Effect of cultivar and Packaging methods on the Marketing Characteristics of Cherry tomatoes in retail Markets

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DOI: https://doi.org/10.36077/kjas/2025/v17i1.12168
Received date: 24/5/2023
Accepted date: 3/6/2023

Abstract

This study was carried out at Agricultural Research Station, Department of Horticulture and Landscaping, Agriculture College, Diyala University, Iraq, the experiment was done during 2021–2022 seasons. The fruits of studied Genotypes harvested at maturity stage. The main aim of this experiment was to find out the suitability of these Genotypes to the market conditions, and which one was cope with consuming criteria, market conditions, and its capability to maintain marketing characteristics. The experiment included six genotypes obtained by crossing of cherry tomatoes lines. Three types of packaging fruits: 1 kg paper bags, 1 kg plastic containers, and packing under rarefied pressure in 1 kg containers, it was offered in the market under the temperature 25°C ± 2 and relative humidity approximately 30%. Measurements were taken four days after it was put on the market. Factorial experiment was carried out using the complete randomized design (CRD) with two factors and three replicates, and the averages were compared with multiple Duncan's range test at a probability level of 0.05. The most important results of the study showed that there were significant differences for all the studied traits between the genotypes and the method of packaging, as some genotype were significantly superior, the genotype T9-H7 was superior as it gave less damage to fruits and less weight loss while the T14-2706 genotype was significantly superior in terms of fruit hardness and lycopene content. As for the genotypeT12-A3381 significantly superior to TSS as for the method of packing process with vacuum pressure bags gave the best method of packing for most of the studied traits.

Keywords: Cherry tomato, genotype and the packing methods.

Introduction

Cherry tomato (*Solanum lycopersicum*) belongs to the Solanaceae family is considered the one of the most promising vegetable crops all over the world because of its commercial and economic importance, nutritional value, and , ability to grow in different environments, relatively short life cycle, high productivity, potential of asexual propagation by cuttings, and the possibility of plant renewal (18). Cherry tomato native to the western coast of South America (from Southern Ecuador to Northern Chile).

The nutritional value of tomatoes is attributed to its components, which have a high capacity for antioxidants (10), and also contain unsaturated fatty acids and primary fatty acids (7). It contains many bioactive compounds that have effects on human health, such as reducing the incidence of heart disease (6) Tomatoes constitute the predominant source of lycopene, a bright red carotenoid pigment that has been associated with the prevention of cardiovascular diseases and cancer. Cherry tomato is one of the most common tomato genotypes characterized by many colors and shapes and its small size (11), also is rich in organic and inorganic compounds (20).

One of the indicators that increases the consumption of the crop is the variation in shapes and colors of the fruits, which will be reflected in the methods and culture of food consumption in the community (3). As a result of its nutritional importance . effective contributions in supplying humans with contains of vitamins and pigmentations, so its necessary to cultivate and know its consumption methods in Iraq. Consumption of one person of tomatoes estimated at 23.9 g.day^{-1} and is low compared to the advanced countries that consume 72.7 g.day^{-1} (9). Tomato fruits are quickly perishable after harvest, as the rate of damage reaches 30% in developing countries and reached to 50% in some countries (12).

Being a climacteric fruit, as the rate of respiration begins to rise at maturity and an appearance of the red color (19), result in consider it as one of the fruit crops that are sensitive to transportation and marketing operations after harvesting; the damage rate is estimated at about 20% when the fruits pass the stage of final maturity and increase in softness; the damage may reach 42% during the first four days of storage in developing countries. It is sensitive to storage and suffers due to many problems, but its most important is increased maturity, followed by an increase in respiration, a loss of carbohydrates, and an increase in the loss resulting from fungal infections (21).

Packaging is an ideal way to preserve stored vegetables and fruits , being inexpensive and easy to use, the choice of packaging materials is very important because the permeability of the used packaging leads to the formation of a suitable atmosphere inside the wrapped package, this atmosphere surrounds the packed fruit is a helpful means to reduce moisture loss, shrinkage, and decomposition, then preserve the quality of stored fruits for a period of three months or more for some types of fruits (2).

Therefore, many studies have been conducted in various parts of the world in an attempt to reduce damage after harvesting, in order to avoid losses resulting from transportation, organizing the display of fruits in the markets, and increasing the period of display in its fresh state and its high quality for consumption. So storage is required, as it has become one of the basic process to prolong the period of display in the local market (5). Therefore, this study aimed to show the effect of six genotypes of cherry tomatoes with applying three different packaging methods on preserving the marketing and quality characteristics of cherry tomatoes to reducing the percentage of damage during the transporting and shipping process to retail markets.

Materials and methods

This study was carried out at the research station of the College of Agriculture at the University of Diyala for the season 2021–2022. as the experiment started on 15/5/2021 and ended on 5/10/2022 under protected cultivation conditions, ten plants were grown in one experimental unit , post harvesting treatments of six cherry tomato genotypes done. The experiment included two factors, first factor: was six genotypes obtained from crosses of cherry tomatoes ,second factor: three types of packaging: 1 kg paper bags, 1 kg plastic containers, and packing under rarefied pressure in 1 kg containers , it was offered in market under the temperature 25°C ± 2 and relative humidity approx. 30%. Measurements were taken four days after it was put on the market. The first genotype T14-2706 (red color), T9-H7 (red color), T10-H2 (red color), T12-LA3381 (apricot color), T4-H8 (light red color), and T6-H3 (yellow-reddish color). The fruits were harvested when the fruit's skin was completely discolored (1). The research was designed according a factorial experiment using the complete randomized design (CRD) with two factors and three replicates, and the program SAS was used in analyzing the results. A Duncan polynomial was used to compare the averages of the results under a probability of 0.05 (4).

Studied traits:

1- Fruits Damage %.
These fruits were considered invalid in terms of appearance and marketing, as stated in as in the following equation(16)

$$\text{damage }\% = \frac{\text{The number of damaged fruits}}{\text{The total number of fruits}} \times 100$$

2- $$\text{weight loss } (\%) = \frac{\text{Weight of fruits before storage} - \text{weight of fruits after storage}}{\text{Weight of fruits before storage}} \times 100$$

3- Fruit firmness (kg/cm^2).
The Fruit Pressure Tests device was used to measure the firmness of the fruits; two readings were taken from two

opposite sides of each fruit in each replicate, and the average of five fruits (samples) was considered as the value of the firmness of the fruits (1).

4- Total acidity (%)
It was estimated by taking a random sample of the fruits of each treatment and squeezing them with a manual juice, then filtering the juice and changing its color using charcoal, then taking 10 ml of clear juice by using a burette with sodium hydroxide (0.1 N) after adding 1 ml of phenolphthalein reagent, and estimating the yield on the basis that the dominant acid is citric (15).

5- Total soluble solids (TSS%) .
It was measured by taking a drop of juice from five fully ripe fruits from each experimental unit, taken at random by device of a pocket refractometer (Pocket PAL-1, ATAGO, Tokyo, Japan).

6- The lycopene pigment.
It was extracted by taking 1 g of tomato fruits and mashing them in glass tubes with 10 ml of a mixture of acetone and hexane at a ratio of 4:6 and mixing them using a mixer. Then the samples were read in a spectrophotometer at wavelengths of (453,505, 645 and 663 nm) (13).

Results and discussion

Fruits Damage %:

The results of table (1) showed that the genotypes had significant and effects on; the T9-H7was significantly superior over all other genotypes in reducing the damage percentage to 2.08%, while the cultivar T10-H2 achieved a high damage percentage of 27.28%, while rarefied pressure containers gave the lowest mean in a fruits damage% 3.91%, with significant differences from paper bags, which recorded the highest mean in a percentage of damage 20.67%, followed by plastic containers 14.26%. Whereas the treatments of T9-H7, T10-H2 , and T6-H3 genotypes and rarefied pressure containers were superior in giving the lowest rate in a percentage of damage 0.00% and also the Cultivar T9-H7 with the paper bags and rarefied pressure was 0.00% at the interaction, while the T10-H2 and paper bags recorded the highest rate in a percentage of fruits damage% 61.42%. Obviously noted that the percentage of damage of stored fruits in the rarefied pressure containers was less than the other packing methods; this may be due to the pressure inside the containers, which leads to a reduction in the processes of catabolism and respiration, which leads to an increase in the resistance of these fruits to damage. In addition, the increase in the percentage of CO_2 and the decrease in the percentage of O_2 provided by the rarefied pressure containers, in turn, lead to a decrease in the speed of vital activities, as it reduces respiration and catabolism processes and decreases the activity of microorganisms(5).

Table 1. Effect of genotypes, and packaging method and their interactions on tomato fruits damage% in retail markets.

Main effect of genotypes	Types of packaging			Mean
	Paper bags	Plastic containers	Rarefied pressure containers	
T9-H7	0.00 e	6.25 e	0.00 e	2.08 d
T10-H2	61.42 a	20.43 dc	0.00 e	27.28 a
T12-LA3381	0.37 e	5.87 e	7.01 e	4.42 cd
T14-2706	3.80 e	10.80 de	9.13 e	7.91 c
T4-H8	25.63 bc	21.82 c	7.36 e	18.27 b
T6-H3	32.82 b	20.42 dc	0.00 e	17.74 b
Main Types of packaging	20.67 a	14.26 b	3.91 c	

*Means with same letters had no significant differences according to Duncan's Multiple range test ($P \leq 0.05$).

Weight loss (%):

Data presented in Table (2) revealed that the cultivar T9-H7 recorded the lowest mean in the percentage of weight loss at 1.52% with significant differences from other genotypes, whereas the cultivar T6-H3 recorded the highest mean at 4.74%. Rarefied pressure containers result in the lowest mean in the percentage of weight loss, 0.71%, with significant differences from paper bags, which recorded the highest mean in the percentage of weight loss, 6.59%. Regarding the interaction between the genotypes and packing method, the cultivar T9-H7 with rarefied pressure containers were superior in giving the lowest rate in a percentage of weight loss 0.00%. The genotype packaged in paper bags had a loss by weight, reached 10.63%.

The genotypes differed among themselves in terms of weight loss, and this is due to differences in the genotypes of the studied genotypes. It was found that displaying fruits in rarefied pressure containers reduced the percentage of weight loss compared to storing them in paper bags or plastic containers. The reason may be due to the fact that the speed of water vapor loss from the fruits depends mainly on the difference between the water vapor pressure around the fruits and the air in the store, which leads to faster evaporation.

As a result, the processes of transpiration and respiration are increased, leading to a high percentage of weight loss. The increase of this characteristic in the texture of the fruits packed in rarefied pressure containers is related to their effect in reducing the percentage of weight loss as well as a decrease in the speed of respiration, and this led to preserving the texture of the fruits during storage and their progressing to maturity. Weight loss is one of the major factors which determines the shelf life of tomato. The weight loss of fresh tomatoes is primarily result from the transpiration and respiration (17).

Table 2. Effect of genotypes, and packaging method and their interactions on weight loss% in tomato fruits. in retail markets

Main effect of genotypes	Types of packaging			Mean
	Paper bags	Plastic containers	Rarefied pressure containers	
T9-H7	2.78 f	1.77 h	0.00 l	1.52 e
T10-H2	6.84 c	2.81 f	1.15 J	3.60 b
T12-A3381	5.75 e	2.76 f	0.23 lk	2.96 c
T14-2706	6.05 d	0.49 k	0.41 k	2.32 d
T4-H8	7.50 b	0.97 J	0.41 k	2.91 c
T6-H3	10.63 a	1.50 I	2.08 g	4.74 a
Main Types of ackaging	6.59 a	1.72 b	0.71 c	

*Means with same letters had no significant differences according to Duncan's Multiple range test (P ≤ 0.05).

Fruit firmness (kg/cm2):

Table 3 showed that the treatments had significant and clear effects on the fruit firmness, where the cultivar T14-2706 was significantly superior to all other genotypes in increasing the fruit firmness to 8.83 kg, while the T6-H3 cultivar recorded a low fruit firmness of 5.50 kg. The rarefied pressure containers had the highest mean in the fruit firmness at 7.16 kg, with significant differences from paper bags, which recorded the lowest mean in the fruit firmness at 6.41kg, followed by plastic containers at 6.58 kg, whereas the T14-2706 cultivar and rarefied pressure containers was superior in giving the highest rate of fruit firmness (9.50 kg) at the interaction The genotype H8, which was packaged in plastic bags, gave the lowest hardness of 4.50. The genotypes were differed in the fruits firmness, and this is due to the difference in the genotypes of the studied genotypes. The fruit's firmness is one of the important qualitative characteristics that differ from one variety to another one. The rate of decrease in firmness value being slower in this packaging can be considered better than other packaging materials. Softness in tomato fruits is caused by the degradation of pectin (pectic) substances. Pectin substances degradation results in drastic changes in texture with an increased softening of the tomato tissues The pectin degradation enzymes are sensitive to oxygen. The availability of more oxygen increases the rate of pectin degradation which results in the softness of fruit. That's why the softening process is slower in packed tomatoes due to the lack of more oxygen,. (19).

Table 3. Effect of genotypes, and packaging materials and their interactions on firmness (kg/cm2) in tomato fruit in retail markets

Main effect of genotypes	Types of packaging			Mean
	Paper bags	Plastic containers	Rarefied pressure containers	
T9-H7	6.00 h	6.00 h	7.50 e	6.50 a
T10-H2	5.00 J	7.00 f	6.50 g	6.16 d
T12-LA3381	7.50 e	8.50 c	6.50 g	7.50 b
T14-2706	9.00 b	8.00 d	9.50 a	8.83 a
T4-H8	5.50 i	4.50 k	7.50 e	5.83 e

T6-H3	5.50 i	5.50 c	5.50 i	5.50 f
Main packaging materials	6.41 b	6.58 b	7.16 a	

*Means with same letters had no significant differences according to Duncan's Multiple range test (P ≤ 0.05).

Table (4): showed that the genotype T10-H2 and genotypes T9-H7 had significantly differences in terms of total acidity in fruits, reaching (0.60, 0.58%) respectively, and the T4-H8 genotype recorded the lowest mean (0.50%), while there were significant in packing methods during marketing the rarefied pressure containers result in the highest mean in the total acidity, with significant differences of rarefied pressure containers and plastic containers recorded(0.57,0.56)%. Interaction between the genotypes and packing methods had a significant effect on the studied trait, where the T14-2706 genotype with and with plastic containers recorded a significant increase in total acidity in fruits (0.61%) in comparison to other treatments. This is due to the fact that is the T10-2706 genotype resistant to packing and has maintained the percentage of total acids stored in the rarefied pressure containers, as the high acidity of the fruits stored in the rarefied pressure containers is due to the reduction of the respiration rate by reducing the permeability of the cell membranes, which reduces the consumption of acids by oxidation as a result of respiration and then maintains acidity content in fruits (14**).**

Table 4. Effect of genotypes, types of packaging materials and their interactions on total acidity% in tomato fruits in retail markets.

Main effect of genotypes	Types of packaging			Mean
	Paper bags	Plastic containers	Rarefied pressure containers	
T9-H7	0.57 Abc	0.58 abc	0.58 Abc	0.58 Ab
T10-H2	0.60 Ab	0.61 a	0.60 Ab	0.60 A
T12-LA3381	0.56 Abcd	0.55 Abcd	0.58 Abc	0.56 B
T14-2706	0.43 F	0.60 ab	0.61 A	0.55 B
T4-H8	0.52 Cde	0.50 ed	0.48 Ef	0.50 C
T6-H3	0.53 Cde	0.55 bcd	0.57 Abc	0.55 B
Main packaging materials	0.53 B	0.56 a	0.57 A	

*Means with same letters had no significant differences according to Duncan's Multiple range test (P ≤ 0.05).

Total Soluble Solids (TSS%):

The results presented in table 5 showed that the genotypes T12-LA3381 , and T10-H2 were significantly superior in recording the highest mean in total soluble solids, which reached (6.00,5.92%), as compared to the other genotypes, and the T4-H8 genotype recorded the lowest mean 5.32% whereas the plastic containers had the highest value in total soluble solids(TSS) at 5.73 % respectively, with significant differences from the paper bags and rarefied pressure containers , had the lowest mean in total soluble solids at (5.64%). The interaction between the genotypes and packing methods had a significant effect on the studied trait, where the T12 cultivar with paper bags recorded a significant increase in total soluble solids at (6.04 %) in comparison to other treatments.T6-H3 genotype with paper bags recorded the lowest percentage in total soluble solids at (5.16%) compared to other treatments.

More TSS content led to more ripening in the fruit , fruits with higher TSS content are preferred for consumption but the rapid increase in TSS content indicates the progression of maturity and decreases the shelf life of the commodity. Hence, a slow increase in TSS content is suitable for prolonging shelf life (8).

Table 5. Effect of genotypes, types of packaging materials and their interactions on TSS% in tomato fruits in retail markets

Main effect of genotypes	Types of packaging			Mean
	Paper bags	Plastic containers	Rarefied pressure containers	
T9-H7	5.69 cd	5.74 c	5.69 dc	5.71 c
T10-H2	5.83 bc	5.95 ab	5.97 ab	5.92 ab
T12-LA3381	6.04 a	5.98 ab	5.98 ab	6.00 a
T14-2706	5.86 bc	5.82 bc	5.34 d	5.67 c
T4-H8	5.28 ef	5.34 e	5.34 e	5.32 e
T6-H3	5.16 f	5.52 d	5.54 d	5.40 d
Main packaging materials	5.64 b	5.73 a	5.64 b	

*Means with same letters had no significant differences according to Duncan's Multiple range test (P ≤ 0.05).

Lycopene content (mg/100 g fresh weight):

Table (6) showed that the treatments had significant and clear effects on the fruit content of lycopene pigment, where the genotype T14-2706 was significantly superior to all other genotypes in increasing the lycopene dye to (16.11 mg), while the T4-H8 cultivar recorded the lowest mean in lycopene at (9.73 mg). The plastic containers and paper bags gave the highest means in lycopene at (13.51 and 13.41 mg), respectively, with significant differences from the rarefied pressure containers, which recorded the lowest mean in lycopene at (13.15 mg). whereas the T14-2706 genotype and paper bags were superior in giving the highest rate of lycopene (16.50 mg) at the interaction. The accumulation of lycopene in T14-H8 genotype may be due to its genetic characteristics. The treatment of paper bags and plastic containers maintained the highest content of lycopene during the marketing period, and this may result from the continuity of physiological activities in fruits such as rapid respiration, ethylene production, chlorophyll decomposition, and the appearance of lycopene (16**).**

Table 6. Effect of genotypes, types of packaging materials and their interactions on lycopene content (mg/100 g fresh weight) in tomato fruits in retail markets.

Main effect of genotypes	Types of packaging			Mean
	Paper bags	Plastic containers	Rarefied pressure containers	
T9-H7	12.86 d	12.70 d	12.68 d	12.75 c
T10-H2	14.65 c	15.10 b	14.40 c	14.71 b
T12-LA3381	15.20 b	14.70 c	14.70 c	14.86 b
T14-2706	16.50 a	16.40 a	15.45 b	16.11 a
T4-H8	9.40 g	10.05 f	9.75 fg	9.73 e
T6-H3	11.85 e	12.15 c	11.95 e	11.98 d
Main packaging types materials	13.41 a	13.51 a	13.15 b	

*Means with same letters had no significant differences according to Duncan's Multiple range test (P ≤ 0.05).

Conclusion

The most important results of this study showed that there were significant differences for all the studied traits between the genotypes and the method of packaging, as some genotypes were significantly superior, as for the packing methods, the treatment with rarefied pressure bags was superior in most of the studied characteristics, as it result in the least percentage of damage, least weight loss, lowest total soluble solids percentage, and lasting preservation of the fruits firmness.

Conflict of interest

The authors declare no conflict of interest.

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