www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 3087-3094

www.thepharmajournal.com
Received: 07-09-2021
Accepted: 16-10-2021

Sreedevi MS
Department of Food Process Engineering, AECRI, TNAU, Coimbatore, Tamil Nadu, India

Rajkumar P
Department of Food Process Engineering, AECRI, TNAU, Coimbatore, Tamil Nadu, India

Palanimuthu V
AICRP on PHET, GKVK Campus, UAS, Bengaluru, Karnataka, India

Geethalakshmi I
Department of Food Process Engineering, AECRI, TNAU, Coimbatore, Tamil Nadu, India

Ganapathy S
Department of Food Process Engineering, AECRI, TNAU, Coimbatore, Tamil Nadu, India

Surendrakumar A
Department of Farm Machinery & Power Engineering, AECRI, TNAU, Coimbatore, Tamilnadu, India

Corresponding Author:
Sreedevi MS
Department of Food Process Engineering, AECRI, TNAU, Coimbatore, Tamil Nadu, India

Influence of storage condition and packaging on bio-chemical traits of tamarind pulp

Sreedevi MS, Rajkumar P, Palanimuthu V, Geethalakshmi I, Ganapathy S and Surendrakumar A

Abstract
The mechanically processed tamarind fruit pulp was packed, sealed and stored for a period of six months to analyze the influence of various storage conditions, treatments and interaction effect on the quality of tamarind pulp. During the study changes in bio-chemical characteristics were analyzed at 15 days interval during 180 days of storage. It was observed that the moisture content, titrable acidity and reducing sugar increased in all packages while pH and ascorbic acid decreased irrespective of storage conditions treatments employed and storage period. The extent of the increase was recorded less when pulp with package compared to pulp without any package in refrigerated conditions. Storage of tamarind pulp in MPP pouches at refrigerated condition was found favorable to preserve the pulp quality.

Keywords: Pulp, packaging materials, quality, storage condition

1. Introduction
Tamarindus indica L., is a multipurpose long-lived tropical fruit tree primarily used for its fruits, which are eaten fresh or processed, used for seasoning as a. Tamarind is indigenous to tropical Central Africa and is a very adaptable species, preferring semi-arid areas and woody grasslands, tolerating salty conditions, coastal winds and even monsoon climates. The tamarind tree was planted as an avenue by Sher Shah Suri (1540–45), while renovating and repairing an ancient road, so that the travelers could take rest in the shade of the tree and have the pulp of tamarind fruit as refreshment.
Currently a higher percentage of tamarind fruit produced is geared to domestic markets. During peak harvesting seasons, the loss is high and the fruits are sold at low price because of inadequate preservation techniques. Processing is therefore necessary to contribute toward expansion of nutritional input and market of tamarind by availing it during off-seasons. Consumers are expecting that the quality of their food has to be maintained at a high level from purchase to consumption. Therefore, possible care should be taken from harvesting to storage of pulp by maintaining favorable quality for better price and marketability. The most common problems reported for quality hazards during post harvest pulp storage are inappropriate environmental conditions and longer duration of the storage and packaging.
However, required scientific knowledge about the storage of tamarind fruit pulp is very scanty. Therefore, the main goal of the present study was to increase the shelf-life pulp and to assess the bio-chemical compositional changes associated with storage under different storage conditions during the course of storage study.

2. Materials and Methods
The materials used and methods adopted for conducting experiments pertaining to the object of the research work are as detailed below.

2.1 Material and preparation of sample
Local variety tamarind fruits are procured from the Botanical Garden, UAS, GKVK, Bengaluru were used for the study. The tamarind fruits were mechanically processed as dissipated in Fig.1. The pulp obtained was packed, sealed and were stored at C1: ambient (27 ± 5 °C) and C2: refrigerated (4 ± 2 °C) storage conditions for a period of six months. The different treatments (Plate.1) are T1: Control (pulp without package), T2: Pulp packed in BD (Bio Degradable) pouch, T3: Pulp packed in LDPE (Low Density Poly Ethylene) pouch, T4: Pulp packed in MPP **(**Metalized Polyester Polyethylene laminate) pouch, T5: Pulp packed in

PP (Poly Propylene) pouch, T6: Pulp packed in EVOH (Ethyl Vinyl alcohol) pouch, T7: Pulp packed in EVOH pouch with vacuum sealing, T8: Pulp packed in LDPE pouch with vacuum sealing, T9: Pulp packed in PP pouch with vacuum sealing and with triplicates. The samples drawn at 15 days interval were subjected to evaluate the bio-chemical quality parameters of tamarind pulp. The chemicals used were of analytical grade for the analysis in this study.

Plate 1: Tamarind pulp packed in different packaging materials

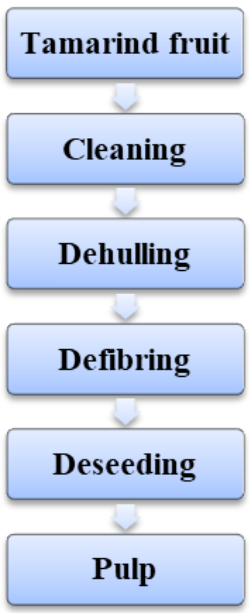

Fig 1: Flow chart for mechanical processing of tamarind pulp

2.2 Bio-chemical characteristics of tamarind pulp

Bio-chemical characteristics of tamarind pulp like moisture content, pH, TSS, titrable acidity, ascorbic acid and reducing sugar of the sample were determined according to standard methods of AOAC [2].

2.3 Statistical analysis

The experimental data was analyzed using complete randomized design with factorial concept at 0.01% significant. The main factor is storage conditions (ambient and refrigerated) and sub factor is packaging materials (BD, LDPE, MPP, PP and EVOH). The analysis included the main effects of packaging material, storage conditions, storage intervals and their interaction.

3. Results and Discussion

Extended shelf-life and high quality could provide consumer a better convenient food. Emphasing this background the present research was carried out and the findings on effect of package and storage conditions were discussed and summarized are as below:

3.1 Moisture content (%) of stored pulp

Moisture content of pulp recorded during storage period is given in Table 1. Statistical analysis demonstrated that the moisture content of pulp increased significantly after 30 days of storage. Among the storage conditions C2 (29.71%) found to be significantly superior over C1 (35.61%). Among the packaging materials employed, pulp packed in MPP pouch: T4 (21.77%) found significantly superior over all other treatments. Whereas the higher moisture content was observed in pulp without packing: T1 (48.18%). MPP pouch allowed less diffusion of water as compared to other packaging materials. Among the interaction effect C2T4 was found to be significantly better over other treatments. Significantly higher moisture content was observed in C2T1. Irrespective of storage conditions MPP pouch did not allowed much gain in moisture. C2T1 recorded significantly highest moisture content (54.27%) and the least was recorded in C2T4 (21.49%). Among the treatments, T4 found to give an extended control over spoilage. This was due to fact that the respiration rate of the pulp and permeability of selected packaging material correlated well. The results revealed that there was increase in the moisture content with lapse of storage time to a significant level and among the packaging materials, MPP and LDPE pouches recorded in this order over other and control recorded highest percent of moisture. The current conclusions are similar to [1, 8] who exposed an increase in moisture content during storage for tamarind pulp and tamarind pulp powder, respectively. The possible reason for increase in moisture content of the pulp during storage is due to the ingress of moisture through the packages which have different degree of permeability to water vapor and due to the storage and environmental conditions.

3.2 pH of stored pulp

Table 2 showed the influence of treatments and storage conditions on tamarind pulp. pH of pulp decreased significantly with irrespective of package and storage conditions after 30 days of storage. Among the storage conditions, C1 (1.46) found to be significantly superior over C2 (2.13). Among the packaging materials, T4 (2.81) performed significantly better over all other treatments. Whereas the higher pH was reduced in pulp without packing: T1 from 2.91% to 0.48% at 180 days of storage. Interaction effect of storage conditions and packaging materials found non-significant. It was observed that the pH of tamarind stored in all packages was found decreasing. The decreasing rate of pH was low at refrigerated storage as compared to

ambient condition. Pulp packed in MPP pouch and stored at refrigerated condition can control pulp quality than ambient condition. The research findings are in agreement with [7] and [10] for tamarind value added products and tamarind paste, respectively. Increase in acidity caused due to the development of acidic compound which is basic for the decline in pH. Likewise, prior writings sustain current study.

3.3 Total Soluble Solids (˚B) of stored pulp

Total soluble solids of pulp recorded in during storage are illustrated in Table 3. It is observed that the TSS of pulp upswing with storage condition and treatments. Storage conditions and treatments recorded significant differences in TSS of pulp from 45 days of storage, whereas the interactions were found significant from 120 days of storage. Least increase in TSS of pulp was observed in C2 (14.58 ˚B) storage condition, T4 (8.47 ˚B) treatment and C2T4 (8.35 ˚B) interaction during the storage period. Highest increase in TSS was observed in C1 (8.13 ˚B) storage condition, T1 (26.51 ˚B) treatment and interaction C2T1 (27.57 ˚B) among all the treatments during the storage period. Among the conditions C2 is better than C1, in treatments T4 (pulp packed in MPP pouch) is best followed by T8 (pulp packed in LDPE pouch with vacuum sealing) and T3 (pulp packed in LDPE pouch); in the interaction effects C2T4 (pulp packed in MPP pouch and stored in refrigerated storage condition) proved best followed by C1T4 (pulp packed in MPP pouch and stored in ambient storage condition) and C2T8 (pulp packed in LDPE pouch with vacuum sealing and storing in refrigerated storage condition) maintaining the quality of pulp during storage. The variation in TSS might be due to the storage conditions and variation of varieties. The current conclusions are similar for tamarind cubes [3], tamarind and plum blended squash [4] who exposed an improvement of TSS during storage time. The increase in TSS might be due to the alteration in cell wall structure and breakdown of complex carbohydrates into simple sugars during storage.

3.4. Ascorbic acid (mg) of stored pulp

Ascorbic acid (Vitamin C) is a major nutrient which signifies a quality characteristic of produce and is essential water–soluble vitamin. It was noted that ascorbic acid of pulp decreased noticeably on treatments and storage conditions (Table 4). Among the storage conditions C1 (3.35 mg) found to be significantly superior over C2 (5.88 mg) after 60 days of storage. Among the packaging materials used, T4 (7.45 mg) found significantly superior over all other treatments after 60 days of storage. Among the interaction effect there was no significant difference throughout the storage period. However, numerically least decline of ascorbic acid of pulp was recorded in C2T4 (7.28 mg) which is on par with C1T4 and C2T8. The least decrease of ascorbic acid was observed in C2T4 (7.28 mg) and highest was observed in C2T1 (0.89 mg). Similar findings were reported by [1] for tamarind pulp [4], for tamarind squash and [9] for green tamarind. Ascorbic acid is an important nutrient of natural origin and very sensitive to oxidative degradation during storage. Loss of ascorbic acid during storage may be due to catalytic degradation by ascorbate oxidase and peroxidase.

3.5 Titrable acidity (% tartaric acid) of stored pulp

Table 5 revealed influence of storage conditions and treatments on titrable acidity of pulp. It was found that the titratable acidity of pulp boost with increase in storage period in all treatments and storage conditions employed. The conversion of sugars into acids may be the possible reason. There is significant increase of titrable acidity of pulp in storage conditions; treatments and interaction effect after 30 days of storage. Among the packaging materials, titrable acidity of pulp well maintained in pulp packed and stored under refrigerated condition. The tamarind fruit is defined as the bitter sweet fruit due to its high content of tartaric acids and sugars reducing combined, it is also said that it is the acidest and sweetest fruit at the same time. The results of current study are similar to the study of [4, 8, 9] for tamarind squash, tamarind pulp power and green tamarind, respectively. The high acidity of pulp might be due to hydrolysis of pectin and degradation of acid. Rise in titrable acidity also caused by a raise in TSS of pulp.

3.6 Reducing sugars (%) of stored pulp

Reducing sugar content of pulp recorded in storage is given in Table 6. It is observed from the data that the reducing sugars of pulp increases with increase in storage period. Among the storage conditions and treatments, up to 60 days after storage, the pulp stored either in refrigerated or ambient conditions and the pulp with packaging or without packaging is found to be non-significant. From 75 days of storage of pulp, significant difference was found with respect to storage condition and the treatments. Among the interactions, up to 105 days of storage observed to be non-significant. From 120 days of storage observed significant difference with respect to storage condition and the treatments. The extent of increase was low when the pulp packed and stored under refrigerated conditions. The above results show similarity with the report of [5] for tamarind candy [6], for tamarind pulp and [10] for tamarind paste. The increase or decrease in sugar content might be due to slow hydrolysis of polysaccharides, acids and pectic substances into simpler substances like sugar. Increase in reducing sugar is because of transfer of sucrose to glucose and fructose, due to temperature and acidic condition.

Table 1: Effect of package and storage conditions on moisture content (%) of stored pulp

Treatments	Storage interval (Days)												
	0	15	30	45	60	75	90	105	120	135	150	165	180
A. Storage conditions (Ambient and Refrigerated)													
C1	21.03	22.23	23.38	24.18	25.34	26.83	28.01	29.19	30.35	31.55	32.86	34.24	35.61
C2	21.03	21.68	22.28	22.82	23.81	24.32	25.04	25.77	26.53	27.33	28.12	28.92	29.71
F-value	NS	NS	NS	**	**	**	**	**	**	**	**	**	**
S.Em±	0.29	0.19	0.29	0.29	0.40	0.28	0.38	0.34	0.21	0.19	0.21	0.34	0.19
CD at 1%	-	-	-	1.11	1.53	1.06	1.48	1.30	0.81	0.74	0.81	1.30	0.74
B. Treatments (Packaging materials)													
T1	21.03	23.22	25.37	27.02	30.03	31.96	34.19	36.42	38.51	40.88	43.24	45.71	48.18
T2	21.03	22.29	23.51	24.14	25.11	27.30	28.45	29.60	30.75	31.89	33.03	34.17	35.31
T3	21.03	21.55	22.02	22.52	23.11	23.68	24.36	25.03	25.81	26.58	27.65	28.72	29.79
T4	21.03	21.08	21.08	21.14	21.15	21.21	21.26	21.31	21.40	21.48	21.58	21.67	21.77
T5	21.03	21.83	22.58	23.56	24.17	24.97	25.97	26.97	27.92	28.86	29.81	30.93	32.05
T6	21.03	22.24	23.40	24.09	25.45	26.79	27.88	28.98	30.10	31.23	32.35	33.48	34.60
T7	21.03	22.14	23.21	24.16	25.41	26.27	27.33	28.39	29.45	30.50	31.44	32.39	33.33
T8	21.03	21.50	21.93	22.39	22.85	23.39	23.93	24.47	25.07	25.84	26.61	27.38	28.15
T9	21.03	21.72	22.37	22.50	23.91	24.60	25.40	26.19	27.00	27.72	28.74	29.76	30.78
F-value	NS	NS	NS	**	**	**	**	**	**	**	**	**	**
S.Em±	0.61	0.40	0.62	0.61	0.85	0.58	0.82	0.72	0.45	0.41	0.45	0.72	0.41
CD at 1%	-	--		2.35	3.26	2.24	3.13	2.75	1.72	1.57	1.72	2.75	1.57
Interactions (C x T)													
C1T1	21.03	22.90	24.72	25.00	27.00	30.16	31.89	33.62	35.07	36.72	38.37	40.23	42.09
C1T2	21.03	22.78	24.48	24.96	26.14	29.68	31.13	32.58	34.03	35.32	36.61	37.90	39.19
C1T3	21.03	21.95	22.82	23.73	24.63	25.53	26.63	27.73	28.83	29.93	31.62	33.31	35.00
C1T4	21.03	21.09	21.10	21.19	21.21	21.27	21.33	21.39	21.52	21.65	21.78	21.91	22.04
C1T5	21.03	22.05	23.02	24.13	25.03	26.03	27.43	28.83	30.23	31.63	33.03	34.78	36.53
C1T6	21.03	22.74	24.40	26.18	27.00	28.89	30.29	31.69	33.09	34.49	35.89	37.29	38.69
C1T7	21.03	22.65	24.22	25.83	27.43	28.43	29.83	31.23	32.63	34.03	35.23	36.43	37.63
C1T8	21.03	21.90	22.72	23.58	24.43	25.42	26.41	27.40	28.39	29.73	31.07	32.41	33.75
C1T9	21.03	22.00	22.92	23.00	25.18	26.08	27.18	28.28	29.38	30.48	32.17	33.86	35.55
C2T1	21.03	23.55	26.02	29.03	33.05	33.76	36.49	39.22	41.95	45.03	48.11	51.19	54.27
C2T2	21.03	21.81	22.54	23.31	24.07	24.92	25.77	26.62	27.47	28.46	29.45	30.44	31.43
C2T3	21.03	21.15	21.22	21.30	21.58	21.83	22.08	22.33	22.78	23.23	23.68	24.13	24.58
C2T4	21.03	21.07	21.06	21.08	21.09	21.15	21.19	21.23	21.27	21.31	21.37	21.43	21.49
C2T5	21.03	21.61	22.14	22.99	23.31	23.91	24.51	25.11	25.60	26.09	26.58	27.07	27.56
C2T6	21.03	21.74	22.40	22.00	23.89	24.68	25.47	26.26	27.11	27.96	28.81	29.66	30.51
C2T7	21.03	21.64	22.20	22.49	23.39	24.11	24.83	25.55	26.27	26.96	27.65	28.34	29.03
C2T8	21.03	21.11	21.14	21.20	21.27	21.36	21.45	21.54	21.74	21.94	22.14	22.34	22.54
C2T9	21.03	21.45	21.82	21.99	22.63	23.12	23.61	24.10	24.61	24.96	25.31	25.66	26.01
F-value	NS	NS	NS	**	**	**	**	**	**	**	**	**	**
S.Em±	0.87	0.56	0.87	0.87	1.20	0.83	1.15	1.02	0.64	0.58	0.64	1.02	0.58
CD at 1%	-	-	-	3.32	4.60	3.17	4.43	3.90	2.43	2.21	2.43	3.90	2.21

Note: NS = Non-significant; ** Significant at 1% level

Table 2: Effect of package and storage conditions on pH of stored pulp

Treatments	Storage interval (Days)												
	0	15	30	45	60	75	90	105	120	135	150	165	180
A. Storage conditions (Ambient and Refrigerated)													
C1	2.91	2.66	2.37	2.11	1.90	1.73	1.63	1.60	1.58	1.55	1.51	1.49	1.46
C2	2.91	2.80	2.65	2.54	2.42	2.34	2.28	2.26	2.23	2.21	2.18	2.16	2.13
F-value	NS	NS	NS	**	**	**	**	**	**	**	**	**	**
S.Em±	0.29	0.19	0.29	0.10	0.11	0.11	0.09	0.07	0.05	0.07	0.01	0.06	0.04
CD at 1%	-	-	-	0.37	0.41	0.41	0.33	0.27	0.21	0.26	0.03	0.23	0.16
B. Treatments (Packaging materials)													
T1	2.91	2.42	1.88	1.38	0.98	0.78	0.67	0.64	0.60	0.57	0.53	0.51	0.48
T2	2.91	2.65	2.35	2.09	1.89	1.74	1.63	1.60	1.57	1.53	1.49	1.47	1.44
T3	2.91	2.82	2.68	2.58	2.47	2.36	2.29	2.26	2.23	2.20	2.16	2.14	2.11
T4	2.91	2.92	2.90	2.91	2.90	2.90	2.90	2.89	2.89	2.88	2.86	2.86	2.81
T5	2.91	2.74	2.53	2.36	2.17	2.03	1.96	1.93	1.90	1.87	1.83	1.81	1.78
T6	2.91	2.67	2.38	2.13	1.94	1.78	1.67	1.64	1.61	1.58	1.54	1.52	1.49
T7	2.91	2.71	2.49	2.31	2.11	1.96	1.85	1.82	1.79	1.76	1.72	1.70	1.67
T8	2.91	2.84	2.73	2.66	2.57	2.52	2.46	2.44	2.43	2.41	2.38	2.37	2.34
T9	2.91	2.80	2.65	2.54	2.41	2.29	2.22	2.19	2.16	2.13	2.09	2.07	2.04
F-value	NS	NS	NS	**	**	**	**	**	**	**	**	**	**

S.Em±	0.61	0.40	0.62	0.20	0.22	0.23	0.18	0.15	0.11	0.14	0.02	0.13	0.09
CD at 1%	-	-	-	0.78	0.86	0.88	0.70	0.56	0.44	0.55	0.06	0.50	0.34
Interactions (C x T)													
C1T1	2.91	2.44	1.92	1.44	1.16	0.96	0.85	0.82	0.79	0.75	0.71	0.69	0.66
C1T2	2.91	2.53	2.10	1.71	1.43	1.23	1.12	1.09	1.06	1.02	0.98	0.96	0.93
C1T3	2.91	2.74	2.52	2.34	2.15	1.96	1.85	1.82	1.79	1.76	1.72	1.70	1.67
C1T4	2.91	2.92	2.89	2.90	2.89	2.89	2.89	2.88	2.88	2.87	2.85	2.85	2.81
C1T5	2.91	2.65	2.34	2.07	1.79	1.59	1.48	1.45	1.42	1.39	1.35	1.33	1.30
C1T6	2.91	2.56	2.16	1.80	1.52	1.32	1.21	1.18	1.15	1.11	1.07	1.05	1.02
C1T7	2.91	2.61	2.30	2.03	1.75	1.55	1.44	1.41	1.38	1.35	1.31	1.29	1.26
C1T8	2.91	2.77	2.58	2.43	2.27	2.16	2.05	2.02	1.99	1.96	1.92	1.90	1.87
C1T9	2.91	2.73	2.50	2.31	2.11	1.91	1.80	1.77	1.74	1.71	1.67	1.65	1.62
C2T1	2.91	2.40	1.84	1.32	0.79	0.59	0.48	0.45	0.42	0.38	0.34	0.32	0.29
C2T2	2.91	2.78	2.60	2.46	2.35	2.24	2.13	2.10	2.07	2.04	2.00	1.98	1.95
C2T3	2.91	2.90	2.84	2.82	2.79	2.76	2.73	2.70	2.67	2.64	2.60	2.58	2.55
C2T4	2.91	2.93	2.90	2.91	2.90	2.90	2.90	2.90	2.89	2.88	2.87	2.86	2.82
C2T5	2.91	2.84	2.72	2.64	2.55	2.46	2.43	2.40	2.37	2.34	2.30	2.28	2.25
C2T6	2.91	2.78	2.60	2.46	2.35	2.24	2.13	2.10	2.07	2.04	2.00	1.98	1.95
C2T7	2.91	2.82	2.68	2.58	2.47	2.36	2.25	2.22	2.19	2.16	2.12	2.10	2.07
C2T8	2.91	2.91	2.88	2.89	2.87	2.87	2.87	2.86	2.86	2.86	2.84	2.84	2.80
C2T9	2.91	2.88	2.80	2.76	2.71	2.66	2.63	2.60	2.57	2.54	2.50	2.48	2.45
F-value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S.Em±	0.87	0.56	0.87	0.29	0.32	0.32	0.26	0.21	0.16	0.20	0.02	0.18	0.13
CD at 1%	3.32	2.16	3.35	1.11	1.22	1.24	1.00	0.80	0.62	0.78	0.09	0.70	0.48

Note: NS = Non-significant; ** Significant at 1% level

Table 3: Effect of package and storage conditions on Total Soluble Solids (ºB) of stored pulp

Treatments	**Storage interval (Days)**												
	0	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**	**135**	**150**	**165**	**180**
A. Storage conditions (Ambient and Refrigerated)													
C1	8.13	9.20	10.22	11.29	12.34	13.38	14.37	15.28	16.17	17.01	17.87	18.73	19.59
C2	8.13	8.84	9.51	10.22	10.91	11.54	12.17	12.73	13.22	13.70	13.99	14.29	14.58
F-value	NS	NS	NS	**	**	**	**	**	**	**	**	**	**
S.Em±	0.29	0.19	0.29	0.29	0.40	0.28	0.38	0.34	0.21	0.19	0.21	0.34	0.19
CD at 1%	-	-	-	1.11	1.53	1.06	1.48	1.30	0.81	0.74	0.81	1.30	0.74
B. Treatments (Packaging materials)													
T1	8.13	9.93	11.69	13.49	15.27	17.01	18.74	20.49	22.12	23.54	24.53	25.52	26.51
T2	8.13	9.35	10.52	11.73	12.93	14.13	15.33	16.25	17.17	18.04	18.79	19.53	20.28
T3	8.13	8.88	9.58	10.32	11.05	11.53	12.01	12.46	12.90	13.35	13.86	14.37	14.88
T4	8.13	8.16	8.17	8.19	8.21	8.23	8.26	8.29	8.32	8.35	8.39	8.43	8.47
T5	8.13	9.01	9.85	10.73	11.59	12.46	13.31	14.16	14.66	15.17	15.69	16.21	16.73
T6	8.13	9.25	10.33	11.45	12.55	13.66	14.53	15.40	16.27	17.14	17.89	18.63	19.38
T7	8.13	9.04	9.91	10.82	11.71	12.56	13.41	14.26	15.10	15.95	16.64	17.34	18.03
T8	8.13	8.61	9.05	9.53	9.99	10.46	10.92	11.37	11.83	12.29	12.74	13.20	13.65
T9	8.13	8.95	9.72	10.53	11.33	12.12	12.91	13.40	13.89	14.38	14.87	15.36	15.85
F-value	NS	NS	NS	**	**	**	**	**	**	**	**	**	**
S.Em±	0.61	0.40	0.62	0.61	0.85	0.58	0.82	0.72	0.45	0.41	0.45	0.72	0.41
CD at 1%	-	-	-	2.35	3.26	2.24	3.13	2.75	1.72	1.57	1.72	2.75	1.57
Interactions (C x T)													
C1T1	8.13	9.90	11.62	13.38	15.13	16.78	18.43	20.08	21.48	22.47	23.46	24.45	25.44
C1T2	8.13	9.70	11.22	12.78	14.33	15.88	17.43	18.42	19.41	20.40	21.39	22.38	23.37
C1T3	8.13	9.06	9.94	10.86	11.77	12.68	13.59	14.43	15.27	16.11	17.07	18.03	18.99
C1T4	8.13	8.18	8.18	8.22	8.25	8.28	8.31	8.35	8.39	8.43	8.48	8.53	8.58
C1T5	8.13	9.14	10.10	11.10	12.09	13.08	14.04	15.00	15.96	16.92	17.90	18.88	19.86
C1T6	8.13	9.55	10.92	12.33	13.73	15.13	16.13	17.12	18.11	19.10	20.09	21.08	22.07
C1T7	8.13	9.15	10.12	11.13	12.13	13.13	14.13	15.12	16.11	17.10	18.09	19.08	20.07
C1T8	8.13	9.04	9.90	10.80	11.69	12.58	13.44	14.30	15.16	16.02	16.87	17.72	18.57
C1T9	8.13	9.10	10.02	10.98	11.93	12.86	13.79	14.72	15.65	16.57	17.49	18.41	19.33
C2T1	8.13	9.97	11.76	13.59	15.41	17.23	19.05	20.90	22.75	24.60	25.59	26.58	27.57
C2T2	8.13	9.00	9.82	10.68	11.53	12.38	13.23	14.08	14.93	15.68	16.18	16.68	17.18
C2T3	8.13	8.70	9.22	9.78	10.33	10.38	10.43	10.48	10.53	10.59	10.65	10.71	10.77
C2T4	8.13	8.15	8.15	8.16	8.17	8.18	8.20	8.22	8.24	8.26	8.29	8.32	8.35
C2T5	8.13	8.89	9.60	10.35	11.09	11.83	12.57	13.31	13.36	13.42	13.48	13.54	13.60
C2T6	8.13	8.96	9.74	10.56	11.37	12.18	12.93	13.68	14.43	15.18	15.68	16.18	16.68
C2T7	8.13	8.94	9.70	10.50	11.29	11.99	12.69	13.39	14.09	14.79	15.19	15.59	15.99
C2T8	8.13	8.19	8.20	8.25	8.29	8.34	8.39	8.44	8.49	8.55	8.61	8.67	8.73

C2T9	8.13	8.80	9.42	10.08	10.73	11.38	12.03	12.08	12.13	12.19	12.25	12.31	12.37
F-value	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**	**	**
S.Em±	0.87	0.56	0.87	0.87	1.20	0.83	1.15	1.02	0.64	0.58	0.64	1.02	0.58
CD at 1%	-	-	-	-	-	-	-	-	2.43	2.21	2.43	3.90	2.21

Note: NS = Non-significant; ** Significant at 1% level

Table 4: Effect of package and storage conditions on ascorbic acid (mg) of stored pulp

Treatments	Storage interval (Days)												
	0	15	30	45	60	75	90	105	120	135	150	165	180
A. Storage conditions (Ambient and Refrigerated)													
C1	7.68	7.27	6.82	6.40	5.98	5.56	5.10	4.66	4.40	4.12	4.01	3.66	3.35
C2	7.68	7.53	7.34	7.19	7.02	6.86	6.65	6.52	6.40	6.27	6.22	6.00	5.88
F-value	NS	NS	NS	NS	NS	**	**	**	**	**	**	**	**
S.Em	0.29	0.19	0.29	0.29	0.40	0.27	0.38	0.33	0.22	0.19	0.08	0.33	0.20
CD	-	-	-	-	-	1.05	1.46	1.27	0.83	0.74	0.30	1.25	0.75
B. Treatments (Packaging materials)													
T1	7.68	6.94	6.16	5.42	4.66	3.91	2.60	2.14	1.95	1.68	1.66	1.34	0.94
T2	7.68	7.28	6.84	6.44	6.02	5.61	5.19	4.78	4.50	4.23	4.04	3.75	3.51
T3	7.68	7.53	7.34	7.19	7.02	6.87	6.71	6.56	6.39	6.23	6.16	5.87	5.69
T4	7.68	7.69	7.66	7.67	7.67	7.67	7.88	7.65	7.65	7.63	7.53	7.51	7.45
T5	7.68	7.43	7.13	6.87	6.60	6.33	6.06	5.83	5.60	5.37	5.32	4.99	4.80
T6	7.68	7.33	6.93	6.57	6.20	5.83	5.49	5.14	4.87	4.60	4.54	4.13	3.89
T7	7.68	7.37	7.01	6.69	6.36	6.03	5.69	5.35	5.09	4.83	4.73	4.38	4.16
T8	7.68	7.57	7.41	7.29	7.16	7.03	6.89	6.74	6.60	6.45	6.43	6.11	5.94
T9	7.68	7.48	7.24	7.04	6.82	6.60	6.38	6.16	5.94	5.72	5.65	5.35	5.17
F	NS	NS	NS	NS	NS	**	**	**	**	**	**	**	**
S.Em±	0.61	0.40	0.62	0.61	0.85	0.58	0.81	0.71	0.46	0.41	0.17	0.69	0.42
CD at 1%	-	-	-	-	-	2.23	3.10	2.70	1.75	1.57	0.63	2.66	1.60
Interactions (C x T)													
C1T1	7.68	6.97	6.21	5.49	4.76	4.03	2.53	2.01	2.00	1.83	1.79	1.73	0.99
C1T2	7.68	7.05	6.37	5.73	5.08	4.43	3.78	3.13	2.76	2.39	2.10	1.81	1.52
C1T3	7.68	7.42	7.11	6.84	6.56	6.30	6.04	5.78	5.52	5.27	5.08	4.69	4.40
C1T4	7.68	7.69	7.66	7.66	7.66	7.65	8.09	7.64	7.64	7.63	7.62	7.62	7.61
C1T5	7.68	7.25	6.77	6.33	5.88	5.43	4.98	4.61	4.24	3.87	3.82	3.29	3.00
C1T6	7.68	7.11	6.49	5.91	5.32	4.73	4.20	3.67	3.30	2.93	2.86	2.35	2.06
C1T7	7.68	7.17	6.61	6.09	5.56	5.03	4.50	3.97	3.60	3.23	3.06	2.65	2.36
C1T8	7.68	7.47	7.21	6.99	6.76	6.53	6.28	6.03	5.78	5.53	5.52	4.95	4.66
C1T9	7.68	7.34	6.95	6.60	6.24	5.87	5.50	5.13	4.76	4.39	4.26	3.81	3.52
C2T1	7.68	6.92	6.11	5.34	4.56	3.78	2.67	2.27	1.90	1.53	1.52	0.95	0.89
C2T2	7.68	7.52	7.31	7.14	6.96	6.78	6.60	6.42	6.24	6.06	5.98	5.68	5.49
C2T3	7.68	7.65	7.57	7.53	7.48	7.43	7.38	7.33	7.26	7.19	7.14	7.05	6.98
C2T4	7.68	7.70	7.66	7.67	7.67	7.70	7.66	7.66	7.65	7.63	7.43	7.40	7.28
C2T5	7.68	7.61	7.49	7.41	7.32	7.23	7.14	7.05	6.96	6.87	6.82	6.69	6.60
C2T6	7.68	7.55	7.37	7.23	7.08	6.93	6.78	6.61	6.44	6.27	6.22	5.91	5.72
C2T7	7.68	7.57	7.41	7.29	7.16	7.03	6.88	6.73	6.58	6.43	6.40	6.11	5.95
C2T8	7.68	7.67	7.61	7.59	7.56	7.53	7.49	7.45	7.41	7.37	7.33	7.27	7.22
C2T9	7.68	7.63	7.53	7.47	7.40	7.33	7.26	7.19	7.12	7.05	7.04	6.90	6.82
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S.Em±	0.87	0.56	0.87	0.87	1.20	0.82	1.15	1.00	0.65	0.58	0.23	0.98	0.59

Note: NS = Non-significant; ** Significant at 1% level

Table 5: Effect of package and storage conditions on titrable acidity (% tartaric acid) of stored pulp

Treatments	Storage interval (Days)												
	0	15	30	45	60	75	90	105	120	135	150	165	180
A. Storage conditions (Ambient and Refrigerated)													
C1	11.94	12.90	13.77	14.71	16.32	16.57	17.36	18.47	19.46	20.58	21.72	22.86	24.01
C2	11.94	12.39	13.29	13.61	13.98	14.26	14.76	15.14	15.62	16.20	16.84	17.37	17.95
F-value	NS	NS	NS	NS	**	**	**	**	**	**	**	**	**
S.Em±	0.29	0.19	0.29	0.29	0.40	0.28	0.38	0.34	0.21	0.19	0.21	0.34	0.19
CD at 1%	-	-	-	-	1.53	1.06	1.48	1.30	0.81	0.74	0.81	1.30	0.74
B. Treatments (Packaging materials)													
T1	11.94	13.60	17.57	18.69	19.81	20.37	21.83	23.27	25.03	26.95	28.94	30.94	32.93
T2	11.94	12.94	13.86	14.85	16.52	16.83	17.55	18.89	19.91	21.07	22.22	23.28	24.34
T3	11.94	12.44	12.86	13.35	13.99	14.30	14.79	15.27	15.76	16.25	16.77	17.29	17.81
T4	11.94	12.01	11.99	12.00	12.13	12.12	12.15	12.20	12.25	12.30	12.42	12.53	12.65
T5	11.94	12.44	12.86	13.35	14.38	14.55	15.04	15.68	16.25	17.11	18.18	18.90	19.83

T6	11.94	12.85	13.67	14.57	16.02	16.40	17.36	18.32	19.20	20.18	21.15	22.13	23.10
T7	11.94	12.63	13.24	13.92	15.12	15.35	16.11	16.88	17.64	18.73	19.81	20.90	21.98
T8	11.94	12.37	12.71	13.13	13.90	14.03	14.42	14.85	15.30	15.75	16.20	16.65	17.10
T9	11.94	12.52	13.01	13.59	14.47	14.77	15.31	15.92	16.55	17.19	17.82	18.46	19.09
F-value	NS	NS	**	**	**	**	**	**	**	**	**	**	**
S.Em±	0.61	0.40	0.62	0.61	0.85	0.58	0.82	0.72	0.45	0.41	0.45	0.72	0.41
CD at 1%	-	-	2.37	2.35	3.26	2.24	3.13	2.75	1.72	1.57	1.72	2.75	1.57
Interactions (C x T)													
C1T1	11.94	13.45	14.88	16.38	18.45	18.90	19.50	21.63	23.26	24.89	26.68	28.47	30.26
C1T2	11.94	13.28	14.54	15.87	18.14	18.51	19.27	21.25	22.60	24.22	25.84	27.46	29.08
C1T3	11.94	12.76	13.50	14.31	15.70	15.91	16.71	17.51	18.32	19.13	19.94	20.75	21.56
C1T4	11.94	12.03	12.04	12.12	12.22	12.24	12.29	12.37	12.45	12.53	12.73	12.93	13.13
C1T5	11.94	12.88	13.74	14.67	16.37	16.53	17.48	18.43	19.38	20.48	21.58	22.68	23.78
C1T6	11.94	13.22	14.42	15.69	17.79	18.27	19.60	20.93	22.26	23.71	25.16	26.61	28.06
C1T7	11.94	12.96	13.90	14.91	16.89	17.00	18.10	19.20	20.30	21.97	23.64	25.31	26.98
C1T8	11.94	12.67	13.32	14.04	15.31	15.54	16.29	17.04	17.75	18.46	19.17	19.88	20.59
C1T9	11.94	12.80	13.58	14.43	16.00	16.21	17.00	17.89	18.84	19.79	20.74	21.69	22.64
C2T1	11.94	13.75	20.25	21.00	21.16	21.84	24.17	24.90	26.80	29.00	31.20	33.40	35.60
C2T2	11.94	12.60	13.18	13.83	14.90	15.15	15.84	16.53	17.22	17.91	18.60	19.10	19.60
C2T3	11.94	12.12	12.22	12.39	12.27	12.69	12.86	13.03	13.20	13.37	13.60	13.83	14.06
C2T4	11.94	11.98	11.94	11.88	12.03	11.99	12.01	12.03	12.05	12.07	12.10	12.13	12.16
C2T5	11.94	12.00	11.98	12.03	12.40	12.56	12.60	12.93	13.12	13.74	14.79	15.11	15.88
C2T6	11.94	12.47	12.92	13.44	14.25	14.53	15.12	15.71	16.14	16.64	17.14	17.64	18.14
C2T7	11.94	12.30	12.58	12.93	13.36	13.69	14.12	14.55	14.98	15.48	15.98	16.48	16.98
C2T8	11.94	12.06	12.10	12.21	12.49	12.52	12.54	12.65	12.84	13.03	13.22	13.41	13.60
C2T9	11.94	12.23	12.44	12.75	12.95	13.33	13.62	13.94	14.26	14.58	14.90	15.22	15.54
F-value	NS	NS	**	**	**	**	**	**	**	**	**	**	**
S.Em±	0.87	0.56	0.87	0.87	1.20	0.83	1.15	1.02	0.64	0.58	0.64	1.02	0.58
CD at 1%	-	-	3.35	3.32	4.60	3.17	4.43	3.90	2.43	2.21	2.43	3.90	2.21

Note: NS = Non-significant; ** Significant at 1% level

Table 6: Effect of package and storage conditions on reducing sugars (%) of stored pulp

Treatments	Storage interval (Days)												
	0	15	30	45	60	75	90	105	120	135	150	165	180
A. Storage conditions (Ambient and Refrigerated)													
C1	15.13	15.63	16.08	16.57	17.05	17.53	18.00	18.43	18.87	19.30	19.65	19.85	19.87
C2	15.13	15.39	15.60	15.84	16.06	16.29	16.44	16.56	16.69	16.81	16.93	17.05	17.16
F-value	NS	NS	NS	NS	NS	**	**	**	**	**	**	**	**
S.Em±	0.29	0.19	0.29	0.29	0.40	0.28	0.38	0.34	0.21	0.19	0.21	0.34	0.19
CD at 1%	-	-	-	-	-	1.06	1.48	1.30	0.81	0.74	0.81	1.30	0.74
B. Treatments (Packaging materials)													
T1	15.13	16.01	16.85	17.73	18.59	19.46	20.32	21.19	22.05	22.92	23.78	24.65	25.11
T2	15.13	15.68	16.18	16.72	17.25	17.78	18.31	18.70	19.09	19.48	19.87	20.25	20.27
T3	15.13	15.37	15.57	15.81	16.03	16.26	16.45	16.65	16.84	17.04	17.06	17.08	17.10
T4	15.13	15.16	15.15	15.18	15.19	15.20	15.21	15.23	15.25	15.27	15.28	15.30	15.31
T5	15.13	15.46	15.70	15.98	16.24	16.51	16.74	16.98	17.19	17.40	17.60	17.62	17.64
T6	15.13	15.61	16.04	16.51	16.97	17.43	17.73	18.02	18.32	18.61	18.82	18.84	18.86
T7	15.13	15.53	15.88	16.27	16.65	17.03	17.33	17.62	17.92	18.21	18.42	18.44	18.46
T8	15.13	15.33	15.48	15.67	15.85	16.03	16.20	16.22	16.25	16.27	16.29	16.31	16.33
T9	15.13	15.44	15.70	16.00	16.24	16.48	16.69	16.90	17.11	17.32	17.53	17.55	17.57
F-value	NS	NS	NS	NS	NS	**	**	**	**	**	**	**	**
S.Em±	0.61	0.40	0.62	0.61	0.85	0.58	0.82	0.72	0.45	0.41	0.45	0.72	0.41
CD at 1%	-	-	-	-	-	2.24	3.13	2.75	1.72	1.57	1.72	2.75	1.57
Interactions (C x T)													
C1T1	15.13	15.98	16.78	17.62	18.45	19.28	20.11	20.94	21.77	22.60	23.43	24.26	24.28
C1T2	15.13	15.90	16.62	17.38	18.13	18.88	19.63	20.38	21.13	21.88	22.63	23.38	23.40
C1T3	15.13	15.51	15.84	16.21	16.57	16.93	17.29	17.65	18.01	18.37	18.39	18.41	18.43
C1T4	15.13	15.17	15.16	15.19	15.21	15.22	15.23	15.25	15.27	15.29	15.31	15.33	15.35
C1T5	15.13	15.59	16.00	16.45	16.89	17.33	17.77	18.21	18.60	18.99	19.38	19.40	19.42
C1T6	15.13	15.81	16.44	17.11	17.77	18.43	18.99	19.55	20.11	20.67	21.06	21.08	21.10
C1T7	15.13	15.71	16.24	16.81	17.37	17.93	18.49	19.05	19.61	20.17	20.56	20.58	20.60
C1T8	15.13	15.46	15.74	16.06	16.37	16.68	16.99	17.02	17.05	17.08	17.10	17.12	17.14
C1T9	15.13	15.54	15.90	16.30	16.69	17.08	17.47	17.86	18.25	18.64	19.03	19.05	19.07
C2T1	15.13	16.05	16.92	17.83	18.73	19.63	20.53	21.43	22.33	23.23	24.13	25.03	25.93
C2T2	15.13	15.46	15.74	16.06	16.37	16.68	16.99	17.02	17.05	17.08	17.10	17.12	17.14
C2T3	15.13	15.24	15.30	15.40	15.49	15.58	15.61	15.64	15.67	15.70	15.72	15.74	15.76

C2T4	15.13	15.16	15.14	15.16	15.17	15.18	15.19	15.21	15.23	15.24	15.25	15.26	15.27
C2T5	15.13	15.34	15.40	15.50	15.59	15.68	15.71	15.74	15.77	15.80	15.82	15.84	15.86
C2T6	15.13	15.41	15.64	15.91	16.17	16.43	16.46	16.49	16.52	16.55	16.57	16.59	16.61
C2T7	15.13	15.35	15.52	15.73	15.93	16.13	16.16	16.19	16.22	16.25	16.27	16.29	16.31
C2T8	15.13	15.20	15.22	15.28	15.33	15.38	15.40	15.42	15.44	15.46	15.48	15.50	15.52
C2T9	15.13	15.34	15.50	15.70	15.79	15.88	15.91	15.94	15.97	16.00	16.02	16.04	16.06
F-value	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**	**	**
S.Em±	0.87	0.56	0.87	0.87	1.20	0.83	1.15	1.02	0.64	0.58	0.64	1.02	0.58
CD at 1%	-	-	-	-	-	-	-	-	2.43	2.21	2.43	3.90	2.21

Note: NS = Non-significant; ** Significant at 1% level

4. Conclusion

Fresh tamarind fruits are seasonal crops. As a result, the preservation of a fresh produce and year round availability is important to meet the demands of consumers. It was confirmed that storage conditions and packaging materials has great influence on the quality of pulp. It can be concluded that among the 9 treatments and 2 conditions, the treatment (C2T4: pulp packed in MPP and stored under refrigerated condition) is recommended for long term storage of tamarind pulp to preserve its quality parameters. Irrespective of storage conditions packing pulp in MPP pouch was found superior over all other packaging materials. The magnitude of the change in bio-chemical characteristics of the pulp measured during storage suggests that MPP pouch is best for long term storage. There was a distinct change in the chemical attributes of the pulp during storage at both storage conditions, although the changes were less pronounced at packed pulp in refrigerated storage.

5. Reference

1. Agrawal AK, Archana Khare, Geetesh Sinha. Storage of tamarind in commonly available packaging materials. The Journal of Research ANGRAU, 2014, 40.
2. AOAC. Official methods of analysis. Association of official analytical chemists. 19th Ed. Gaithersburg, Maryland USA. 2009;2:2087-2417.
3. Deokar, Vishakha Tatyasaheb. Development of blended sapota (*Manilkara achras* (mill) fosberg) and tamarind (*Tamarindus indica* L.) Jelly Cubes. PhD diss., Dr. BS KKV., Dapoli, 2018.
4. Khan Ibrahim AU, Rehman SH, Khan Qazi IM, Shah FN, Arsalan Khan, Rehman TU, *et al*. Development and quality evaluation of tamarind plum blended squash during storage. J Food Process Technol. 2017;8(662):2.
5. Kiranmai E, Rajeswari K, Sukreeti Sharma, Uma Maheswari K. Standardization and development of tamarind candy by blending with mango pulp. J Pharmacogn. Phytochem. 2018;7(2):2042-2047.
6. Kotecha PM, Kadam SS. Studies on browning in tamarind pulp during storage. Journal of food science and technology (Mysore). 2003;40(4):398-399.
7. Manjula B, Arun R, Prasanna NS, Ramana C. Studies on physical and bio-chemical analysis of value added products developed from tamarind pulp. International Journal of Processing and Post-Harvest Technology. 2017;8(2):99-103.
8. Muzaffar Khalid, Pradyuman Kumar. Moisture sorption isotherms and storage study of spray dried tamarind pulp powder. Powder Technology. 2016;291:322-327.
9. Om, Prakash. Influence of pretreatments on post-harvest quality characteristics and shelf life extension of green tamarind fruits stored under different conditions. International Journal of Agriculture Sciences, 2016. ISSN: 0975-3710.
10. Pattar Archana, Laxman Kukanoor, Hegde NK, Praveen Jholgiker. Studies on keeping quality of tamarind paste during storage. The Asian Journal of Horticulture. 2010;8(2):430-432.