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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(9): 1135-1139

www.thepharmajournal.com
Received: 21-06-2023
Accepted: 26-07-2023

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Studies on physicochemical properties of mandarin jam

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Abstract
An experiment entitled “Studies on physicochemical properties of mandarin jam” was carried out during year 2020-21 at Post Harvest Technology Laboratory, Horticulture Section, College of Agriculture, Nagpur with objective to study the effect of sugar and pectin levels on physicochemical and properties of mandarin jam and to find out the suitable combinations of sugar and pectin level(s) for preparation of mandarin jam. The experiment was set up using a Factorial Completely Randomized Design (FCRD), with two factors: factor A being the amount of sugar in the mandarin jam (650 g, 750 g, 850 g, 950 g, 1050 g, and 1 150 g), and factor B being the amount of pectin in the jam (P1, P2, and P3). There were 18 treatment combinations in total, and the experiment was replicated three times. Mandarin jam's physicochemical analysis was observed and recorded on a regular basis at intervals of 30 days. the finding it was observed that, there was gradual increase in TSS, pH, dry matter, titrable acidity, reducing sugars, total sugars content of mandarin jam. Whereas moisture, ascorbic acid and non-reducing sugars content of mandarin jam found to decreased with advancement of storage period.

Keywords: Mandarin, jam, *Citrus reticulata*, physicochemical properties, Nagpur mandarin, Santra

1. Introduction
Since ancient times, the nutritional and therapeutic significance of citrus fruit has been understood. The fruits are well renowned for their energizing scent, capacity to satisfy thirst, and availability of sufficient vitamin C. In addition to ascorbic acid, these fruits contain several phytochemicals, which play the role of nutraceuticals, such as carotenoids (Lycopene and B carotene), limonoid, flavanones (Naringins and rutinoside), vitamin-B complex and related nutrients (thiamine, riboflavin, nicotinic acid/niacin, pantothenic acid, pyridoxine, folic acid, biotin, choline and inositol). Citrus fruits are rich in nutrients and, thanks to their high flavonoid content, have positive benefits on human health. Mandarin (Citrus unshiu March) is a type of citrus fruit that is consumed as fresh juice, juice concentrate, or juice that has been processed. The purpose of this research was to make jam from inferior or unusable satsuma mandarins and assess its physical, chemical, and sensory properties. The jam was made using a conventional method in an open container with a 1:1 fruit to sugar ratio. According to the hedonic scale, the produced whole fruit mandarin jam had a respectable favor rating. The average values of the jam sample's total soluble solid, titratable acidity as citric acid, dry matter, ash percentage, and pH were found to be 70.38, 0.098, 74.77, 0.28, and 2.87, respectively. According to Salih Aksay *et al*.'s 2018 [14] research, the tangerine jam's Hunter L, a, and b values were 45.34, 11.48, and 21.16, respectively (Salih Aksay *et al*., 2018) [14].

2. Materials and Methods
Nagpur mandarin fruits were procured from the Centre of Excellence for Citrus (CEC), Horticulture section, college of Agriculture, Nagpur. Other ingredients i. e. sugar, pectin, citric acid were purchased from local market of Nagpur.
For the purpose of making jam, fully ripened Nagpur mandarin fruits are picked. Fruits are categorized according to color and maturity. Fruits without flaws were chosen. On the production day, the fruits were washed with portable running water and then immersed for 10 minutes. The segments were divided. The seeds and white fiberous pith are removed. Fruit pulp is produced by homogenizing cleaned section in a blender. Different levels of sugar and pectin were used in the creation of jam that had just been freshly extracted. According to the treatments, sugar comes in weights of 650 g, 750 g, 850 g, 950 g, 1050 g, and 1150 g, and pectin weighs 2 g and 4 g. First, combine pulp, sugar, and pectin in an open container. The mixture continues to be stirred as the heating process begins. then using a hand refractometer set to 70 °B to determine the end point.

Total jam solids were calculated by deducting moisture content from 100 whereas titratable acidity, reducing sugars, and total sugars were assessed in accordance with Ranganna's (1986) [13] description. The Srivastava and Kumar (1994) [5] titration method was used to determine the vitamin C concentration. Three duplicates of each experiment were conducted. The F.C.R.D. factorial experiment was used to conduct the statistical analysis of the data according to the procedure outlined by Panse and Sukhatme (1961) [4].

3. Result and Discussions

3.1 Physical Characteristics of Fresh Mandarin Fruits (Making of jam)

Fully ripened Nagpur mandarin fruits are harvested for preparation of jam. Fruits are sorted by maturity and colour. Fruits free from defects were used. The fruits of average weight, volume, length and specific gravity.

3.2 Fresh Mandarin fruit chemical properties

Table 1 displays the results of tests conducted on fresh mandarin fruits to determine various chemical characteristics. According to the table, the nutritional breakdown of fruit is as follows: Calories, Protein, Carbohydrates, Fiber, Sugar, Vitamin C, Thiamin, Riboflavin, Niacin.

3.3 Changes in Proximate Composition of mandarin jam during storage

3.3.1 Total Soluble Solid (^{O}B)

The information regarding the total soluble solids content of mandarin jam as influenced by various combinations of pectin and sugar was gathered up to 90 days of storage and is shown in table 2. With the exception of treatment combination S1P1 (650 g sugar), the interaction effect of sugar and pectin combination on total soluble solids content of mandarin jam steadily increased with increasing time of storage and was found significant at 0 to 90 days of storage. At 0 days maximum total soluble solid was recorded 70.99°B in treatment combination S_6P_3 (1150 g sugar and 4 g pectin). Where, as minimum total soluble solid was found 70.20°B in treatment combinations S_1P_1 (650 g sugar and control of pectin) at par with 70.23°B in treatment combination S_1P_2 (650 g sugar and 2 g pectin). This same trend was observed in the storage of 30, 60 and 90 days.

This pattern of rising total soluble solid during storage (oBrix) may be brought about by partial hydrolysis of complex polysaccharide and solubilization of pulp components. The findings of Patel *et al*. (2015) [11] are supported by the findings of this study. This result are in agreement with the findings of Patel *et al*., (2015) [11].

Fruit samples had the lowest °B value at 11.5 whereas jam samples had a mean °B value of 74.7. Food with a high °B value has less water activity, making it more resistant to microbial and some metabolic deteriorations. The addition of sugar and water loss during the boiling process may be the causes of the jam sample's increased °B. reported by Salih Aksay *et al*. (2018) [14].

3.3.2 pH

Data pertaining to the effect of different sugar and pectin combination on pH of mandarin jam during storage are presented in Table 3. The data presenting the interaction effect of sugar and pectin combination on pH of mandarin jam. The data revealed that, the interaction effect of different sugar and pectin concentrations of mandarin jam was statistically significant up to 0 days to 90 days of storage. The pH was found to decrease with increased in storage period significantly up to 90 days. At 0 days maximum pH was recorded 2.86 in S_3P_3 (850 g sugar and 4 g pectin) at par with 2.85 in treatment combination S_3P_2 (850 g sugar and 2g of pectin), S_5P_1 and S_5P_3. Were the minimum pH noticed in treatment combination 2.70 in S_1P_1 (650 g sugar and control of pectin) at par with pH 2.73 in treatment $S_1P_{2.}$ This trend goes same in 30, 60 and 90 days of storage significantly. The decrease of pH of mandarin jam it might be due to increase in storage period of the jam and environmental changes.

The increase in storage may be the cause of the pH decrease after processing. The jam's excellent stability will be facilitated by the low pH. The study's measured jam pH value is lower than those obtained by Yu *et al*., 2007.

The pH values were found to fall as the amount of sugar increased; this is clearly seen when the amount of wood apple pectin increased in the treatment regimen. The outcomes support the conclusions of N. R. Rangare *et al*., (2017) [13].

According to the scientists, the acidity may have increased due to the degradation of fermentable substrates, particularly the carbohydrates in pineapple fruits, and the addition of sugars. Similar modifications that led to some products' elevated pH may have also occurred in this investigation. The study's findings that some items' pH levels rose corroborate a considerable pH rise in untreated given by Christine Mukantwali *et al*., (2017) [7].

3.3.3 Moisture Content (%)

The information regarding the moisture content (%) of mandarin jam as affected by various quantities of sugar and pectin during ambient storage conditions was compiled and is shown in Table 2.

The moisture was found to decrease with increased in storage period with the exception of treatment combination S_1P_1 significantly. At 0 days maximum moisture content was observed 35.67 % in the treatment combination S_1P_1 (650 g sugar) at par with 35.00 % in treatment combination S_1P_2 (650 g sugar and 2 g of pectin) and 34.33 % moisture in treatment combination S_1P_3 (650 g sugar and 4 g of pectin). Were the minimum percentage of moisture content recorded 17.00 % in S_6P_3 (1150 g sugar and 4 g pectin) at par with 17.67% in S_6P_2 (1150 g sugar and 2 g pectin). This trend goes same in the storage of 30, 60 and 90 days.

The loss of moisture from the jam during storage may be the cause of the decrease in moisture content in mandarin jam with increased storage time, reported by Samaila James *et al*., (2016) [4].

These findings demonstrate uneven moisture fluctuations for several jam sources throughout a 12-month storage period. One of the metrics used to evaluate the fruit products' genuineness is moisture. The improper packaging materials (such as packaging that doesn't close properly) or the packaging material's inherent moisture permeability could both be to blame for the change in moisture content of some samples, reported by Christine Mukantwali *et al*., 2017) [7]

The variation in moisture is to be expected given the heating action taken during heating. The impact of moisture on a product's shelf life is significant. Jam processing caused the water to be removed, which concentrated the nutrients in the food. The amount of moisture and dry matter in any food material is a gauge for how long it will stay fresh, observed by Olugbenga Olufemi Awolu *et al.*, 2018 [1].

3.3.4 Dry Matter (%)

Up to 90 days of storage were tracked for the results in Table no. 3 on the dry matter content of mandarin jam as influenced by various sugar and pectin combinations.

The data representing the interaction effect in respect of dry matter content of mandarin jam as influence by different sugar and pectin combination at ambient storage conditions was recorded up to 90 days of storage. The interaction effect of sugar and pectin of mandarin jam on dry matter content was found significant at 0, 30, 60 and 90 days of storage. At 0 days significantly maximum dry matter percentage recorded 84.33 % in treatment combination S_6P_3 (1150 g sugar and 4 g pectin). Where the minimum dry matter percentage observed 64.00 % in treatment combination S_1P_1 (650 g sugar) at par with 64.33 in treatment combination S_1P_2 (650 g sugar and 2 g pectin). Same trend was studied in 30, 60 and 90 days of storage period significantly.

3.3.5 Titrable Acidity (%)

The information in Table 3 shows how the interaction between sugar and pectin gradually increases the acidity percentage of mandarin jam.

An interaction effect of sugar and pectin combination on titrable acidity (%) of mandarin jam was found significant at 0, 60 and 90 Days. Significantly maximum titrable acidity was recoded 0.24 % in treatment combination S_1P_2 (650 g sugar and 2 g pectin). Where, significantly minimum titrable acidity recorded 0.15 % in treatment combination S_6P_3. At 30 days titrable acidity was recorded non – significant and trend at 0 days goes same in 60 and 90 days of storage significantly at 1 %.

Increased acidity may also result from the breakdown of pectin compounds, oxidation of reducing sugars, and degradation of polysaccharides. It is given by Helen O. Okudu *et al*., (2015) [8].

Since days of storage were found to have a substantial impact on the acidity of jam, it may be inferred from the fact that there was a progressive increase in acidity during storage. It might be caused by both the steady loss of pectin content and the synthesis of organic acids from the breakdown of ascorbic acid. It also results from the production of acids from sugar. Similar increases in acidity with longer periods of storage was also reported by Pushpa Parihar *et al*., (2018) [10].

3.3.6 Ascorbic acid / Vit. C (mg/100 gm)

It presents that, information regarding the interactions between various sugar and pectin combinations and the ascorbic acid level in mandarin jam is not significant.

The ascorbic acid level of mandarin jam steadily drops during the course of 0 to 90 days of storage, and an interaction effect of sugar and pectin combination on that content was determined to be non-significant.

With longer product storage, the vitamin C level falls. The development of dehydroascorbic acid as a result of oxidation trapped by oxygen in a polythene pouch may be the cause of a reduction in vitamin C levels. Additionally, it was shown that the value of ascorbic acid reduced as storage time rose. The oxidation of leftover oxygen in glass bottles may be the cause of the ascorbic acid's modest decrease. Similar result was reported by Vidhya *et al*., (2011) [15]

Due to ascorbic acid's thermomobile nature, which was destroyed with temperature during storage, this trend of decreasing ascorbic acid (mg/100 g) during the duration of storage may have been caused by a rise in temperature, given by Patel *et al*., (2015) [11]

During storage, the amount of ascorbic acid in guava-papaya jam drastically decreased. Ascorbic acid's sensitivity to oxygen, light, heat produced by enzymatic and non-enzymatic catalysts, and oxygen was definitely a contributing factor. These modifications may be the result of variations in the chemical make-up of the ingredients used in the recipes. These findings are in conformity with those of Singh *et al*. (2014) in whey guava beverage and Rahman *et al*., (2018) [12] in guava jam.

In storage of 15 days, 30 days and 45 days shows slight decrease in vitamin C observed by Chorage *et al*., (2020) [3].

3.3.7 Reducing sugar (%)

At all stages of storage, it was discovered that the combined influence of sugar and pectin on the decreasing sugars (%) of mandarin jam was not significant. It illustrates a trend of rising lowering sugars (%) of all sugar combinations stored for 90 days.

The hydrolysis of fruit sugar caused by the acid in fruit juices led to a rise in reducing sugar during the storage period.

The increased proportion of reducing sugar may be caused by a larger degree of sugar inversion or by an increase in reducing sugars with improved storage.

With the lengthening of the storage period, there was a progressive and considerable rise in the total and reducing sugars of the guava-papaya jam. The hydrolysis of polysaccharides into sugars and the inversion of sugars may be responsible for the rise in sugar levels, given by Brandao *et al*., (2018) [2].

3.3.8 Non-reducing Sugars (%)

In general, there was a decrease in non - reducing sugars of mandarin jam during storage at 0 to 90 days recorded. At 0 days of storage significantly maximum non reducing sugars was recorded 25.91 % in treatment S_4 (950 g sugar). Significantly minimum non - reducing sugars was recorded 24.89 % in treatment S_1 (650 g sugar). At 30, 60 and 90 days of storage days of storage this trend goes same significantly under study.

It was noticed that the non-reducing sugar levels may have decreased due to some non-reducing sugar being converted to reducing sugar via the process of glucogenesis.

The study of banana blended jam over a storage duration of 3 months to 9 months indicated that all chemical components increased up to 90 days, with the exception of non-reducing sugar. Concluded by Patel *et al.*, (2015) [11].

3.3.9 Total Sugars (%)

The findings showed that at 0, 30, 60, and 90 days of storage, the interaction effect caused by the varying quantities of sugar and pectin in Mandarin jam was determined to be non-significant. The results are in agreement with the findings of Allah Bakhsh Javaid Lakho *et al*., (2017) [6]. After 42 days of storage, the highest total sugar content (66.37%) was discovered. However, jam that had been preserved for at than 28 days had the lowest total sugar content, 64.36%. According to Allah Bakhsh Javaid Lakho *et al*.'s (2017) [6] research, the results are not statistically significant among the treatments at the (P0.01) level of probability.

Table 1: Chemical characteristics of fresh Mandarin fruit.

Chemical parameters	Vitamin C	Thiamin	Riboflavin	Niacin	Calories	Protein	Carbohydrate	Fiber	Sugar
Observations	29.1 mg/100 g	0.06 mg	0.04 mg	0.41 mg	47 cal	1g	12g	2g	9g

Table 2: Interaction effect of different combination of sugar (g) and pectin (g) on total soluble solid, pH and Moisture content on Storage life of mandarin jam.

Treatment Combination	T.S.S. (°B) Storage in Days				pH Storage in Days				Moisture (%) Storage in Days			
	0 Days	30 Days	60 Days	90 Days	0 Days	30 Days	60 Days	90 Days	0 Days	30 Days	60 Days	90 Days
S_1P_1	70.20	70.30	69.60	68.00	2.70	2.70	2.62	2.63	35.67	34.67	34.33	36.00
S_1P_2	70.23	67.23	69.97	72.33	2.73	2.71	2.62	2.61	35.00	34.67	33.33	32.00
S_1P_3	70.33	69.33	71.33	73.33	2.73	2.71	2.63	2.62	34.33	33.33	32.00	30.00
S_2P_1	70.40	68.47	70.00	74.03	2.74	2.73	2.64	2.63	33.33	33.00	31.67	30.67
S_2P_2	70.49	69.17	72.03	75.13	2.76	2.73	2.63	2.62	32.67	32.67	31.67	30.67
S_2P_3	70.50	69.33	71.33	74.00	2.79	2.74	2.66	2.65	31.00	30.67	29.67	28.33
S_3P_1	70.55	71.17	73.03	75.70	2.85	2.84	2.84	2.83	30.33	30.33	30.33	30.00
S_3P_2	70.60	72.27	74.03	75.17	2.85	2.85	2.85	2.82	27.67	26.67	25.00	24.33
S_3P_3	70.60	72.97	74.03	75.93	2.86	2.85	2.85	2.84	27.98	27.00	24.00	22.33
S_4P_1	70.65	73.17	75.03	76.17	2.85	2.85	2.84	2.82	26.00	26.00	25.00	23.33
S_4P_2	70.70	73.70	76.13	77.23	2.85	2.85	2.84	2.83	25.00	24.67	24.33	23.33
S_4P_3	70.81	74.63	76.07	77.93	2.85	2.85	2.84	2.82	24.33	23.67	23.00	21.67
S_5P_1	70.85	75.03	77.33	80.00	2.85	2.82	2.81	2.81	22.67	22.67	22.33	21.33
S_5P_2	70.90	75.50	78.07	80.67	2.84	2.82	2.82	2.82	22.33	22.33	21.67	21.00
S_5P_3	70.95	76.30	78.70	81.17	2.85	2.83	2.83	2.83	20.67	20.67	20.00	19.67
S_6P_1	70.98	76.03	79.00	81.67	2.84	2.84	2.83	2.82	18.00	17.67	17.00	16.33
S_6P_2	70.98	76.10	79.83	81.70	2.84	2.84	2.83	2.81	17.67	16.67	16.33	15.33
S_6P_3	70.99	76.93	80.00	82.67	2.84	2.83	2.83	2.81	17.00	16.33	15.67	14.67
F – test	Sig	Sig	Sig	Sig	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.E(m)±	0.44	0.31	0.32	0.52	0.02	0.01	0.03	0.04	0.78	0.69	1.03	0.76
CD at 1%	1.19	0.41	0.87	1.48	0.05	0.03	0.07	0.06	2.12	1.89	2.81	1.86

All values are mean± SEM of three replicates.

The test values along the same column carrying different superscripts for each composition contents are significantly different ($p<0.05$) within days.

S1P1(650 g Sugar), S1P2 (650 g Sugar: 2 g Pectin), S1P3(650 g Sugar:4 g Pectin), S2P1(750 g Sugar), S2P2(750 g Sugar:2 g Pectin), S2P3 (750 g Sugar:4 g Pectin), S3P1 (850 g Sugar), S3P2 (850 g Sugar:2 g Pectin), S3P3(850 g Sugar:4 g Pectin), S4P1 (950 g Sugar), S4P2 (950 g Sugar:2 g Pectin), S4P3 (950 g Sugar:4 g Pectin), S5P1 (1050 g Sugar), S5P2(1050 g Sugar:2 g Pectin), S5P3 (1050 g Sugar:4 g Pectin), S6P1 (1150 g Sugar), S6P2 (1150 g Sugar:2 g Pectin), S6P3 (1150 g Sugar:4 g Pectin.

Table 3: Interaction effect of different sugar and pectin combination on Dry matter content and Titrable acidity on Storage of mandarin jam.

Treatment Combination	Dry Matter (%) Storage in Days				Titrable Acidity (%) Storage in Days			
	0 Days	30 Days	60 Days	90 Days	0 Days	30 Days	60 Days	90 Days
S_1P_1	64.00	64.33	64.67	63.67	0.23	0.23	0.22	0.21
S_1P_2	64.33	64.67	65.33	66.00	0.24	0.24	0.28	0.29
S_1P_3	66.33	66.67	66.67	68.00	0.24	0.24	0.26	0.29
S_2P_1	68.00	68.33	68.33	69.00	0.22	0.22	0.27	0.28
S_2P_2	68.67	69.00	69.33	69.67	0.22	0.22	0.27	0.28
S_2P_3	70.00	70.33	71.00	71.67	0.21	0.21	0.25	0.27
S_3P_1	70.33	71.00	71.33	72.00	0.21	0.21	0.25	0.26
S_3P_2	71.67	72.00	72.00	72.33	0.20	0.20	0.26	0.27
S_3P_3	72.00	73.00	73.33	74.00	0.19	0.20	0.25	0.25
S_4P_1	74.00	74.67	75.33	76.00	0.19	0.20	0.25	0.25
S_4P_2	75.67	75.67	76.33	76.33	0.18	0.20	0.24	0.25
S_4P_3	76.00	76.33	77.00	77.33	0.18	0.19	0.24	0.24
S_5P_1	78.00	78.00	78.33	78.33	0.17	0.19	0.23	0.24
S_5P_2	78.00	78.67	79.00	79.00	0.17	0.19	0.22	0.22
S_5P_3	80.33	81.00	81.33	81.67	0.16	0.18	0.22	0.22
S_6P_1	82.33	83.00	83.67	84.67	0.16	0.18	0.21	0.21
S_6P_2	82.67	83.33	84.00	85.00	0.17	0.18	0.21	0.21
S_6P_3	84.33	85.00	86.00	86.00	0.15	0.15	0.16	0.17
F – test	Sig	Sig	Sig	Sig	Sig	NS	Sig	Sig
S.E(m)±	0.43	0.69	1.03	0.80	0.05	0.06	0.03	0.08
CD at 1%	1.17	1.89	2.82	2.19	0.14	-	0.07	0.21

All values are mean± SEM of three replicates.

The test values along the same column carrying different superscripts for each composition contents are significantly different ($p<0.05$) within days. S1P1(650 g Sugar), S1P2 (650 g Sugar: 2 g Pectin), S1P3(650 g Sugar:4 g Pectin), S2P1(750 g Sugar), S2P2 (750 g Sugar:2 g Pectin), S2P3(750 g Sugar:4 g Pectin), S3P1 (850 g Sugar), S3P2(850 g Sugar:2 g Pectin), S3P3 (850 g Sugar:4 g Pectin), S4P1 (950 g Sugar), S4P2 (950 g Sugar:2 g Pectin), S4P3 (950 g Sugar:4 g Pectin), S5P1(1050 g Sugar), S5P2(1050 g Sugar:2 g Pectin), S5P3 (1050 g Sugar:4 g Pectin), S6P1 (1150g Sugar), S6P2 (1150 g Sugar:2 g Pectin), S6P3(1150 g Sugar:4 g Pectin

Conclusion

TSS content of jam increased with increase in sugar and pectin level at 0 days of storage. Maximum TSS was obtained in S_3P_2 combination of sugar 850 g and pectin 2 g in jam. Similar trend was found in jam stored at 30, 60 and 90 days.

pH of mandarin jam increased with increasing sugar and pectin level. At 0 days maximum pH was recorded in S_3P_3 (850 g sugar and 4 g pectin). Similar trend was found in jam at 30, 60 and 90 days of storage.

Moisture content of jam decreased with increasing the sugar and pectin level at storage of 0 days, except the treatment S_1P_1, S_1P_2 and S1P3. Minimum moisture content was recorded in treatment S_6P_3 (1150 g sugar and 4 g pectin) which is at par with S_6P_2. Similar trend was recorded in storage of 30, 60 and 90 days.

Dry matter content of mandarin jam increased with increasing sugar and pectin levels. Maximum dry matter content recorded in S_6P_3 (1150 g sugar and 4 g pectin) at 0 days of storage. Same trend noticed in storage of 30, 60 and 90 days.

Titrable acidity of jam was decreased with increasing sugar and pectin levels. Maximum titrable acidity was found in treatment S_1P_2 (650 g sugar and 2 g pectin) and S_1P_3 (650 g sugar and 4 g pectin). While minimum titrable acidity recorded in treatment S_6P_3 (1150 g sugar and 4 g pectin). Similar trend recorded at storage of 30, 60 and 90 days.

Acknowledgement

This study was made possible with the help of Post-Harvest Technology Laboratory, Department of Horticulture, College of Agriculture, Nagpur, PDKV, Akola by providing necessary laboratory facilities for the experiment and my guide for their support and guidelines in conducting the experiment.

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