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Shelf Life of Daisy Tangerine as Influenced by Different Treatments During Cold Storage

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Abstract

The present investigation entitled "Shelf life of Daisy tangerine as influenced by different treatments during cold storage" was conducted in P.G. Department of Agriculture, Khalsa College, Amritsar during 2021-22. The fruits were harvested at colour break stage and coated with Stafresh, Citra shine wax, Rice straw wrapping, Packing in CFB with paper shredding, Packing in CFB covered with polysheet 100-gauge, Butter paper wrapping, HDPE 10 µm, HDPE 20 µm, LDPE 100 gauze, LDPE 200 gauze, while control fruits dipped in plain water. All the treated and control fruits packed in corrugated fibre board (CFB) boxes and stored under cold storage conditions for 100 days with cold conditions (0-5 ºC temp & 90-95 % RH). The experiment was laid out in completely randomized design (CRD) with three replications. The fruits from each treatment were analyzed for physico-biochemical characteristics at an interval of fifteen days in cold storage conditions respectively. The Results revealed that physiological loss in weight, spoilage and TSS/TA of fruits increased with storage intervals whereas, TA, juice content and ascorbic acid content showed declining trend with the advancement of storage period. Others parameters like TSS, organoleptic rating, total sugars, reducing sugars and non-reducing sugars showed an increasing trend at earlier stages of storage and later on start declining. Citrashine wax showed a significant reduction in weight loss, spoilage and maintained TSS, TA, sugars and ascorbic acid contents as compared to other treatments and uncoated fruit. The various organoleptic parameters in terms of flavour, taste, appearance, colour and overall acceptability were also found superior in fruits treated with citrashine wax. on the basis of the study, it was concluded that postharvest application of citrashine wax was effective in delaying the ripening process, extend the shelf life and storage of Daisy tangerine with acceptable fruit quality up to 60^{th} day to 75^{th} day respectively.

Keywords: Daisy tangerine surface coatings; Packaging treatments; Shelf life; Cold storage

Introduction

Citrus is considered as the most famous group of fruit occupying an important place in the tropical and subtropical fruit growing all over the world. Its a evergreen plant belongs to family Rutaceae, sub family Aurantioideae and order Geraniales. It includes mandarins, oranges, lemons, limes, grapefruits and shaddocks. Mandarin (*Citrus reticulata* Blanco) characterised with loose skin, bright coloured peel and pulp; with excellent flavour and separatable segments (Joshi et al., 2019). The major citrus producing countries of the world are Brazil, USA, China, Spain, Mexico, India, Italy, Egypt etc. Brazil leads in the production of oranges succeeded by China and USA while, China is at I^{st} position in mandarin fruit production. India has the highest production of lime and lemons. In total citrus production, India attained 3^{rd} position after China and Brazil.

In India major mandarin growing states are Madhya Pradesh, Punjab, Maharashtra, Rajasthan, Assam, Nagaland, Arunachal Pradesh, Karnataka, Himachal Pradesh and Haryana. In India, mandarins occupy about 409 thousand ha of total citrus fruit area and production of 6264.62 MT (Anon, 2022). Daisy is the one which is common after Kinnow under Punjab conditions. Daisy mandarin is a cross between Fortune and Fremont mandarin considered to be better than either of its parent, it is moderately seedy with 1-3 seeds per section and is considered as early maturing variety (Bal, 2014). Mandarins are acknowledged for their high juice content, flavour delicious taste and as a rich source of vitamin-C, A, B, B_6 and minerals like calcium, folic acid, iron, magnesium and potassium (Turner and Burri, 2013). Average fruit weight of Daisy is 210 g with TSS 11.5%, acidity 0.54%, juice content 41.8% and average yield is 57 kg per plant at 5^{th} year of age. The soil pH less than 8.0 is suitable for Daisy cultivation when raised on Carrizo rootstock (Anon, 2021). Daisy is suitable for the area having soil pH less than 8.0 when raised on Carrizo rootstock (Anon, 2021). Edible coatings are used to enhance the quality, shelf life, through provide the boundary layer resistance, which may regulate oxygen, carbon dioxide and water vapour around the commodities. Various technologies like use of edible coatings, wax coating, cold storage, controlled atmosphere storage and growth retardants etc have been used to increase the shelf life of harvested fruits in past decades (Rokaya et al., 2016).

The most common technologies used commercially are low temperature storage, polyethylene packaging, chlorination and emulsion applications as wax coatings (Perez et al., 2002; Thakur et al., 2002). In harvested Kinnow fruits, loss in water vapour, results in shrinkage with peel, turgidity reduction, lowered resistance to gas diffusion, results in negative consequences with the taste and flavour (Salvatore et al., 2001).

Material and methods

The present study entitled "Shelf life of Daisy tangerine as influenced by different treatments during cold storage" was conducted in the laboratory Department of Horticulture, Khalsa College, Amritsar during 2021-2022. The material used for the present experiment were freshly harvested mature fruits of cv. Daisy tangerine. The fruits of uniform size, disease and bruise free were picked randomly from all the four directions of the plants with the help of secateurs at physiological mature stage and collected in plastic crates from the daisy mandarin orchard of PAU Fruit Research Station, Jallowal-Lesriwal, Jalandhar and were transferred to the laboratory Department of Horticulture, Khalsa College Amritsar. In the laboratory, the fruits were sorted, graded and washed with water. Thereafter fruits were divided into requisite lot for further handling. In the present study, the packaging films used were purchased from Amritsar commercial market area. The experiment was laid out in Complete Randomized Design (CRD) with three replications. Data analyses were performed by analysis of variance (ANOVA) using statistical software Statistix 10. Multiple comparisons among the treatments with significant tested with ANOVA were conducted by using least significant difference (LSD) at $p \leq 0.05$ level. Eleven treatments viz. T_1 (stafresh), T_2 (Citrashine wax), T_3 (Rice straw wrapping), T_4 (Packing in CFB with Paper shredding), T_5 (Packing in CFB covered with polysheet 100 gauge), T_6 (Butter paper wrapping), T_7 (HDPE 10 µm) and T_8 (HDPE 20 µm), T_9 (LDPE 100 gauge), T_{10} (LDPE 200 gauge) and T_{11} (control) in control the fruits were treated with distilled water. The fruits were analyzed after every 15 days up to the last stage of shelf life of fruits for different physical and biochemical characteristics. Fruits were coated with edible coatings of stafresh and citrashine wax were kept on trays. For the application of edible wax coatings on the fruits, a piece of foam pad was drenched with particular coating material and coating was applied gently on the surface of fruits. Thereafter fruits were air dried and stored at cold storage condition (0-5 °C & 90-95 % RH).

Results and Discussion

Physiological loss in weight (%)

The data with regard to physiological loss in weight (PLW%) are presented in Fig. 1 Minimum physiological loss in weight (4.51%) was recorded on 15^{th} day of storage then it increased to 6.36, 9.51, 13.56 and 14.87 per cent on 30th, 45th, 60th and 75th day of storage. The differences were found to be statistically significant.

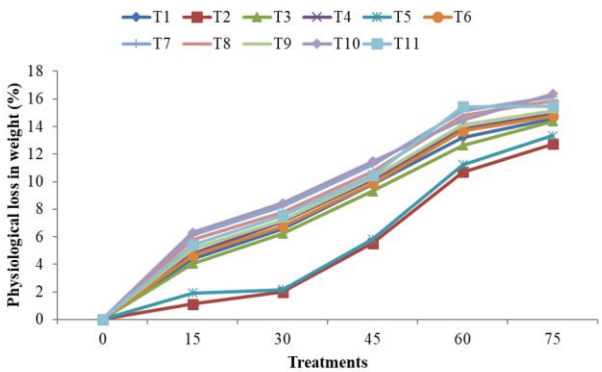

Fig. 1. Effect of different treatments on physiological loss in weight (%) of Daisy tangerine during cold storage

Different treatments of edible coatings had a significant ($p \leq 0.05$) effect on PLW of Daisy tangerine fruits during cold storage. Minimum level of PLW (5.34) per cent was estimated in Daisy tangerine fruits under treatment T_2 (citrashine wax), it was followed by T_5 (packing in CFB with poly sheet 100 gauge), T_3 (rice straw wrapping) and T_1 (stafresh) with 5.74, 7.70 and 8.08 per cent PLW respectively. Treatments T_1 and T_3 were found to be at par with each other. Treatment T_{10} showed maximum physiological loss in weight of fruits.

The interaction between days of storage and treatments were found to be statistically significant. On 15th day of storage, minimum physiological loss in weight (1.13%) was recorded with citrashine wax (T_2) however, the maximum PLW (16.37%) was noted in fruits applied with LDPE 200 gauge on 75th day of storage. Wax coated fruits glossiness and fresh appearance being a, moisture barrier in the study carried by (Mahajan et al., 2005). The wax coatings on fruit surface acted as barrier and prevented loss in moisture (Pal et al., 1997). Singhrot et al. (1987) reported that reduction in physiological weight loss in Kinnow fruits treated with waxing might be due to prevention of water loss. Gupta and Rattanpal (2017) reported that the physiological loss in weight was minimum in citrashine wax treated fruits after 21 days of storage whereas, in control fruits physiological loss in weight was maximum. The findings of this study is also correlated with the findings of Jhalegar et al. (2015) and Mahajan et al. (2013). Mahajan and Singh (2014) revealed that citrashine coated fruits recorded minimum PLW and control fruits showed the highest PLW.

Juice content (%)

The data with regard to juice content of Daisy tangerine fruits as effected by different treatments are presented in Fig. 2. Maximum juice content (45.26%) of fruits was estimated on 15th day of storage. The differences were found to be significant statistically. Different treatments of edible coatings had a significant ($p \leq 0.05$) effect on juice content of Daisy tangerine fruits during the storage interval. Maximum level of juice content that was 46.73 per cent was estimated in tangerine fruits treated with citrashine wax (T_2) it was followed by T_5 (packing in CFB with poly sheet 100 gauge), T_3 (rice straw wrapping) and T_1 (stafresh) with 44.68, 43.73 and 42.00 per cent juice content respectively.

The interaction between days of storage and treatments were found to be statistically significant. On 15th day of storage, maximum juice content (50.46%) was recorded in tangerine fruits treated with citrashine wax however, minimum juice content (27.16%) was noted in fruits applied with LDPE 200-gauge fruits on 75th day of storage. The trend of decrease in juice percentage during the storage might be due to loss of moisture from the surface of the fruits. Juice content showed a decreasing trend with packaging materials and time during the storage period in all the treatment. The results are in conformity with Paudel et al. (2019), Hayat et al. (2017) and Bullar (1988) who reported similar observations during post-harvest dipping and various packaging materials on quality traits of mandarin. Rattanpal et al. (2010) noted that maximum juice per cent in Kinnow fruits treated with citrashine wax.

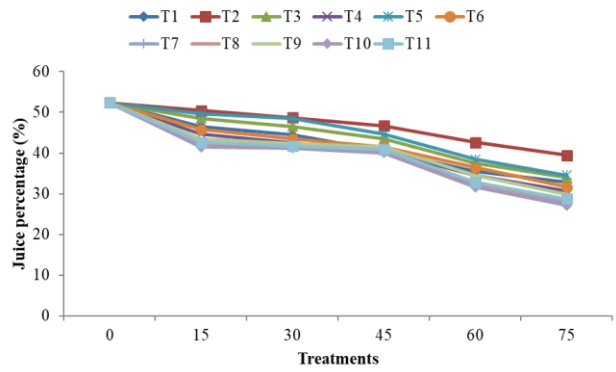

Fig. 2. Effect of different treatments on juice percentage (%) of Daisy tangerine during cold storage

Organoleptic rating (1-9 hedonic scale)

The data with regard to organoleptic rating (Fig. 3) as awarded by a panel of five judges showed its increasing trend from 0 day of storage up to 45th day of storage afterwards it followed descending trend up to last day of storage. Daisy tangerine were awarded minimum organoleptic rating (5.32) on 0 day of storage, showed an increasing trend to 6.18, 6.52 and 6.61 score on 15th, 30th and 45th day of storage and then decreased to 6.48, 5.72 scoring on 60th and 75th day of storage and the differences were found to be significant statistically.

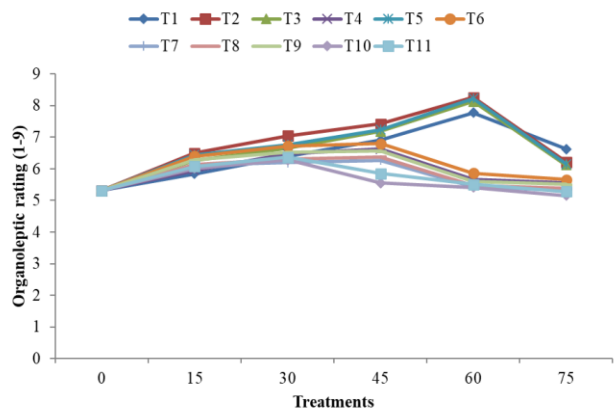

Fig. 3. Effect of different treatments on organoleptic rating (1-9) of Daisy tangerine during cold storage

Different treatments of edible coatings had a significant ($p \le 0.05$) effect on organoleptic rating of Daisy tangerine fruits during the storage interval. Maximum awarded of organoleptic score (6.79) were awarded in fruits under treatment T_2 (citrashine wax), it was followed by T_5 (packing in CFB with poly sheet 100 gauge), T_3 (rice straw wrapping) and T_1 (stafresh) with 6.69, 6.61 and 6.47 organoleptic rating scores respectively.

The interaction between days of storage and treatments were found to be statistically significant. On the start of experiment (0 day) organoleptic score 5.32 was awarded to fruits which were treated with citrashine wax after 60 days of storage, however, minimum organoleptic scoring i.e. 5.16 was given to fruits which were packed with LDPE 200 gauge on 75th day of storage. Wax coating have been reported to maintain the gloss, flavour and aroma of fruits (Olivas and Barbosa-Canovas 2005). Since consumers buy fruits keeping their visual observations, a commodity that exhibits a better visual quality will be perceived by a consumer fruits. Mahajan et al. (2005) reported that wax treated Kinnow fruits showed higher palatability rating than uncoated fruits during storage. Gupta and Rattanpal (2017) reported that grapefruit cv. Star Ruby treated with citrashine wax depicted higher organoleptic rating during storage. Citrashine emerged as the best treatment with maximum organoleptic rating during storage in kinnow (Rattanpal et al., 2010) also confirms the results of present studies. The results are in conformity with the finding of Wang et al. (2004) in Jincheng orange and Rattanpal et al. (2010).

Total soluble solids (%)
The data with regard to total soluble solids are delineated in Fig. 4. The trend showed an increase in total soluble solids from 0 day up to 45th day of storage then it started declining. At the start of experiment total soluble solids of Daisy tangerine were estimated to be 8.26 per cent then it increased to 10.22,11.34 and 11.80 per cent on 15th, 30th and 45th day of storage respectively and then decreases to 10.85, 6.72 per cent on 60th and 75th day of storage. The differences were found to be statistically significant.

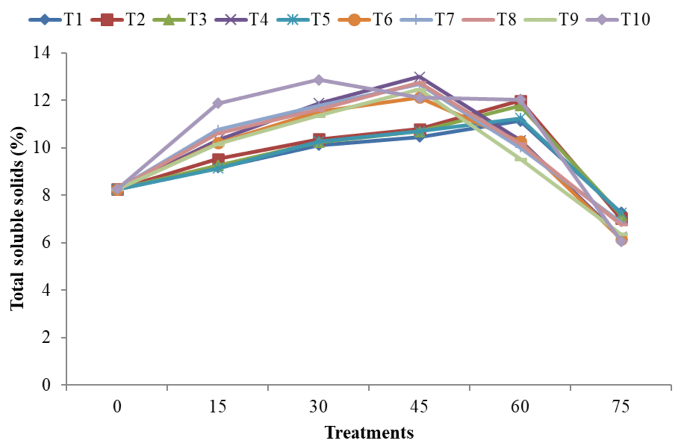

Fig. 4. Effect of different treatments on total soluble solids (%) of Daisy tangerine during cold storage

Fruits wrapped with LDPE 200 gauge exhibited maximum total soluble solids content i.e 10.53 percent, it was followed under control i.e. 10.35 percent. Minimum total soluble solids content (9.41%) recorded in T_1 (stafresh) followed by T_6 (butter paper wrapping), T_3 (rice straw wrapping) and T_2 (citrashine wax) treatments with 9.47, 9.56 and 9.65 percent total soluble solids content and these were found to be at par with each other.

The interaction between days of storage and treatments were found to be statistically significant. At the start of experiment total soluble solids of Daisy tangerine fruits were 8.26 per cent. Maximum total soluble solids (12.75%) were registered in HDPE 20 µm (T_8) treatment whereas, minimum total soluble solids (6.07%) were found in fruits under (T_{10}) treatment on 75th day of storage.

The increase in TSS during storage may possibly be due to the breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars (Wills et al., 1980). The delayed increase in TSS over a longer period of time in coated Daisy fruits might be attributed that coatings delayed the metabolic and respiratory activity of fruit and hence might have retarded the fruit ripening and senescence processes. Similar increase trend of TSS content during cold storage in Kinnow mandarin has been reported by Thakur et al. (2002). The wax coated fruits showed less increase in TSS as compared to untreated fruits. Gupta and Rattanpal (2017) reported that grapefruit cv. Star Ruby treated with citrashine wax showed higher total soluble solids during storage. Mandal (2015) also reported a sharp decline in TSS of uncoated Kinnow fruits after storage under ambient conditions due to rapid metabolic breakdown in these fruits. Rattanpal et al. (2010) reported fruits of Kinnow when treated with wax coating total soluble solids increased with the increase of interval of storage. The findings are also correlate with the findings of Mahajan et al. (2005) in Kinnow and Ladaniya and Sonker (1997) in Nagpur mandarin.

Titratable acidity (%)

The data with regard to titratable acidity (%) are presented in Fig. 5. At the start of experiment, acidity of Daisy tangerine fruits was analyzed to be 0.80 per cent on 15th day of storage then it decreased to 0.46, 0.41, 0.34 and 0.28 per cent on 30th, 45th, 60th and 75th day of storage respectively. The differences were found to be significant statistically.

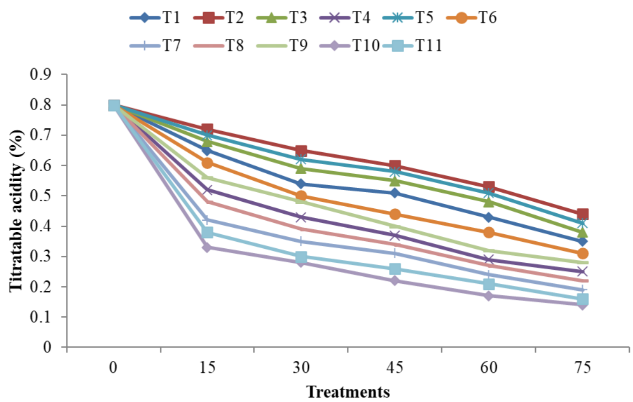

Fig. 5. Effect of different treatments on titratable acidity (%) of Daisy tangerine during cold storage

Different treatments of edible coatings had a significant ($p \leq 0.05$) effect on Daisy tangerine fruits during cold storage. Maximum level of titratable acidity that was 0.62 per cent was estimated in tangerine fruits under treatment T_2 (citrashine wax), it was followed by T_5 (packing in CFB with poly sheet 100 gauze), T_3 (rice straw wrapping) and T_1 (stafresh) with 0.60, 0.58 and 0.54 per cent titratable acidity respectively.

The interaction between days of storage and treatments were found to be statistically significant. At the start of experiment, it was 0.80 per cent on 15th day of storage, titratable acidity i.e. 0.72 per cent was recorded in Daisy tangerine fruits treated with citrashine wax however, the minimum titratable acidity (0.14%) was noted in LDPE 200 gauge wrapped tangerine fruits on 75th day of storage. The decrease in titratable acidity during storage may be attributed to utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits (Pool et al., 1972). When the fruits were coated, the lowering of acidity was delayed, which might de due to the effect of coatings in delaying the respiratory and ripening process (Mahajan and Singh, 2014). Gupta and Rattanpal (2017) reported that grapefruit cv. Star Ruby treated with citrashine wax showed titratable acidity decreased non-significantly with the increase in storage interval. The results are in conformity with the findings of Hayat et al. (2017) in citrus, Seehanam et al. (2010) and Boonyakiat et al. (2012) in Sai Nam Peung tangerine.

Reducing sugars (%)

Reducing sugars of Daisy tangerine fruits showed an ascending trend from 0 day of storage to 45th day of cold storage, afterwards it started declining. Minimum reducing sugars (3.60%) were analyzed at the start of experiment Fig. 6, then 4.47, 4.72 and 4.99 per cent on 15th, 30th and 45th day of storage then decreased to 4.56, 3.38 per cent on 60th and 75th day of storage. The differences were found to be significant statistically.

Different treatments of edible coatings had a significant ($p \leq 0.05$) effect on reducing sugars of Daisy tangerine fruits during cold storage. Maximum level of reducing sugars that was 4.50 per cent was recorded in Daisy tangerine fruits under treatment (T_{10}) LDPE 200 gauge, it was followed by (T_7) (HDPE 10 µm), (T_8) (HDPE 20 µm) and control with 4.49 4.44 and 4.43 per cent reducing sugars respectively. Minimum percentage of reducing sugars 4.01 % were estimated in (T_2) treatment followed in line by (T_3) and (T_1) treatments which were found to be par with each other.

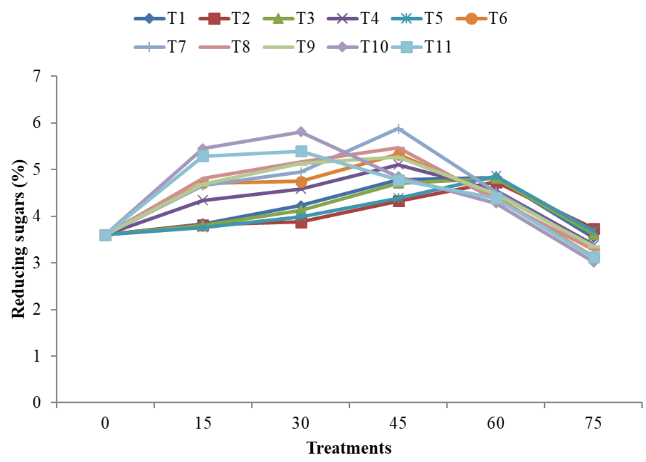

Fig. 6. Effect of different treatments on reducing sugars (%) of Daisy tangerine during cold storage

The interaction between days of storage and treatments were found to be statistically significant. At the start of experiment Daisy tangerine fruits registered 3.60 per cent reducing sugars content. On 30th day of storage the maximum reducing sugars contents (5.81%) were recorded in LDPE 200-gauge treatments whereas on 75th day minimum reducing sugars (3.71%) were registered in fruits treated with citrashine wax.

Reducing sugars are commonly consumed in respiration so these are expected to decline during storage but increase in reducing sugars with storage could be due moisture loss which increased concentration of fruits juice. The increase in sugars in the juice were observed during post-harvest storage due to cell wall hydrolysis by various enzymes such as pectinase, cellulase or hemicellulose (Echeverria and Ismail, 1987). Gul et al. (1990) observed that reducing sugars increased slowly in wax coated fruits than control. Ahmad et al. (1986) who reported the effect of seal-britex-65 wax on Blood red oranges and found that reducing sugars increased during storage. The findings of the above researchers confirm the results of the present studies.

Total sugars (%)

The data with regard total sugars Fig. 7. showed an increase in total sugars from 0 day of storage up to 45th day of storage afterwards it started declining. Minimum total sugars (5.26%) were analysed at the start of experiment then it showed an experiment trend with i.e. 6.64, 7.16 and 7.52 per cent total sugars on 15th, 30th and 45th day of storage and then decreases to 7.37, 5.34 per cent on 60th and 75th day of storage. The differences were found to be significant statistically.

Different treatments of edible coatings and wrappings had a significant ($p \leq 0.05$) effect on total sugars of Daisy tangerine fruits during cold storage. Maximum level of total sugars that was 6.95 per cent was recorded in fruits under treatment T_{10} (LDPE 200 gauge), it was followed by T_{11} (control), T_9 (LDPE 100 gauge) and T_8 (HDPE 20 µm) which recorded 6.77, 6.62 and 6.46 per cent total sugars respectively. Minimum total sugars were analysed in treatments T_2 (citrashine wax) followed in ascending trend by T_3, T_5 and T_1 with 6.33, 6.35 and 6.46 per cent total sugars. Treatments T_2, T_3 and T_5 were found to be statistically at par with each other.

The interaction between days of storage and treatments were found to be statistically significant. On 30th day of storage the maximum total sugars (8.02%) were reported in LDPE 200 gauze whereas, minimum total soluble solids (5.55%) were registered in citrashine wax. The total sugars increase at slower rate up to 60th day of storage in citrashine wax treated fruits but afterwards decreases at same rate on 75th day of storage. On 75th day of storage maximum total sugars (7.48%) noted in fruits treated with citrashine wax and minimum (5.01%) recorded in LDPE 200 gauge. Sandhu et al. (1983) also reported an increasing trend of total sugars content during storage of Kinnow fruits. The greater increase in sugar content under ambient conditions may be due to rapid hydrolysis of insoluble polysaccharides into sugars (Siddiqui et al., 2011; Jawandha et al., 2012). The increase in total sugars during storage may possibly be due to the breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars (Wills et al., 1980). The results of the present findings are correlated with the findings of Gull et al. (1990) and Ahmad et al. (1986) in Blood red orange.

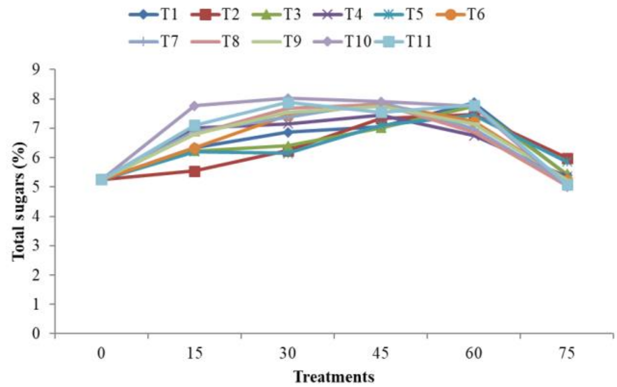

Fig. 7. Effect of different treatments on total sugars (%) of Daisy tangerine during cold storage

Ascorbic acid (mg/100 ml juice)

While going through the data of ascorbic acid presented in Fig. 8. It was observed that maximum ascorbic acid (24.43) was recorded on 15th day of storage then it showed a descending trend with to 21.10, 18.05, 14.86 and 12.79 of its content 30th, 45th, 60th and 75th day of storage. The differences were found to be significant statistically.

Different treatments of edible coatings had a significant ($p \leq 0.05$) effect on ascorbic acid of Daisy tangerine fruits during cold storage. The findings of the above researchers are in line with the findings of present study. Maximum level of ascorbic acid that was 20.91 mg/100 ml was recorded in Daisy tangerine fruits under treatment T_2 (citrashine wax), it was followed by T_5 (packing in CFB with poly sheet 100 gauge), T_3 (rice straw wrapping) and T_1(stafresh) with 20.45, 20.29, 20.11 ascorbic acid treatments T_3 and T_5 were found to be at par with each other respectively.

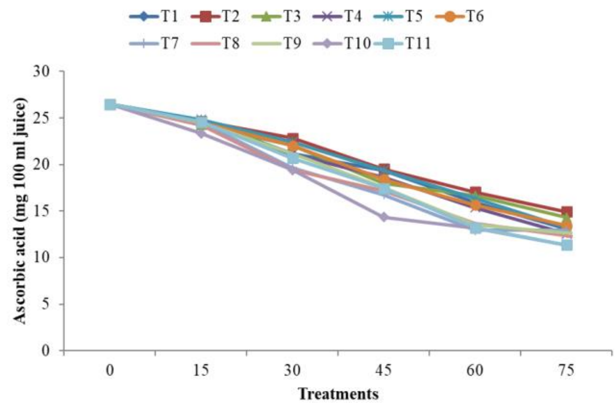

Fig. 8. Effect of different treatments on of Daisy tangerine during Ascorbic acid (mg/100 ml juice) cold storage.

The interaction between days of storage and treatments were found to be statistically significant. At the start of experiment Daisy tangerine fruits registered 26.48 (mg/100 ml juice) of ascorbic acid content, on 15th day of storage the maximum ascorbic acid (24.66%) mg/100 ml was recorded in tangerine fruits treated with citrashine wax however, minimum ascorbic acid content (11.33%) mg/100 ml was analysed in LDPE 200-gauge tangerine fruits on 75th day of storage.

The retention of ascorbic acid content in coated fruits as compared to uncoated fruits might be due to lowering of respiration of fruits or oxidation of ascorbic acid content from the fruits. The decline in vitamin C content seems to be caused by the oxidation of ascorbic acid by enzymes surface coating treatments might have triggered the action of the enzymes during storage (Singh and Chauhan 1993). Hayat et al. (2017) results revealed that citrus wax gave best results in maintained relatively higher levels of ascorbic acid content of lime fruits. Kumar et al. (2000) found that ascorbic acid decreased with increasing period of storage in Kinnow but the decline was less in coated fruits as compared to control. Verma and Dashora (2000) who narrated that when storage period proceeded, TSS increased while, ascorbic acid of Kagzi lime fruits decreased.

Conclusion

The research study resulted that the physical and biochemical traits of Daisy tangerine were significantly influenced by different treatments up to 75th days of storage at cold storage condition. Hence it can be concluded that the prolongation of shelf life and quality of fruits might be better retained with citrashine wax and stafresh to ensure availability in national and international markets for a long span which will fetch good prices to commercial growers. The present findings suggests that among the different treatments, Daisy tangerine fruits treated with citrashine wax had minimum physiological loss in weight, spoilage loss, total soluble solids, total sugars, reducing sugars, non-reducing sugars and TSS:acid ratio, better organoleptic rating, maximum juice content, titratable acidity and ascorbic acid content of fruits as compared to others treatments up to 75th day of storage. Therefore, application of citrashine wax coating on Daisy tangerine considered the most benefit tested one in extending the shelf life and quality of fruits.

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