The Pharma Innovation Journal 2023; 12(10): 1335-1339

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 1335-1339

www.thepharmajournal.com
Received: 02-07-2023
Accepted: 10-08-2023

AR Parmar
Ph.D. Scholar, Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh, Gujarat, India

TH Barad
Ph.D. Scholar, Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh, Gujarat, India

NK Dhamsaniya
Principal, Polytechnic in Agro-processing, Junagadh Agricultural University, Junagadh, Gujarat, India

GV Marviya
Senior Scientist and Head, Krishi Vigyan Kendra, Junagadh Agricultural University, Targhadia, Rajkot, Gujarat, India

Corresponding Author:
AR Parmar
Ph.D. Scholar, Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh, Gujarat, India

Effects of different process variables on functional properties of refractance window dried papaya pulp

AR Parmar, TH Barad, NK Dhamsaniya and GV Marviya

Abstract
Papaya (*Carica papaya* L.) is a valuable tropical fruit due to its rich nutritional and medicinal properties. This study focuses on optimizing the refractance window drying process for papaya pulp to enhance two critical functional properties: water absorption index and water solubility index. By varying water temperature (75 to 95 °C) and pulp layer thickness (1.5 to 4.5 mm), yielded maximum water absorption index (381.27%) and water solubility index (59.86%). Conversely, a decreasing trend in the water absorption index was observed at the highest water temperature (95 °C) and minimum pulp layer thickness (1.5 mm). Simultaneously, the water solubility index increased with rising water temperature and decreasing pulp layer thickness. These findings highlight the impact of process variables on enhancing the quality and versatility of dried papaya products in the food industry.

Keywords: Papaya, papaya pulp, drying, refractance window drying, functional properties

1. Introduction

Papaya (*Carica papaya* L.) is one of the important fruit crop of tropical and subtropical regions. It was originated in Mexico as a cross between two species of the genus Carica. During the 16th century, papaya was introduced to India from Malacca (Kumar and Abraham, 1943) [6]. The most important papaya growing states in India are Gujarat, Tamil Nadu, Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh, Bihar, Uttar Pradesh, West Bengal and Assam. As far as production of papaya is concerned, Gujarat stands at second position in the country. The total production of papaya in Gujarat was about 11.07 lakh MT over an area of 0.19 lakh hectares during the year 2021-22 (Anon., 2023) [2].

The main papaya cultivars that are mostly grown in Gujarat include the Honey Dew, Washington, Pusa Dwarf, Taiwan and Gujarat Junagadh Papaya-1 (GJP-1). GJP-1, a notable variety, features medium-sized fruits with an oblong shape and green colour. The fruit's pulp is orange-yellow, offering a soft and palatable texture. Papaya holds significant economic potential due to its nutritional and medicinal value. Apart from its delicious taste, papaya is a rich source of antioxidants like vitamin C, carotenes and flavonoids. It also provides essential vitamins such as B, pantothenic acid and folate, making it a valuable addition to both culinary and health-conscious endeavors. Papaya is a highly perishable fruit with a limited shelf life. Therefore, the processing of papaya plays a crucial role in preserving its nutritional value. The total postharvest loss of papaya worked out to the tune of 25.49% (Gajanana *et al.*, 2010) [4].

Refractance window drying is a thin film drying technique that achieves rapid heat and mass transfer rates by combining conduction, convection and infrared radiation transmitted through a circulating plastic sheet placed over hot water. This method, classified as the fourth generation of drying techniques along with infrared and microwave drying (Vega-Mercado *et al.*, 2001) [11], has proven to be highly efficient and cost-effective. In comparison to other drying methods, refractance window drying is remarkably economical, requiring 50–70% less expenditure and utilizing more than half the energy needed for freeze drying (Nindo and Tang, 2007) [9].

The refractance window dryer is constructed using a specialized plastic sheet called Mylar, known for its high transmittance of infrared energy wavelengths. This method involves spreading a uniform thin layer of the pulpy wet product onto a Mylar sheet, which is a type of polyester film that is transparent to infrared radiation the pulp is evenly spread over this sheet at a specific thickness and there's a mechanism for adjusting this thickness uniformly. Beneath the Mylar sheet, a hot water tank with a heating and circulation system ensures a continuous supply of heat energy (Parmar and Dhamsaniya 2023) [10].

The transmittance of infrared energy from Mylar sheet is contributed as radiation energy of drying process. The conduction energy from the circulating hot water and heated plastic sheet ads in removing the moisture from the thin layer pulp placed on a Mylar sheet. The pulp does not come directly in contact with the heating medium which ensures great microbiological advantages. A chilled water tank is placed after the drying chamber to reduce the temperature of the dried material below the glass transition phase so that scrapper at the end of the sheet can remove the dried product easily.

The functional properties *viz*., water absorption index and water solubility index are crucial for any dried product in food industry. The water absorption index is the ability to absorb and hold the water in the dried product. It is the measure to predict the quantity of water to be absorbed during the product development for better texture and mouth feel of product. The water solubility index is ability of dried product to dissolve in the water. By calculating water solubility index, the consistency and solubility of reconstituted food products *viz*., juice, sauces, dressings, thickeners can be predicted to desired thickness and mouthfeel of products. When ingredients to make instant soup, drink powders, cake mixes are mixed with water, the problem of lumping and insolubility can be solved by predicting water solubility index of food products. This research primarily focuses on the optimization of process variables of refractance window drying for the functional properties *viz*., water solubility index and water absorption index of papaya pulp.

2. Materials and Methods

2.1 Raw material selection

The GJP-1 variety has become one of the most popular varieties for commercial plantations in Gujarat. It has medium-sized oblong fruits with a green colour and orange-yellow pulp with a soft and palatable texture. The GJP-1 variety was developed by the Department of Horticulture at Madhadibaug Farm, Junagadh Agricultural University, Junagadh, during the year 2017-18. In aspect of this, GJP-1 variety of papaya was selected for the present investigation. Fully ripened fruits (9±1 °Brix) without any damage were carefully selected from the Madhadibaug Farm of the Horticulture Department.

2.2 Pulp preparation

The procured ripe papayas were thoroughly washed, cleaned and halved. Slicing and peeling were performed using a sharp knife and seeds were separated from the pulp. Subsequently, the ripe papaya was cut into small pieces of 13-15 mm. These papaya pieces were then ground in a juicer cum mixer grinder (M/S Usha Juicer Mixer Grinder, Model: JMG 3345) until uniform pulp mixture was obtained. The resulting pulp was carefully placed in a plastic container and utilized for the further drying through refractance window dryer.

2.3 Experimental design and treatment details

The experiment was designed as per the Response Surface Methodology (RSM) for drying process parameters (Montgomery, 2001) [7]. Two-factor three-level Central Composite Face Centered Design (CCFCD) with a quadratic model was utilized to investigate the combined effect of two independent variables, namely water temperature (X_1) and thickness of the pulp layer (X_2), on various response variables. The range of water temperature and thickness of pulp layer were kept between 75-95 °C and 1.5-4.5 mm respectively.

2.4 Drying of papaya pulp

Papaya pulp was filled in hopper and poured on Mylar belt. Pulp was spread concentrically and thickness of pulp was maintained with the help of adjustable thickness mechanism. Spread pulp with uniform thickness was placed inside drying chamber by moving Mylar belt. Drying experiment was carried out by varying the drying temperature and pulp thickness as per experimental run given in Table 1.1. Sample was taken out from drying chamber after completion of drying and was cooled to ambient temperature. The thin sheet of dried product was scrapped by acrylic scrapper situated at the end of Mylar belt. The dried product was packed in 50-micron LDPE bag for further functional properties evaluation.

2.5 Determination of functional properties

2.5.1 Water solubility index

The solubility of dried papaya pulp in normal water was determined using the method proposed by Anderson (1982) [1]. The water solubility index (WSI) is defined as the weight of dissolved solids in the supernatant per weight of dry solid powder and it is expressed as a percentage. To determine the water solubility index, 2.5g of sample was mixed with 25 ml of distilled water at room temperature. The mixture was stirred for 30 min. and then the dispersions were transferred to tarred centrifuge tubes. The tubes were centrifuged at 3000 rpm for 10 min. Carefully, the supernatant liquid was poured into a tared evaporating dish. The dried solids were recovered by evaporating the supernatant. The water solubility index was calculated using the following equation.

$$\text{Water solubility index } (\%) = \left[\frac{\text{Weight of dissolve solid in supernatant (g)}}{\text{Weight of dry solid powder (g)}}\right] \times 100$$

2.5.2 Water absorption index

Water absorption index is the ratio of the weight of sediments to that of weight of dry solid powder and expressed in per cent. The sediment obtained in the estimation of water solubility index was used for determination of water absorption index and calculated by the following equation.

$$\text{Water absorption index } (\%) = \left[\frac{\text{Weight of sediments (g)}}{\text{Weight of dry solid powder (g)}}\right] \times 100$$

3 Results and Discussions

3.1 Functional properties of refractance window dried papaya pulp

The treatment wise values of water solubility index and water absorption index of dried papaya pulp are presented in Table 1. The experimental values of water solubility index and water absorption index were found in the range of 41.13 to 57.72% and 256.95 to 381.27% respectively, depending upon the experimental conditions.

Table 1: Experimental values of Functional Properties of dried papaya pulp

Run	Uncoded variable		Responses	
	Water temperature (℃)	Thickness of pulp layer (mm)	Water absorption index (%)	Water solubility index (%)
1	75	1.5	349.00	47.12
2	95	3.0	271.96	57.52
3	85	4.5	341.11	47.80
4	95	4.5	290.62	57.72
5	85	3.0	324.59	54.49
6	85	3.0	319.36	50.38
7	85	3.0	330.80	51.04
8	95	1.5	256.95	59.86
9	85	3.0	321.18	52.56
10	75	4.5	381.27	41.13
11	85	3.0	323.98	52.17
12	75	3.0	361.57	44.09
13	85	1.5	308.47	53.69

From the Table 1 it can be observed that the minimum water absorption index was found as 256.95% for the run no. 8 having a combination of water temperature and thickness of pulp layer as 95 ℃ and 1.5 mm, respectively. While the maximum water absorption index was observed in the run no. 10 (381.27%) at water temperature of 75 ℃ and pulp layer thickness of 4.5 mm. The highest value of water solubility index was observed as 59.86% for the run no. 8 holding the combination of water temperature and thickness of pulp at 95 ℃ and 1.5 mm, respectively. The lowest value of water solubility index (41.13%) was obtained for the run no. 10 for which the value of water temperature and thickness of pulp layer stands at 75 ℃ and 4.5 mm, respectively.

3.2 Response surface analysis

The response surface curves for the individual response parameters were developed through Design Expert software. Each response surface curve explains the effect of two variables on response parameters. The Analysis of Variance (ANOVA) and regression analysis of both functional properties are given in the Table 2. The explanation on effect of different independent variables on response parameters along with the graphical presentation are given in preceding section.

Table 2: Analysis of variance (ANOVA) and regression coefficients for response surface quadratic model of different functional properties of dried papaya pulp

Source	Water absorption index (%)	Water solubility index (%)
Intercept	323.72	51.85
Linear terms		
A (X_1)	-45.39***	7.13***
B (X_2)	16.43***	-2.34**
Interaction terms		
AB (X_1X_2)	0.3520	0.9606
Quadratic terms		
A^2 (X_1^2)	-6.30*	-0.3379
B^2 (X_2^2)	1.72	-0.4003
Indicators for model fitting		
R^2	0.9944	0.9594
Adj-R^2	0.9904	0.9304
Pred.-R^2	0.9902	0.8580
Adeq. Precision	53.97	19.36
F-value	247.90	33.08
Lack of fit	NS	NS
C.V. %	1.05	2.79

A or X1 = Water temperature, B or X2 = Thickness of pulp layer, ***Significant at $p<0.001$, **Significant at $p<0.01$, *Significant at $p<0.05$, NS = Non-significant

3.3.1 Effect of water temperature and thickness of pulp layer on water absorption index of dried papaya pulp

The response surface curve for the variation in the water absorption index of dried papaya pulp as a function of water temperature (X_1) and thickness of pulp layer (X_2) is shown in Fig. 1. It shows the interactive effect of water temperature and thickness of pulp layer on the water absorption index of dried papaya pulp. The decrease in water absorption index was observed as the water temperature increased up to its maximum level i.e., 95 ℃ and at that time, thickness of pulp layer found at its lower level i.e., 1.5 mm. The maximum water absorption index (375.32%) was found at combination of water temperature 75.84 ℃ and thickness of pulp layer 4.3 mm as indicated in the Fig.1. The higher temperature caused denaturation of protein, which leads to aggregation and coagulation of the protein molecules. Thus, the water absorption was decreased because of the reduction in the protein surface which could be in contact with water. Franco *et al.*, (2016) [3] for foam mat drying of Yacon fruit and Wilson *et al.*, (2014) [12] for foam mat drying of mango fruit found similar trends.

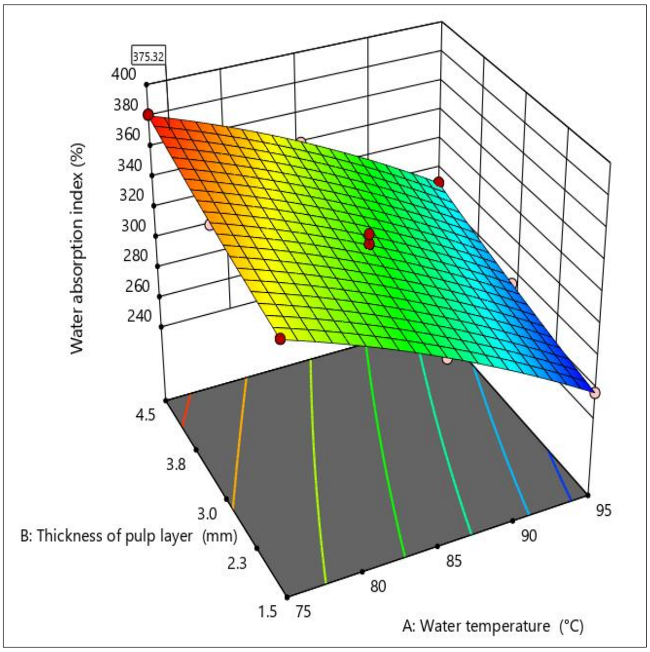

Fig. 1: Response surface plot for water absorption index as a function of water temperature and thickness of pulp layer

The regression analysis and ANOVA results for the water absorption index are shown in the Table 2. The linear effect of water temperature indicated the negative effect while linear effect of thickness of pulp layer had positive effect on water absorption index at significance of $p<0.001$. The quadratic effect of water temperature had a negative effect at 5% significance and thickness of pulp layer had a non-significance effect on water absorption index. Interaction effect of both the parameters was found to be non-significant ($p>0.05$).

The derived model giving the empirical relationship between the water absorption index and the test variables in coded units was obtained as under:

Water absorption index (%) = $323.72 - 45.39 X_1 + 16.43 X_2 + 0.3520 X_1X_2 - 6.30 X_1^2 + 1.72 X_2^2$

Where, X_1 and X_2 are the coded factors of water temperature and thickness of pulp layer, respectively.

The calculated F-value for water absorption index (247.90) was significant at $p<0.001$. At the same time, it possessed non-significant lack of fit ($p>0.05$). These values indicated that the model for water absorption index was fitted and reliable. The R^2 value and Adj-R^2 value for the water absorption index were 0.9944 and 0.9904, respectively, indicating the adequacy, good fit and high significance of the model. The Pred-R^2 (0.9902) was in reasonable agreement with the Adj-R^2. The high Adeq. Precision value (>4) again supported the significance of the model for water absorption index. The small value of coefficient of variation (1.05%) for water absorption index explained that the experimental results were precise and reliable (Table 2).

3.2.2 Effect of water temperature and thickness of pulp layer on water solubility index of dried papaya pulp

The effect of water temperature (X_1) and thickness of pulp layer (X_2) on water solubility index of dried papaya pulp is shown in Fig. 2. The water solubility index was found to be increased as the water temperature increased up to its maximum level and with decreased in thickness of pulp layer which was found at its lowest level. Water solubility index was found to be maximum 59.24% at a combination of water temperature and thickness of pulp layer, 94.5 °C and 1.6 mm, respectively. This may be due to the fact that higher temperature takes shorter time to complete the drying process which leads to less protein denaturation, thus increased water solubility index. Franco *et al.*, (2016) [3] for foam mat drying of Yacon fruit and Wilson *et al.*, (2014) [12] for foam mat drying of mango fruit found similar trends.

The regression analysis and ANOVA results for the water solubility index of dried papaya pulp are shown in the Table 2. The linear effect of water temperature indicated the positive effect with 0.01% significance. While linear effect of thickness of pulp layer shows negative effect on water solubility index with 0.1% significance. The quadratic effect of both the parameters had a negative effect on water solubility index. Interaction effect of both the parameters was found to be not significant ($p>0.05$).

The derived model giving the empirical relationship between the water solubility index and the test variables in coded units was obtained as under:

Water solubility index (%) = $51.85 + 7.13 X_1 - 2.34 X_2 + 0.9606 X_1X_2 - 0.3379 X_1^2 - 0.4003 X_2^2$

Where, X_1 and X_2 are the coded factors of water temperature and thickness of pulp layer, respectively.

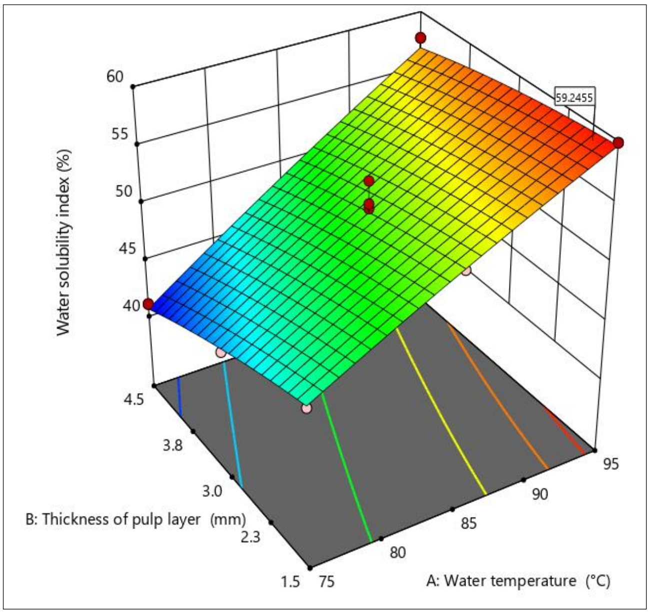

Fig. 2: Response surface plot for water solubility index as a function of water temperature and thickness of pulp layer

The calculated F-value for water solubility index (33.08) was significant at $p<0.001$. At the same time, it possessed non-significant lack of fit ($p>0.05$). These values indicated that the model for water solubility index was fitted and reliable. The R^2 value and Adj-R^2 value for the water solubility index were 0.9594 and 0.9304, respectively, indicating the adequacy, good fit and high significance of the model. The Pred-R^2 (0.8580) was in reasonable agreement with the Adj-R^2. The high Adeq. Precision value (>4) again supported the significance of the model for water solubility index. The small value of coefficient of variation (2.79%) for water solubility index explained that the experimental results were precise and reliable (Table 2).

4. Conclusion

The research findings revealed notable trends in the water absorption index and water solubility index of refractance window dried papaya pulp in relation to the water temperature used for drying of pulp and thickness of pulp layer kept for drying. The maximum water absorption index (381.27%) and water solubility index (59.86%) was found for the run no. 10 at water temperature of 75 °C and pulp layer thickness of 4.5 mm. and run no. 8 for combination of water temperature and thickness of pulp at 95 °C and 1.5 mm, respectively. The decreasing trend of water absorption index was found at highest level of water temperature (95 °C) and at that time thickness of pulp layer was found at its minimum level (1.5 mm). While, the water solubility index was found in increasing trend as increasing water temperature and decreasing thickness of pulp layer. These findings suggest that specific combinations of water temperature and thickness of pulp layer can significantly impact the functional properties of refractance window dried papaya pulp.

5. Future scope

Dried papaya pulp and leather offers many bioactive compounds as well as functional characteristics. The future research should involve effect of novel drying techniques on bioactive and other functional compounds and the utilization of dried papaya pulp for the new product development with improvement in functional properties.

6. References

1. Anderson RA. Water absorption and solubility and amylograph characteristics of roll-cooked small grain products; c1982.
2. Anonymous. Department of Horticulture, District wise area and production of horticultural crops for the year 2021-22. Director of Horticulture, Agriculture, Farmar Welfare and Co-operation Department, Government of Gujarat; c2023. Available at https://doh.gujarat.gov.in/Images/directorofhorticulture/pdf/statistics/Area-Production-horticulture-2021-22.pdf, Accessed on 16th May, 2023.
3. Franco, Talita Szlapak, Camila Augusto Perussello, Luciana Neves Ellendersen, Maria Lucia Masson. Effects of foam mat drying on physicochemical and microstructural properties of yacon juice powder. LWT-Food Science and Technology. 2016;66:503-513.
4. Gajanana TM, Gowda IND, Reddy BMC. Exploring market potential and developing linkages–A case of underutilized fruit products in India. Agricultural economics research review. 2010;23:437-444.
5. Khuri, Andre I, John A. Cornell. Response surfaces: designs and analyses. Routledge; c2018.
6. Kumar LSS, Abraham S. The papaya, its botany, culture and uses. Jour. Bombay Nat'l History Soc. 1943;44(2):252-256.
7. Montgomery, Douglas C. Design and analysis of experiments, John Wiley & Sons. Inc., New York. 2001;1997:200-1.
8. Myres RH. Response surface methodology, department of statistics, virginia polytechnic institute and state university, blacksburg, virginia, distributed by edwards brothers. Inc., Ann Arbor, Michigan; c1976.
9. Nindo CI, Tang J. Refractance window dehydration technology: a novel contact drying method. Drying technology. 2007;25(1):37-48.
10. Parmar AR, Dhamsaniya NK. Refractance window drying: A novel drying technique for quality retention; c2023.
11. Vega-Mercado, Humberto, Marcela Góngora-Nieto M, Gustavo V. Barbosa-Cánovas. Advances in dehydration of foods. Journal of food engineering. 2001;49(4):271-289.
12. Wilson, Robin A, Dattatreya M, Kadam, Sonia Chadha, Manpreet Kaur Grewal, Monika Sharma. Evaluation of Physical and Chemical Properties of Foam-Mat Dried Mango (*M angifera indica*) Powder during Storage. Journal of Food Processing and Preservation. 2014;38(4):1866-1874.