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Effect of different precooling and storage temperatures on quality of mango cv. Alphonso

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Abstract
An experiment was conducted to study the effect of different precooling and storage temperatures on quality of mango cv. Alphonso. The experiment was carried out during the season May 2016 at R.F.R.S., Vengurle, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli with five precooling temperatures (P_1 – Control, P_2 – 21 ± 2˚C, P_3 - 18 ± 2˚C, P_4 – 15 ± 2˚C and P_5 - 12 ± 2˚ C.) and four storage temperatures (S_1 – Ambient temperature (27-30 ˚C), S_2 - 18 ± 2˚C, S_3 – 15 ± 2˚C and S_4 - 12 ± 2˚ C.). After precooling fruits were stored for 21 days at different storage temperatures and again brought to above precooling temperature by air cooling after 21 days. Then the cooled fruits were kept for ripening for seven days at room temperature. It was found that the quality of Alphonso mango fruits were improved with minimum T.S.S. in the P_3S_2 (15.95 %), reducing sugar (3.75 %) in P_2S_2, total sugar (13.15 %) in P_1S_2, titrable acidity (0.29 %) and β-carotene (10018.95 µg/100 g) in P_1S_4 at 28th days of storage due to interactions effect of precooling and storage temperature. Each chemical parameter has shown best result with separate interaction except P_1S_4, which showed best results with titratable acidity and β-carotene content.

Keywords: precooling, storage, temperature and quality

Introduction
Mango (*Mangifera indica* L.) is a delicious fruit. Besides its fine taste, high palatability, sweet fragrance, attractive colour and nutritional value, it is called as 'the king of fruits' and is also a national fruit of India. It is good source of vitamin A, and C. India is the largest producer of mango in the world and ranks first in area and production. The total production of mango in India is 18.832 million MT from about 2.218 million ha area with the productivity of 8.49 MT/ha (Anon., 2015 a) [1]. In Maharashtra, mango is occupying an area of 0.156 million ha with annual production of 0.876 million MT and productivity of 5.60 MT/ha (Anon., 2015 b) [2]. Post-harvest handling is the problem of mango as due to climacteric nature of the fruit. So, post-harvest handling can play a major role to reduce the losses. The post-harvest losses in mango are about 25 to 30 per cent post-harvest losses. This is mainly due to the non-availability of commercial low temperature store houses, lack of cool chain during transport and storage (Krishnamurthy and Rao, 2001) [7]. One of the most important factors affecting post-harvest life and quality of horticultural crops is temperature. Similarly, low-temperature storage has been one of the most effective methods for maintaining the quality of most of the fruits and vegetables. This method reduces the rate of respiration, ethylene production, ripening, senescence, undesirable metabolic changes and further decay (Niranjana *et al.*, 2009) [11]. Kapse (1993) [6] reported that the pre-cooling of mango cv. Kesar at 12 and 16 ºC temperature resulted in improving the quality of ripened fruits and delayed ripening. Alphonso is premium export cultivar and the export by air is very costly. Hence, if shelf life of fruits increased without affecting the quality up to about 30 days, it can be exported through sea route. This will reduce the freight cost and will boost the export of fresh fruits. However, harvested mango fruits, are kept in cold storage with or without precooling. After storage they are directly brought to ambient temperature for ripening. This affects the quality of fruits and cause losses. In order to reduce these losses, it is necessary to standardize precooling and storage methods at different temperatures. In view of this, the present investigation was undertaken.

Materials and Methods
Physiologically mature, hard green fruits at optimum maturity of mango Cv. Alphonso were

harvested with the help of Nutan Zela with keeping 2.5 to 3.5 cm stalk during morning hours from the Regional Fruit Research Station, Vengurle Dist. Sindhudurg (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli) during May 2016**.** After harvesting, the fruits were treated with 0.1% carbendazine and kept under shade for 1-2 hours in order to dry them. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with two replications. Initial observation was recorded and fruits were kept in forced air cooling chamber for the pre-cooling at P_1 – Control, P_2 – 21 ± 2 ^{0}C, P_3 - 18 ± 2 ^{0}C, P_4 – 15 ± 2 ^{0}C and P_5 - 12 ± 2 ^{0}C. The precool temperature was checked by using thermometer which was inserted in the pulp of the fruit and the constant temperature maintained. Precooled fruits were stored for 21 days at different storage temperature like S_1- Ambient temperature (27-30 ^{0}C), S_2-18 ± 2 ^{0}C, S_3-15 ± 2 ^{0}C and S_4 -12 ±2 ^{0}C. After 21 days storage, fruits were again brought to above precooling temperature by forced air cooling and kept for ripening for 7 days at room temperature.

Results and Discussion

Total soluble solid (^{0}Brix0029)

The data pertaining to total soluble solids of mango as influenced by precooling and storage temperature is given in Table 1. The results indicated that the total soluble solids of mango fruits was increased during storage at different storage temperature, irrespective of precooling and storage temperature. On 7th day, Minimum T.S.S. was observed in S4 (9.8 0B) and it was significantly superior over others. On 21st day, 18±2 0C (S2) recorded significantly the lowest T.S.S. (14.90 0B) and it was superior over rest of the storage treatments. At 28 day storage, fruits of ambient temperature (S_1) at different precooling temperatures were found to be spoiled, hence reading were not taken. The minimum T.S.S. was observed in P_3S_2 (15.95 0B). From the present findings it is evident that in the storage condition up to 7 days storage, the increase in T.S.S. was noticed at ambient temperature (S1) than the cold temperatures. After 7 days decrease in T.S.S. was observed at ambient temperature, it may be due to higher rate of microbial fermentation as high temperature is favourable for microbial growth was available at ambient temperature (S1). However in case of S2, S3 and S4 T.S.S. was found to increase during storage. It may be due to enhanced carbohydrates degradation metabolism. At 21 day storage fruits were removed from cold storage and kept for ripening at ambient storage. Hence from the data of 21 days storage it was observed that T.S.S. of fruits at 12±2°C (S4) and 15±2°C (S3) storage was suddenly increased, irrespective of precooling temperature. It may be due to sudden change in storage temperature. Whereas in case of precooling temperature, lowest T.S.S. was recorded by P2 (21±2°C) may be due to minimum change in storage temperature after 21 days as compared to other precooling temperatures. Minimum T.S.S. was recorded by P3S2 may be due to effect of precooling and storage temperature and minimum change in storage temperature after 21 days as compared to other precooling and storage temperatures. Similar findings were recorded by Padhye (1997) [12] and Joshi and Roy (1985) [5] in mango.

Table 1: Effect of precooling and storage temperature on TSS (^{O}Brix) of mango fruits during storage

	P1	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**
S1	6.25	7.15	7.10	6.80	6.25	6.71	19.35	19.15	19.60	19.10	18.35	19.11	16.25	15.75	16.75	17.30	16.75	16.56
S2	7.10	7.35	7.25	6.50	8.20	7.28	11.75	11.25	12.25	12.25	10.75	11.65	15.25	13.50	13.25	14.25	15.25	14.30
S3	8.40	5.90	6.40	7.30	7.15	7.03	11.75	12.50	13.00	12.25	13.25	12.55	13.25	13.00	14.75	14.25	14.25	13.90
S4	6.15	7.30	6.30	6.60	7.95	6.86	10.25	9.25	10.25	9.75	9.50	9.80	10.75	11.00	10.75	11.25	11.25	11.00
Mean	6.98	6.93	6.76	6.80	7.39	6.97	13.28	13.04	13.78	13.34	12.96	13.28	13.88	13.31	13.88	14.26	14.38	13.94
	S.Em+			C.D.@ 1%			S.Em+			C. D.@ 1%			S.Em+			C.D.@ 1%		
S	0.19			NS			0.11			0.43			0.11			0.46		
P	0.21			NS			0.12			0.48			0.13			0.51		
SxP	0.42			NS			0.24			0.96			0.25			1.02		
Treat-	21 Days						28 Days											
ment	P1	P2	P3	P4	P5	Mean	P1	P2	P3	P4	P5	Mean						
S1	15.50	15.30	16.35	15.75	16.60	15.90	-	-	-	-	-	-						
S2	15.25	14.75	14.25	15.25	15.00	14.90	16.45	16.50	15.95	16.25	16.30	16.29						
S3	18.50	17.75	19.40	18.90	19.10	18.73	19.25	19.15	19.25	19.35	18.90	19.18						
S4	18.95	18.85	19.25	18.25	18.75	18.81	18.75	18.85	18.75	18.40	19.60	18.87						
Mean	17.05	16.66	17.31	17.04	17.36	17.09	-	-	-	-	-	-						
	S.Em+			C. D.@ 1%			S.Em+			C. D.@ 1%								
S	0.11			0.44			-			-								
P	0.12			0.49			-			-								
SxP	0.24			0.98			-			-								

Precooling temperature: - 1) P_1 – Control, 2) P_2 – 21 ± 2˚C, 3) P_3 - 18 ± 2˚C, 4) P_4 – 15 ± 2˚C, 5) P_5 - 12 ± 2˚ C
Storage temperature: - 1) S_1 – Ambient temperature, 2) S_2 - 18 ± 2˚C, 3) S_3 – 15 ± 2˚C, 4) S_4 - 12 ± 2˚ C
SxP: - Interaction (Storage x Precooling), NS: - Non Significant
(At 28 days storage, fruits at ambient temperature (S1) with different precooling temperatures were found to be spoiled, hence reading were not taken.)

Titratable acidity

The data pertaining to titratable acidity of mango as influenced by precooling and storage temperature is given in Table 2. The results indicated that the titratable acidity of mango fruits decreased up to 21 days during storage at different storage conditions, irrespective of precooling and storage temperature. On 7th day, maximum titratable acidity (2.74 %) was recorded when the fruits which were kept in storage temperature at 12±2°C (S_4) and it was significantly superior over others. On 21st day, it was observed that storage temperature showed significant difference. S_4 (12±2°C) treatment recorded significantly the maximum acidity (1.19 %) and was superior over rest. The maximum titratable acidity was observed in P_5 (0.74 %) which was at par with P_4

(0.73 %). In interactions, the maximum titratable acidity was observed in P_5S_4 (1.38 %) and it was at par with P_4S_4 (1.28 %). At 28 days storage, Maximum titratable acidity was noticed in S_4 (0.25 %) while, minimum titratable acidity was noticed in S_2 (0.10 %). In interactions, the maximum titratable acidity was observed in P_1S_4 (0.29 %) and minimum titratable acidity was recorded in P_5S_2 (0.07 %). Considerable decline in the acidity content in the mango fruit during ripening can be attributed mainly due to decrease in citrate and malate present in high amount in unripe fruits but decrease towards ripening (Medlicott and Thompson, 1985). The acidity of mango fruits was found to be decreased in both the storage conditions, irrespective of precooling. Ambient temperature storage exhibited greater reduction in acidity than cold storage. The slower decrease in acidity of mango fruits at cold storage could be possibly due to slower degradation of organic acids due to low temperature and high humidity in cold storage. The reduction in acidity during storage might be associated with the conversion of organic acids into sugars and their derivatives or their utilization in respiration. Present results are in conformity with the findings reported by Gole (1986) [3] and Kulkarni (2000) [8] in mango fruits.

Table 2: Effect of precooling and storage temperature on titratable acidity (%) of mango fruits during storage

Treat-ment	0 Days						7 Days						14 Days					
	P1	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**
S1	3.55	3.10	3.07	3.64	3.60	3.39	0.42	0.65	0.60	0.65	0.48	0.56	0.23	0.16	0.17	0.17	0.22	0.19
S2	2.95	3.65	3.08	3.51	3.26	3.29	2.11	2.11	2.08	2.21	2.24	2.15	1.57	1.63	1.86	1.89	1.66	1.72
S3	3.08	3.40	3.64	3.49	3.20	3.36	2.37	2.30	2.46	2.21	2.30	2.33	1.54	1.47	1.60	1.73	1.76	1.62
S4	3.45	2.98	3.60	3.72	3.17	3.38	2.59	2.91	2.78	2.59	2.82	2.74	1.34	1.38	1.38	1.54	1.50	1.43
Mean	3.26	3.28	3.35	3.59	3.31	3.36	1.87	1.99	1.98	1.92	1.96	1.94	1.17	1.16	1.25	1.33	1.29	1.24
	S.Em+			C.D. @1%			S.Em+			C. D. @1%			S.Em+			C.D.@ 1%		
S	0.07			NS			0.02			0.06			0.02			0.07		
P	0.08			NS			0.02			0.07			0.02			0.07		
SxP	0.16			NS			0.03			0.14			0.04			0.15		
Treat-ment	21 Days						28 Days											
	P1	P2	P3	P4	P5	Mean	P1	P2	P3	P4	P5	Mean						
S1	0.17	0.14	0.19	0.22	0.29	0.20	-	-	-	-	-	-						
S2	1.09	0.99	0.90	1.02	0.83	0.97	0.10	0.12	0.08	0.14	0.07	0.10						
S3	0.38	0.45	0.48	0.38	0.48	0.44	0.17	0.21	0.23	0.26	0.26	0.23						
S4	1.04	1.12	1.12	1.28	1.38	1.19	0.29	0.22	0.20	0.27	0.26	0.25						
Mean	0.67	0.68	0.67	0.73	0.74	0.70	-	-	-	-	-	-						
	S.Em+			C. D.@1%			S.Em+			C.D.@1%								
S	0.01			0.05			-			-								
P	0.01			0.05			-			-								
SxP	0.03			0.10			-			-								

Reducing sugar (%)

The data pertaining to reducing sugar of mango as influenced by precooling and storage temperature is given in Table 3. The results indicated that the reducing sugar of mango fruits increased up to 21 days during storage at different storage conditions, irrespective of precooling and storage temperatures. On 7th day, Minimum reducing sugar content was observed in S_4 (2.25 %) and it was significantly superior over others. Maximum reducing sugars were found in S_1 (3.25 %), irrespective of precooling temperature. In precooling temperature minimum reducing sugars were noticed in P_4 (2.66 %). In interactions, minimum reducing sugar was recorded in P_2S_4 (2.13 %) and significantly the highest reducing sugar was recorded in P_3S_1 (3.53 %), irrespective of precooling and storage temperature. On 21st day, The minimum reducing sugar was observed in S_1 (2.98 %) however, reducing sugar was found to decrease in S_1 at 21 days storage as compared to 14 days storage (4.45 %). Significantly maximum reducing sugar was recorded in S_4 (3.92 %) and was superior over all other storage temperatures. The minimum reducing sugar was observed in P_3 (3.31 %) and Maximum reducing sugar was recorded in P_5 (3.73 %) irrespective of storage temperatures. In interactions, the minimum reducing sugar as observed in P_1S_1 (2.65 %) and it was at par with P_2S_1 (2.80 %), P_3S_1 (2.85 %) and P_4S_1 (2.95 %) however, reducing sugar was found to decreased in S_1 as explained above. Maximum reducing sugar as recorded in P_1S_3 (4.20 %), irrespective of precooling and storage temperature. At 28 day storage, Minimum reducing sugars were noticed in S_2 (4.00 %) and maximum reducing sugars were noticed in S_3 (4.08 %). In interactions the minimum reducing sugars were observed in P_2S_2 (3.75 %), and maximum reducing sugars were recorded in P_5S_3 (4.18 %), irrespective of precooling and storage temperature. The normal ripening marks with the upsurge of ethylene and initiation of conversion of starch to sugars. Mango being a climacteric fruit, temperature surrounding fruit during ripening plays a crucial role in controlling the ethylene production and overall starch metabolism (Lee *et al*., 1995 and Walls *et al*., 2007). After 14 days decrease in reducing sugar was observed at ambient temperature, it may be due to higher rate of microbial fermentation as high temperature is favourable for microbial growth was available at ambient temperature (S_1). Hence, from the data of 21 days storage it was observed that reducing sugar of fruits at 12±2°C (S_4) and 15±2°C (S_3) storage was suddenly increased, irrespective of precooling temperatures. An increase in reducing sugar content during cold storage was probably due to conversion of starch in to soluble sugars and dehydration of fruits and further due to sudden change in storage temperature. Whereas, in case of precooling temperature the lowest reducing sugar was recorded by P_3, followed by P_4 and P_2, may be due to minimum change in storage temperature after 21 days as compared to other precooling temperatures. Minimum reducing sugar as recorded by P_1S_1 it may be due to higher rate of microbial fermentation due to high temperature which was available at ambient temperature (S_1) favourable for microbial growth. Similar results were obtained by Naik (1985) [10] and Padhye (1997) [12] in mango which are in conformity with present findings. At the end of storage (28

day) minimum reducing sugar was recorded by P_2S_2 and hence found to be best.

Table 3: Effect of precooling and storage temperature on reducing sugar (%) of mango fruits during storage

Treat-ment	0 Days						7 Days						14 Days					
	P1	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**
S1	1.03	1.03	1.34	1.03	1.35	1.16	3.23	3.20	3.53	3.13	3.18	3.25	4.58	4.48	4.55	3.83	4.82	4.45
S2	0.89	1.20	1.06	1.08	0.86	1.02	2.93	2.83	2.94	2.78	2.98	2.89	3.11	3.03	3.13	3.18	3.23	3.13
S3	1.30	0.93	1.21	0.89	1.08	1.08	2.68	2.73	2.68	2.53	2.78	2.68	3.28	3.23	3.25	3.25	3.33	3.27
S4	0.91	0.88	0.91	1.12	1.10	0.98	2.18	2.13	2.33	2.22	2.43	2.25	3.14	3.08	2.98	3.13	2.93	3.05
Mean	1.03	1.01	1.13	1.03	1.09	1.06	2.75	2.72	2.87	2.66	2.84	2.77	3.52	3.45	3.48	3.34	3.57	3.47
	S.Em+			C.D. @1%			S.Em+			C. D. @1%			S.Em+			C.D.@1%		
S	0.04			NS			0.02			0.07			0.01			0.05		
P	0.05			NS			0.02			0.08			0.01			0.05		
SxP	0.10			NS			0.04			0.15			0.03			0.11		
Treat-ment	21 Days						28 Days											
	P1	P2	P3	P4	P5	Mean	P1	P2	P3	P4	P5	Mean						
S1	2.65	2.80	2.85	2.95	3.65	2.98	-	-	-	-	-	-						
S2	3.63	3.23	3.28	3.41	3.29	3.36	4.00	3.75	3.97	4.12	4.16	4.00						
S3	4.20	3.48	3.45	3.48	3.85	3.69	4.13	4.03	3.93	4.13	4.18	4.08						
S4	4.15	4.05	3.65	3.60	4.13	3.92	4.03	3.93	3.98	4.05	4.13	4.02						
Mean	3.66	3.39	3.31	3.36	3.73	3.49	-	-	-	-	-	-						
	S.Em+			C. D. @1%			S.Em+			C.D. @1%								
S	0.05			0.20			-			-								
P	0.06			0.22			-			-								
SxP	0.11			0.45			-			-								

Total Sugar (%)

The data pertaining to total sugar of mango as influenced by precooling and storage temperature is given in Table 4. The results indicated that the total sugars of mango fruits increased up to 21 day during storage at different storage conditions, irrespective of precooling and storage temperature. On 7th day, Minimum total sugars were observed in S_4 (6.88 %) and Maximum total sugars were found in S_1 (10.80 %), irrespective of precooling temperature. The precooling temperature 12±2°C (P_5) recorded significantly the lowest total sugars (7.17 %) and it was superior over rest of the precooling temperatures. In interactions between precooling and storage temperature, minimum total sugars were recorded in P_5S_3 (6.71 %) and maximum total sugars were recorded in P_4S_1 (11.65 %), irrespective of precooling and storage temperatures. On 21st day, the minimum total sugars were observed in S_2 (11.62 %). However, total sugars were found to decrease in S_1 at 21 days (12.37 %) as compared to total sugar of S_1 (13.39 %) at 14 day storage. Maximum total sugars were recorded in S_4 (13.20 %), irrespective of precooling temperature. The minimum total sugars were observed in P_2 (11.15 %), and Maximum total sugars were recorded in P_4 (13.09 %), irrespective of storage temperature. In interactions the minimum total sugars were observed in P_2S_2 (9.65 %), Maximum total sugars were recorded in P_1S_4 (14.35 %), irrespective of precooling and storage temperature. At 28 day storage, Minimum total sugars was noticed in S_2 (13.50 %) and maximum total sugars were noticed in S_3 (14.22 %). In interactions the minimum total sugars were observed in P_1S_2 (13.15 %) and maximum total sugars were recorded in P_5S_3 (14.32 %), irrespective of precooling and storage temperature. The normal ripening indicate the upsurge of ethylene and initiation of conversion of starch to sugars. Mango being a climacteric fruit, temperature surrounding fruit during ripening plays a crucial role in controlling the ethylene production and overall starch metabolism (Lee *et al*., 1995 Walls *et al*., 2007). At 21 days storage, fruits were removed from cold storage and kept for ripening at ambient storage. Hence, from the data of 21 days storage, it was observed that total sugars of fruits at 12±2°C (S_4) and 15±2°C (S_3) storage was suddenly increased, irrespective of precooling temperature. An increase in total sugars content during cold storage was probably due to conversion of starch in to soluble sugars and dehydration of fruits. It may be due to sudden change in storage temperature. Whereas, in case of precooling temperature lowest total sugars were recorded by P_3 may be due to minimum change in storage temperature after 21 days as compared to other precooling temperatures. Present findings are in agreement with the results reported by Naik (1985) [10] and Padhye (1997) [12] in mango. At 28th day P_1S_2 recorded minimum total sugars.

β–carotene (µg /100 g of pulp)

The data pertaining to β- carotene of mango as influenced by precooling and storage temperature are given in Table 5. The results indicated that the β- carotene of mango fruits increased up to 21 day during storage at different storage conditions, irrespective of precooling and storage temperature. On 7th day, Significantly the lowest β-carotene content (1867.97 µg/100 g) was observed when the fruits were kept at 12±2°C storage temperature (S_4) and it was superior over others. Interactions between precooling and storage temperature showed minimum β-carotene in P_5S_4 (1841.65 µg/100 g) and maximum β-carotene was recorded in P_3S_1 (4213.00 µg/100 g), irrespective of precooling and storage temperature. On 21st day, the S_4 (12±2°C) storage condition recorded minimum β-carotene in S_4 (8202.05 µg/100 g) and it was significantly superior over others. Maximum recorded in S_1 (10493.81 µg/100 g), irrespective of precooling temperature. However, β-carotene was found to decrease as compared to β- carotene of S_1 at 14 days storage. In interactions, The minimum β-carotene was observed in P_2S_4 (8006.15 µg/100 g) and it was significantly superior over others. At 28 day storage, However, minimum β-carotene was noticed in S_4 (10236.91 µg/100 g) and maximum in S_3 (11900.05 µg/100 g). In interactions the minimum β-carotene was observed in P_1S_4 (10018.95 µg /100 g) and maximum β-carotene was recorded in P_4S_3 (11945.45 µg/100 g), irrespective of precooling and storage temperatures. From the present findings it is seen that,

storage conditions up to 7 days of storage increased the β-carotene content at ambient temperature (S_1) than the cold temperatures. After 14 days decrease in β-carotene was observed at ambient temperature, it may due to that, under ambient temperature (S_1) there was high temperature that lead to enhancement of the microbial growth resulted in to the microbial fermentation as compared to cold storage conditions. At 21 days storage fruits were removed from cold storage and kept for ripening at ambient storage. Hence, from the data of 21 days storage it was observed that β- carotene of fruits at 12±2°C (S_4) and 15±2°C (S_3) storage was suddenly increased, irrespective of precooling temperature. It may be due to sudden change in storage temperature. Whereas, in case of precooling temperature lowest β- carotene was recorded by P_2 may be due to minimum change in storage temperature after 21 days as compare to other precooling temperatures. Minimum β- carotene was recorded by P_2S_4 may be due to effect of precooling and storage temperature and minimum change in storage temperature after 21 days as compared to other precooling and storage temperatures. Present investigation are in line with the result reported by Salvi (1991) [13], Gunjate *et al*. (1995) [4] and Padhye (1997) [12] in mango. At 28 day P_1S_4 recorded minimum β- carotene and found to be best.

Table 4: Effect of precooling and storage temperature on total sugar (%) of mango fruits during storage

Treatment	0 Days						7 Days						14 Days					
	P1	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**
S1	4.77	4.17	5.90	3.91	4.47	4.64	11.63	11.37	11.50	11.65	7.85	10.80	14.09	14.61	14.61	14.50	9.18	13.39
S2	4.20	5.34	4.28	4.59	4.04	4.49	8.20	7.17	7.94	7.11	7.36	7.55	9.18	9.01	9.13	9.14	9.15	9.12
S3	4.77	4.39	4.75	4.14	4.77	4.56	7.25	7.14	7.25	7.25	6.71	7.12	9.08	9.18	9.23	9.24	9.75	9.29
S4	4.31	4.26	4.07	4.48	4.94	4.41	7.04	6.85	6.95	6.80	6.76	6.88	9.15	9.45	9.28	9.25	9.38	9.30
Mean	4.51	4.54	4.75	4.28	4.55	4.53	8.53	8.13	8.41	8.20	7.17	8.09	10.37	10.56	10.56	10.53	9.36	10.28
	S.Em+			C.D. @1%			S.Em+			C. D.@ 1%			S.Em+			C.D.@ 1%		
S	0.15			NS			0.10			0.39			0.05			0.18		
P	0.17			NS			0.11			0.44			0.05			0.20		
SxP	0.35			NS			0.22			0.87			0.10			0.41		
Treatment	21 Days						28 Days											
	P1	P2	P3	P4	P5	Mean	P1	P2	P3	P4	P5	Mean						
S1	13.85	11.30	11.90	11.75	13.05	12.37	-	-	-	-	-	-						
S2	12.58	9.65	13.20	12.40	10.25	11.62	13.15	13.23	13.48	13.70	13.94	13.50						
S3	11.15	11.25	10.65	14.30	12.00	11.87	14.11	14.15	14.22	14.30	14.32	14.22						
S4	14.35	12.40	11.30	13.90	14.05	13.20	13.83	13.90	14.25	14.14	14.26	14.07						
Mean	12.98	11.15	11.76	13.09	12.34	12.26	-	-	-	-	-	-						
	S.Em+			C. D.@1%			S.Em+			C.D.@ 1%								
S	0.31			1.24			-			-								
P	0.34			1.39			-			-								
SxP	0.69			2.77			-			-								

Table 5: Effect of precooling and storage temperature on beta carotene (vit. A) (ug/100 g) of mango fruits during storage

Treat	0 Days						7 Days						14 Days					
	P1	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**	**P1**	**P2**	**P3**	**P4**	**P5**	**Mean**
S1	753.20	748.15	749.55	747.50	744.00	748.48	4145.25	4145.45	4213.00	4160.40	4166.90	4166.20	11033.25	10894.85	10997.20	10892.80	11012.20	10966.06
S2	741.25	762.30	747.85	756.25	754.40	752.41	2018.00	2131.30	2055.50	2029.90	2117.70	2070.48	5197.75	5525.15	5400.35	5245.40	5130.55	5299.84
S3	743.25	743.75	763.30	754.85	745.90	750.21	1935.45	1938.85	1948.85	1931.50	1984.95	1947.92	4530.50	4483.00	4445.35	4360.45	4318.00	4427.46
S4	748.85	741.10	754.95	760.55	744.15	749.92	1888.45	1876.45	1847.50	1885.80	1841.65	1867.97	4129.35	4084.75	4120.90	4263.30	4255.35	4170.73
Mean	746.64	748.83	753.91	754.79	747.11	750.26	2496.79	2523.01	2516.21	2501.90	2527.80	2513.14	6222.71	6246.94	6240.95	6190.49	6179.03	6216.02
	S.Em+			C.D. @1%			S.Em+			C. D.@ 1%			S.Em+			C.D.@ 1%		
S	3.692			NS			4.57			18.39			4.48			18.03		
P	4.128			NS			5.11			20.57			5.01			20.16		
SxP	8.257			NS			10.22			41.13			10.02			40.33		
Treat	21 Days						28 Days											
	P1	P2	P3	P4	P5	Mean	P1	P2	P3	P4	P5	Mean						
S1	10535.20	10227.80	10330.55	10530.30	10845.20	10493.81	-	-	-	-	-	-						
S2	9135.45	9145.35	9232.85	9331.30	9445.35	9258.06	10186.15	10237.65	10346.00	10462.65	10582.90	10363.07						
S3	8847.85	8782.80	8660.40	8907.80	8947.90	8829.35	11838.00	11848.00	11872.85	11945.45	11995.95	11900.05						
S4	8172.50	8006.15	8147.70	8287.90	8396.00	8202.05	10018.95	10111.55	10247.90	10345.15	10461.00	10236.91						
Mean	9172.75	9040.53	9092.88	9264.33	9408.61	9195.82	-	-	-	-	-	-						
	S.Em+			C. D.@ 1%			S.Em+			C.D. @1%								
S	4.61			18.54			-			-								
P	5.15			20.73			-			-								
SxP	10.30			41.46			-			-								

Conclusion

Hence, from the data of 28th day's storage it was observed that no any interaction was found to be prominent with respect to changes in chemical composition of mango fruits during

storage. Each chemical parameter have shown best result with separate interaction except P_1S_4, which showed best results with titratable acidity and β-carotene content.

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