

Changes in Biochemical Constituents of Tomato Juice During Storage

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Abstract
A study was carried out to evaluate biochemical changes in processed tomato juice stored for 12 and 6 months at ambient conditions. Tomato juice was processed from eight genotypes, juice stored and periodical analysis was carried out. Significant differences were observed among the genotypes/progenies in respect to product keeping qualities. In F_5 generation, the mean biochemical constituents in processed juice at the time of preparation and after 12 months of storage were, total soluble solids 5.84 and 4.8°Brix; titratable acidity 0.83 and 0.32 per cent; pH, 3.97 and 4.00; ascorbic acid, 25.74 and 4.11 mg/100 g; fruit total sugars, 3.5 and 3.1 per cent; lycopene, 3.36 and 1.31 mg/100 g; β-*carotene*, 2.44 and 1.2 mg/100 g, respectively. While in F_6 generation, 6.52 and 5.6°Brix, total soluble solids; 0.75 and 0.49 per cent, titratable acidity; 3.99 and 4.05, pH; 23.85 and11.63 mg/100 g, ascorbic acid; 3.71 and 3.46 per cent total sugars; 3.21 and 2.27 mg/100 g, lycopene; 2.10 and 1.74 mg/100 g β-*carotene* at the time of preparation and after 6 months storage, respectively. Among the genotypes treatment 8 (progeny of cross M-3-1 x H-24) and 25, 26 and 32 (three of them from progenies of cross 87-2 x 18-1-1) showed better retention of biochemical constituents. During storage at ambient temperature significant changes were not observed in processed products in respect to sugars and total soluble solids while significant changes were observed in ascorbic acid, lycopene and β-*carotene* content.
Keywords: ambient condition, generation, keeping qualities, processing, progenies

1. Introduction
Tomato is known for its outstanding nutritive and medicinal values and therefore grouped under protective foods. The fruits are eaten raw or cooked, and large quantities of fruits are used to produce soup, juice, ketchup, puree, paste, sauce and powder. Tomato fruit supplies minerals, vitamin A and B and is excellent source of vitamin C and adds variety of colours and flavours to the food (Tiwari *et al*., 2002). Processing plays an important role in conservation and effective utilization of perishable produces. However, only less than two per cent of the total production of fruits and vegetables are processed (Sudheer and Indira, 2007). Since the tomato fruits are highly perishable, growers are obligated to sell their produce immediately after harvest resulting in lower incomes. Therefore, it is necessary to overcome the problem of excessive production during glut period. It can be facilitated very effectively with the processing of the tomato fruits in the form of juice so as to stabilize the market prices in the interest of growers and to maintain a steady supply of tomatoes to the consumer in processed form. The changes in total soluble solids, sugars, as ascorbic acid, titratable acidity, pH, lycopene and β-*carotene* were lacking particularly during storage of processed tomato products such as juice at ambient condition. Therefore this investigation was conducted with the objective of identifying promising genotypes for processing qualities in to juice and its keeping quality during storage.

2. Materials and Methods
The study was conducted at All India Coordinated Research Project on Vegetable Crops, and at Post Harvest Technology Unit of Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri.

2.1. Experimental material
The seeds of tomato genotypes of F_4 generation of crosses M-3-1 x H-24 (2 progenies) and 87-2 x 18-1-1 (4 progenies) were obtained from All India Coordinated Research Project on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri. Standard checks 'Bhagyashree' and 'Dhanashree' were obtained from Tomato Improvement Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri.

2.2. Experimental design
Completely Randomized Design with three replications and statistical data were analyzed following procedures as recommended by Gomez and Gomez (1984); Panse and Sukhatme (1985).

2.3. Methods

Tomato genotypes for processing qualities were grown in spring-summer season of 2009/10 and 2010/11. The plot size was 11.88 m^2 (3.6 m x 3.3 m) and 4.86 m^2 (1.8 m x 2.7 m) gross and net plot size, respectively. The plot size comprising four rows 0.9 m apart and 0.3 m part in the row with 44 plants in each plot. Ridges were opened at 90 cm apart. Plots were laid out and seedlings were transplanted in to the main field at 30 cm distance on one side of ridges on 08, December, 2009, one month after seedling emergence.Fertilizer was applied at the rate of 200, 100 and 100 kg NPK/ha of Urea (as source of N), Phosphorus (P) and Potassium (K), respectively. Full dose of farm yard manure, P, K and half dose of N were applied before transplanting and remaining half dose of N were applied in three equal split doses at 20, 40, and 60 days after transplanting as a top dressing. Other cultural practices such as irrigation, weeding, staking, tying, and earthing up were carried out as per the requirement of the crop. But no any pesticides applied to control diseases and insect pests in both the years.

In 2010/11 cropping season, tomato seeds of F_5 generations were sown on 01, November 2010 on nursery beds and 3 weeks old seedlings (on1st December, 2010) were transplanted to the field. The plot size, spacing and method of planting, fertilizers application and other operations followed the previous year practices. Juice was prepared from eight promising genotypes following the methods suggested by Lal and Siddappa(1998) and Srivastava and Kumar (2002) procedures and prepared juice was stored at ambient condition. Every three months interval changes in biochemical constituent of juice was analysed for its quality at ambient room at Horticulture Laboratory, at Mahatma Phule Agricultural University. All the chemical analysis was done by following the procedures as suggested by Ranganna (1986) and A.O.A.C. (1990).

3. Result and Discussion

3.1. Total soluble solids

The total soluble solids is the main criteria in selection of tomato genotypes for processing as high total soluble solids reduces processing time for product concentration. Data pertaining to the periodical analysis of total soluble solids (TSS) revealed that there were reduction in TSS of juice during storage periods (Table 1). In F_5 generation, there were significant differences among the genotypes in respect to TSS content at 0, 3 and 12 months after storage. In F_5, the maximum and the minimum TSS of juice was observed in treatment (T_8) (6.24^{o}Brix) and T_{30} (5.71^{o}Brix) at the time of preparation and at the end of 12 months it was noted that maximum was 5.04^{o}Brix (T_{25}) which was at par with T_{32} (4.87^{o}Brix) and minimum was 4.72^{o}Brix (T_6). At the initial period the mean juice TSS was 5.84^{o}Brix and at the end of one year storage it found 4.8^{o}Brix. The processed juice TSS content in F_6 generation did not show significant differences except after six months storage (Table 1). At the time of preparation TSS of juice were ranged from 6.44 (T_{21}) to 6.57^{o}Brix (T_8, T_{25}, T_{26} and T_{32}) and after six months of storage significantly varied from 5.27 (T_{21}) to 6.17^{o}Brix (T_{25}). Total soluble solids in juice varied from 5.71 to 6.24^{o}Brix (F_5) and 6.44 to 6.57^{o}Brix (F_6) at the time of preparation, and 4.72 to 5.04^{o}Brix (F_5) and 5.27 to 6.17^{o}Brix (F_6) at the end of twelve and six months storage period, respectively. The reduction in the content of TSS during storage might be due to the biochemical changes during storage owing to hydrolysis of polysaccharide and non-reducing sugars. Similar results in reduction of TSS content were reported by Agarwal *et al*. (1995), Nithya and Premalatha (2006), Mahmude *et al*. (2009) and Wasim and Singh (2015).

3.2. Titratable acidity

Titratable acidity is one of the parameters for good flavour of processed tomato products. In F_5 genotypes/progenies, the mean titratable acidity of juice was declined from 0.83 per cent at the time of preparation to 0.32 per cent after one year storage at the ambient temperatures (Table 2). At zero day storage the titratable acidity of juice was significantly maximum in T_{32} (0.9 per cent) which was at par with T_{20} and T_{26} (0.88 per cent) and the minimum was in T_{25} (0.74 per cent) which was at par with T_8 (0.76 per cent). While at the end of 12 months storage the maximum titratable acidity of juice was noted in T_{25} (0.37 per cent) and the minimum was in T_6 (0.29 per cent) although there were no significant differences among the progenies in titratable acidity. There were significant differences in F_6 progenies in juice titratable acidity during the course of storage. Significantly maximum titratable acidity of juice was found in T_6 (0.87 per cent) which was at par with T_{26} (0.83 per cent) and the minimum was in T_{20} (0.65 per cent) which was at par with T_{21} (0.66 per cent) at the time of preparation and after six months storage significantly maximum and minimum titratable acidity were 0.59 per cent (T_{26}) and 0.44 per cent (T_6), respectively. The mean titratable acidity of juice was 0.75 per cent at the time of preparation and 0.49 per cent at the end of six months storage. The declining phenomenon perhaps due to the utilization of acids for formation of alkali base compounds (Sharma *et al*., 2004). The decrease in titratable acidity of juice and puree during storage was reported by Pruthi *et al*. (1980), Ibrahim (2008) and Mahmude *et al*. (2009).

3.3. pH

The results obtained on pH of juice during the course of storage period are presented in Table 3. As it is shown in the table there were significant differences among F_5 progenies in pH of juice throughout storage periods except at the time of preparation. The pH value of juice was lowest in T_{32} (3.89) and highest in T_{21} (4.09) at the time of preparation while the minimum and maximum pH value was observed in T_{30} (3.94) and T_{21} (4.08) at the end of 12 months storage period. Significant differences in juice pH value among F_6 progenies were registered, which was ranged from 3.93 (T_{30}) to 4.09 (T_{20}) and from 4.01(T_{30}) to 4.12 (T_{20}) at the time of preparation and after six months of storage, respectively. The pH value in juice decreased from 4.05 to 4.00 after six months storage onwards in F_5 generation. There was an increasing trend in pH value in F_6 generation during six months storage, the mean pH was 3.99 at the time of preparation and 4.05 at the end of six months storage. It was observed that the mean pH value of juice increased up to six months storage then after it was declined. Present findings are supported by the work done by Agarwal *et al*. (1995), Kaur *et al*. (1999) and Ibrahim (2008) who reported slight increase in pH values of juice during storage. The reduction in pH values may be attributed to an increase in H^+ activity in the packed bottles. These results are in accordance with findings reported by Benal *et al*. (2005), Garande (2006) and Safdar *et al.* (2010) and Wasim and Singh (2015).

3.4. Ascorbic acid

Ascorbic acid is one of the natural antioxidants found in fruits and vegetables. There were no significant differences observed in ascorbic acid content of juice prepared from F_5 progenies during 12 months storage except at 6 months storage period. Juice ascorbic acid content was ranged from 23.19 (T_{21}) to 27.77 mg/100 g (T_8 and T_{26}) and from 3.33 (T_6) to 4.55 mg/100 g (T_{32}) at the time of preparation and at the end of 12 months storage period, respectively (Table 4). In F_6, ascorbic acid content of processed juice was significantly maximum in T_{25} (27.5 mg/100 g) which was at par with T_{32} (25 mg/100 g) and minimum was in T_{21} (21.67 mg/100 g) which was at par with T_{20} (22.08 mg/100 g) at the time of preparation while maximum ascorbic acid was recorded in T_{25} (12.37 mg/100 g) which was at par with T_8 (12.22 mg/100 g) and the minimum ascorbic acid was in T_6 (10.88 mg/100 g) which was at par with T_{21} (10.9 mg/100 g) at the end of 6 months storage. The mean ascorbic acid content were 25.74 (F_5) and 23.85 mg/100 g (F_6) at the time of preparation and 4.11(F_5) and 11.63 mg/100 g (F_6) at the end of 12 and 6 months storage period, respectively. It was observed that ascorbic acid content declined with storage time. The variations in ascorbic acid content of juice were perhaps due to differences in genotypes, its interaction with growth resources. Declining in ascorbic acid contents of both juice with storage periods were reported by several workers, Agarwal *et al*. (1995), Kaur *et al*. (2004), Sharma *et al.* (2004) and Safdar *et al*. (2010). The losses of ascorbic acid are probably attributable to oxidation and non enzymatic reactions of ascorbic acid to dehydroascorbic acid followed by hydrolysis of the latter to 2,3-diketogluconic acid, which then undergoes polymerization to other nutritionally inactive products (Dewanto *et al*., 2002; Kaur *et al*., 2004; Rajchl *et al*.,2009).

3.5. Fruit Sugars

3.5.1. Reducing sugars.

There were no significant differences observed in the content of juice reducing sugars among F_5 progenies/genotypes during the storage period at ambient condition. Reducing sugars decreased upon three months of storage then it showed an increasing trend at 6 months storage and thereafter (Table 5). The content of reducing sugars were maximum in T_{26} (2.91 and 3.03 per cent) and minimum in T_{21} (2.51 and 2.78 per cent) at the time of preparation and after 12 months storage period, respectively. The mean content of reducing sugars increased from 2.79 per cent at the time of preparation to 2.97 per cent after 12 months of storage. In F_6, reducing sugars of processed juice was observed significant among the genotypes. At the time of preparation, significantly maximum reducing sugars was registered in T_{32} (3.07 per cent) which was at par with T_{25} (3.05 per cent) and minimum was in T_{30} (2.59 per cent) which was at par with T_{21} (2.74 per cent). After six months of storage, significantly maximum reducing sugars was also found in T_{32} (3.11 per cent) which was at par with T_{25} (3.1 per cent) and the minimum was in T_{30} (2.65 per cent) which was at par with T_{21} (2.79 per cent). It was noted that mean content of reducing sugars were 2.86 and 2.91 per cent at the time of preparation and after 6 months of storage period, respectively (Table 5).

3.5. 2. Non-reducing sugar.

Storage of processed juice at ambient condition for 12 months resulted in non significant differences among F_5 progenies/genotypes in content of non-reducing sugar except at 9^{th} months of storage. At the time of preparation, the content of juice non-reducing sugar was ranged from 0.61 (T_6) to 0.92 per cent (T_{21}) while after 12 months storage it was varied from 0.1 (T_{21}) to 0.17 per cent (T_{26} and T_6) in F_5 generation (Table 6). In F_6, significant differences in content of juice non-reducing sugar were observed whereby non-reducing sugar content varied from 0.76 (T_{30}) to 0.91 per cent (T_{21}) and from 0.49 (T_{30}) to 0.64 per cent (T_8) at the beginning and after 6 months storage, respectively. The mean value of non-reducing sugar was between 0.71 and 0.14 per cent at the beginning and after 12 months of storage in F_5, and 0.85 to 0.55 per cent at beginning and after 6 months storage period, in F_6, respectively. It was observed that the content of non-reducing sugar was declined during storage in both generations.

3.5.3. Total sugars.

The per cent total sugars of processed juice were not found significantly different among genotypes in F_5**.** The maximum and minimum total sugars was recorded in T_{26} (3.63 per cent) and T_{20} (3.40 per cent) at the time of preparation while it was ranged from 2.88 per cent (T_{21}) to 3.20 per cent (T_{26}) at the end of 12 months storage (Table 7). In F_6 generation, significant differences was noted in the content of total sugars which was varied from 3.35 (T_{30}) to 3.96 per cent (T_{32}) at the time of preparation and from 3.14 (T_{30}) to 3.65 per cent (T_{32}) after 6 months storage. It was observed that per cent total sugar of processed juice in both generations declined throughout storage period. Hence the mean total sugars of juice were recorded from 3.5 to 3.1 per cent (F_5) and 3.71 to 3.46 per cent (F_6) at the end of 12 and 6 months storage, respectively. The mean total sugars of juice reduced from 3.58 to 3.10 (F_5) and 3.71 to 3.46 (F_6) after 12 months and six months storage, respectively. Similar trends were observed for non-reducing sugar while there was an increase in content of reducing sugars of juice at the end of six months storage period and thereafter. Decrease in total sugars of juice perhaps was due the hydrolysis of polysaccharides and inversion of non-reducing sugars. Similar results were reported by Agarwal *et al.* (1995), Sharma *et al*. (2004), Garande (2006) in tomato juice, puree and paste.

3.6. Lycopene

Lycopene is the pigment principally responsible for the characteristic deep-red color of ripe tomato fruits and tomato products. It has attracted attention due to its biological and physicochemical properties, especially related to its effects as a natural antioxidant. Although it has no provitamin A activity, it exhibits a physical quenching rate constant with singlet oxygen almost twice as high as that of β-carotene (Shi and Maguer, 2000). The data pertaining to lycopene content of processed juice during storage showed significant differences among progenies in both generations (Table 8).Significantly maximum lycopene was found in T_{26} (4.13 and 4.03 mg/100 g) while minimum was registered in T_{30} (2.63 and 2.56 mg/100 g) at the time of preparation in F_5 and F_6 progenies, respectively. After 12 months storage the maximum lycopene was in T_{26} (1.62 mg/100 g) which was at par with T_6 (1.36 mg/100 g) and minimum was in T_{30} (1.06 mg/100 g) which was at par with T_8 (1.16 mg/100 g) in F_5 generation. Similar trends was observed in F_6 generation in respect to lycopene content of juice after 6 months storage which was significantly varied from 2.87 (T_{26}) to 1.61 mg/100 g (T_{21}). During storage period lycopene content of processed juice declined in irrespective of the genotypes in both generations. Accordingly, the mean lycopene content of juice was declined from 3.36 to 1.31 mg/100 g (F_5) and from 3.21 to 2.27 mg/100 g (F_6) after 12 and 6 months storage, respectively. The variation in lycopene content might be due to variations in genotypes. The present findings are in agreement with the results reported by Gowda *et al*. (1994), Seybold *et al*. (2004) and Ibrahim (2008). The declining trend in lycopene content was possibly attributed to lycopene sensitivity to heat, light and other biochemical reactions occurred during storage (Shi and Maguer, 2000; Kaur *et al.* 2004; Rajchl *et al*., 2009).

3.7. β-*carotene*

There were significant differences in β-*carotene* content of processed juice among progenies in F_5 and F_6 during storage. In F_5 and F_6 progenies T_{32} and T_{26} had significantly maximum β-*carotene* content (2.77 and 2.45 mg/100 g) while significantly minimum β-*carotene* content was recorded in T_{20} and T_{30} (1.93 and 1.46 mg/100 g), respectively, at the time of preparation (Table 9). Similarly, upon 12 months storage T_{26} showed maximum β-*carotene* content, 1.46 mg/100 g which was at par with T_{32} (1.3 mg/100 g) and significantly minimum in T_{30} (1.0 mg/100 g) which was at par with T_{21} (1.08 mg/100 g) in F_5 generation. At the end of six months storage in F_6 generation, significantly maximum β-*carotene* content was 2.09 mg/100 g in T_{26} which was at par with T_6 (2.04 mg/100 g), and the minimum was 1.12 mg/100 g in T_{30} which was at par with T_{20} (1.54 mg/100 g). The mean β-*carotene* content in juice was showed a decreasing trend from 2.44 (initial) to 1.2 mg/100 g after one year storage (F_5) and from 2.10 (initial) to 1.74 mg/100 g after six months storage (F_6). Decline in the content of β-*carotene* during storage was reported by Abushita *et al*. (2000) and Kaur *et al*. (2004) and Ibrahim (2008). Decline in β-*carotene* content might be due to its sensitivity to oxidation, light and temperature, and changes in re-arrangements of molecules from *trans* to *cis* isomerisation.

4. Conclusion

The study conducted on changes on biochemical constitute of tomato juice stored at ambient temperature for one year (F_5 generations) and 6 months (F_6 generations) showed that there was a gradual reduction in total soluble solids, titratable acidity, sugars, ascorbic acid, lycopene and β-*carotene* content of juice except pH of juice that increased from 3.97 and 3.99 (at initial) to 4.0 (after 12 months of storage) and 4.05 (after 6 months of storage) in F_5 and F_6 generations, respectively. It can be concluded that tomato juice processed and packed in bottle and stored at ambient temperature could retain its nutritional quality as old as 12 months.

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Table 1. Changes in total soluble solids (°Brix) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	5.74	6.47	5.26	6.32	5.09	5.43	4.91	4.72
8 (M-3-1 x H-24)	6.24	6.57	5.71	6.42	5.30	5.83	5.11	4.78
20 ('Bhagyashree')	5.77	6.50	5.46	6.37	5.20	5.70	5.01	4.75
21 ('Dhanashree')	5.77	6.44	5.67	6.32	5.40	5.27	5.05	4.75
25 (87-2 x 18-1-1)	5.84	6.57	5.71	6.43	5.42	6.17	5.23	5.04
26 (87-2 x 18-1-1)	5.77	6.57	5.74	6.44	5.21	5.63	5.02	4.77
30 (87-2 x 18-1-1)	5.71	6.50	5.57	6.34	5.10	5.30	4.90	4.75
32 (87-2 x 18-1-1)	5.84	6.57	5.57	6.41	5.08	5.50	5.02	4.87
General mean	5.84	6.52	5.59	6.38	5.23	5.60	5.03	4.80
S.E±(mean)	0.05	0.08	0.05	0.08	0.09	0.18	0.10	0.06
C.D. at 5%	0.14	NS	0.16	NS	NS	0.53	NS	0.19

Table 2. Changes in titratable acidity (%) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	0.85	0.87	0.56	0.58	0.47	0.44	0.44	0.29
8 (M-3-1 x H-24)	0.76	0.78	0.57	0.67	0.51	0.49	0.47	0.35
20 ('Bhagyashree')	0.88	0.65	0.63	0.53	0.56	0.48	0.44	0.32
21 ('Dhanashree')	0.82	0.66	0.55	0.58	0.49	0.47	0.45	0.30
25 (87-2 x 18-1-1)	0.74	0.73	0.59	0.66	0.52	0.51	0.48	0.37
26 (87-2 x 18-1-1)	0.88	0.83	0.64	0.65	0.57	0.59	0.45	0.30
30 (87-2 x 18-1-1)	0.77	0.78	0.61	0.64	0.56	0.49	0.51	0.36
32 (87-2 x 18-1-1)	0.90	0.67	0.61	0.64	0.55	0.47	0.46	0.30
General mean	0.83	0.75	0.60	0.62	0.53	0.49	0.46	0.32
S.E±(mean)	0.04	0.03	0.02	0.02	0.02	0.02	0.02	0.02
C.D. at 5%	0.10	0.08	0.06	0.07	0.06	0.04	NS	NS

Table 3. Changes in pH of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	3.92	3.98	4.02	4.01	4.04	4.03	4.02	4.00
8 (M-3-1 x H-24)	3.92	3.95	3.98	4.05	4.01	4.07	4.03	3.95
20 ('Bhagyashree')	4.08	4.09	4.09	4.10	4.10	4.12	4.07	4.04
21 ('Dhanashree')	4.09	4.05	4.10	4.08	4.12	4.10	4.11	4.08
25 (87-2 x 18-1-1)	3.90	3.99	3.99	4.01	4.02	4.04	4.03	4.00
26 (87-2 x 18-1-1)	4.03	3.97	4.04	4.00	4.04	4.03	4.01	3.97
30 (87-2 x 18-1-1)	3.93	3.93	3.96	3.98	3.99	4.01	3.97	3.94
32 (87-2 x 18-1-1)	3.89	3.94	4.04	3.97	4.06	4.02	4.03	4.02
General mean	3.97	3.99	4.03	4.03	4.05	4.05	4.03	4.00
S.E±(mean)	0.06	0.03	0.03	0.02	0.02	0.02	0.02	0.02
C.D. at 5%	NS	0.10	0.07	0.07	0.07	0.06	0.06	0.07

Table 4. Changes in ascorbic acid (mg/100 g) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	24.49	23.75	23.63	19.44	7.88	10.88	4.83	3.33
8 (M-3-1 x H-24)	27.77	24.17	26.47	22.61	8.56	12.22	5.90	4.17
20 ('Bhagyashree')	22.34	22.08	20.67	20.23	6.32	11.16	5.37	3.75
21 ('Dhanashree')	23.19	21.67	23.67	19.83	8.97	10.90	6.44	4.25
25 (87-2 x 18-1-1)	27.76	27.50	26.53	24.20	10.52	12.37	6.79	4.50
26 (87-2 x 18-1-1)	27.77	22.50	27.20	20.23	11.01	11.98	5.79	4.17
30 (87-2 x 18-1-1)	25.81	24.17	24.57	20.63	7.34	11.50	5.71	4.17
32 (87-2 x 18-1-1)	26.82	25.00	25.90	23.01	9.80	12.04	6.77	4.55
General mean	25.74	23.85	24.83	21.27	8.80	11.63	5.95	4.11
S.E±(mean)	1.66	1.09	1.61	0.72	0.76	0.45	0.43	0.35
C.D. at 5%	NS	3.28	NS	2.14	2.29	NS	NS	NS

Table 5. Changes in reducing sugars (%) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	2.85	2.80	2.80	2.84	2.84	2.86	2.90	2.96
8 (M-3-1 x H-24)	2.85	2.88	2.81	2.91	2.88	2.92	2.99	3.02
20 ('Bhagyashree')	2.72	2.81	2.67	2.84	2.78	2.86	2.88	2.93
21 ('Dhanashree')	2.51	2.74	2.48	2.77	2.58	2.79	2.73	2.78
25 (87-2 x 18-1-1)	2.80	3.05	2.74	3.10	2.82	3.10	2.93	3.00
26 (87-2 x 18-1-1)	2.91	2.97	2.87	3.00	2.85	3.01	2.95	3.03
30 (87-2 x 18-1-1)	2.82	2.59	2.78	2.63	2.86	2.65	2.92	2.99
32 (87-2 x 18-1-1)	2.85	3.07	2.79	3.09	2.89	3.11	2.94	3.01
General mean	2.79	2.86	2.74	2.90	2.81	2.91	2.91	2.97
S.E±(mean)	0.10	0.07	0.10	0.07	0.11	0.06	0.10	0.10
C.D. at 5%	NS	0.22	NS	0.20	NS	0.18	NS	NS

Table 6. Changes in non-reducing sugar (%) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	0.61	0.83	0.56	0.76	0.39	0.53	0.28	0.17
8 (M-3-1 x H-24)	0.68	0.86	0.64	0.80	0.40	0.64	0.25	0.15
20 ('Bhagyashree')	0.68	0.84	0.64	0.77	0.38	0.57	0.23	0.13
21 ('Dhanashree')	0.92	0.91	0.83	0.82	0.44	0.52	0.17	0.10
25 (87-2 x 18-1-1)	0.70	0.83	0.66	0.74	0.41	0.52	0.23	0.13
26 (87-2 x 18-1-1)	0.73	0.89	0.66	0.81	0.51	0.59	0.34	0.17
30 (87-2 x 18-1-1)	0.70	0.76	0.65	0.68	0.43	0.49	0.26	0.14
32 (87-2 x 18-1-1)	0.71	0.90	0.65	0.83	0.35	0.54	0.24	0.14
General mean	0.71	0.85	0.66	0.78	0.41	0.55	0.25	0.14
S.E±(mean)	0.06	0.03	0.06	0.03	0.04	0.03	0.02	0.01
C.D. at 5%	NS	0.09	NS	0.09	NS	0.07	0.05	NS

Table 7. Changes in total sugars (%) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	3.46	3.64	3.51	3.61	3.23	3.39	3.18	3.13
8 (M-3-1 x H-24)	3.52	3.74	3.30	3.71	3.28	3.56	3.24	3.16
20 ('Bhagyashree')	3.40	3.64	3.36	3.61	3.17	3.43	3.11	3.06
21 ('Dhanashree')	3.43	3.65	3.29	3.59	3.01	3.31	2.90	2.88
25 (87-2 x 18-1-1)	3.50	3.88	3.38	3.84	3.23	3.62	3.15	3.12
26 (87-2 x 18-1-1)	3.63	3.85	3.53	3.81	3.36	3.60	3.29	3.20
30 (87-2 x 18-1-1)	3.52	3.35	3.49	3.31	3.29	3.14	3.18	3.13
32 (87-2 x 18-1-1)	3.56	3.96	3.47	3.92	3.24	3.65	3.19	3.15
General mean	3.50	3.71	3.42	3.68	3.23	3.46	3.16	3.10
S.E±(mean)	0.13	0.09	0.12	0.08	0.13	0.07	0.11	0.01
C.D. at 5%	NS	0.25	NS	0.23	NS	0.21	NS	NS

Table 8. Changes in lycopene (mg/100 g) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	3.59	3.30	3.28	2.97	3.08	2.26	2.16	1.36
8 (M-3-1 x H-24)	3.55	3.27	3.15	2.79	2.94	2.22	2.06	1.16
20 ('Bhagyashree')	3.40	3.25	3.20	2.30	3.01	2.17	2.11	1.34
21 ('Dhanashree')	3.20	2.97	3.11	2.22	2.78	1.61	1.73	1.23
25 (87-2 x 18-1-1)	3.19	3.12	2.80	2.80	2.63	2.52	2.06	1.31
26 (87-2 x 18-1-1)	4.13	4.03	3.67	3.01	3.37	2.87	2.44	1.62
30 (87-2 x 18-1-1)	2.63	2.56	2.43	2.15	2.21	1.88	1.66	1.06
32 (87-2 x 18-1-1)	3.21	3.16	2.95	2.80	2.84	2.66	2.21	1.41
General mean	3.36	3.21	3.07	2.63	2.86	2.27	2.05	1.31
S.E±(mean)	0.16	0.07	0.16	0.09	0.19	0.09	0.08	0.05
C.D. at 5%	0.47	0.20	0.49	0.26	0.57	0.28	0.23	0.15

Table 9. Changes in β-carotene (mg/100 g) of juice during storage

Treatment (T)	Zero day storage		three months storage		Six months storage		Nine months storage	One year storage
	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_5
6 (M-3-1 x H-24)	2.41	2.40	2.34	2.29	2.15	2.04	1.82	1.22
8 (M-3-1 x H-24)	2.50	2.16	2.35	1.96	2.23	1.72	1.90	1.18
20 ('Bhagyashree')	1.93	1.89	1.80	1.71	1.70	1.54	1.50	1.10
21 ('Dhanashree')	2.25	2.07	2.01	1.99	1.92	1.73	1.69	1.08
25 (87-2 x 18-1-1)	2.72	2.35	2.51	2.27	2.25	2.02	1.78	1.27
26 (87-2 x 18-1-1)	2.71	2.45	2.40	2.33	2.27	2.09	1.74	1.46
30 (87-2 x 18-1-1)	2.23	1.46	2.03	1.33	1.73	1.12	1.33	1.00
32 (87-2 x 18-1-1)	2.77	2.01	2.45	1.89	2.17	1.65	1.78	1.30
General mean	2.44	2.10	2.24	1.97	2.05	1.74	1.69	1.20
S.E±(mean)	0.09	0.08	0.08	0.07	0.08	0.07	0.06	0.06
C.D. at 5%	0.27	0.24	0.24	0.20	0.24	0.22	0.17	0.18