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EFFECT OF DIFFERENT STORAGE CONDITIONS ON QUALITY OF PLUM (*PRUNUS SELICINA* LINDL.) PULP CV. SUTLEJ PURPLE

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ABSTRACT
Experiment was conducted to study the effect of different storage conditions on quality of pulp of plum. The pulp samples were pasteurized and stored at ambient, refrigerated (6 ± 2°C) and frozen temperature (-10 ± 5°C). The pulp was analyzed for quality parameters at 15 days of interval up to 4 month of storage. The maximum total soluble solids (11.39%) and acidity (1.79%) were found in the pulp stored at room temperature, while minimum was observed in pulp stored at frozen temperature (11.13% and 1.74% respectively). The maximum ascorbic acid (8.02 mg/100g) content was found in pulp stored at frozen temperature and it decreased progressively with the increase in storage period. The maximum total sugars (8.66%) were recorded in pulp stored at room temperature but no effect was recorded on reducing sugars. No significant changes in total and reducing sugars were observed up to 90th day of storage; however, in later storage periods it increased significantly. There was no microbial infection and browning in the pulp and it remained suitable for further use even after 120 days of storage. The pulp stored at frozen temperature showed stability for physicochemical attributes in comparison to other treatments during 120 days of storage.

INTRODUCTION

Plum, a member of genus *Prunus*, belongs to the family Rosaceae and subfamily Prunoideae. Plum has been cultivated since prehistoric times, perhaps longer than any other fruit except apple (Anon., 2004). The major plum producing countries are China, Serbia, Romania, Chile, Iran, United States of America, Turkey, Spain, India and Italy. It was introduced in India as early as in 1870. In India, it occupies an area of 24601 hectares with an annual production of 199241 tonnes (Anon., 2011). After evaluation, only Japanese plums have been recommended for commercial cultivation in Himachal Pradesh, Jammu and Kashmir and hills of Uttar Pradesh and also to some extent in Nilgiri hills of south India.

Plum is a climacteric fruit but has a short shelf life. In Haryana, the fruits ripen in the month of May-June, when the day temperature is very high (>45ºC) and relative humidity is very low. Under such conditions, the fruits cannot be stored for a longer period at ambient room temperature, resulting in market glut and farmers are bound to sell their produce at throwaway price. Secondly, storage of fresh plum fruit is a tedious, time consuming and costly process. Its transportation is non-practical and difficult. Even at low temperature (1ºC), the Japanese plum can only be stored for 3 to 5 weeks (Navarro *et al*., 2005), but at ambient room temperature, its fruit cannot be stored for more than 4 days, which increases the post-harvest losses. Therefore, it is need of the time to utilize its fruits in a different way so that the post-harvest loses may significantly be minimized. This problem can be solved by converting the fruits into pulp for regular supply to the processing industry so that the industry may remain viable round the year. Although the literature reveals ample work (Durrani *et al*., 2010; Jain *et al*., 2011; Sakhale *et al*., 2012) on storage of fruits pulp but the information on the plum pulp preservation is rather scanty. Gothwal *et al*. (1998) found the three commercially important varieties of plum *viz*., Santa Rosa, Mariposa and Early Transparent Gage acceptable for the storage of pulp for a period of nine months at room temperature (13 to 42ºC). The objective of present investigation was to study the effect of different storage conditions on stored pulp of plum cv. Satluj Purple.

MATERIALS AND METHODS

The present study on "Effect of different storage conditions on quality of plum pulp" was conducted in the Fruit Technology Laboratory of Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2013 to 2014. The fully mature diseased free fruits of plum cv. Satluj Purple were harvested from the 10 year old plants grown in orchard of the Department of Horticulture, CCS HAU, Hisar. The fresh fruits were analyzed for physico-chemically parameters. Fully ripe, uniform and medium sized disease free fruits were selected and washed thoroughly under running tap water to remove dirt and dust particles. The pulp was extracted with the help of electric pulper-homogenizer. The homogenized pulp was treated with sodium benzoate @ 2000 ppm and filled in sterilized glass jars of 500 g capacity and sealed. The pulp samples were pasteurized at 100ºC for 15 minutes and stored under different conditions, T_1-ambient, T_2-refrigerated (6 ± 2ºC)

and T_3-frozen temperature (-10 ± 5ºC). The treatments were replicated four times under completely randomized design. The quality of pulp was analyzed at 15 days interval up to 4 month of storage for physico-chemical parameters *viz.*, TSS (%), acidity (%), TSS to acid ratio, ascorbic acid (mg/100g), total sugars (%), reducing sugars (%), microbial evaluation, browning (NEB). The total soluble solids of pulp samples were determined at room temperature by using Pocket Digital Refractometer having a range of 0 to 32º Brix by putting a drop of pulp on the prism and taking the readings. Acidity and ascorbic acid were determined as per the method suggested by AOAC (1990). The ratio of total soluble solids to acid was obtained by dividing the total soluble solid with total acid. Sugars were determined by using the potassium ferricyanide method of Hulme and Narain (1993). The increase in absorbance of a sample at 440 nm was taken as measure of non-enzymatic browning as described by Ranganna (1977). The statistical method described by Panse and Sukhatme (1967) was followed for analysis and interpretation of the experimental results.

RESULTS

The data pertaining to total soluble solids presented in Table1reveal that the maximum TSS (11.39%) was recorded in the pulp stored at ambient room temperature (T_1), while it was minimum (11.13%) in pulp stored at frozen temperature (T_3). No significant change was observed in TSS although it ranged from 11.10 to 11.37% during 120 days of storage. The interaction between storage conditions and storage periods was also found non-significant.

The data presented in Table 2 reveal that the per cent acidity was affected significantly by different storage conditions and the minimum (1.74%) was observed in pulp stored at frozen temperature (T_3), whereas, the maximum (1.79%) was recorded in the pulp stored at ambient room temperature (T_1). There was non-significant increase in the acidity with the increase in storage period. The acid content was ranging between 1.74 and 1.78% during storage. The interaction between storage conditions and storage periods was also non-significant.

The data given in the Table 3 indicate that the TSS to acid ratio was not affected significantly by various storage conditions and storage durations. The TSS to acid ratio was in the range of 6.37 to 6.39. The interaction between storage conditions and storage duration was also found to be non-significant.

The data presented in the Table 4 reveal that ascorbic acid content was significantly affected by different storage conditions and the maximum (8.02 mg/100 g pulp) retention was recorded in pulp stored at frozen temperature (T_3) followed by T_2 (7.46 mg/100 g pulp), whereas, the minimum (6.87 mg/100 g pulp) was recorded in the pulp stored at ambient room temperature (T_1). It is also evident from the data that ascorbic acid content decreased significantly with the advancement of storage period and the maximum (8.50 mg/100 g) was observed on 0 day of storage, which decreased to 6.51 mg/100 g pulp after 120th day of storage. The interaction between storage conditions and duration in combination was also significant. The maximum ascorbic acid (8.50 mg/100 g pulp) was recorded on 0 day of storage and minimum (5.43 mg/100 g pulp) after 120th day of storage at ambient room temperature (T_1).

The data pertaining to total sugars in pulp during storage have been presented in Table 5. The total sugars were recorded maximum (8.66%) in pulp stored at room temperature (T_1)and the minimum (8.56%) was observed in pulp stored at frozen temperature (T_3), which was at par with T_2 (8.58%). No change in total sugars was observed up to 90th day of storage and thereafter it increased significantly. It was found maximum (8.71%) at 120th day of storage, whereas, the minimum (8.52%) was recorded on 0 day of storage.

The data presented in the Table 6 indicate that reducing sugars in pulp did not differ significantly with respect to various storage conditions. However, it varied from 5.73 to 5.92%. The reducing sugars increased with the increase in storage period but non-significantly up to 90th day of storage and the maximum (6.16%) was observed after 120th day of storage and minimum (5.69%) on 0 day of storage. The interactions among storage conditions and storage periods were found to be non-significant.

The perusal of data given in Table 7 reveals that the non-

Table 1: Effect of storage conditions on TSS (%) of pulp during storage

Storage condition	Storage period (days)									
	0	15	30	45	60	75	90	105	120	Mean
T_1	11.10	11.15	11.25	11.33	11.40	11.48	11.55	11.64	11.64	11.39
T_2	11.10	11.13	11.15	11.20	11.26	11.27	11.30	11.30	11.30	11.22
T_3	11.10	11.10	11.11	11.13	11.13	11.15	11.15	11.16	11.17	11.13
Mean	11.10	11.13	11.17	11.22	11.26	11.30	11.33	11.37	11.37	
CD at 5%	Storage condition (SC) - 0.18			Storage period (SP) - NS			SC x SP - NS			

T_1- Pulp stored at ambient temperature, T_2- Pulp stored at refrigerating temperature (6 ± 2°C), T_3- Pulp stored at frozen temperature (-10 ± 5°C)

Table 2: Effect of storage conditions on acidity (%) of pulp during storage

Storage condition	Storage period (days)									
	0	15	30	45	60	75	90	105	120	Mean
T_1	1.74	1.76	1.77	1.78	1.80	1.80	1.81	1.82	1.82	1.79
T_2	1.74	1.75	1.75	1.76	1.76	1.77	1.77	1.77	1.78	1.76
T_3	1.74	1.74	1.74	1.74	1.74	1.75	1.75	1.75	1.75	1.74
Mean	1.74	1.75	1.75	1.76	1.76	1.77	1.78	1.78	1.78	
CD at 5%	Storage condition (SC) - 0.02			Storage period (SP) - NS			SC x SP - NS			

Table 3: Effect of storage conditions on TSS to acid ratio of pulp during storage

Storage condition	Storage period (days)									
	0	15	30	45	60	75	90	105	120	Mean
T_1	6.38	6.33	6.36	6.37	6.36	6.37	6.39	6.41	6.41	6.37
T_2	6.38	6.38	6.37	6.37	6.41	6.37	6.38	6.38	6.36	6.38
T_3	6.38	6.38	6.39	6.41	6.41	6.39	6.39	6.40	6.40	6.39
Mean	6.38	6.36	6.37	6.38	6.39	6.38	6.39	6.40	6.39	
CD at 5%	Storage condition – NS		Storage period – NS		SC x SP - NS					

Table 4: Effect of storage conditions on ascorbic acid (mg/100g) of pulp during storage

Storage condition	Storage period (days)									
	0	15	30	45	60	75	90	105	120	Mean
T_1	8.50	7.97	7.70	7.26	6.82	6.37	6.02	5.75	5.43	6.87
T_2	8.50	8.32	8.10	7.79	7.35	7.08	6.87	6.62	6.51	7.46
T_3	8.50	8.50	8.37	8.14	7.88	7.80	7.69	7.69	7.59	8.02
Mean	8.50	8.26	8.05	7.73	7.35	7.08	6.86	6.69	6.51	
CD at 5%	Storage condition - 0.14		Storage period - 0.23		SC x SP - 0.4					

Table 5: Effect of storage conditions on total sugars (%) of pulp during storage

Storage condition	Storage period (days)									
	0	15	30	45	60	75	90	105	120	Mean
T_1	8.52	8.55	8.58	8.60	8.63	8.64	8.75	8.82	8.83	8.66
T_2	8.52	8.52	8.54	8.54	8.57	8.58	8.62	8.66	8.68	8.58
T_3	8.52	8.52	8.53	8.53	8.54	8.55	8.58	8.62	8.63	8.56
Mean	8.52	8.53	8.55	8.55	8.58	8.59	8.65	8.70	8.71	
CD at 5%	Storage condition - 0.07		Storage period- 0.13		SC x SP - NS					

enzymatic browning of the pulp did not alter significantly under different storage conditions and storage periods. However, it ranged from 0.08 to 0.14 in pulp among different treatments. The interaction between storage conditions and storage duration was also found non-significant. The microbial growth was observed visually at 15 days interval up to 120th day of storage of pulp. No microbial growth was found in the pulp stored under different storage conditions up to 120th day of storage. Hence, the pulp was fit for preparation of value added products even up to 120th days of storage.

DISCUSSION

In the present investigation, the total soluble solids and acid content in pulp were influenced by storage conditions and a significant increase in TSS and acidity was observed at room temperature as compared to frozen and refrigerated temperatures (Tables 1, 2 and 3). It might be due to increase in the activity of different enzymes responsible for degradation of stored starch, cellulose, pectin, *etc.* in stored pulp and also because of conversion of sugars into acid during processing at room temperature, while it was slower at frozen and refrigerated temperature because of reduced activities of hydrolyzing enzymes at low temperature conditions. However, no significant increase in TSS and acidity was observed with respect to storage period. It means that the quality of pulp remained unchanged and was suitable for use even after 120th day of storage for processing. Similarly, no significant changes were found in TSS to acid ratio by different storage conditions and storage periods. These results are also in agreement with the results of Durrani *et al*. (2012) who reported an increase in TSS and acid content of mango pulp during storage at room temperature as compared to refrigerated temperature. Bons and Dhawan (2013) also reported an increase in acidity in guava pulp during storage at low temperature. Gothwal *et al*. (1998) also observed no alteration in TSS and acid content of plum pulp during storage for nine months, whereas, Ahmed *et al*. (2000), Muhammad *et al*. (2011) and Sharma (2014) reported a gradual increase in TSS and acidity in guava, apple pulp and *jamun*-mango blended jam during storage, respectively.

The ascorbic acid in pulp was significantly affected by different storage conditions. The maximum retention of ascorbic acid was recorded at frozen temperature and minimum at room temperature. A significant decreasing trend in ascorbic acid was observed during storage and minimum was found at the end of storage period (Table 4). The possible reason could be that ascorbic acid is more sensitive to oxygen and temperature, thereby leading to its degradation during pasteurization and subsequent storage at room temperature. These results are in agreement with Hayati (1987) who reported a decrease in ascorbic acid content in guava pulp during storage but loss was comparatively lesser at low temperature than at room temperature. Kumhar *et al*. (2014) also reported higher retention of ascorbic acid in custard apple pulp during storage at low temperature as compared to ambient temperature. Similar decreasing trend in ascorbic acid content was observed in apple pulp during storage of 90 days at ambient temperature (Durrani *et al*., 2010; Muhammad *et al*., 2011).

Table 6: Effect of storage conditions on reducing sugars (%) of pulp during storage

Storage condition	Storage period (days)									
	0	15	30	45	60	75	90	105	120	Mean
T_1	5.69	5.71	5.73	5.75	5.78	5.87	6.05	6.30	6.46	5.92
T_2	5.69	5.69	5.71	5.73	5.74	5.81	5.94	6.07	6.20	5.84
T_3	5.69	5.69	5.69	5.69	5.71	5.71	5.76	5.78	5.83	5.73
Mean	5.69	5.70	5.71	5.72	5.74	5.79	5.92	6.05	6.16	
CD at 5%	Storage condition - NS		Storage period- 0.32		SC x SP - NS					

Table 7: Effect of storage conditions on browning (NEB) of pulp during storage (OD at 440 nm)

Storage condition	Storage period (days)									
	0	15	30	45	60	75	90	105	120	Mean
T_1	0.07	0.08	0.10	0.12	0.13	0.15	0.18	0.21	0.22	0.14
T_2	0.07	0.07	0.08	0.08	0.08	0.09	0.10	0.11	0.11	0.09
T_3	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.08
Mean	0.07	0.08	0.08	0.09	0.10	0.11	0.12	0.14	0.14	
CD at 5%	Storage condition - NS		Storage period - NS		SC x SP – NS					

Storage conditions have a significant effect on the total sugar content in pulp and the maximum sugar was recorded in pulp stored at room temperature. It was minimum in the pulp stored at frozen temperature, whereas, no significant variation in reducing sugars was noticed in the pulp under different storage conditions (Tables 5 and 6). It was also noticed that the total and reducing sugars increased with the increase in storage period but non-significantly up to 90th day of storage and thereafter it increased significantly. The increase in total sugars in the pulp stored in different conditions might be due to the fast hydrolysis of polysaccharides like pectin, cellulose, starch, *etc*. and its conversion into simple sugars at room temperature, while it was slower at low temperature. Increase in reducing sugars content in the pulp during storage might be due to conversion of non-reducing to reducing sugars (Ranote and Bains, 1982). These results are in conformity with the results of Kumhar *et al*. (2014) who observed higher increase in total sugar content of custard apple pulp during storage at ambient temperature as compared to low temperature. Gothwal *et al*. (1998) also observed an increase in reducing sugars in chemically preserved and heat processed plum pulp during nine months of storage, while the total sugars remained more or less constant. Hussain *et al*. (2003) also observed an increasing trend in content of reducing sugars during storage of mango pulp for 270 days. Similar trend in reducing sugars during storage period was observed by Karanjalker *et al*. (2013) in guava nector blended with soymilk.

No significant variation in browning of pulp was found among different storage conditions and storage periods (Table 7). However, the extent of browning was more at room temperature as compared to refrigerated and frozen temperature storage. Sethi (1995) also observed reduced non-enzymatic browning in mango pulp during storage at low temperature. Similarly, Saini *et al*. (2003) observed higher non-enzymatic browning in sand pear pulp during storage at room than at low temperature. Increase in browning during storage was mainly due to non-enzymatic reaction of organic acid with sugars or oxidation of phenols, which leads to the formation of brown pigments. No microbial growth was noticed in the pulp stored under different storage conditions up to 120th day of storage. It indicates that the pulp stored under different storage conditions was free from microorganism even up to 120th day of storage. It means that pulp remained suitable for processing even by 120 days of storage.

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