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Physico-chemical assessment of underutilized Tendu (*Diospyros melanoxylon* Roxb.) Fruit Jam

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Abstract
The experiment was carried out to "Physico-chemical Assessment of Underutilized Tendu (*Diospyros melanoxylon* Roxb.) Fruit Jam" during the year 2022 in the Horticultural Processing Laboratory, College of Agriculture, Indira Gandhi Agricultural University, Raipur (C.G.). All the samples were packed in pre-sterilized glass jars and were analysed for various physico-chemical parameters (total sugar, reducing sugar, non-reducing sugar, acidity, ascorbic acid, pH and TSS) during 6 months of storage under refrigerated conditions. The treatments were T_1 (100% Tendu pulp), T_2 (75% Tendu pulp), T_3 (50% Tendu pulp), T_4 (25% Tendu pulp + 75% Apple pulp), and T_5 (50% Tendu pulp + 50% Apple pulp). The results revealed that there was an increase in total sugar content, reducing sugars, acidity, TSS while, a decreasing trend was recorded in non-reducing sugars, ascorbic acid and pH during storage period of six months after manufacturing.

Keywords: Underutilized fruit, Tendu, Jam, physico-chemical, storage condition

Introduction
Tendu or Kendu tree (*Diospyros melanoxylon* Roxb.) belonging to Family Ebenaceae, which is endemic to Indian Sub – continent. It is drought and frost hardy but sensitive to water logging. It is also one of the important lesser-known fruits which is available during summer in the local market of Madhya Pradesh, Chhattisgarh, Jharkhand and Orissa state was recognized as an underutilized fruit. Tendu grows naturally and the fruit's maturing time is between March and April. The generic name is derived from the Greek 'dios' (divine) and 'pyros' (fruit), referring to the excellent fruit of the genus. The specific name is Greek and means 'dark wood'. The fruit is round in shape with 1.25 inch in diameter with sweet taste when fully matured. Fruit contains 4 to 6 seeds. Tendu fruit is used as a cooling astringent. Foresters use this fruit to resist heat to consume orally. Tribes use this fruit to increase energy and efficiency, so they can work long hours without fatigue. The fruit pulp is sweet in taste and have pleasant flavor. Fruit weight maximum 15-18 g per fruit. The fruit is highly nutritive and rich source of phenols and fibers. Its fruit pulp is yellow, glutinous, soft, sweet and slightly astringent. These fruits are rich in sugars, proteins, fiber and vitamin C. Further, to presence of several benevolent phytochemicals such as ß–Carotene, terpenoids, flavonoids saponin and tannin in the fruit add advantages to its nutritive value (Maridass, 2010) [6].
This plant has been well documented in ayurveda and Unani texts and also ethnobotanically for its multi-purpose use in different diseases including diarrhea, cholera, cramps, pneumonia, syphilis, tumors etc. They can be an instant source of energy in a compact form. The most important thing about this fruit is that it is easily available in local market and tribal areas and have a very low price in market around 10-15 Rs/Kg. It is 100% organic as fruit is found in forest areas. Tendu fruit are available for a very short period of time in a bulk quantity so to make it available round the year it can be processed into different products. Looking to the nutritional and medicinal value of tendu fruit it can be used for making various processed products like RTS, Nectar, Jam, Ice cream etc.

Materials and Methods
The present experiment was conducted at Horticulture processing laboratory, College of Raipur, IGKV, Raipur during the year 2022. The experiment was carried out with 5 treatments: T_1, T_2, T_3, T_4, T_5 with 3 replications under Completely Randomized Design (CRD).

The prepared product i.e., Tendu Jam was stored under refrigerated condition and were analysed at an interval of 30 days upto 180 days of storage duration for various physico-chemical parameters like total sugar, reducing sugar, non-reducing sugar, ascorbic acid, acidity. Total soluble solid, pH.

Results and Discussion

Physico-chemical analysis of Jam

Total sugars (%)

The Tendu Fruit Jam was analysed for total sugars during 6 months of storage period. The total sugars values increased in T_1 (100% Tendu pulp) (21.57 to 27.66), T_2 (31.07 to 38.46), T_3 (50% Tendu pulp) (25.55 to 30.69), T_4 (25% Tendu pulp + 75% Apple pulp) (29.54 to 33.30), T_5 (50% Tendu pulp + 50% Apple pulp) (27.62 to 30.71) days of the storage intervals. Total sugar mean value recorded highest (35.40%) in treatment T_2 (75% Tendu pulp) followed by (31.09%) treatment T_4 (25% Tendu pulp + 75% Apple pulp) and (29.28%) treatment T_5 (50% Tendu pulp + 50% Apple pulp) and minimum value recorded (24.54%) in T_1 (100% Tendu pulp) treatment (Table 1). The total sugar per cent increases continuously with the increase in storage period due to the conversion of polysaccharides like starch and pectin into simple sugar. Similar findings were also recorded by Saket *et al.* (2018) [10] in which they concluded that the total sugar per cent of custard apple jam was influenced by the storage period.

Table 1: Effect of storage duration on total sugar (%) of Tendu Jam

Treatments	Storage period (days)							
	0	30	60	90	120	150	180	Mean
T_1	21.57	22.44	23.83	24.92	25.70	25.67	27.66	24.54
T_2	31.07	33.31	35.29	35.89	36.50	37.26	38.46	35.40
T_3	25.55	25.07	25.98	27.48	28.12	28.98	30.69	27.41
T_4	29.54	28.51	30.86	31.21	32.23	32.02	33.30	31.09
T_5	27.62	27.91	28.38	28.67	30.17	31.50	30.71	29.28
S.Em±	0.146	0.448	0.313	0.247	0.321	0.28	0.284	-
CD at 5%	0.443	1.363	0.953	0.75	0.976	0.852	0.864	-

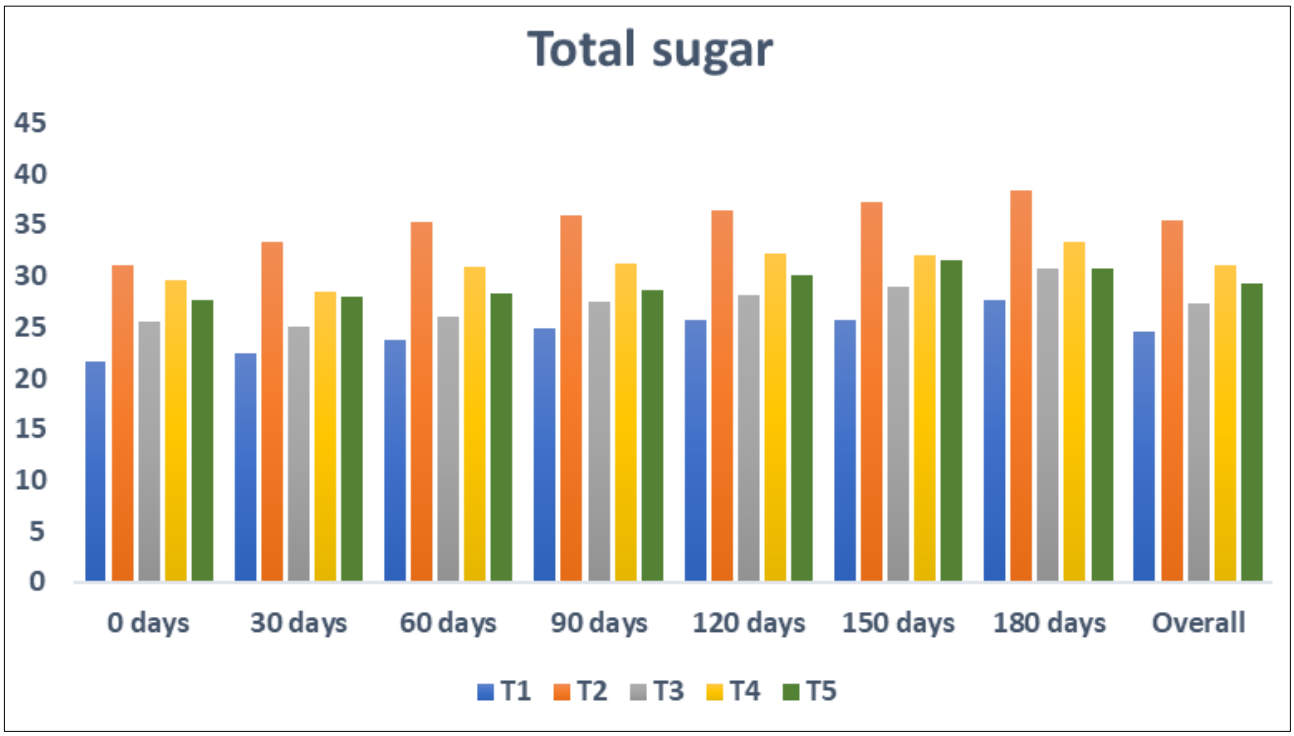

Fig 1: Total sugar (%) of Tendu jam

Reducing sugars (%)

It was analysed that reducing sugar increased in T_1 (100% Tendu pulp) (4.34 to 7.34), T_2 (75% Tendu pulp) (4.15 to 7.45), T_3 (50% Tendu pulp) (6.33 to 7.61), T_4 (25% Tendu pulp + 75% Apple pulp) (3.91 to 7.32), T_5 (50% Tendu pulp + 50% Apple pulp) (4.88 to 6.73) days of the storage intervals. Reducing sugar mean value recorded highest (7.20%) with the treatment T_3 (50% Tendu pulp) followed by (6.34%) treatment T_2 (75% Tendu pulp) and (6.21%) treatment T_1 (100% Tendu pulp) and minimum recorded for (5.63%) in treatment T_4 (25% Tendu + 75% Apple pulp) (Table 2). The reducing sugar percent increases continuously with the increase in storage period might be due to the inversion of sucrose to reducing sugar (glucose + fructose) due to acid and high temperature during storage. The results similar by Muhammad *et al.* (2008) [7] were similar with the present experiment on diet apple Jam was influenced by the storage period.

Table 2: Effect of storage duration on reducing sugar (%) of Tendu Jam

	Storage period (days)							
Treatments	**0**	**30**	**60**	**90**	**120**	**150**	**180**	**mean**
T_1	4.34	5.16	5.90	6.39	7.10	7.26	7.34	6.21
T_2	4.15	5.12	6.40	6.75	7.13	7.34	7.45	6.34
T_3	6.33	6.80	7.36	7.34	7.40	7.53	7.61	7.20
T_4	3.91	4.09	4.85	5.56	6.49	7.23	7.32	5.63
T_5	4.88	5.06	5.65	6.27	6.29	6.32	6.73	5.88
S.Em±	0.019	0.027	0.025	0.063	0.031	0.016	0.019	-
CD at 5%	0.059	0.082	0.076	0.193	0.094	0.048	0.058	-

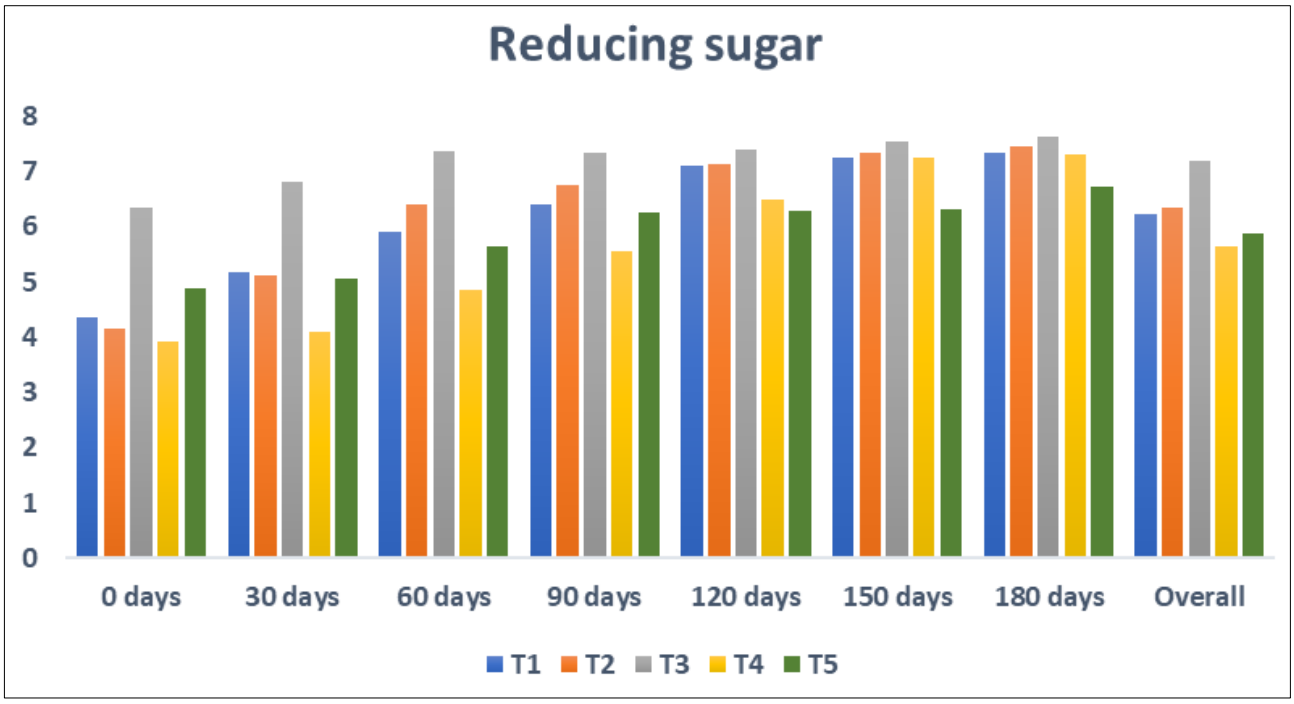

Fig 2: Reducing sugar (%) of Tendu jam

Non reducing sugars

The Tendu Fruit Jam was analysed for non- reducing sugars during 6 months of storage period. The non-reducing sugars values decreased in T_1 (100% Tendu pulp) (20.31 to 17.22), T_2 (75% Tendu pulp) (31.00 to 26.91), T_3 (50% Tendu pulp) (23.07 to 18.27), T_4 (25% Tendu pulp + 75% Apple pulp) (26.00 to 24.42), T_5 (50% Tendu pulp + 50% Apple pulp) (25.18 to 22.40) days of the storage intervals. Maximum (29.06%) with the treatment T_2 (75% Tendu pulp) followed by T_4 (25% Tendu pulp + 75% Apple pulp) (25.46%), T_5 (50% Tendu pulp + 50% Apple pulp) (23.39%) and T_3 (50% Tendu pulp) (20.21%). While, minimum was observed (18.32%) with the treatment T_1 (100% Tendu pulp) (Table 3). The non-reducing sugar per cent decreases continuously with the increase in storage period due to the sucrose content of the fruit in Jam converted to glucose and fructose during storage period. The present findings were similar with Khan *et al.* (2012) [5]. He observed that the non-reducing sugar of strawberry Jam was influenced by the storage period.

Table 3: Effect of storage duration on non-reducing sugar (%) of Tendu Jam

Treatments	**Storage period (days)**							
T	**0**	**30**	**60**	**90**	**120**	**150**	**180**	**mean**
T_1	20.31	18.6	18.53	18.41	17.93	17.28	17.22	18.32
T_2	31.00	29.92	29.15	29.36	28.89	28.18	26.91	29.06
T_3	23.07	21.45	20.13	20.71	19.21	18.61	18.27	20.21
T_4	26.00	25.98	25.63	25.73	25.65	24.78	24.42	25.46
T_5	25.18	23.98	22.84	23.88	22.74	22.73	22.40	23.39
S.Em±	0.336	0.221	0.257	0.339	0.279	0.272	0.423	-
CD at 5%	1.021	0.673	0.783	1.03	0.848	0.827	1.286	-

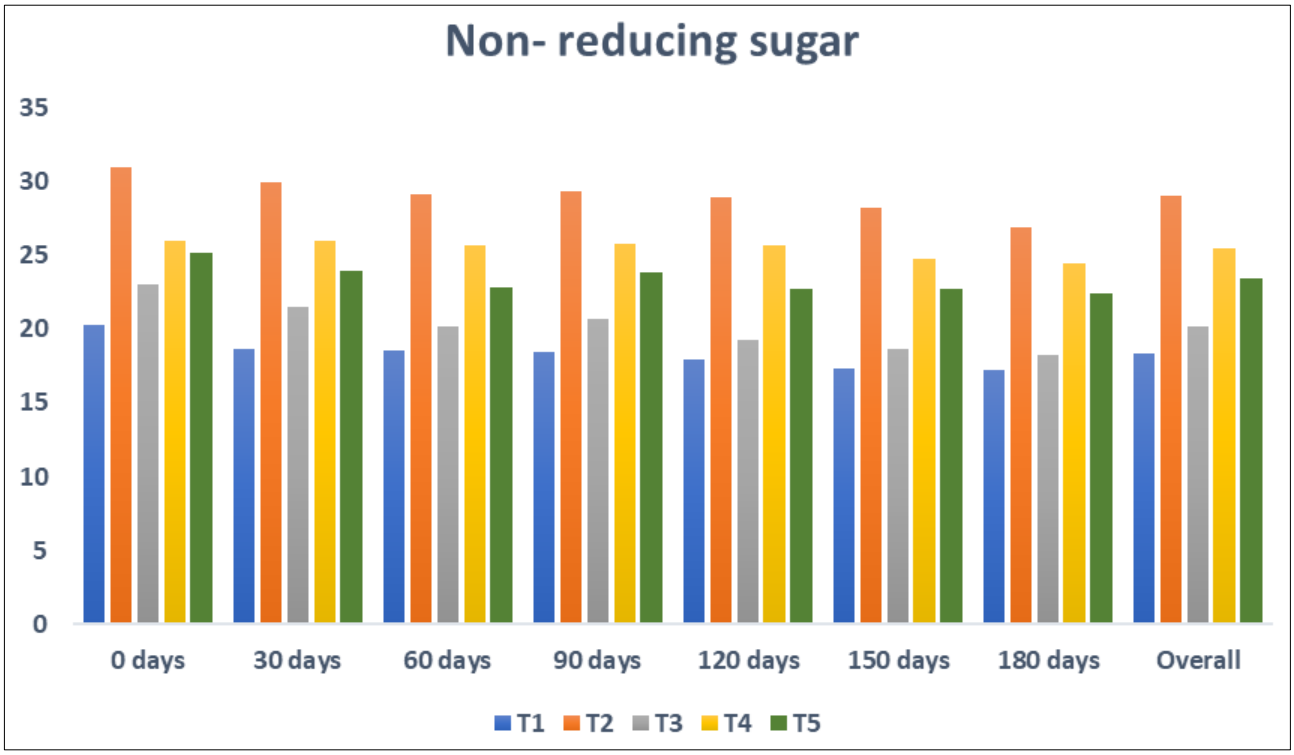

Fig 3: Non-reducing sugar (%) of Tendu jam

Acidity (%)

The Tendu Fruit Jam was analysed for acidity during 6 months of storage period. The acidity values increased in T_1 (100% Tendu pulp) (0.21 to 0.53), T_2 (75% Tendu pulp) (0.31 to 0.71), T_3 (50% Tendu pulp) (0.26 to 0.67), T_4 (25% Tendu pulp + 75% Apple pulp) (0.34 to 0.84), T_5 (50% Tendu pulp + 50% Apple pulp) (0.17 to 0.44) days of the storage intervals. The acidity mean value recorded highest for (0.60) T_4 (25% Tendu pulp + 75% Apple pulp) followed by (0.49) T_2 (75% Tendu pulp) and (0.42) T_3 (50% Tendu pulp) and minimum value recorded for (0.31) T_5 treatment (50% Tendu pulp + 50% Apple pulp) (table 4). The acidity percent increases continuously during storage period. The increase in acidity of carrot and apple blended Jam might be due to the hydrolysis of pectin and degradation of ascorbic acid. Similar conclusions were drawn by Ullah *et al.* (2018) [11] he also concluded that the acidity percent of carrot and apple blended Jam was influenced with the storage period.

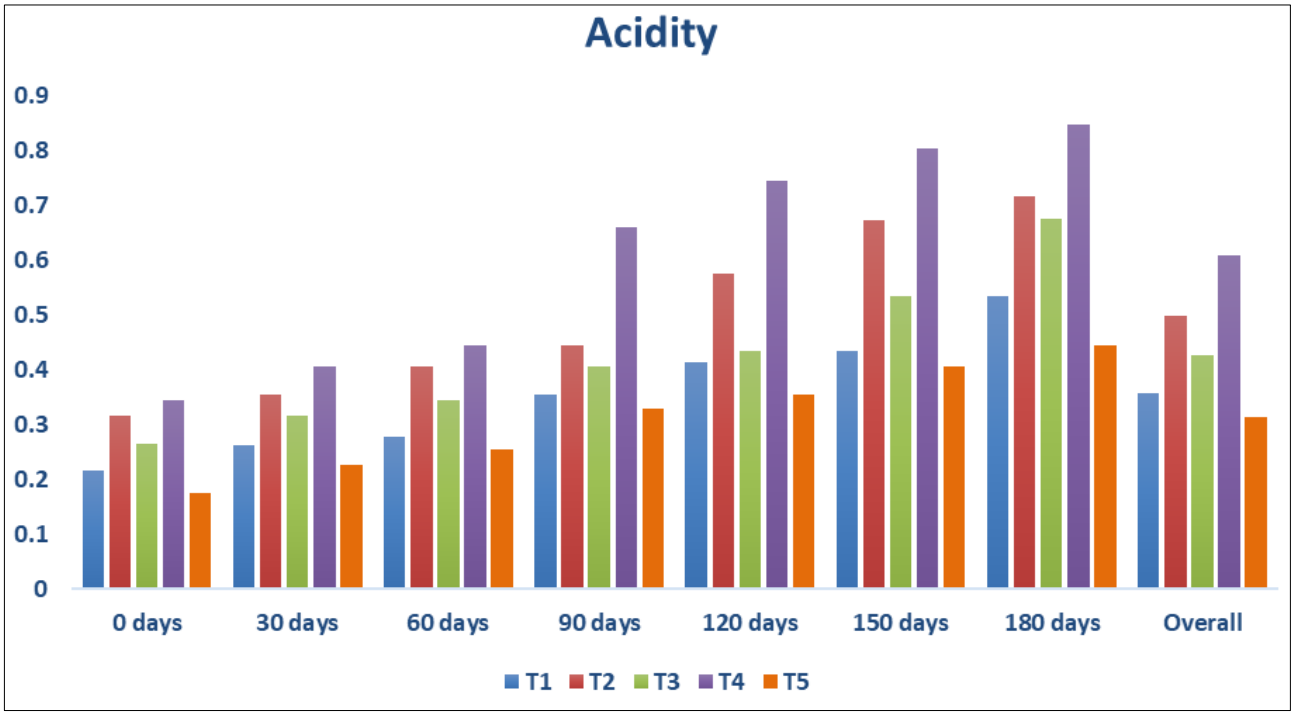

Fig 4: Acidity (%) of Tendu jam

Table 4: Effect of storage duration on acidity (%) of Tendu Jam

Treatments	Storage period (days)							
	0	30	60	90	120	150	180	mean
T_1	0.21	0.26	0.27	0.35	0.41	0.43	0.53	0.35
T_2	0.31	0.35	0.40	0.44	0.57	0.67	0.71	0.49
T_3	0.26	0.31	0.34	0.40	0.43	0.53	0.67	0.42
T_4	0.34	0.40	0.44	0.66	0.74	0.80	0.84	0.60
T_5	0.17	0.22	0.25	0.32	0.35	0.40	0.44	0.31
S.Em±	0.006	0.007	0.008	0.01	0.007	0.007	0.0081	-
CD at 5%	0.02	0.021	0.024	0.031	0.021	0.02	0.025	-

Ascorbic acid (mg/100 g)

The Tendu Fruit Jam was analysed for ascorbic acid during 6 months of storage period. The ascorbic acid values decreased in T_1 (100% Tendu pulp) (45.4 to 36.25), T_2 (75% Tendu pulp) (49.75 to 37.3), T_3 (50% Tendu pulp) (46.6 to 35.32), T_4 (25% Tendu pulp + 75% Apple pulp) (43.45 to 34.55), T_5 (50% Tendu pulp + 50% Apple pulp) (47.52 to 34.65) days of the storage intervals. The ascorbic acid value recorded highest for (42.08 mg) T_2 (75% Tendu pulp) followed by (40.30 mg) treatment T_1 (100% Tendu pulp) and (40.21 mg) treatment T_5 (50% Tendu pulp + 50% Apple pulp). and minimum value recorded for (38.33 mg) T_4 treatment (25% Tendu pulp + 75% Apple pulp). (Table 5). its degradation due to dehydro-ascorbic acid or furfural or hydroxyl methyl furfural at ambient condition. Parihar *et al*. (2018) [8] examined that the ascorbic acid content decreasing during storage in custard apple Jam.

Table 5: Effect of storage condition on ascorbic acid (mg/100 gm) of Tendu jam

Treatments	Storage period (days)							
	0	30	60	90	120	150	180	mean
T_1	45.4	43.62	41.45	39.55	38.57	37.30	36.25	40.30
T_2	49.75	45.60	42.52	41.52	39.45	38.47	37.3	42.08
T_3	46.60	42.65	39.52	38.70	37.42	36.50	35.32	39.53
T_4	43.45	41.47	39.52	37.37	36.65	35.30	34.55	38.33
T_5	47.52	42.52	41.52	40.50	39.25	35.52	34.65	40.21
S.Em±	0.119	0.15	0.152	0.124	0.122	0.131	0.118	-
CD at 5%	0.362	0.457	0.461	0.378	0.37	0.4	0.359	-

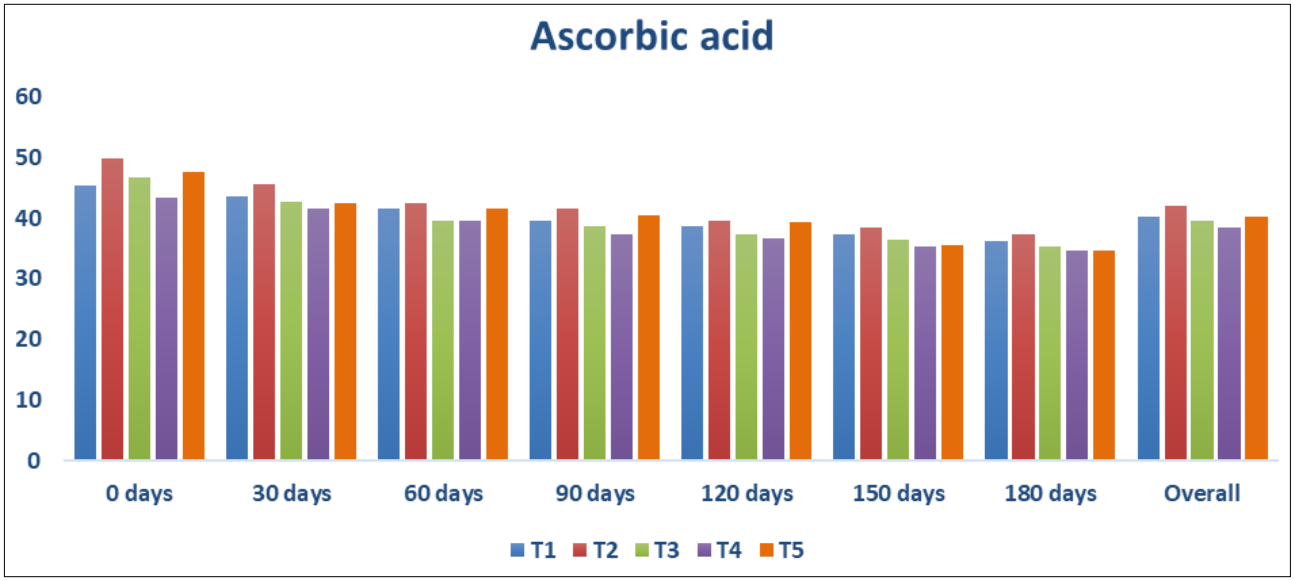

Fig 5: Ascorbic acid (mg/100 gm) of Tendu jam

Total soluble solid (° Brix)

The Tendu Fruit Jam was analysed for TSS during 6 months of storage period. The TSS values increased in T_1 (100% Tendu pulp) (67.50 to 67.83), T_2 (75% Tendu pulp) (67.23 to 68.22), T_3 (50% Tendu pulp) (67.43 to 68.16), T_4 (25% Tendu pulp + 75% Apple pulp) (68.32 to 69.11), T_5 (50% Tendu pulp + 50% Apple pulp) (68.35 to 69.20) days of the storage intervals. The total soluble solids content in Tendu Fruit Jam was recorded the highest (68.79^{0}B) in treatment T_5 (50% Tendu pulp + 50% Apple pulp) followed by (68.56^{o}B) treatment T_4 (25% Tendu pulp + 75% Apple pulp). and (67.76 °B) treatment T_3 (50% Tendu pulp). and minimum value was recorded (67.59 °B) in treatment T_2 (75% Tendu pulp) (table 6). The increase in TSS contents of the Tendu fruit jam might be due to the solubilization of jam constituents during storage. Similar with Muhammad *et al.* (2008) [7].

Table 6: Effect of storage duration on total soluble solid of Tendu Jam

Treatments	Storage period (days)							
	0	30	60	90	120	150	180	mean
T_1	67.50	67.52	67.53	67.57	67.71	67.74	67.83	67.62
T_2	67.23	67.26	67.34	67.52	67.73	67.83	68.22	67.59
T_3	67.43	67.52	67.63	67.63	67.82	68.14	68.16	67.76
T_4	68.32	68.36	68.42	68.43	68.55	68.72	69.11	68.56
T_5	68.35	68.43	68.63	68.74	69.04	69.16	69.20	68.79
S.Em±	0.059	0.052	0.05	0.056	0.01	0.032	0.043	-
CD at 5%	0.179	0.158	0.152	0.172	0.032	0.098	0.131	-

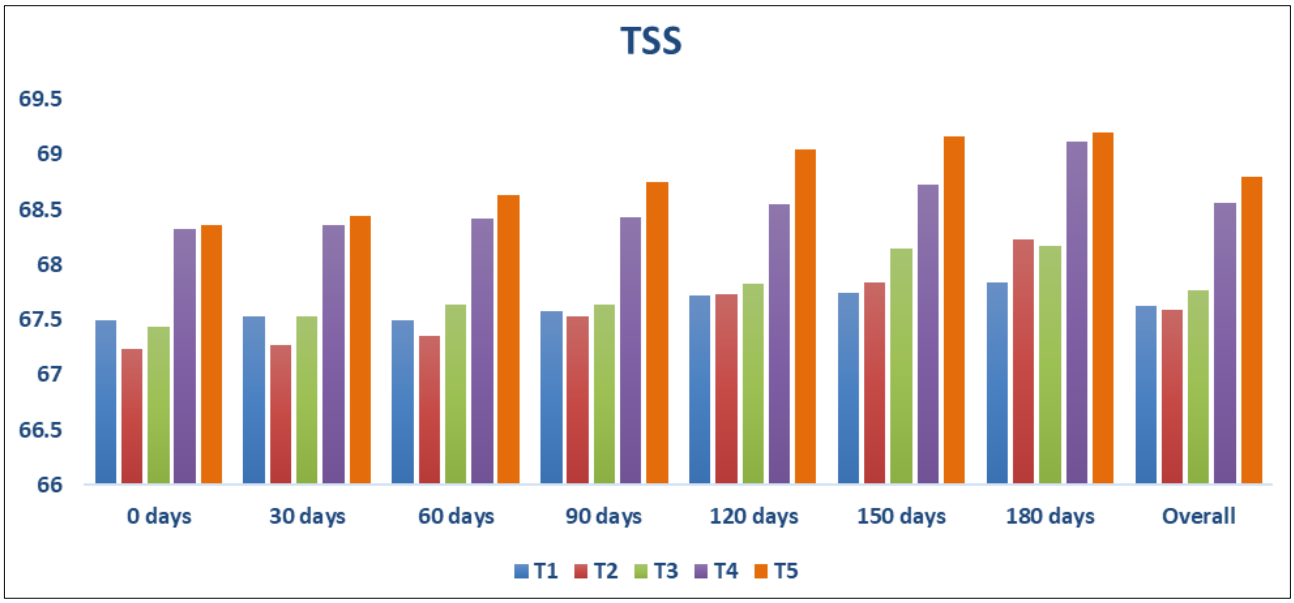

Fig 6: Total soluble solid (°Brix) of Tendu Jam

pH

The Tendu Fruit Jam was analysed for pH during 6 months of storage period. The pH values decreased in T_1 (100% Tendu pulp) (5.25 to 3.70), T_2 (75% Tendu pulp) (4.44 to 2.93), T_3 (50% Tendu pulp) (4.07 to 3.63), T_4 (25% Tendu pulp + 75% Apple pulp) (4.57 to 3.27), T_5 (50% Tendu pulp + 50% Apple pulp) (4.03 to 3.16) days of the storage intervals. For treatments maximum mean values were recorded in T_1 (100% Tendu pulp) (4.50), significantly followed by the treatment T_4 (25% Tendu pulp + 75% Apple pulp) having (4.04), T_3 (50% Tendu pulp) (3.85), T5 (50% Tendu pulp + 50% Apple pulp) (3.61) value, while the treatment T_2 (75% Tendu pulp) recorded the minimum pH value 3.44 (table 7). The decreasing trend of pH in tendu jam might be due to increasing trend of acidity during storage of jam. In Similar findings were also observed by Rahman *et al*. (2018) [9] in which they concluded that the pH level of strawberry Jam decreased slowly as the storage period increases.

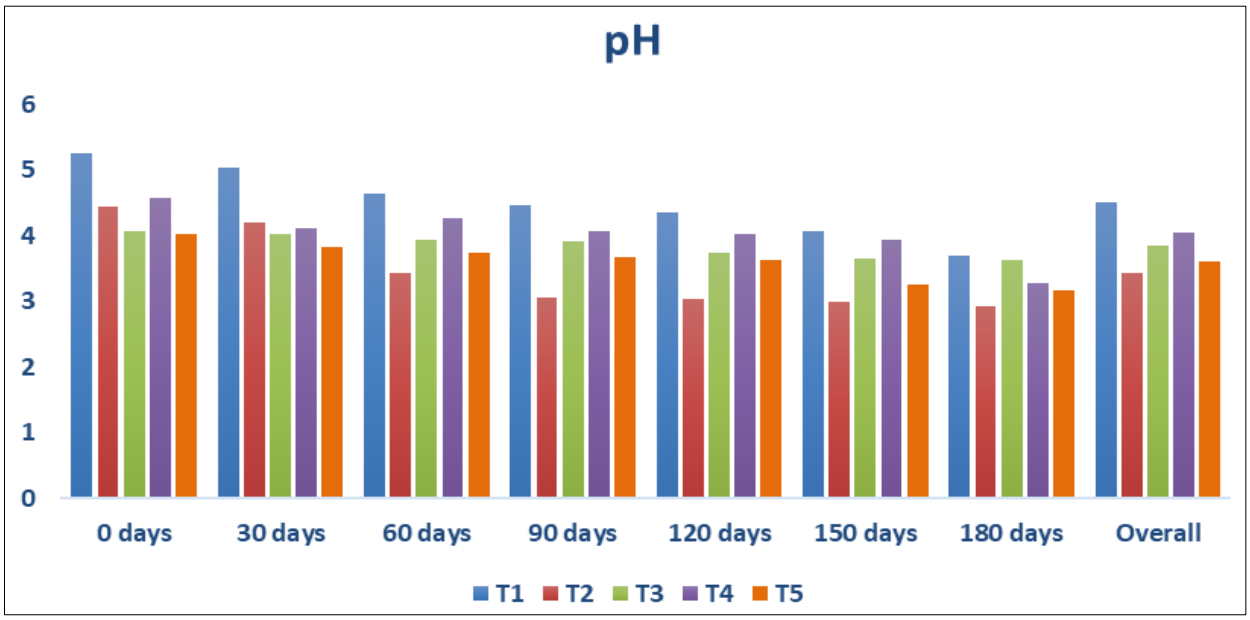

Fig 7: pH of Tendu Jam

Table 7: Effect of storage duration on pH of Tendu Jam

Treatments	Storage period (days)							
0	**30**	**60**	**90**	**120**	**150**	**180**	**Mean**	**0**
T_1	5.25	5.05	4.65	4.47	4.35	4.07	3.70	4.50
T_2	4.44	4.19	3.43	3.06	3.03	2.99	2.93	3.44
T_3	4.07	4.03	3.94	3.92	3.73	3.65	3.63	3.85
T_4	4.57	4.12	4.27	4.06	4.03	3.93	3.27	4.04
T_5	4.03	3.82	3.73	3.68	3.62	3.24	3.16	3.61
S.Em±	0.08	0.05	0.049	0.041	0.055	0.043	0.049	-
CD at 5%	0.243	0.152	0.149	0.124	0.167	0.132	0.148	-

Conclusion

In this investigation, it was discovered that high-quality Tendu Fruit Jam could be produced and kept refrigerated for 180 days with just minor quality alterations. Additionally, this fruit has some nutritional and therapeutic significance. When the finished product with processing, value-adding and innovative packaging is made available on the market.

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