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The improvement of the quality and shelf life of sweet orange cv. Red blood at ambient temperature through the application of ginger (Zingiber officinale) extracts

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Abstract
A study was conducted at the Horticulture Laboratory at the University of Haripur to investigate the effect of ginger extract on maintaining the quality of matured sweet oranges, Red blood **(**Citrus) fruits. Matured sweet oranges from Khan Pur, District Haripur, Khaiber Pukhtoonkha, Pakistan, were selected and treated with various 20% and 30%) ginger extracts. The fruits were stored at room temperature for 0, 3, 6, 9, and 12 days and trailed qualities and quantities analysis. During the storage period, the fruit weight loss maximum (73.26 mg/g) significantly increased while maintaining the minimum (53.84 mg/g) under treatment. The TSS content of sweet oranges increased with storage duration, with the highest TSS value of 16.75 brix after 12 days of storage duration compared to the minimum (10.30 brix) control. The results of HPLC analysis revealed that hesperidin was abundant in the fruit treated with ginger extract and was three times more than nobiletin. Fruit ascorbic acid increased under 20% treatment (48.25 mg/100 ml) and lowest (46.06 mg/100 ml) in control. It was concluded that the treatment with 20% ginger extract improved the quality and extended the shelf life of the fruits.
Keywords: *Blood Red, shelf life, Ginger extract, treatment*

Highlights:
- Ginger treatment for the safety of sweet orange fruits
- Hesperidin was more bioactive than any other molecule.
- TSS increased during storage, and the acidity of fruits decreased.

1. Introduction

Citrus fruits, known by their scientific name (*Citrus sinensis)*, are the most extensively cultivated fruit. They are grown in over 140 nations globally, with a cultivation history stretching back over 4000 years (Curk *et al.,* 2022). Citrus is a fruit-bearing plant in the family Rutaceae, commonly known for its juicy and acidic fruits (Dwivedi et al., 2022). Red blood, one of the best citrus varieties, is a rich source of vitamins and minerals, such as vitamin C and potassium, and is often used in cooking and as garnish (Ebert et al., 2022). Citrus cultivation is widespread in warm climates, with the largest production happening in Brazil, the United States, Spain, and China (Kesbiç et al., 2022). Pakistan produces 1,943.7 thousand metric tons of citrus fruits on 183.8 thousand hectares (Azeem et al., 2022). Citrus fruits play a pivotal role in meeting domestic demand and can serve as a potential source of foreign exchange earnings (Alzubi et al., 2022). The citron fruits typically harvest in November and December, after which they are stored in refrigerated conditions (Adewoyin et al., 2022). Starting in January, the demand for citrus fruits increases, but the quality of the fruit deteriorates over time (Cifuentes et al., 2022). Inadequate storage causes a rapid decline in sugar and ascorbic acid levels. (Nandavarman et al., 2022). Citrus fruits are frequently stored at low temperatures to delay spoiling, but since they are sensitive to low temperatures, they are also susceptible to chilling harm (Makule et al., 2022).

Ginger is a perennial plant widely cultivated in tropical and subtropical regions, primarily for its aromatic, pungent rhizome, widely used as a spice, medicinal herb, and traditional medicine (Singh et al., 2023). Ginger has been used for thousands of years in traditional medicine and has a long history of treating various ailments, such as nausea and digestive issues, and reducing inflammation (Badnale et al., 2022). Ginger is a versatile and widely used herb known for its medicinal properties and its use as a natural wax coating for fruits (Sousa et al., 2022). Ginger is also a natural wax coating for fruits such as apples and pears to maintain their freshness and extend their shelf life (Sanjay et al., 2022). The wax, made from a mixture of natural substances, including beeswax, carnauba wax, and ginger, forms a protective barrier around the fruit, preventing moisture loss and reducing the risk of rot and decay (Barbosa et al., 2022).

This study aimed to examine the impact of ginger extract on the quality and quantity of Citrus. The analysis includes measuring the weight loss, fruit length, fruit width, juice weight, rag weight, and peels weight while measuring the total soluble sugar, Ascorbic acid, and antioxidant through HPLC to evaluate its efficacy in controlling decay.

2. Materials and Methods

The Red blood variety of citrus fruit from Khan Pur, District Haripur, Khaiber Pukhtoonkha, Pakistan, was selected for the study, and different levels of ginger extract treatment (20% and 30%) were applied from December 2020 to January 2021 from the Horticulture Laboratory at the University of Haripur

2.1 Collection of fruits

The mature and healthy Red Blood orange cultivars fruit were selected based on size, shape, and colour and packed in cardboard boxes to prevent damage during transportation.

2.2 Washing and cleaning

Running tap water was used to clean and wash to eliminate dirt, dust or other particles. Once cleaned, the fruits were left to air-dry completely, allowing for proper evaporation of excess moisture to maintain their quality.

2.3 Preparation of ginger extracts

The ginger extract was prepared using the method described by Stoilova et al. (2007). The ginger rhizomes were air-dried and then ground into powder. An aqueous extract was created by mixing 250g of ginger powder with 500 ml of distilled water, yielding a stock solution. Concentrations of 20% and 30% were derived from the stock solution.

2.4 Application of Treatment

Sweet orange CV Red Blood treated with ginger extract. The fruits were first dipped in the ginger extract for 10 minutes. After the dip, the fruits were left to dry in the open air for 30 minutes at ambient temperature. Finally, the fruits are stored in baskets. This storage method is likely chosen to keep the fruits protected and contained and maintain their freshness and quality.

2.5 Storage duration.

After applying two ginger extract treatments, the fruits were left at room temperature for 12 days. Every three days, data were recorded at 0, 3, 6, 9, and 12 days.

2.6 Measurements of essential parameters of Citrus cv red blood.

Fruit Weight loss (%). The fruit weight was measured as a percentage using a digital weighing balance. The calculation was based on the formula

$$\text{Fruit weight } \%) \ \frac{\text{Initial weight} - \text{weight after interval}}{\text{Initial weight}} \times 100$$

2.7 Fruit Length (mm).

Fruit length was measured using a vernier calliper in millimetres. After correcting for zero error, red blood fruits were selected from each replication and positioned in the calliper's jaws, ensuring that both the top and bottom of the fruit were in contact with the jaws.

2.8 Fruit width (mm).

Fruit width was measured using a millimetre vernier calliper by placing the central, thickest portion of the blood-red fruits between the jaws.

2.9 Rag weight (mg).

The weight of the rag was measured using a digital balance by extracting it from each red blood fruit and recording its accurate weight in milligrams.

2.10 Ascorbic acid and Vitmain C contents

The method described by Ahmed (2021) was used to estimate vitamin C in juice. For this purpose, extracted juice from each sample was filtered through filter paper. 10 ml of filtered aliquot was taken in a 100 ml round bottom flask, and then the volume was made up to the mark by adding 0.4% oxalic acid. Out of 100 ml aliquot, 5 ml was taken in a beaker and titrated against 2, 6 – dichlorophenol indophenol's Dye to a light pink colour which persisted for 10-15 seconds.

2.11 Preparation of Dye for Ascorbic acid and Vitmain C contnets

The Dye was prepared by adding 42 mg $NaHCO_3$ and 52 mg 2, 6-dichlorophenol indophenol in a 200 ml volumetric flask. Volume was made up to the mark by adding distilled water. It was filtered and used as freshly prepared Dye.

Vitamin C was calculated as ascorbic acid by using this formula:

Ascorbic Acid (mg/100 ml) = [(Vb - Va) × N × Mw × 100] / W

Where

R1 = ml dye used in the titration of aliquot.

R = ml of Dye used in the titration of 1 ml standard ascorbic acid solution prepared by adding 1 ml of 0.1% ascorbic acid + 1.5 ml of 0.4% oxalic acid.

V1 = ml of juice used.

V = volume of aliquot made by adding 0.4% oxalic acid.

W = ml of aliquot used for titration.

2.12 Total soluble solids (Brix^{o}).

The juice extraction process involved carefully selecting fully mature fruits. The juice's of total soluble solids (TSS) were measured using KROSS HRN-16 hand-held refractometer. A single drop of juice was placed on the prism plate for each measurement, and the reading was recorded to the nearest tenth of a degree Brix. The final data was obtained by averaging the readings and recorded in Brix units with calcuations of below formula:

TSS (in °Brix) = (100 x Ws) / (Ws + Ww)

Ws = weight of the dissolved solids (in grams)

Ww = weight of the sample (in grams)

2.13 Peel Weight.

The process of determining the weight of each citrus cv (red blood) fruit peel involved utilizing a digital balance machine. This machine was designed to provide precise and accurate measurements down to the milligram level. This measurement was essential in determining the weight of the fruit peels, which could then be used in various calculations and analyses that the measurements were objective, repeatable, and free from human error.

2.14 Juice Weight.

A digital balance machine was used to find out the weight of the juice. The process involved extracting the juice from each citrus cv (red blood) fruit and putting it on the machine weighing platform.

2.15 Statistical analysis

Standard error and analysis of variance (ANOVA) at p 0.05 were used to analyze data from two factorial designs in a complete random design (CRD). The means were compared using the latest version of Statistics 8.1, where the P test was significant.

3. Results and Discussion

The physico-morphological parameters of Citrus, including fruit weight loss, fruit length, fruit width, juice weight, rag weight, and peel weight under ginger extract, were monitored and discussed as follows.

3.1 Weight loss (mg/g) of Citrus cv red blood during storage

It was observed that the weight loss was significantly affected by storage duration. In the storage duration, the highest fruit weight (73.66 mg/g) was recorded in 0 days (control), while the lowest fruit weight loss (53.84 mg/g) was recorded in fruits stored for 12 days of interval storage, as shown in Table 1. It was noted that the lowest weight loss was recorded in 30% treatment after 12 days of intervals compared to any other treatment. In the treatment, Citrus fruits treated with 0% ginger extract (the control) had the longest fruit weight loss (68.71 mg/g), followed by treatments with 20% ginger extract (61.63 mg/g), and fruits treated with 30% ginger extract had the shortest fruit weight loss (60.96 mg/g). Interaction between treatments and interval storage days on the citrus fruits showed the highest fruit weight loss (75.32 mg/g) was recorded in fresh fruits treated with 0% (control) ginger. While treated with 30% ginger extract, the lowest fruit weight loss (49.66 mg/g) was recorded in fruits stored for 12 days. Similar results were reported by (Iftikhar et al., 2022) concluded that increasing weight loss with prolonged storage duration is due to moisture loss from the fruit.

Table 1: Weight loss (mg/g) of Citrus cv red blood during storage and under application of ginger treatment

Storage duration	**Ginger Treatments**			**Storage duration Means**
	Control	**20% ginger**	**30% ginger**	
0 day	62.15 a	73.51 ab	70.97 abc	73.26 a
3rd day	65.22 abc	67.93 abcd	62.51 bcdf	67.59 b
6th day	68.55 cde	61.56 def	58.93 defg	63.01 c
9th day	72.34 efgh	55.43 fghi	62.76 fghi	61.13 d
12th day	75.32 ghi	49.73 hi	49.66 i	53.84 e
Treatments Mean	68.71 a	61.63 ab	60.96 b	

Different letters in superscript within the same row indicate significant differences among different harvesting dates at p<0.05 by LSD test.

3.2 Length (mm) of Citrus cv red blood during storage

The analysis of variance showed non-significance that fruit length shrinkages with storage duration. In the storage interval, the highest fruit Length (51.43mm) was recorded in fresh fruits, and the lowest fruit length (48.08 mm) was recorded in fruits stored for 12 days of interval storage, as shown in Table 2. Citrus fruits treated with 0% ginger extract (the control) had the longest fruit length (50.67 mm), followed by treatments with 20% ginger extract (49.79 mm), and fruits treated with 30% ginger extract had the shortest fruit length (49.40 mm). Interaction between treatments and interval storage days on the citrus fruits showed significance. The highest fruit length (51.70 mm) was recorded in fresh fruits treated with 0% ginger, while the lowest fruit length (46.43 mm) was recorded in fruits after 12 days of storage treated with 30% ginger extract.

Table 2: Length**(mm)** of Citrus cv red blood during storage and under application of ginger treatment

Storage Intervals	**Ginger Treatments**			**Storage Interval Means**
	Control	20% ginger	30% ginger	
0 day	51.70 a	51.62 ab	50.97 bc	51.43 a
3rd day	51.65 cd	50.96 de	50.55 ef	51.05 b
6th day	50.34 fg	49.77 g	50.76 gh	50.29 c
9th day	49.70 hi	48.76 i	48.31 ij	48.92 d
12th day	49.96 jk	47.86 kl	46.43 i	48.08 e
Treatments Mean	50.67 a	49.79 b	49.40 c	

Different letters in superscript within the same row indicate significant differences among different harvesting dates at $p<0.05$ by LSD test.

3.3 Width (m).of Citrus cv red blood during storage

The analysis of variance showed fruit width a storage duration. In the storage interval, the highest fruit width (52.94 mm) was recorded in fresh fruits, and the lowest fruit width (45.63 mm) was recorded in fruits stored for 12 days of interval storage, as shown in Table 3. The application of ginger resulted in citrus fruits treated with 0% (control) having the greatest fruit width (50.46 mm), followed by treatments with 20% ginger (49.45 mm), and fruits treated with 30% ginger extract having the smallest fruit width (47.93 mm). Interaction between treatments and interval storage days on the citrus fruits showed the highest fruit width (54.76 mm) was recorded in fresh fruits treated with 0% (control) ginger. The lowest fruit width (44.73 mm) was recorded in fruits stored for 12 days and treated with 30% ginger extract.

Table 3: Width (mm)of Citrus cv red blood during storage and under application of ginger treatment

Storage Intervals	**Ginger Treatments**			**Storage Interval Means**
	Control	**20% ginger**	**30% ginger**	
0 day.	54.76 a	53.53 ab	50.53 bc	52.94 a
3rd day	52.86 bc	51.93 cd	50.30 de	51.69 b
6th day	49.83 ef	48.75 ef	47.96 fg	48.84 c
9th day	48.55 gh	47.26 hi	46.15 ij	47.43 d
12th day	46.34 jk	45.82 jk	44.73 k	45.63 e
Treatments Mean	50.46 a	49.45 b	47.93 c	

Different letters in superscript within the same row indicate significant differences among different harvesting dates at $p<0.05$ by LSD test.

3.4 Juice Weight of Citrus Cv red blood during storage (%)

The statistical analysis showed that juice weight decreased in storage duration. The highest juice weight (50.01 %) was recorded in citrus fruits for 0 days (control) and the lowest juice weight (43.64 %) was recorded in citrus fruits stored for 12 days of duration storage, as shown in Table 4. The application of ginger significantly caused an increase in fruit juice compared with other treatments in citrus fruits treated with 20% having the highest juice weight (48.25 %), followed by treatments of 30% ginger values (47.18 %), while the lowest juice weight (46.06%). Interaction between treatments and storage duration on the citrus fruits showed the highest juice weight (51.73 %) was recorded in citrus fruits treated with 20% ginger extraction while the lowest juice weight (42.23 %) was recorded in fruits stored for 12 days.

Our result matched (Bordoh et al., 2022) concluded that Ginger extract treatments effectively create a barrier against moisture loss, delaying dryness and fruit shrivelling , leading to fruits that maintain a substantial amount of juice.

Table 4: Juice Weight of Citrus cv red blood during storage and under application of ginger treatment

Storage Duration	Ginger Treatments			Storage Duration Means
	Control	20% ginger	30% ginger	
0 day	50.20 a	51.73 ab	48.12 abc	50.01 a
3rd day	47.76 bcd	48.81 cde	45.23 def	47.26 b
6th day	46.83 efg	49.85 fgh	44.86 fghi	47.18 c
9th day	43.31 ghi	44.94 hij	43.90 ijk	44.05 d
12th day	42.23 jk	45.96 jk	42.73 k	43.64 e
Treatments Mean	46.06 c	48.25 a	47.18 ab	

Different letters in superscript within the same rowindicate significant differences among different harvesting dates at $p<0.05$ by LSD test.

3.5 Rag Weight of Citrus Cv red blood during storage

Statistically, the analysis revealed that rag weight increases as storage duration decreases.In the storage interval, the maximum rag weight (18.26 g) was recorded in fresh fruits, and the minimum rag weight (6.71 g) was recorded in fruits stored for 12 days of interval storage, as shown in Table 5. The application of ginger resulted in citrus fruits treated with 0% (control) having the highest rag weight (12.10 g), followed by treatments with 20% ginger (10.94 g), and fruits treated with 30% ginger extracts having the shortest fruit length (10.15 g).Interaction between treatments and interval storage days on the citrus fruits showed the highest rag weight (20.53 g) was recorded in fresh fruits treated with 0% (control) ginger, while the lowest rag weight (6.56 g) was recorded in fruits after 12 days of storage interval treated with 30% ginger extract.

Table 5: Rag weight of Citrus cv red blood during storage and under application of ginger treatment

Storage Intervals	Ginger Treatments			Storage Interval Means
	Control	20% ginger	30% ginger	
0 day	20.53 a	18.10 ab	16.16 bc	18.26 a
3rd day	14.20 cd	12.90 de	11.80 def	12.96 b
6th day	10.90 efg	9.30 fgh	8.83 gh	9.67 c
9th day	8.00 gh	7.70 h	7.40 h	7.70 d
12th day	6.86 h	6.70 h	6.56 h	6.71 d
Treatments Mean	12.10 a	10.94 ab	10.15 b	

Different letters in superscript within the same rowindicate significant differences among different harvesting dates at $p<0.05$ by LSD test.

3.6 Peel Weight of Citrus Cv red blood during storage

The statistical analysis showed that peel weight increased with the decrease in storage duration. In the storage interval, the maximum fruit weight (19.21 g) was recorded in fresh fruits, and the minimum peel weight (14.21 g) was recorded in fruits stored for 12 days of interval storage, as shown in Table 6. The application of ginger resulted in citrus fruits treated with 0% (the control) having the highest peel weight (17.53 g), followed by 20% ginger treatments (16.73 g), and fruits treated with 30% ginger extracts having the lowest peel weight (16.23 g).Interaction between treatments and interval storage days on the citrus fruits showed the highest peel weight (19.46 g) was recorded in fresh fruits treated with 0% (control) ginger, while the lowest peel weight (13.56 g) was recorded in fruits stored for 12 days and treated with 30% ginger extract.

Table 6: Peel weight of Citrus cv red blood during storage and under application of ginger treatment

Storage Intervals	Ginger Treatments			Storage Interval Means
	Control	20% ginger	30% ginger	

0 day	19.46 a	19.17 a	19.01 b	19.21 a
3rd day	18.89 c	17.67 d	16.69 d	17.75 b
6th day	17.84 e	17.23 ef	17.05 ef	17.37 c
9th day	16.55 ef	15.43 ef	14.88 ef	15.62 cd
12th day	14.93 ef	14.15ef	13.56 f	14.21 d
Treatments Mean	17.53 a	16.73 b	16.23 c	

Different letters in superscript within the same rowindicate significant differences among different harvesting dates at p<0.05 by LSD test.

3.7 Ascorbic acid of Citrus cv red blood during storage

The statistical analysis result showed significantly that ascorbic acid decreased during the storage duration. In the 3 days storage duration, the highest vitamin C (14.51 mg.100ml^{-1}) was recorded in citrus fruits and the lowest ascorbic acid value (6.41 mg.100ml^{-1}) was recorded in fruits stored for 12 days of interval storage as shown in Table 8. Application of ginger result showed significantly utilized vitamin C that Citrus fruits treated with 20% ginger extraction had the maximum values in ascorbic acid (10.28 mg.100ml^{-1}) followed by the treatments of 0% ginger values (10.03 mg.100ml^{-1}) while the lowest ascorbic acid (8.61mg/100g) were noted in fruit treated with 0% ginger extracts. Interaction between treatments and storage duration days on the citrus fruits showed the highest ascorbic acid (19.76 mg.100ml^{-1}) was recorded in citrus fruits treated with 20% ginger, while the lowest ascorbic acid (5.12 mg.100ml^{-1}) was recorded in citrus fruits 0 (control) days of storage duration.

Our result matches with (Yin et al., 2022) concluded that One cause for the decrease in ascorbic acid during storage may be due to the quick transformation of L-ascorbic acid into dehydroascorbic acid when it is exposed to L-ascorbic acid oxidase.

Table 7. Ascorbic acid (mg.100ml^{-1}) of Citrus cv red blood during storage and under application of ginger treatment

Storage Intervals	Ginger Treatments			Storage Interval Means
	Control	**20% ginger**	**30% ginger**	
0 day	7.34 ab	8.67	10.51	8.84bc
3rd day	11.34 bcde	19.76 a	12.45 b	14.51 a
6th day	9.12 defgh	7.34 cdefg	11.05 bc	9.15 b
9th day	10.13 fghi	8.98 efghi	9.21 defghi	9.44ab
12th day	5.12 c	6.67 hi	7.45 ghi	6.41c
Treatments Mean	8.61b	10.28 a	10.03 c	

3.8 TSS (Brix).of Citrus cv red blood during storage

The statistical analysis showed that juice TSS increased with the storage duration. the maximum juice TSS (16.75 Brix) was recorded during 12 days of storage duration and the minimum (10.30 Brix) during 0 days of storage duration, as shown in Table 9. The application of treatment showed non-significant the highest juice TSS (13.93 Brix), followed by ginger treatments (13.81 Brix), while the lowest juice TSS (13.43 Brix). Interaction between treatments and interval storage days on the citrus fruits showed the highest juice TSS (17.56 Brix) was recorded in citrus fruits treated with 30% ginger, while the lowest juice TSS (8.30 Brix) was recorded in fruits stored for 0 days.

When the storage period was increased from 0 to 12 days, there was a significant increase in TSS % (patel et al., 2022) stated that the TSS content of guava fruits increased as the storage duration was prolonged. The breakdown of complex, insoluble chemicals like starch into simpler, soluble ones like sugars, which are the largest cotributors to total suspended solids, may be the source cause of these findings (sethi et al., 2022).

Table 8: TSS (Brix).of Citrus cv red blood during storage and under application of ginger treatment

Citrus cv red blood Juice TSS (Brix).

Storage Duration	Ginger Treatments			Storage Duration Means
	Control	20% ginger	30% ginger	
0 day	8.30 c	10.20 ab	10.00 ab	10.30 e
3rd day	12.67 abc	12.94 bcd	13.03 bcde	12.88 d
6th day	13.34 bcdef	13.90 cdefg	13.05 defgh	13.43 c
9th day	14.54 defghi	15.88 efghi	15.45 fghi	15.29 b
12th day	15.93 ghi	16.76 hi	17.56 a	16.75 a
Treatments Mean	13.43 ab	13.93 a	13.81a	

Different letters in superscript within the same rowindicate significant differences among different harvesting dates at $p<0.05$ by LSD test.

3.9 Effect of ginger extraction on Total Antioxidant of sweet orange cv red blood.

Statistically, the analysis revealed that TA increases as storage duration decreases.In the storage interval, the highest TA (25.18) was recorded in fresh fruits, and the lowest TA of 17.41 was recorded in fruits stored for 12 days of interval storage, as shown in Table 8. The application of ginger resulted in citrus fruits treated with 0% (the control) having the highest TA (20.54), followed by treatments with 20% ginger (21.64), and citrus fruits treated with 30% ginger extract having the lowest TA (22.03). Interaction between treatments and interval storage days on the citrus fruits showed the highest TA (25.79) was recorded in fresh fruits treated with 0% (control) ginger, while the lowest TA (18.56) was recorded in fruits after 12 days of storage treated with 30% ginger extract (Table 10).

Table 10: Effects of ginger extraction on TA of sweet orange cv red blood.

Storage Intervals	Ginger Treatments			Storage Interval Means
	Control	20% ginger	30% ginger	
0 day	25.79 a	25.20 a	24.56 a	25.18 a
3rd day	22.15 b	24.03 b	23.76 b	23.31 b
6th day	20.00 c	22.90 c	21.76 c	21.55 c
9th day	19.09 d	19.33 d	20.32 d	19.58 cd
12th day	16.23 e	16.76 e	18.56 e	17.41 d
Treatments Mean	20.54 a	21.64 a	22.03a	

Different letters in superscript within the same rowindicate significant differences among different harvesting dates at $p<0.05$ by LSD test.

3.10 Targeted Compounds analysis with High-performance liquid chromatography Quantification of ginger.

HPLC (High-Performance Liquid Chromatography) evaluation of the consequential extract was an obligatory instrumental step for further cataloguing and quantification of bioactive moieties. Depending on phytochemical profiling and in vitro prospects Three treatments were selected from each category (ethanol, methanol-water) for qualitative and quantitative analyses of the bioactive moiety, i.e., hesperidin and nobiletin. The quantification of ginger extracts through HPLC has revealed that hesperidin was three times more intense as compared to nobiletin and bioactive moieties. Hence, the resultant peaks obtained from HPLC were compared with the standard peak area, retention time, and spectral exploration. HPLC assessment for Citrus (Figure 2) proved that the highest hesperidin value concentration in the ethanolic extract of 20% ginger was 28.51 mg/g, followed by 30% ginger extract at 24.96 mg/g, and the least in the control at 21.38 mg/g. For nobiletin, the maximum concentration was quantified in the ethanolic extract at 9.92 mg/g in 20% ginger, 7.31 mg/g in 30% ginger, and 6.08 mg/g in the control (Figure 3). The current findings were in line with the findings of Kim and Kim (27), who reported that the hesperidin quantification of Citrus was 0.104 0.05 g/100 g. Moreover, Garcia-Castello et al. (28) suggested that by using different concentrations of ethanol and water, the hesperidin concentration in grapefruit peel varied from 0.23 to 0.74 mg/g. Previously, Inoue et al. (33) reported that the hesperidin and nobiletin content in mature citrus waste was 18.80.1 and 0.10.00 mg/g of citrus peel.

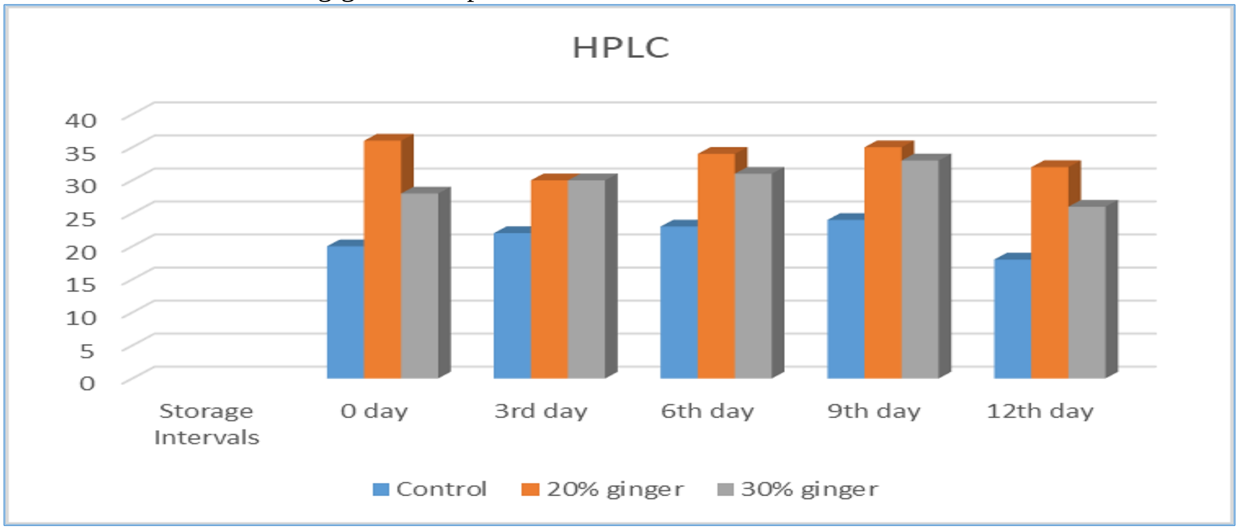

Figure 1. HPLC assessment for Citrus

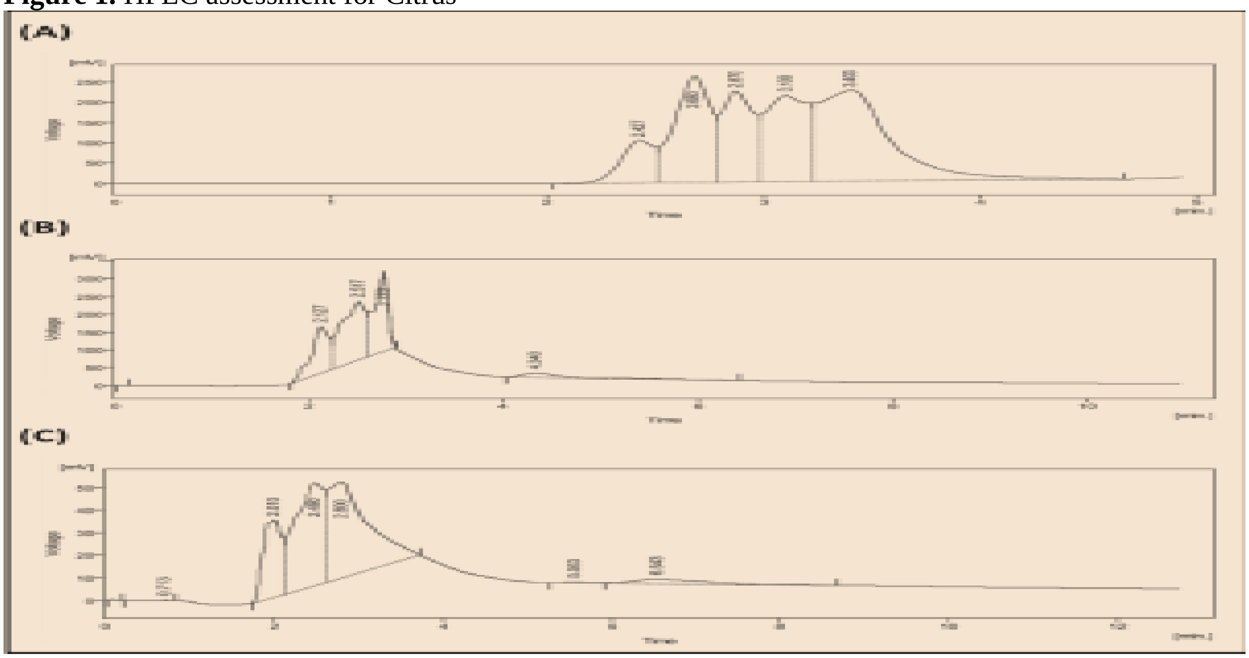

Figure 2. HPLC chromatograph of hesperidin in (A) methanolic (B) ethanolic and (C) water extract of ginger in Citrus.

4. Conclusion

Ginger extracts play a vital role in the post-harvest management of citrus fruit during storges. Because natural extracts are applied to citrus fruits, the application of extracts to reduce postharvest loss has a lower health effect. It was noticed that fruit weight, length, width, and firmness decreased within 9–12 days of storage at ambient temperature. Increasing storage duration resulted in an increase in total soluble solids (TSS), , the application of extracts enhanced the bioactive compounds after the storage of citrus fruit.

Recommendation

On the basis of research, it is recommended that oranges should be stored in cold storage at above chilling temperature to minimize postharvest losses and prolong the shelf life of orange fruit.

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