Plant Archives Vol. 25, Supplement 1, 2025 pp.2634-2642 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.362

STUDIES ON DIFFERENT DRYING METHODS AND PACKAGING MATERIAL ON STORABILITY OF JAMUN PULP POWDER

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(Date of Receiving : 11-10-2024; Date of Acceptance : 30-12-2024)

ABSTRACT

The study envisaged the shelf life and sensory quality of jamun pulp powder using different drying methods and packaging materials. Pulp without seeds was dried using cabinet drying (C_1) and microwave oven drying (C_2), powdered and packaged in five materials *viz.*, LDPE pouches (P_1), aluminium foil pouches (P_2), metallised polyester polyethylene laminated pouches (MPE) (P_3), PET jars (P_4) and glass jars (P_5). The Factorial Completely Randomized Design (FCRD) with 10 treatment combinations and three replications was employed for observing physicochemical changes every 30 days interval over 180 days. Findings revealed that, increase in moisture, TSS, total and reducing sugars, polyphenols, tannins and antioxidants, while pH, titratable acidity, ascorbic acid and non-reducing sugars declined over the time. Microwave oven drying with aluminium foil pouches (C_2P_2) preserved quality parameters best, achieving the highest storability, sensory acceptability and economic feasibility with a Benefit Cost Ratio of 4.31 followed by treatment C_2P_3 (microwave oven drying with MPE pouches).
***Keywords*:** Cabinet drying, jamun pulp powder, microwave oven drying, packaging, storability

Introduction

Jamun *(Syzygium cumini)*, also known as Java plum or Indian blackberry, is a highly nutritious and medicinal fruit belonging to the Myrtaceae family. Native to the Indian subcontinent, this fruit known for its therapeutic and nutraceutical properties, including anti-diabetic, antioxidant and anti-inflammatory benefits (Kapoor *et al*., 2015). Despite its high medicinal and nutritional value, Jamun remains underutilized due to its highly perishable nature and short shelf life, which restrict its distribution and commercialization. At room temperature, the fruit deteriorates within 24 hours, while under cool conditions (3-4°C), it lasts only about 12 days (Periyathambi, 2007). This limited storability poses significant challenges in post-harvest management, leading to substantial losses of this valuable crop (Manganaris *et al*., 2014).

India contributes about 15.4% of total global Jamun production, yet the processing and value addition of this fruit remain underdeveloped (Patil *et al*. 2012). Seasonal availability, coupled with inadequate processing techniques and a lack of awareness about potential by-products, exacerbates the issue. Post-harvest losses of Jamun are estimated to be over 20-30%, highlighting the critical need for advanced preservation methods to enhance its marketability. Dehydration is a promising approach to

extend the shelf life of perishable fruits like Jamun, allowing their use in various value-added products like dehydrated powder, beverages, candies and syrups.

This study focuses on standardizing effective drying methods and packaging techniques to prepare Jamun pulp powder with retention of its nutritional and bioactive properties. The research also aims to address supply chain limitations and promote year-round availability of Jamun products. By improving the storability and application of Jamun pulp powder, this study seeks to support small-scale industries and farmers, reduce post-harvest losses and meet the growing demand for convenient, nutritionally enriched food products.

Material and Methods

Experimental details

The study entitled, 'Studies on different drying methods and packaging material on storability of Jamun pulp powder', was carried out during 2022-23at Analytical Laboratory, Post-Harvest Technology Laboratory of the Department of Fruit Science and Processing Technology Unit of the Agricultural Engineering Department, College of Agricultural Engineering and Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS).

Treatment details

The experiment consisted of five packaging materials *viz.,* P_1: Low Density Polyethylene (LDPE) (240 Gauge Pouches), P_2: Aluminium foil pouches, P_3: Metallised Polyester Polyethylene Laminated (MPE) (12.5 µ Pouches), P_4: Polyethylene Terephthalate (PET) jars and P_5: Glass jars; two levels of drying methods *viz.,* C_1: Cabinet drying and C_2: Microwave oven drying and its 10 treatment combinations. For each treatment combination, 100 g of jamun pulp powder was placed in the respective packaging material. The packed bags were stored at ambient conditions, and chemical changes and sensory qualities were evaluated at 30-day intervals over a 180-day period.

Methodology

The physicochemical analysis of jamun pulp powder was conducted using various standard methods as elaborated, pH was measured using a pH meter as per A.O.A.C. (2000). The initial moisture content of jamun pulp was found to be (85.6 ± 1.3) %, measured using the A.O.A.C. (1999) method involving oven drying at 105°C for 30 minutes. Additionally, the Total Soluble Solids (TSS) of jamun pulp powder were measured using an Alago RX 1000 digital refractometer. The total sugars content of the jamun pulp powder sample was determined as per Lane and Eynon method described by Ranganna (1986). Titratable acidity was determined following the A.O.A.C. (1995) method. Ascorbic acid content was estimated using the 2,6-dichlorophenol indophenol dye method, as described by A.O.A.C. (1986).The total phenolic content was determined using the colorimetric method of Folin-Ciocalteu, as described by Singleton and Rossi (1965). The determination of total tannin content was carried out using Folin-Ciocalteu method (Singleton & Rossi, 1965), as outlined by Makkar (2003). The antioxidant activity of jamun pulp powder was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method, as described by Brand-Williams *et al.* (1995).

Organoleptic evaluation was performed by a panel of 10 judges from the Department of Post-Harvest Technology was selected to perform the organoleptic evaluation of the jamun pulp powder. The evaluation took place in the Post-Harvest Technology Laboratory at the Department of Fruit Science, Dr. P.D.K.V, Akola. The sensory characteristics, including colour, appearance, texture, taste, flavour, and overall acceptability, were evaluated using a 9-point hedonic scale at 30 days intervals during storage, following the scorecard outlined by Amerine *et al.* (1965). The mean scores for each sensory characteristic were calculated and reported.

The data obtained during the investigation were statistically analyzed using the Factorial Completely Randomized Design (FCRD) (Panse and Sukhatme, 1985). The critical difference (CD) for treatment means was calculated at a 5% level of significance to determine the significance of variations among treatments.

Preparation of jamun pulp powder

Procurement of jamun fruits: The jamun fruits used in the study were sourced from the local fruit market in Akola, Maharashtra, India (77.00°E longitude and 20.70°N latitude). Rotten and unripe fruits were discarded and only fresh, ripe fruits were selected after thorough cleaning. The selected fruits were washed with fresh tap water and the pulp was mechanically separated from the seeds using a jamun pulp extractor for further processing. Additional ingredients, including maltodextrin powder, edible glycerine and various packaging materials were procured from the local market in Akola.

Washing: The jamun fruits were first washed with tap water to remove soil particles, cleaned with a muslin cloth and air dried to remove surface moisture.

Pulp extracting: Pulp extraction involved separating seeds using a Jamun Pulp Extractor, minimizing pulp wastage and collecting seeds for by-product.

Pulp homogenization: The pulp was homogenized using a juice mixer and sieved to eliminate impurities.

Drying: Before drying, the pulp was spread on steel trays coated with edible glycerine to prevent sticking and ensure easy removal of the powder. Drying methods followed were Cabinet drying @ 60°C for 7 hours and Microwave oven drying @ 400 W for 6.5 hours. Water and 10 g of maltodextrin per treatment was added to maintain powder consistency.

Grinding into powder: The dried jamun pulp was ground into powder using an electric grinder for 15-20 minutes and cooled to room temperature.

Packaging and storage of jamun pulp powder: 100 g of powder was packed into separate packaging materials, sealed using a polythene sealing machine and stored at room temperature.

Results and Discussion

pH Changes in Jamun Pulp Powder During Storage

Table 1 reveals that the, lowest decrease in pH percentage was observed in the combination of Microwave Oven drying (C_2) and Aluminium foil pouches (P_2), with a decrease of 6.48%. In contrast, the highest decrease was recorded in the Cabinet drying method followed by LDPE pouches (C_1P_1), showing a 7.29% reduction. A higher reduction in pH percentage indicates greater stability of the jamun pulp powder throughout the storage period. Lower pH values suggest the acidic nature of the jamun pulp powder, which plays a key role in determining its taste.

Kadam *et al.* (2011) reported a decline in pH during various drying methods and storage periods in mandarin powder over three months. Similarly, Sarker *et al.* (2014) found that the pH of tomato powder stored in Laminated Aluminium Foil (LAF) pouches decreased from 4.3 to 3.77 over six months, indicating LAF pouches as a suitable packaging material for prolonged storage.

Moisture content

Significant differences in moisture content, as depicted in Table 1, were observed in jamun pulp powder due to variations in drying methods and packaging materials. A slower increase in moisture was recorded for microwave drying with aluminum foil packaging (C_2P_2) at 23.51%, compared to cabinet drying with LDPE pouches (C_1P_1) at 33.92%. The reduced moisture gain in C_2P_2 indicates better stability of the powder over six months. Jamun pulp powder dried using a microwave oven and stored in aluminum foil pouches demonstrated superior performance compared to other treatments.

Similar results were reported by Kassem *et al.* (2011) for grapes, where microwave drying followed by a hot air cabinet dryer achieved 78% of the optimum selection percentage. Wong and Lim (2016) also found Aluminium-laminated polyethylene pouches to be ideal for storing spray-dried papaya powder at 38°C and 90% relative humidity.

Total Soluble Solid (TSS)

Aluminium foil pouches (P_2) combined with Microwave Oven drying (C_2) recorded the highest TSS, showing a 5.77% increase compared to Cabinet drying with LDPE pouches (C_1P_1), which resulted in 2.87% increase over as depicted in table 2.

The rise in TSS might be attributed to the breakdown of complex carbohydrates into simpler soluble carbohydrates. This increase in gain of TSS content was due to break down of complex carbohydrates into simple soluble carbohydrates.

The findings indicate minimal variation in TSS content of jamun pulp powder, ranging from 13.55°B to 14.22°B. These findings align with Ghosh *et al.* (2016), who reported a TSS content of 14.86°B for jamun fruit.

Total sugar

The data presented in Table 3. indicates that, Microwave Oven drying (C_2) with Aluminium foil pouches (P_2) showed a higher increase in total sugar content (1.71%) compared to Cabinet drying with LDPE pouches (C_1P_1), which showed a 0.83% increase.

This rise in total sugar could be attributed to the conversion of starch into sugar during storage. Similar observations were made by Mahajan *et al.* (2022), who reported an increase in total sugar content in all microwave-dried samples compared to fresh/control samples.

Bharani *et al.* (2018) founded that the Aluminium foil covers were found to be best packaging materials followed by glass bottles in retaining various nutrients and quality attributes of dried banana flour when compared to the other packaging materials.

Reducing sugar

Microwave Oven drying (C_2) with Aluminium foil pouches (P_2) recorded the highest increase in reducing sugar content (9.67%) compared to Cabinet drying with LDPE pouches (C_1P_1), which showed a 5.98% increase as showed in Table 3. The gradual rise in

reducing sugar across all treatments was attributed to the rapid hydrolysis of polysaccharides and their conversion into sugars.

These findings are consistent with observations by Reni *et al.* (2000) and Pareek and Kaushik (2012) in dehydrated tomato and aonla powder, respectively.

Non-reducing sugar

Microwave Oven drying (C_2) with Aluminium foil pouches (P_2) showed a lower reduction in non-reducing sugar content (3.59%) compared to Cabinet drying with LDPE pouches (C_1P_1), which exhibited a 4.82% decrease over as depicted in Table 3.

The gradual decline in non-reducing sugars across all treatments was attributed to their inversion into reducing sugars during prolonged storage under ambient conditions. Similar trends were reported by Bala *et al.* (2017) in sapota powder and Bharathi *et al.* (2020) in banana flour.

Titratable acidity

Table 4, depicted that the Titratable acidity consistently decreased over the storage period, with Microwave Oven drying (C_2) and aluminium foil pouches (P_2) showing the least reduction (24.03%) compared to Cabinet drying with LDPE pouches (C_1P_1), which showed a 47.10% decrease.

This decline in titratable acidity could be attributed to biochemical interactions leading to the binding of acids with other components over time. Similar results were reported by Dabhade and Khedkar (1980) for mango powder stored at room temperature (25±5°C).

Verma *et al.* (2021) also observed a reduction in titratable acidity of instant mango powders during 90 days of storage in aluminium laminated packaging due to the involvement of organic acids in browning reactions at ambient temperatures.

Ascorbic acid

Table 5, depicts that, the combination of Microwave drying (C_2) and Aluminium foil pouches (P_2) recorded the lowest reduction in ascorbic acid content (22.07%) compared to Cabinet drying with LDPE pouches (C_1P_1), which showed a higher decrease (30.12%).

The reduction during microwave drying may cause destruction of Vitamin-C by microwave electromagnetic waves during the drying process. Thus, Ascorbic acid losses during storage are primarily due to the oxidation of dehydroascorbic acid, influenced by temperature and light exposure. Similar trends of ascorbic acid reduction were reported by Ganjyal *et al.* (2005) in sapota fruit powder and Abou-Zaid and Ibraheem (2015) in tomato powder. Hyndavi *et al.* (2022) and Sarkar *et al.* (2018) highlighted the superior retention of ascorbic acid in aluminium foil pouches due to their effective protection against oxidation in jackfruit powder and dehydrated sapota slices, respectively.

Total polyphenol content

The highest increase in total polyphenol content was observed in the combination of Microwave Oven drying (C_2) followed by Aluminium foil pouches (P_2) at 1.39%, compared to Cabinet drying with LDPE pouches (C_1P_1), which showed an increase of 1.33%. These findings align with Cansino *et al.* (2013), who reported the highest total phenol content in pear powder dried using a microwave oven and packaged in aluminium foil pouches as showed in Table 5.

Similar results were found by Mechlouch *et al.* (2015), Chahbani *et al.* (2018), and Soproni *et al.* (2023) in microwave-dried palm dates, green peas and apple slices, respectively.

Tannin content

The highest increase in tannin content as shown in Table 6 was observed in the treatment combination of microwave drying (C_2) followed by glass jars (P_5), with an increase of 0.82%, compared to the lowest increase of 0.44% in the cabinet drying (C_1) followed by LDPE pouches (P_1) at the end of the 180 days of storage period. Similarly, Youssef *et al.* (2018) found that microwave oven-dried banana flour exhibited higher levels of total phenolic compounds, flavonoids and tannins.

Antioxidant content

The antioxidant content of jamun pulp powder, as shown in Table 6, was highest in the combination of microwave oven drying (C_2) and aluminium foil pouches (P_2) during the 180-day storage period. On the first day, the antioxidant content for C_2P_2 was 44.38%, increasing to 44.90% by the 180th day, indicating a consistent rise throughout storage. This was followed by the treatment combination of microwave oven drying with metallized polyester (C_2P_3). In contrast, cabinet drying with LDPE pouches (C_1P_1) showed the lowest increase in antioxidant content. The study observed a general increase in antioxidant content over time, with $_{C2P2}$ exhibiting a 1.17% higher increase compared to C_1P_1, which recorded only a 0.41% increase.

This increase in antioxidants was likely linked to enhanced phenolic compounds, supported by similar findings of Turkmen *et al.* (2005) and Chumyam *et al.*

(2013), noted increased antioxidant activity in microwave treated foods. The findings align with the notion that microwave drying disrupts cell walls, enhancing antioxidant activity as reported in studies on various foods.

Sensory evaluation

The overall sensory evaluation of prepared product from jamun pulp powder at different storability period, depicts that C_2P_2 i.e. Microwave dried powder packaged in Aluminium foil pouches and C_2P_3 i.e. Microwave dried powder packaged in MPE have the capability to restore the quality of powder up to 180 days of storage. The sensory score decreased continuously with increase in storage period. This might be due to degradation of chemical constituents during storage. Good quality of jamun pulp powder with respect to organoleptic characters can be obtained in treatment combination C_2P_2 (Microwave Oven dried + Aluminium Foil Pouches). It was found to be best as it gives purple colour and smooth texture. Similar result was obtained by Piotrowski *et al.* (2011), El-Sharnouby *et al.* (2007) and Behera *et al.* (2021).

Recovery of jamun pulp powder

Maximum recovery percentage of jamun pulp powder was obtained from Microwave Oven Drying (C_2) i.e., 41.58% followed by Cabinet Drying (C_1) i.e., 38.77% respectively.

Benefit Cost Ratio

The benefit cost ratio was observed highest (4.31) in treatment combination C_2P_2 (Microwave Oven dried + Aluminium foil pouches) packaging respectively from, the physicochemical analysis of jamun pulp powder at different days of storability period and calculated economics.

Conclusion

By overall consideration of physico-chemical characteristics and organoleptic evaluation it was concluded that, the quality of jamun pulp powder dried by microwave oven drying (C_2) packaged in Aluminium foil pouches (P_2) followed by C_2P_3 (Microwave oven drying+ MPE) was found good and of marketable quality till 180 days of storage, preserved the quality of jamun pulp powder. The benefit cost ratio of the same treatment was recorded highest (4.31) from calculated economics of all treatments. Overall, the findings underscore the significance of adopting strategic drying and packaging techniques to maximize the shelf life of Jamun pulp powder, thereby ensuring their availability and nutritional potency for extended durations around the year thereby minimizing postharvest losses.

Table 1 : Interaction effect of drying methods and packaging material on pH and moisture content of Jamun pulp powder at ambient storage condition

Treatment Combination	pH							Increase (%)	Moisture content (%)							Increase (%)
	Storage period (Days)								Storage period (Days)							
	1st	30th	60th	90th	120th	150th	180th		1st	30th	60th	90th	120th	150th	180th	
C_1P_1	4.11	4.06	4.04	3.98	3.93	3.89	3.81	7.29	3.35	3.72	3.97	4.25	4.39	4.55	5.07	33.92
C_1P_2	4.09	4.04	4.01	3.95	3.91	3.87	3.80	7.09	3.35	3.55	3.76	3.90	3.81	3.90	4.59	27.01
C_1P_3	4.06	4.04	4.00	3.90	3.84	3.84	3.78	6.89	3.35	3.60	3.81	3.99	4.13	4.33	4.78	29.91
C_1P_4	4.07	4.03	3.98	3.93	3.89	3.85	3.79	6.87	3.35	3.69	3.77	3.83	3.95	4.41	4.87	31.21
C_1P_5	4.07	4.01	3.99	3.90	3.88	3.84	3.79	6.87	3.35	3.64	3.76	3.94	4.00	4.51	4.99	32.86
C_2P_1	4.09	4.04	4.01	3.95	3.91	3.87	3.80	7.09	3.35	3.51	3.64	3.73	3.88	4.35	4.82	30.49
C_2P_2	4.01	3.96	3.94	3.88	3.80	3.77	3.75	6.48	3.35	3.43	3.50	3.65	3.79	4.00	4.38	23.51
C_2P_3	4.05	3.97	3.96	3.89	3.85	3.82	3.78	6.66	3.35	3.50	3.62	3.70	3.80	4.12	4.56	26.53
C_2P_4	4.07	3.99	3.97	3.92	3.88	3.83	3.79	6.87	3.35	3.58	3.63	3.72	3.81	4.17	4.66	28.11
C_2P_5	4.08	4.04	4.01	3.95	3.91	3.87	3.80	6.86	3.35	3.60	3.69	3.79	3.85	4.30	4.75	29.47
'F'-Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	-	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	-
SE(m)±	0.123	0.117	0.113	0.120	0.191	0.123	0.126	-	0.10	0.105	0.109	0.113	0.115	0.125	0.139	-
CD at 5%	0.27	0.31	0.34	0.36	0.35	0.36	0.40	-	-	-	0.31	0.32	0.33	0.35	0.40	-

Table 2 : Interaction effect of drying methods and packaging material on Total Soluble Solid (TSS) of Jamun Pulp Powder at ambient storage condition.

Treatment Combination	Total Soluble Solids (TSS) (^{0}B) Storage Period (Days)							Increase (%)
	1st	30th	60th	90th	120th	150th	180th	
C_1P_1	13.55	13.56	13.61	13.65	13.76	13.82	13.95	2.87
C_1P_2	13.55	13.64	13.72	13.76	13.80	13.88	13.98	3.08
C_1P_3	13.55	13.60	13.64	13.68	13.82	13.92	14.02	3.35
C_1P_4	13.55	13.58	13.62	13.67	13.80	13.90	14.00	3.21
C_1P_5	13.55	13.57	13.63	13.66	13.81	13.95	14.08	3.76
C_2P_1	13.55	13.58	13.65	13.74	13.88	13.92	14.05	3.56
C_2P_2	13.55	13.71	13.75	13.80	13.95	14.20	14.38	5.77
C_2P_3	13.55	13.67	13.72	13.76	13.93	14.15	14.30	5.24
C_2P_4	13.55	13.62	13.67	13.70	13.89	14.05	14.15	4.24
C_2P_5	13.55	13.62	13.70	13.73	13.91	14.11	14.20	4.58
'F'- Test	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	-
SE(m)±	0.399	0.403	0.405	0.408	0.411	0.414	0.418	-
CD at 5%	1.14	1.15	1.16	1.18	1.18	1.19	1.20	-

Table 3 : Interaction effect of drying methods and packaging material on total sugars, reducing sugars and non-reducing sugars of Jamun pulp powder at ambient storage condition

Treatment Combination	Total sugars (%) Storage period (Days)							Increase (%)	Reducing sugars (%) Storage period (Days)							Increase (%)	Non-reducing sugars (%) Storage period (Days)						Decrease (%)
	1st	30th	60th	90th	120th	150th	180th		1st	30th	60th	90th	120th	150th	180th		1st	30th	60th	90th	120th	150th	180th
C_1P_1	16.78	16.80	16.82	16.85	16.87	16.90	16.92	0.83	8.49	8.55	8.62	8.69	8.78	8.89	9.03	5.98	7.87	7.83	7.79	7.75	7.68	7.60	7.49
C_1P_2	16.83	16.87	16.88	16.92	16.95	16.99	17.05	1.29	8.62	8.65	8.72	8.88	8.96	9.08	9.20	6.79	7.79	7.80	7.81	7.79	7.77	7.51	7.45
C_1P_3	16.80	16.81	16.84	16.90	16.89	16.97	17.01	1.25	8.70	8.73	8.79	8.92	9.04	9.17	9.32	6.65	7.69	7.67	7.64	7.58	7.45	7.41	7.38
C_1P_4	16.82	16.85	16.87	16.90	16.93	16.95	16.99	1.01	8.74	8.85	8.90	8.99	9.15	9.22	9.29	6.29	7.67	7.60	7.57	7.51	7.39	7.34	7.31
C_1P_5	16.81	16.84	16.86	16.88	16.90	16.93	16.95	0.84	8.79	8.88	8.92	8.99	9.10	9.25	9.33	6.14	7.61	7.56	7.54	7.49	7.41	7.29	7.23
C_2P_1	16.82	16.85	16.87	16.91	16.92	16.94	16.97	0.89	9.00	9.05	9.10	9.19	9.25	9.45	9.70	7.77	7.42	7.41	7.38	7.33	7.28	7.11	6.90
C_2P_2	16.91	16.95	16.98	17.00	17.04	17.07	17.20	1.71	9.20	9.47	9.53	9.62	9.68	9.77	10.09	9.67	7.30	7.10	7.07	7.01	6.99	6.93	6.75
C_2P_3	16.89	16.93	16.95	16.98	17.01	17.05	17.13	1.42	9.18	9.30	9.45	9.56	9.62	9.68	10.00	8.93	7.32	7.24	7.12	7.04	7.02	7.00	6.77
C_2P_4	16.88	16.90	16.92	16.95	16.99	17.02	17.11	1.36	9.07	9.12	9.16	9.22	9.39	9.42	9.76	7.60	7.41	7.39	7.37	7.34	7.23	7.22	6.98
C_2P_5	16.86	16.89	16.90	16.93	16.96	17.00	17.08	1.30	9.05	9.13	9.18	9.26	9.42	9.46	9.63	6.40	7.41	7.37	7.33	7.28	7.16	7.14	7.07
'F'-Test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	-	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	-	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m)±	0.06	0.06	0.07	0.07	0.07	0.06	0.08	-	0.06	0.06	0.07	0.07	0.07	0.06	0.08	-	0.03	0.02	0.05	0.06	0.04	0.03	0.07
CD at 5%	0.17	0.19	0.17	0.18	0.16	0.17	0.17	-	0.09	0.10	0.07	0.08	0.08	0.11	0.13	-	0.15	0.16	0.14	0.15	0.13	0.14	0.14

Table 4 : Interaction effect of drying methods and packaging material on Titratable Acidity of Jamun pulp powder at ambient storage condition

Treatment Combinations	Titratable Acidity (%) Storage Period (Days)							Decrease (%)
	1st	30th	60th	90th	120th	150th	180th	
C_1P_1	1.21	1.12	1.05	0.94	0.82	0.77	0.64	47.10
C_1P_2	1.21	1.14	1.08	0.99	0.91	0.84	0.70	42.14
C_1P_3	1.21	1.16	1.11	1.06	0.98	0.83	0.78	35.53
C_1P_4	1.21	1.18	1.16	1.14	1.11	1.06	0.82	32.23
C_1P_5	1.21	1.17	1.15	1.12	1.10	0.90	0.88	33.00
C_2P_1	1.29	1.17	1.14	1.10	1.08	1.06	0.90	30.23
C_2P_2	1.29	1.25	1.20	1.16	1.12	1.09	0.98	24.03
C_2P_3	1.29	1.23	1.18	1.15	1.09	1.04	0.95	26.35
C_2P_4	1.29	1.19	1.12	1.10	1.05	1.03	0.93	27.90
C_2P_5	1.29	1.21	1.17	1.15	1.07	1.05	0.92	28.68
"F"- Test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	-
SE(m)±	0.037	0.034	0.033	0.031	0.029	0.026	0.024	-
CD at 5%	-	0.09	0.09	0.08	0.08	0.07	0.06	-

Table 5 : Interaction effect of drying methods and packaging material on ascorbic acid and polyphenols of Jamun pulp powder at ambient storage condition

Treatment Combination	Ascorbic acid (mg/100g)							Decrease (%)	Polyphenols (mg Gae/g)							Increase (%)
	Storage period (Days)								Storage period (Days)							
	1st	30th	60th	90th	120th	150th	180th		1st	30th	60th	90th	120th	150th	180th	
C_1P_1	37.21	37.02	35.55	34.57	32.86	28.45	27.00	30.12	197.15	197.26	197.4	197.55	198.52	198.86	199.78	1.33
C_1P_2	37.21	36.84	34.97	32.30	29.88	28.35	26.88	24.56	197.35	197.49	197.61	197.76	198.75	198.97	199.97	1.34
C_1P_3	37.21	36.98	35.37	34.12	31.38	29.77	26.59	28.54	197.74	197.85	198.01	198.14	199.1	199.75	200.39	1.34
C_1P_4	37.21	36.72	33.01	31.29	28.74	27.49	25.96	27.84	198.13	198.24	198.41	198.57	199.5	199.8	200.8	1.35
C_1P_5	37.21	36.60	34.22	32.43	30.50	28.61	26.03	30.04	198.17	198.28	198.46	198.56	199.54	199.83	200.85	1.35
C_2P_1	34.39	33.50	31.28	30.06	29.55	26.59	26.00	27.30	198.30	198.42	198.61	198.71	199.68	199.98	200.97	1.35
C_2P_2	34.39	33.12	30.97	29.66	28.13	27.33	25.00	22.07	198.91	199.02	199.22	199.79	200.28	200.60	201.68	1.39
C_2P_3	34.39	33.25	31.00	29.68	28.54	27.95	25.13	24.01	198.52	198.63	198.84	198.95	199.89	200.22	201.23	1.38
C_2P_4	34.39	33.87	32.29	30.45	29.72	28.63	26.07	24.19	197.54	197.65	197.88	197.98	198.91	199.24	200.25	1.37
C_2P_5	34.39	33.66	32.48	31.59	30.63	28.87	24.93	27.30	197.89	198.01	198.24	198.34	199.26	199.61	200.62	1.37
'F'-Test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	-	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	-
SE(m)±	1.055	1.048	0.876	0.931	0.871	0.734	0.765	-	5.70	5.75	5.80	5.88	5.89	5.90	5.94	-
CD at 5%	-	2.98	2.67	2.65	2.59	2.27	2.21	-	11.43	11.45	11.46	11.48	11.52	11.55	11.60	-

Table 6 : Interaction effect of different drying methods and packaging material on the tannins and antioxidants content of Jamun pulp powder at ambient storage condition

Treatment Combination	Tannins (Mg/100g)							Increase (%)	Antioxidants (%)							Increase (%)
	Storage period (Days)								Storage Period (Days)							
	1st	30th	60th	90th	120th	150th	180th		1st	30th	60th	90th	120th	150th	180th	
C_1P_1	91.58	0.44	43.80	43.85	0.44	43.80	43.85	0.44	43.80	43.85	43.89	43.91	43.95	43.96	43.98	0.41
C_1P_2	91.65	0.50	43.80	44.10	0.50	43.80	44.10	0.50	43.80	44.10	44.17	44.21	44.25	44.27	44.30	0.72
C_1P_3	91.68	0.46	44.27	44.32	0.46	44.27	44.32	0.46	44.27	44.32	44.40	44.48	44.56	44.62	44.60	0.75
C_1P_4	91.72	0.45	44.36	44.48	0.45	44.36	44.48	0.45	44.36	44.48	44.55	44.60	44.66	44.70	44.70	0.74
C_1P_5	91.69	0.46	43.82	43.89	0.46	43.82	43.89	0.46	43.82	43.89	43.92	44.00	44.09	44.13	44.20	0.91
C_2P_1	91.77	0.57	44.01	44.09	0.57	44.01	44.09	0.57	44.01	44.09	44.16	44.29	44.48	44.63	44.75	0.99
C_2P_2	92.10	0.82	44.38	44.67	0.82	44.38	44.67	0.82	44.38	44.67	44.71	44.76	44.81	44.87	44.90	1.17
C_2P_3	91.94	0.76	44.36	44.59	0.76	44.36	44.59	0.76	44.36	44.59	44.63	44.69	44.74	44.77	44.80	1.13
C_2P_4	91.92	0.72	44.28	44.48	0.72	44.28	44.48	0.72	44.28	44.48	44.54	44.60	44.64	44.72	44.79	1.05
C_2P_5	91.80	0.65	44.10	44.14	0.65	44.10	44.14	0.65	44.10	44.14	44.20	44.27	44.35	44.42	44.50	1.01
'F'-Test	Sig.	-	NS	Sig.	-	NS	Sig.	-	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	
SE(m)±	2.72	-	1.41	1.36	-	1.41	1.36	-	1.41	1.36	1.38	1.34	1.30	1.28	1.31	-
CD at 5%	7.69	-	-	3.80	-	-	3.80	-	-	3.80	3.70	3.77	3.75	3.76	3.73	-

Acknowledgement

A.M. Gaharwal and B.N. Patil were research supervisors during course of work. Research expenditure including material was solely beared by Anjali Dilip Giri and drying facility was made available by Bhagyashree Patil from Department of Agriculture Process Engineering, College of Agricultural Engineering and Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Assistance during experiment and manuscript draft preparation was served by Kaustubh Yashvant Deshmukh, Shashwat Prafulla Mahalle along with Anjali Dilip Giri. Statistical analysis and equal financial contribution for publication is provided by Giri A.D., Deshmukh K.Y., Mahalle S. P. and Bahadure A.B.

Conflict of interest

Authors declare no conflict of interest.

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