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RESEARCH PAPER

Effect of Storage Temperature and Duration on Quality of Stored Pulp of 'Ofra' Strawberry

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Abstract

The present investigation was carried out with the objective to find out the effect of different treatments on preservation of strawberry pulp at ambient and low storage temperature condition. The samples were pasteurized at 100°C for 15 minutes (T_1), preserved with sodium benzoate 250 ppm (T_2) and sodium benzoate 500 ppm (T_3). The respective samples were stored for two months at room (25±5°C) and low (7±2°C) temperature conditions and various physic-chemical characteristics were recorded at three days interval. The total soluble solids, ascorbic acid and anthocyanin decreased and acidity increased in the stored pulp at room temperature and finally spoiled completely on 18th day of storage. However, in TSS, in acidity increased and ascorbic acid and anthocyanin decreased at low temperature upto 60 days of storage. Among the treatments, sodium benzoate @ 500 ppm was found to be the most effective which maintained the qualitative characteristics of preserved pulp at low (7±2°C) temperature condition up to the 60 days of storage.

Keywords: Ofra, Pulp, Quality, Sodium Benzoate, Storage, Strawberry

The Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most delicious, refreshing and soft fruit of the world and it is widely appreciated for its characteristic aroma, bright red colour, juicy texture and sweetness. Worldwide, it is also the most widely distributed fruit crop due to its genotypic diversity, highly heterozygous nature and broad range of environmental adaptations (Childers *et al.*, 1995). In recent past, the strawberry cultivation has been becoming popular in India due to very high returns per unit area in the shortest possible span. In India, the cultivated area under strawberry is nearly 15600 hectare and commercially grown in Himachal Pradesh, Maharashtra, Uttarakhand, Punjab, Haryana, Western Uttar Pradesh and Madhya Pradesh (Anonymous, 2015). It is an excellent source of anthocyanin and good source of vitamin C, and have tonic, diuretic, re-mineralizing and astringent properties (Hannum, 2004).

Generally, strawberry fruits are harvested early in the morning or cooler part of the day and sent to the market on the same day. During peak season, when there is a glut in the local market, the prices fall down and the crop becomes less remunerative. Preservation of strawberry as a whole fruit or in the form of pulp during peak harvest season and its utilization by processing industry in the later seasons could be one of the effective ways to make this crop remunerative. However, its post-harvest preservation is difficult because of its high rate of metabolic activity and great

susceptibility to the attack of micro-organisms. The freezing is known mocrobial spoilage to increase the length of fruit viability and provides an environment which favors reduced chemical reactions leading to increased storage stability (Zaritzky, 2006). But freezing process influences the final quality of the fruit (Suutarinen *et al*., 2002) since it triggers the formation of ice crystals, leading to fruit structure breakdown (Fennema, 1996). Therefore, the main objective of this research programme is to assess the changing in the quality parameters of strawberry pulp at different time intervals.

MATERIALS AND METHODS

The study on "Effect of storage temperature and duration on quality of strawberry pulp" was conducted in the Fruit Technology Laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar. The strawberry cultivar 'Ofra' was selected for the present investigation.

Preparation of Pulp

Uniform red colour, medium size disease free fruits were selected for the preparation of pulp. The sepals were removed manually and the fruits were crushed with the help of Pulp-Homogenizer mixture. The total pulp was divided into three lots. The pulp of first lot was packed in sterilized glass bottles of size 450 g and was pasteurized at 100°C temperature for 15 min. The pulp of second and third lots were treated with sodium benzoate @ 250 and 500 ppm, respectively and then, packed in sterilized glass bottles of 450 g. The filled jars of each lot were divided into two sub-groups and stored at two temperature; ambient room (25±5°C) and low (7±2°C) temperature, respectively.

Analysis

Estimation of TSS, acidity, ascorbic acid, anthocyanin content was carried out at three days of interval with four replications. The total soluble solids of preserved fruits and pulp were determined at room temperature by using Pocket Digital Refractometer having a range of 0 to 32º Brix by putting a drop of juice obtained by pressing the pulp on the prism and taking the readings. Acidity and ascorbic acid were determined as per the method suggested by AOAC (1990) while total anthocyanin content was estimated as per the method suggested by Harborne (1973).

The experiment was arranged in Completely Randomized Design and all data were subjected to OPSTAT software for analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The data of total soluble solids of strawberry pulp during storage up to 18 days have been presented in Table 1(a) and during later storage period in Table 1(b). Average total soluble solids (8.1%) was maximum in treatments T_6 and T_4 followed by T_2 (8.0%) upto 18th day of storage and after 18th day at storage, the maximum TSS (8.6%) was recorded in treatment T_6 which was significantly higher than T_2 (8.4%). Average total soluble solids increased continuously with the Increase in storage period except between 9th to 18th days of storage. The TSS of the pulp decreased drastically in treatments T_1, T_3 and T_5 after 9th day of storage, and observation were not recorded on later stage of storage period as the pulp got spoiled due to excessive microbial growth. However, the pulp treated with different chemicals and stored at low temperature was fit for preparing the products even after 60th days after storage.

Sodium benzoate @ 500 ppm was most effective in maintaining the TSS of the pulp at low temperature as compared to pasteurized pulp. The sodium benzoate and pasteurization helped in maintaining the quality of pulp up to 9 days at room temperature and 60 days of storage at low temperature, possibly by not allowing the multiplication of micro-organisms. The constituents of cell wall present in the pulp might have got converted to soluble sugars slowly at low temperature while it was faster at room temperature. These results are in agreement with Ruiz-Nieto *et al.* (1997), where an increase in glucose and fructose contents in strawberry juice was observed. Similar results were recorded by Ayub *et al.* (2010) who reported that TSS in strawberry pulp increased when it was preserved by different chemical preservatives

and stored at 4-15 ºC for three months except in pasteurized pulp.

The data of acidity (%) of strawberry pulp during storage upto 18 days have been presented in Table 2(a) and during later storage period in Table 2(b). Total acidity of strawberry pulp was maximum (1.65%) in treatment T_1 which was at par with treatment T_3 and T_5 and it was significantly higher than treatments T_2, T_4 and T_6 upto 18 days after storage. After 18th day of storage, the maximum acidity was recorded in T_6 which was at par with treatment T_2 and significantly higher than T_4. The average acid content of the pulp increased continuously and significantly with the increase in storage period. The increase in acidity in the pulp was significantly higher in T_1, T_3 and T_5 after 9th day of storage. The minimum acidity (1.35%) was recorded in treatment T_1 and T_2 on 0 day of storage and maximum (1.92%) in the treatment T_5 on 18th days of storage. However, the pulp treated with different treatment and stored at low temperature, the maximum acidity (1.75%) was recorded in T_6 which is significantly higher than T_2 the after 60 days of storage. Maximum mean titrable acidity was recorded in the strawberry pulp under various treatments stored for 18 days at room temperature as compared to the pulp stored at low temperature. It indicated that the pulp stored for ≥ 18 days at room temperature was not fit for further utilization. The increase in acidity was at faster rate at room temperature, possibly due to faster chemical reactions converting the sugars into acids. At low temperature, there was non-significant change in acid content of the pulp up to 60 days of storage, indicating that the pulp was suitable for further use even after 60 days of storage. As expected, all the treatments were more effective at low temperature for maintaining the quality of pulp than at higher

Table 1(a): The total soluble solids (%) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)							Mean
	0	3	6	9	12	15	18*	
Pasteurized+RT (T_1)	7.9	8.0	8.1	8.3	7.0	6.9	4.8	**7.3**
Pasteurized+LT (T_2)	7.9	7.9	7.9	8.0	8.0	8.0	8.0	**8.0**
Sodium Benzoate 250ppm+RT (T_3)	8.0	8.1	8.2	8.3	8.3	7.3	4.9	**7.6**
Sodium Benzoate 250ppm +LT (T_4)	8.0	8.0	8.0	8.1	8.1	8.1	8.2	**8.1**
Sodium Benzoate 500ppm+RT (T_5)	8.0	8.1	8.2	8.3	8.0	7.5	5.0	**7.6**
Sodium Benzoate 500ppm+LT (T_6)	8.0	8.0	8.0	8.1	8.1	8.1	8.2	**8.1**
Mean	8.0	8.0	8.1	8.2	7.9	7.7	6.5	
CD at 5%	Treatments- 0.09, Storage period (Days)- 0.11 Treatments x Storage period- 0.25							

*Pulp stored at room temperature T_1, T_3 and T_5 got spoiled after 18 days of storage.

* RT = Room temperature, LT = Low temperature

Table 1(b): The total soluble solids (%) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)														Mean
	21	24	27	30	33	36	39	42	45	48	51	54	57	60	
T_2	8.1	8.1	8.1	8.2	8.3	8.3	8.4	8.4	8.4	8.5	8.5	8.6	8.6	8.7	8.4
T_4	8.2	8.2	8.3	8.3	8.3	8.4	8.4	8.4	8.5	8.6	8.8	8.8	8.9	8.9	8.5
T_6	8.2	8.3	8.3	8.3	8.4	8.4	8.5	8.7	8.8	8.8	8.9	8.9	9.0	9.1	8.6
Mean	8.2	8.2	8.2	8.3	8.3	8.4	8.4	8.5	8.6	8.6	8.7	8.8	8.8	8.9	
CD at 5%	Treatments- 0.2, Storage period- 0.4 , Treatments x Storage period- NS														

temperature. These results are in agreement with the findings of Nunes *et al.* (1995) who reported an increase in acidity of strawberry during storage. The results are in conformity with the findings of Riaz *et al.* (1999). The increase in acidity during subsequent storage of strawberry pulp might be due to certain tri-carboxylic acid cycle (TCA) activities and part or the sugars being utilized to yield various acids resulting in increased acidity (Barmanray *et al.,* 1995).

The observations related to affect of treatments on ascorbic acid content of strawberry pulp during storage up to 18 days have been presented in Table 3(a) and during later storage period in Table 3(b). Average ascorbic acid content of strawberry pulp differed significantly in all the treatments except in Treatments T_4 and T_6 upto 18th day of storage and after then the maximum ascorbic acid content was recorded in T_6 (34.5 mg/ 100g) which was significantly higher than the T_4 and T_2. Throughout the storage period, the average ascorbic acid content of the pulp decreased progressively with increase in storage period. The ascorbic acid of the pulp decreased drastically in treatments T_1, T_3 and T_5 after 9th day of storage. However the pulp treated with different treatments and stored at low temperature retain significantly highest ascorbic acid in T_6 (29.8 mg/100g) followed by T_4 (26.1 mg/ 100g) after 60th day of storage. Ascorbic acid is the least stable vitamin and most difficult to be preserved during pasteurization and storage. In the present study, a decreasing trend in ascorbic acid of strawberry pulp during storage was recorded. The possible factor responsible for loss of ascorbic acid could be its oxidation to dehydro-ascorbic acid. Minimum decrease in ascorbic acid content in strawberry pulp was recorded in sample treated with sodium benzoate @ 500 ppm and maximum in pasteurized samples, after 9 days of storage room temperature and 60 days at low temperature,

Table 2(a): The acidity (%) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)							Mean
	0	3	6	9	12	15	18*	
Pasteurized+RT (T1)	1.35	1.45	1.58	1.65	1.78	1.82	1.90	**1.65**
Pasteurized+LT (T2)	1.35	1.40	1.45	1.45	1.47	1.47	1.50	**1.44**
Sodium Benzoate 250ppm+RT (T3)	1.40	1.45	1.50	1.58	1.68	1.83	1.87	**1.62**
Sodium Benzoate 250ppm +LT (T4)	1.40	1.40	1.43	1.45	1.48	1.48	1.51	**1.45**
Sodium Benzoate 500ppm+RT (T5)	1.40	1.43	1.55	1.60	1.70	1.88	1.92	**1.64**
Sodium Benzoate 500ppm+LT (T6)	1.40	1.40	1.46	1.46	1.48	1.50	1.53	**1.46**
Mean	1.38	1.42	1.50	1.53	1.60	1.66	1.71	
CD at 5%	**Treatments- 0.05, Storage period- 0.06 Treatments X Storage period - 0.14**							

*Pulp stored at room temperature (T_1, T_3 and T_5) got spoiled after 18 days of storage.

Table 2(b): The acidity (%) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)														Mean
	21	24	27	30	33	36	39	42	45	48	51	54	57	60	
T_2	1.52	1.55	1.55	1.59	1.59	1.59	1.62	1.62	1.64	1.64	1.67	1.67	1.69	1.69	1.62
T_4	1.53	1.53	1.55	1.57	1.57	1.59	1.59	1.59	1.63	1.65	1.68	1.68	1.68	1.72	1.61
T_6	1.55	1.55	1.58	1.58	1.62	1.64	1.65	1.67	1.67	1.69	1.69	1.72	1.75	1.75	1.65
Mean	1.53	1.54	1.56	1.58	1.59	1.61	1.62	1.63	1.65	1.66	1.68	1.69	1.71	1.72	
CD at 5%	Treatments- 0.04, Storage period- 0.09 Treatments X Storage period- NS														

respectively. The other possible reason could be that ascorbic acid is more sensitive to oxidation and got destroyed very quickly in the presence of oxygen, thereby leading to its decreased content during pasteurization and subsequent storage. In a similar study, Viberg *et al.* (1999) reported a decreased ascorbic acid in strawberry pulp subjected to freezing, heating and accelerated storage. These results are in agreement with the findings of Sabina *et al.* (2012) who reported that ascorbic acid content of strawberry pulp decreased when it was preserved by using different chemical preservatives and stored at 4-16 °C for three months.

The data pertaining to effect of treatments on anthocyanin pigment of strawberry pulp during storage up to 18 days have been presented in Table 4(a) and during later storage period in Table 4(b). Average retention of anthocyanin content was found maximum in treatment T_6 (50.6 mg/ 100g) which is significantly higher among the all treatments and minimum in T_1 (30.3 mg/ 100g) upto 18th day of storage and after 18th day of storage, the maximum anthocyanin (44.2 mg/ 100g) was recorded in treatment when the pulp was preserved with Sodium Benzoate 500ppm and stored at low temperature (T_6) which was significantly higher than T_2 (31.6 mg/ 100g). Throughout the storage period, the average anthocyanin content of the pulp decreased progressively with increase in storage period. The retention of maximum anthocyanin content was observed in T_6 (39.0 mg/ 100g) and minimum in T_2 (27.8 mg/ 100g) after 60 days of storage. Decreasing trend in anthocyanin pigments of strawberry pulp during storage was recorded in the present study. Maximum retention of anthocyanin pigments was recorded in sodium benzoate @ 500 ppm treated pulp stored for 18 days at room temperature and 60 day at low temperature. The possible reasons of decrease in anthocyanin might be due to hydrolysis of unstable aglycones, degradation of intermediaries,

Table 3(a): The ascorbic acid (mg/100 g) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)							Mean
	0	3	6	9	12	15	18*	
Pasteurized+RT (T_1)	36.5	35.0	34.1	30.0	26.2	18.0	8.0	26.8
Pasteurized+LT (T_2)	36.4	35.4	34.0	32.8	32.1	30.3	29.9	33.0
Sodium Benzoate 250ppm+RT (T_3)	42.4	40.6	37.9	33.8	30.4	20.0	12.0	31.0
Sodium Benzoate 250ppm +LT (T_4)	42.4	41.8	40.6	40.3	39.8	39.3	38.5	40.4
Sodium Benzoate 500ppm+RT (T_5)	42.5	40.6	37.3	35.3	31.0	25.0	14.0	32.2
Sodium Benzoate 500ppm+LT (T_6)	42.5	42.5	41.8	41.3	40.0	39.5	39.0	40.9
Mean	40.5	39.3	37.6	35.6	33.3	28.7	23.6	
CD at 5% Treatments- 1.09 Storage period- 1.18 Treatments x Storage period - 2.90								

*Pulp stored at room temperature T_1, T_3 and T_5 got spoiled after 18 days of storage

Table 3(b): The ascorbic acid (mg/100 g) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)														Mean
	21	24	27	30	33	36	39	42	45	48	51	54	57	60	
T_2	29.4	28.6	28.4	28.0	27.5	26.9	25.8	24.5	23.3	22.8	22.0	21.4	20.3	19.0	24.8
T_4	36.3	35.8	35.1	34.6	33.5	33.3	32.7	32.3	31.6	30.0	29.5	28.2	27.9	26.1	31.9
T_6	38.4	37.9	37.0	36.5	36.1	35.8	35.2	34.6	34.2	33.6	32.3	31.4	30.0	29.8	34.5
Mean	34.7	34.1	33.5	33.1	32.4	32.0	31.2	30.5	29.7	28.8	28.0	27.0	26.1	25.0	
CD at 5%	Treatments- 0.49, Storage period- 1.07, Treatments X Storage period- NS														

Table 4(a): The anthocyanin (mg/100 g) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)							Mean
	0	3	6	9	12	15	18*	
Pasteurized+RT (T_1)	40.8	39.0	36.8	32.5	28.0	21.8	13.3	30.3
Pasteurized+LT (T_2)	41.0	40.8	40.0	39.0	38.3	37.5	36.8	39.0
Sodium Benzoate 250ppm+RT (T_3)	53.5	52.0	49.0	40.3	34.3	26.5	20.3	39.4
Sodium Benzoate 250ppm +LT (T_4)	52.3	51.5	50.3	49.0	48.5	47.8	47.0	49.5
Sodium Benzoate 500ppm+RT (T_5)	54.8	52.5	46.5	40.0	38.0	28.0	24.0	40.5
Sodium Benzoate 500ppm+LT (T_6)	52.3	51.5	51.0	50.5	50.3	49.5	49.0	50.6
Mean	49.1	47.9	45.6	41.9	39.5	35.2	31.7	
CD at 5% Treatments- 0.93, Storage period- 1.01, Treatments x Storage period- 2.46								

*Pulp Stored at room temperature T_1, T_3 and T_5 got spoiled after 18 days of storage.

Table 4(b): The anthocyanin (mg/100 g) of strawberry pulp during storage as affected by various treatments

Treatments	Storage period (Days)														Mean
	21	24	27	30	33	36	39	42	45	48	51	54	57	60	
T_2	35.5	34.8	34.0	33.5	32.5	32.3	31.8	31.3	31.0	30.3	29.8	29.3	28.5	27.8	**31.6**
T_4	46.5	46.3	45.5	45.0	44.5	43.8	43.3	42.5	41.5	40.8	39.5	38.5	37.5	36.5	**42.3**
T_6	48.5	48.0	47.5	47.0	46.5	45.5	44.5	44.0	42.5	42.0	42.0	41.3	40.3	39.0	**44.2**
Mean	43.5	43.0	42.3	41.8	41.2	40.5	39.8	39.3	38.3	37.7	37.1	36.3	35.4	34.4	
CD at 5%	Treatments- 0.24 Storage period - 0.53 Treatments x Storage period- 0.92														

formation of copigment complexes with flavonoids, and degradation due to polyphenoloxidase (Wesche-Ebeling and Montgomery, 1990). The strawberry pulp/juices lost their anthocyanin pigments and redness quickly during storage. In a similar study, the degradation of anthocyanin contents of different berry juices or products during storage have also been reported in strawberry juice (Garzon and Wrolstad, 2002), blood orange juice concentrate (Kirca and Cemeroglu, 2003) as well as raspberry pulp (Ochoa *et al*., 1999).

CONCLUSION

The strawberry is a highly perishable fruit cannot be stored for a longer period but among different treatments, sodium benzoate @ 500 ppm was found most effective and maintained the qualitative characteristics of preserved pulp at low (7±2°C) temperature condition. The total soluble solids, ascorbic acid and anthocyanin decreased and acidity increased in the stored pulp at room temperature and spoiled completely on 18th day of storage. However, TSS, acidity increase and ascorbic acid and anthocyanin decreased at low temperature upto 60 days of storage.

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