J Food Sci Technol (July–August 2011) 48(4):484–488
DOI 10.1007/s13197-010-0189-8

ORIGINAL ARTICLE

Effect of storage temperature on physico-chemical and sensory attributes of purple passion fruit (*Passiflora edulis* Sims)

Kundan Kishore · K. A. Pathak · Rohit Shukla · Rinku Bharali

Revised: 11 January 2010 / Accepted: 19 January 2010 / Published online: 22 December 2010

Abstract Physico-chemical and sensory quality of juice from purple passion fruit under different storage temperature and time were assessed. The maximum loss in fruit weight was recorded under room temperature (25±1°C) followed by at 11±1°C. There was an increase in juice percentage up to 9 and 13 days under room temperature and storage at 11±1°C respectively. The optimum flavour in juice was up to 5 days at 25±1°C and up to 21 days at 8±1°C. A significant reduction in sourness was recorded on 5th day under all treatments and the scores for sourness became almost constant after 17 days. The maximum increase in the mean scores of sweetness on 5th day was observed at 25±1°C followed by at 11±1°C. The optimum level of juice sweetness was maintained up to 21 days at 8±1°C. Total soluble solids content increased in initial stage followed by reduction. There was a reduction in the titrable acidity up to 21 days at 8±1°C. A decreasing trend in the reducing and non-reducing sugar of passion fruit was observed under all the treatments. Fruits stored at 25±1°C, developed off-flavour in juice after 5 days, while storage at 8±1°C produced no off-flavor even up to 21 days. Fruits can be stored for 5 days only at 25±1°C as the overall sensory quality of juice reduced significantly afterwards, while juice maintained the optimum overall quality up to 21 days at 8±1°C.

Keywords Purple passion fruit · Physico-chemical properties · Sensory attributes

K. Kishore (✉)
ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok 737102, India
e-mail: kkhort2003@yahoo.com

K. A. Pathak · R. Shukla · R. Bharali
ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib 796081, India

Introduction

The genus *Passiflora* L. belongs to family Passifloraceae with its major centre of diversity in Brazil (Knight and Winters 1962). There are two recognized forms of edible passion fruit (*Passiflora edulis*): purple (*Passiflora.edulis* Sims) and yellow (*Passiflora edulis* f. *flavicarpa* Deg.). The purple passion fruit is native of Tropical America while yellow passion fruit is being considered as a mutation of purple variety, or as a natural hybrid between purple and another related species of passion fruit (Akamine and Girolami 1959). The cultivation of passion fruit is dominated in Latin American countries and its processed products are exported to European countries. In India it is mainly cultivated in South India but now its cultivation has been extended to NorthEastern region due to the prevalence of suitable climate.

Purple variety is grown mainly for fresh juice and its flavour is a vital attribute which make the juice a desirable ingredient for many formulated beverages (Chen et al. 1987). The unique flavour of passion fruit is attributed to several volatile compounds which get deteriorated with the increase in temperature (Jagtiani et al. 1988). Purple passion fruit begins to loose moisture after harvesting and the continuous moisture loss for a week leads shriveling of fruits, which cause reduction in juice quality. Storage of passion fruit juice under low temperature is aiming to increase the shelf life, by controlling the action of enzymes and microbial activity.

In India, limited work has been done on the post harvest quality of passion fruit. The intervention in this aspect has better scope in improving the shelf life of fruits and in minimizing the loss by extending the storage life. The objective of the present experiment was to study some of the alterations taking place in juice quality during storage.

Materials and methods

Fruits of purple type were harvested after the development of purple colour (74 days old) during May–June and September–October in 2005, 2006 and 2007. Harvested fruits were properly washed and stored at room temperature (25±1°C) (T_1), 6±1°C (T_2), 8±1°C (T_3) and at 11±1°C (T_4). The RH at room temperature was 68–73% and fruits under T_2, T_3 and T_4 were also kept at the same RH. Colton BOD Incubator was used to keep the fruits under different temperature ranges and at constant RH. There were 200 fruits under each treatment and 25 fruits under each treatment were taken for juice extraction at 4 days interval. Aril was extracted manually and macerated and sieved using nylon cheese cloth to separate pulp and seed from juice. The quality of juice under each treatment and extracted at every interval was measured.

Physicochemical analysis The physiological loss in weight (PLW) was calculated by considering mean weight differences over time and the juice percentage was calculated by dividing the juice content (ml) and fruit weight (g) and by multiplying the resultant with 100. The total soluble solids (TSS) content was recorded with the help of hand refractometer (0–32° Brix). The titrable acidity, reducing sugar and total sugar were determined by following the methods of Ranganna (1986).

Sensory analysis A panel of six judges familiar with passion fruit juice was trained prior to the start of the experiment by using triangular test method (ISO 1983). Flavour profiling (ISO 1985) was used to evaluate the juices. Flavour descriptive attributes of passion fruit juice unanimously agreed upon were flavour intensity, acidity (sourness), sweetness, off-flavour and overall quality of juice. Judges

Table 1 Changes in physico-chemical quality parameters of purple passion fruit during storage at different temperatures

Storage temp.	Storage period, days						
	1	5	9	13	17	21	25
PLW,%							
T_1	0.0^{ap}	4.1^{cs}	4.2^{ds}	5.1^{ct}	2.2^{br}	1.5^{aq}	1.3^{aq}
T_2	0.0^{ap}	1.5^{aq}	1.7^{ar}	2.0^{ars}	2.3^{bt}	1.8^{brs}	1.7^{br}
T_3	0.0^{ap}	1.6^{as}	2.2^{bt}	2.5^{bu}	1.0^{aq}	1.5^{as}	1.3^{ar}
T_4	0.0^{ap}	1.9^{b}	2.5^{cr}	2.6^{br}	2.9^{cs}	1.8^{bq}	1.7^{bq}
Juice, %							
T_1	27.3^{aq}	32.5^{cr}	39.6^{cs}	33.2^{cr}	28.5^{aq}	26.5^{ap}	25.7^{ap}
T_2	27.5^{ap}	28.7^{aq}	29.6^{ar}	32.2^{bs}	33.4^{bt}	32.7^{cs}	34.5^{cu}
T_3	27.2^{ap}	28.6^{aq}	30.5^{br}	30.9^{ar}	33.6^{bs}	35.4^{dt}	36.5^{du}
T_4	27.4^{ap}	28.9^{bq}	29.8^{ar}	34.6^{du}	33.4^{bt}	31.9^{bs}	33.2^{bt}
TSS, %							
T_1	15.2^{as}	16.0^{bt}	15.8^{at}	15.7^{at}	14.2^{ar}	13.5^{aq}	13.0^{ap}
T_2	15.3^{ap}	15.4^{ap}	15.7^{aq}	15.9^{aq}	16.0^{cr}	15.8^{dq}	15.5^{dp}
T_3	15.2^{ap}	15.6^{aq}	16.0^{abr}	15.8^{aq}	15.7^{cq}	15.2^{cp}	15.0^{cp}
T_4	15.3^{ar}	15.6^{as}	15.9^{abs}	15.7^{as}	15.0^{br}	14.5^{bq}	14.0^{bp}
Titrable acidity, %							
T_1	3.8^{at}	3.2^{ar}	2.9^{aq}	2.7^{ap}	2.6^{ap}	3.2^{acr}	3.6^{cs}
T_2	3.7^{at}	3.6^{ct}	3.4^{bs}	3.0^{br}	2.8^{bq}	2.6^{ap}	2.6^{ap}
T_3	3.7^{ar}	3.4^{br}	3.1^{aq}	3.0^{bq}	2.8^{bp}	2.7^{ap}	2.8^{bp}
T_4	3.8^{as}	3.3^{ar}	3.0^{aq}	2.9^{bp}	2.8^{bp}	2.8^{abp}	2.9^{bp}
Reducing sugar, %							
T_1	10.2^{au}	8.3^{at}	8.5^{at}	7.8^{as}	7.5^{ar}	7.2^{aq}	6.9^{ap}
T_2	10.3^{av}	10.0^{cu}	9.7^{ct}	9.4^{ds}	9.2^{dr}	9.0^{dq}	8.7^{dp}
T_3	10.2^{at}	9.9^{cs}	9.4^{br}	9.1^{cq}	8.9^{cq}	8.6^{cp}	8.4^{cp}
T_4	10.1^{au}	9.7^{bt}	9.2^{bs}	8.8^{br}	8.6^{br}	8.2^{bq}	7.8^{bp}
Non- reducing sugar, %							
T_1	1.8^{au}	1.6^{at}	1.4^{as}	1.2^{ar}	0.9^{ap}	1.1^{aq}	1.2^{ar}
T_2	1.7^{as}	1.7^{bs}	1.6^{cr}	1.5^{cq}	1.4^{cp}	1.4^{bp}	1.4^{bp}
T_3	1.8^{at}	1.7^{bs}	1.6^{cr}	1.5^{cq}	1.4^{cp}	1.4^{bp}	1.4^{bp}
T_4	1.7^{av}	1.6^{au}	1.5^{bt}	1.4^{bs}	1.3^{br}	1.1^{ap}	1.2^{aq}

PLW: Physiological loss in weight, (n=3). T_1=25±1°C, T_2=6±1°C, T_3=8±1°C, T_4=11±1°C

Values with different superscripts in a column (a, b, c, d, ...) and in a row (p, q, r, s, ...) differ significantly ($p \leq 0.05$)

were served with the coded juice samples at the ambient temperature (25±1°C). The attributes were rated at a 7-point scale (1 = imperceptible to 7—very pronounced). A score of 4 for flavour intensity, sweetness and overall impression was the optimum level below which attributes were considered undesirable while it was the desired level of acidity and off-flavour. A score of 1 was the desired level that indicated absence of any off-flavour in the juice.

Statistical analysis The data recorded on various attributes by taking three replicates during the study were statistically analyzed by completely randomized design following the methods of Panse and Sukhatme (1985). The critical difference at 5% level of probability was used for comparing between treatments.

Results and discussion

Physico-chemical characteristics Maximum PLW of 4% was recorded on 5th day at 25±1°C (T_1) followed by at 11±1°C (T_1) (Table 1). Rate of PLW increased with increase in storage temperature (Mahajan et al. 2009) and this was largely due to water loss through lenticels of fruits, which permit free water vapour movement (Salaheddin and Kader 1984). An increase of 27.3–39.6% in juice quality was recorded at 25±1°C on 9th day of storage followed by reduction. The change in the juice content was relatively slower at 6±1°C and 8±1°C. Increase in the juice percentage for certain period was directly correlated with the temperature increase. The increase in juice per cent may be due to the high rate of weight loss.

The TSS of juice showed an increase up to 5th day at 25±1°C followed by a gradual reduction (Table 1). The reduction in TSS was relatively more rapid at higher temperature. Similar results were also observed by Patel et al. (2008) in onion. Changes in TSS content were natural phenomenon that occur during storage and it is correlated with hydrolytic changes in carbohydrates during storage. The reduction in TSS during storage indicate faster metabolic rates at higher temperature as also reported by Mahajan et al. (2006).

Table 2 Changes in sensory quality attributes of purple passion fruit during storage at different temperatures

Storage temp.	Storage period, days						
	1	5	9	13	17	21	25
Flavour intensity							
T_1	5.6^{at}	6.2^{bu}	3.6^{as}	2.5^{ar}	1.8^{aq}	1.0^{ap}	1.0^{ap}
T_2	5.6^{at}	5.2^{as}	4.2^{br}	3.8^{bq}	3.0^{bp}	3.0^{bp}	3.0^{cp}
T_3	5.6^{au}	5.7^{bu}	5.5^{dt}	5.3^{cs}	5.1^{dr}	4.8^{dq}	4.2^{dp}
T_4	5.6^{av}	5.2^{au}	4.8^{ct}	4.5^{ds}	3.8^{cr}	3.4^{cq}	2.4^{bp}
Sourness							
T_1	5.0^{ar}	3.2^{aq}	3.0^{ap}	3.0^{ap}	2.9^{ap}	2.9^{ap}	2.9^{ap}
T_2	4.9^{au}	4.5^{bt}	4.3^{bs}	3.8^{br}	3.7^{bq}	3.6^{bp}	3.6^{bp}
T_3	5.0^{at}	3.9^{cs}	3.4^{ar}	3.2^{aq}	3.0^{ap}	3.0^{ap}	3.0^{ap}
T_4	5.0^{au}	3.8^{ct}	3.2^{a}s	3.0^{a}r	2.9^{aq}	2.8^{ap}	2.8^{ap}
Sweetness							
T_1	3.8^{ar}	4.6^{at}	4.0^{as}	3.5^{aq}	3.0^{ap}	3.0^{ap}	3.0^{ap}
T_2	3.8^{ap}	4.1^{br}	4.2^{as}	4.2^{bs}	4.2^{bs}	4.0^{bq}	4.3^{bt}
T_3	3.8^{ap}	4.4^{cr}	4.6^{bt}	4.5^{cs}	4.4^{cr}	4.0^{bq}	3.8^{cp}
T_4	3.8^{aq}	4.5^{ct}	4.6^{bu}	4.2^{bs}	4.1^{br}	3.8^{cq}	3.5^{dp}
Off-flavour							
T_1	1.6^{ap}	2.3^{aq}	4.8^{ar}	5.6^{as}	6.0^{at}	6.2^{at}	6.5^{au}
T_2	1.6^{ap}	1.7^{bq}	1.8^{br}	1.8^{br}	2.4^{bs}	2.5^{bt}	2.8^{bu}
T_3	1.6^{ap}	1.8^{bq}	2.1^{br}	2.3^{cs}	2.4^{bs}	2.6^{bt}	2.9^{bu}
T_4	1.6^{ap}	2.0^{bq}	3.1^{cr}	3.6^{ds}	4.0^{ct}	4.8^{cu}	5.2^{cv}
Overall quality							
T_1	5.8^{au}	5.4^{at}	3.2^{as}	2.1^{ar}	1.8^{aq}	1.0^{ap}	1.0^{ap}
T_2	5.8^{au}	5.0^{bt}	4.0^{bs}	3.5^{br}	2.5^{bq}	2.4^{bp}	2.4^{bp}
T_3	5.8^{av}	5.6^{au}	5.0^{ct}	4.8^{cs}	4.5^{cr}	4.3^{cq}	3.8^{cp}
T_4	5.8^{av}	5.4^{au}	4.6^{dt}	4.4^{ds}	3.6^{dr}	3.4^{dq}	3.0^{dp}

T_1–T_4: As in Table 1

Values with different superscripts in a column (a, b, c, d, ...) and in a row (p, q, r, s, ...) differ significantly ($p \leq 0.05$)

Rate of reduction in acidity increased with the increase in temperature (Table 1). The reduction in acidity during storage is probably due to catabolism of citrate and malate and the pace of catabolism increases with the temperature (Sammi and Masud 2007).

A declining trend in the content of reducing sugar of passion fruit with the storage time was observed under all treatments (Table 1). The content of reducing sugar decreased more rapidly at 25±1°C than at lower temperatures. The results are in agreement with the findings of Tembo et al. (2008) in ber fruits. The reduction in reducing sugar during storage could be attributed to higher respiratory activity when reducing sugar (glucose and fructose) and non-reducing sugar (sucrose) are used up in the respiratory process (Sammi and Masud 2007).

Sensory attributes A sharp increase in flavour intensity on 5th day followed by a sudden decrease at 25±1°C was noticed (Table 2). At 11±1°C and 6±1°C the flavour fell below the optimum level after 13 days and 9 days, respectively and the optimum flavour intensity of juice was maintained up to 21 days at 11±1°C. The sudden increase in the flavour intensity with the increase in temperature may be due to the increase in the volatile compounds particularly esters in fruits (Nisperos-Carriedo and Shaw 1990).

Sourness was high on the day of harvest and a significant reduction in acidity was recorded on 5th day in all treatments. Reduction in sourness was more at higher temperature. Sourness became almost constant after 17 days. The reduction in acidity may be attributed to the conversion of organic acid (citric acid) to carbohydrate catalyzed by enzymes produced during climacteric peak (Satyan and Patwardhan 1984).

The highest increase in sweetness was recorded at 25±1°C (Table 2) and the optimum sweetness in the juice was maintained up to 9th day at 25±1°C and up to 17 days at 11±1°C and up to 21 days at 8±1°C. The increase in the sweetness may be due to higher conversion of organic acids into sugar (Fang et al. 1991) and breakdown of starch into glucose and sucrose (Selvaraj et al. 1989).

Fruits stored at 25±1°C developed off-flavour in their juice only after 5 days (Table 2). The juice stored at 11±1°C developed off-flavour after 13 days and at 8±1°C off-flavour did not develop even up to 21 days. The development of off-flavour in juice with the increase in the temperature may be due to more synthesis of ethanol and ethyl acetate in fruit juice (Namutebi 1998).

Passion fruit can be stored only for 5 days at 25±1°C as the overall quality reduced significantly afterwards (Table 2). Fruits stored at 8±1°C maintained the optimum scores for overall quality up to 21 days. The rapid reduction in the scores of overall quality of juice at 25±1°C may be due to greater synthesis of ethanol and ethyl ester and imbalance between sugar and acid due to rapid conversion of organic acid into sugar (Fang et al. 1991, Namutebi 1998).

Conclusion

The quality of fruit juice reduced rapidly at 25±1°C and fruit can hardly be stored for 5 days without any deterioration in quality. However, storage at 8±1°C, produced better result in terms of physicochemical and sensorial attributes. The sensorial attributes of fruit juice was retained up to 21 days at 8±1°C while at 6±1°C and 11±1°C these attributes were retained only up to 13 days. Therefore it can be concluded that under storage temperature of 8±1°C, passion fruit can be stored for 21 days without any deterioration in juice quality.

References

Akamine EK, Girolami G (1959) Pollination and fruit set in the yellow passion fruit. Hawaii, Agric Stat Technol Bull 59:1–44

Chen SL, Wu JSB, Wu CM (1987) The preparation of concentrated passion fruit juice by methods of flavour recovery and enzyme treatment. J Chinese Agric Chem Soc 25:177–187

Fang TT, Chao H, Wen S (1991) Effect of processing parameters on the quality of passion fruit (*Passiflora edulis*) juice concentrates. J Chinese Soc Hort Sci 37:226–236

ISO 1983. ISO: 4120, Sensory analysis methodology—Triangular test. 1st edn, Geneva Switzerland, pp 1–10

ISO 1985. ISO: 6564, Sensory analysis methodology—Flavour profile methods. 1st edn, Geneva Switzerland, pp 1–6

Jagtiani J, Chan HT Jr, Sakai WS (1988) Passion fruit. In: Tropical fruit processing. Academic Press Inc, San Diego, pp 157–167

Knight RJ, Winters HF (1962) Pollination and fruit set of yellow passion fruit in southern Florida. Proc Florida Hort Soc 75:412–418

Mahajan BVC, Bhatt AS, Satish K, Manohar L (2006) Effect of pre-storage treatments and packaging on the storage behavior and quality of kinnow mandarin. J Food Sci Technol 43:589–593

Mahajan BVC, Sharma SR, Dhall RK (2009) Optimization of storage temperature for maintaining quality of guava. J Food Sci Technol 46:604–605

Namutebi A (1998) Effect of preservation method and storage conditions on the flavour and colour of passion fruit juice. Afr Crop Sci J 6(4):397–405

Nisperos-Carriedo MO, Shaw PE (1990) Comparison of volatile flavour components in fresh and processed orange juice. J Agri Chem 38:1048–1052

Panse VG, Sukhatme PV (1985) Statistical methods for agricultural workers, 3rd edn. Indian Council of Agricultural Research, New Delhi, pp 258–268

Patel NC, Dabhi MN, Dhamsaniya NK (2008) Effect of storage conditions on the quality characteristics of onion. J Food Sci Technol 45:376–377

Ranganna S (1986) Handbook of analysis and quality control of fruit and vegetable products. Tata McGraw Hill Publ Co Ltd, New Delhi

Salaheddin ME, Kader AA (1984) Post harvest physiology and storage behavior of pomegranate fruits. Scientia Hort 24:287–298

Sammi S, Masud T (2007) Effect of different packaging system on storage life and quality of tomato (*Lycopersicon esculentum* var. Rio Grande) during different ripening stages. Int J Food Safety 9:37–44

Satyan SH, Patwardhan MV (1984) Enzyme related to gluconeogenesis and organic acid metabolism in ripening of fruits. J Food Sci Technol 21:175–177

Selvaraj Y, Kumar R, Pal DK (1989) Changes in sugar, organic acids, amino acids, lipid constituents and aroma characteristics of ripening mango (*Mangifera indica* L) fruits. J Food Sci Technol 26:308–313

Tembo L, Chiteka ZA, Kadzere I, Akinifesi KF, Tagwira F (2008) Storage temperature affects fruit quality attributes of Ber (*Ziziphus maurtitiana* Lamk.) in Zimbabwe. African J Biotechnol 7:3092–3099