continues, moisture content of the sample goes on decreasing continuously which increases the refractive index. That's why drying stops and radiant energy is refracted back into water. In RWD, energy is required for water evaporation from the air puree interface (Nindo and Tang, 2007) [28].

Drying Kinetics during RWD of Ripened Papaya: Using RWD method we did drying of ripened papaya under different thickness varying from 1-3 mm and at different temperature- 70, 85 and 90 °C and visualized the drying process after an interval of every 10 minutes.

For 1 mm thickness Drying Process of Ripened Papaya

Table 2: Drying Kinetics during RWD of Ripened Papaya at 1mm thickness

70	70	70	70	85	85	85	85	90	90	90	90
Time	**Weight**	**MR**	**ln MR**	**Time**	**Weight**	**MR**	**ln MR**	**Time**	**Weight**	**MR**	**ln MR**
0	97.35	1	0	0	96.92	1	0	0	96.8	1	0
30	95.65	0.04	-3.21	10	95.46	0.02	-3.91	10	95.45	0.06	-2.81
45	95.58	0.005	-5.29	20	95.43	0	Not defined	20	95.37	0.06	Not defined
60	95.57	0	Not defined	30	95.43	0	Not defined	30	95.36	0	Not defined

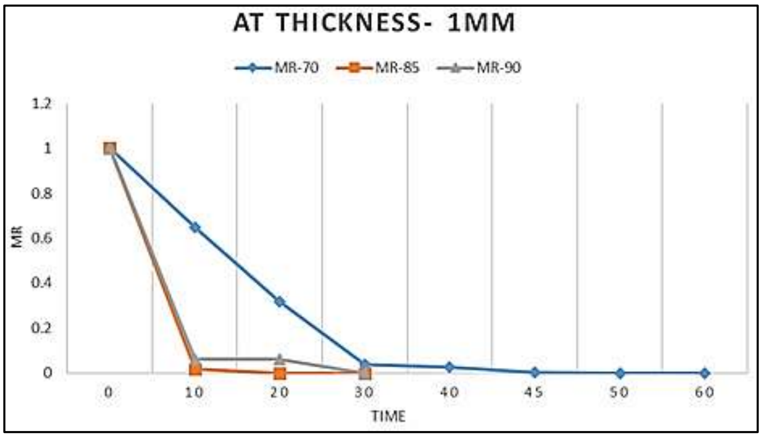


Fig 2: Graphical representation of the Drying Kinetics during RWD at 1 mm

For 2mm thickness Drying Process of Ripened Papaya

Table 3: Drying Kinetics during RWD of Ripened Papaya at 2mm thickness

70 Time	70 Weight	70 MR	70 ln MR	85 Time	85 Weight	85 MR	85 ln MR	90 Time	90 Weight	90 MR	90 ln MR
0	99.59	1	0	0	98.27	1	0	0	98.64	1	0
30	96.81	0.26	-1.34	10	96.42	0.32	-1.13	10	96.76	0.371	-0.991
45	96.22	0.106	-2.24	20	95.83	0.086	-2.45	20	96.04	0.13	-2.04
60	95.93	0.029	-3.54	30	95.63	0.011	-4.5	30	95.78	0.043	-3.14
75	95.83	0.002	-6.21	40	95.6	0	Not defined	40	95.67	0.006	-5.11
90	95.82	0	Not defined	50	95.6	0	Not defined	50	95.65	0	Not defined

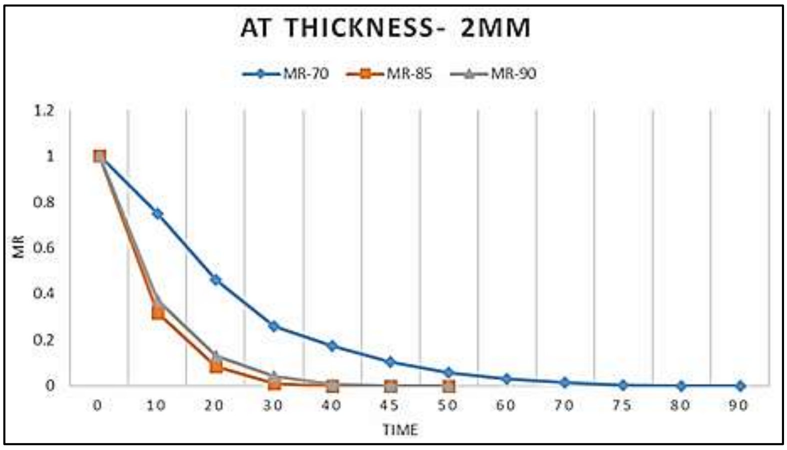


Fig 3: Graphical representation of the Drying Kinetics during RWD at 2mm

For 3mm thickness Drying Process of Ripened Papaya

Table 4: Drying Kinetics during RWD of Ripened Papaya at 3mm thickness

70 Time	70 Weight	70 MR	70 ln MR	85 Time	85 Weight	85 MR	85 ln MR	90 Time	90 Weight	90 MR	90 ln MR
0	97.46	1	0	0	100.19	1	0	0	98.37	1	0
30	96.32	0.41	-0.89	10	98.15	0.54	-0.61	10	97.09	0.56	-0.57
45	95.95	0.22	-1.51	20	97.04	0.29	-1.23	20	96.41	0.32	-1.13
60	95.76	0.132	-2.02	30	96.37	0.139	-1.97	30	95.99	0.184	-1.69
75	95.64	0.07	-2.65	40	96.03	0.063	-2.76	40	95.75	0.102	-2.28
90	95.53	0.015	-4.19	50	95.8	0.011	-4.5	50	95.59	0.047	-3.05
105	95.5	0	Not defined	60	95.76	0.002	-6.21	60	95.49	0.013	-4.34
				70	95.75	0	Not defined	70	95.46	0.003	-5.8
								80	95.45	0	Not defined

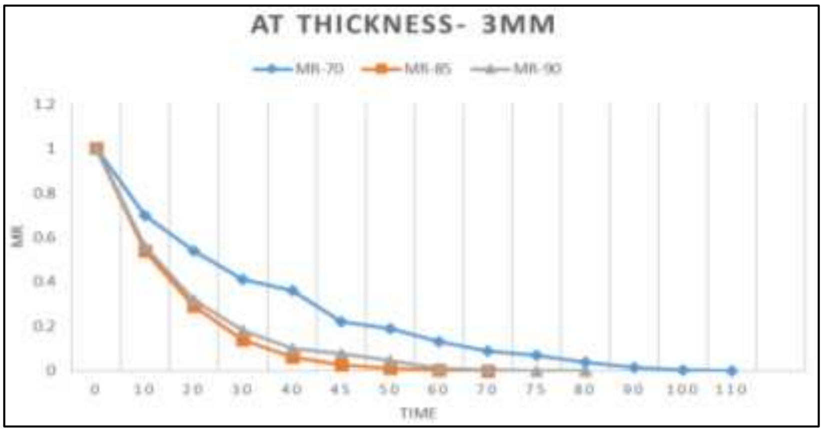


Fig 4: Graphical representation of the Drying Kinetics during RWD at 3mm

Moisture Analysis: Total moisture content is estimated using the Refractive Window Drying method under which a sample is taken in petri dish and the initial weight is taken and the kept in the water with at given temperature 75 °C for 82.5 minutes at the thickness of 2 mm and after 82.5 minutes the end weight is taken and then weight and the moisture content is calculated and it comes out to be 91.85%. That means 91.85% of moisture was present in ripe papaya initially. The results are given in table below.

Table 5: Results of Moisture Analysis

Sample	Initial Weight (g)	End Weight (g)	Moisture content (%)	Average Value (%)
S1	10	0.78	92.2	91.85%
S2	10	0.78	92.2	
S3	10	0.73	92.7	
S4	10	0.78	92.2	
S5	10	0.82	91.8	
S6	10	0.80	90.0	

Vitamin C: Vitamin C of any sample is determined using the method of Ravula *et al*. (2017) [29]. The procedure to the following method is by taking 100 mg of dried sample extracted with 10ml 4% oxalic acid using mortar and pestle. Now the sample is centrifuged and the supernatant is collected for further experiment. Now from that supernatant 5ml was pipetted out and is mixed with 10 ml 4% oxalic acid. The mixture is now titrated with 2, 6-dichlorophenol indophenol dye solution. During the titration experiment Ascorbic acid is taken as standard. And the values are determined below.

Table 6: Results of Vitamin C Content

Sample	Vitamin C (mg/100 gm)	Average Value (mg/100 gm)
S1	215.78	214.90
S2	215.78	
S3	213.157	
S4	213.157	
S5	218.42	
S6	213.157	

Total Flavonoid Content: Is estimated by aluminium chloride colorimetric assay (Sadh *et al*., 2018) [30]. 0.2 ml sodium nitrite (5%) is mixed with 2 ml of extraction solution and then 0.2 ml of aluminium chloride (10%) is added after 5 minutes and mixed well (Sadh *et al*., 2018) [30]. Then 1 M sodium hydroxide (2 ml) is added to the mixture. Absorbance is measured at 510 nm and the values are determined against quercetin. The final content is expressed as mg QE/g.

Results of Total Flavonoid Content

Sample	Flavonoid Content (mg QE/g)	Average Value (mg QE/g)
Standard	0.00	0.00
S1	0.811	0.402
S2	0.272	
S3	0.374	
S4	0.185	
S5	0.193	
S6	0.580	

Conclusion

The study highlights the exceptional nutritional content of *Carica papaya* and highlights the significance of using suitable drying techniques to preserve its vital elements. The findings of this study highlight how crucial it is to comprehend drying kinetics in order to maximise the preservation of vital nutrients in *Carica papaya*. It is feasible to extend papaya's shelf life while maintaining its nutritional value by using the right drying techniques, helping to promote a healthy diet and food security. It open the door to the creation of novel papaya-based products with improved nutritional advantages, satisfying the rising demand for quick and easy-to-prepare meal options.

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