Effect of Ripeness Degree on The Storage Characteristics of Two Cultivars of Tomato

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Abstract

A storage experiment was conducted on the fruits of two cultivars (hybrids) of tomatoes grown inside plastic tunnels obtained from one of the private farms in Bani Saad district during the spring season 2021. The study included two factors; the variety and the degree of ripeness, where two hybrids of tomatoes were used i.e., Newton, Siemens. Half-ripe fruits, were the fruits colored bright red by 50%, and fully-ripened fruits that were colored bright red by 60-90%. The fruits were stored in a refrigerator at a temperature of 5 ° C for a month. The experiment was carried out as a factorial experiment with a fully randomized design (CRD) with three replications. The obtained data were collected and analyzed according to the design using LSD test at a probability level of 0.05 using Genstat program. The results of the study showed that there were no significant differences between the two cultivars, as well as the absence of significant differences between the two degrees of ripeness in terms of total soluble solids (TSS), and the incompletely ripened fruits excelled in most of the chemical characteristics, which gave the highest content of vitamin C, (9.980 mg. 100 ml^{-1}), carotenoid pigments (98.91 $mg.100gm^{-1}$), and acidity level (0.464%). While the fully-ripened fruits excelled in giving the lowest rate of fruits respiratory (3.091 mg CO^2/kg/hour).

Keywords: Tomato, ripeness, cultivars, Storage.

Introduction:

Tomato (*Solanum lycopersicum*) is a vegetable crop with high yield and its production is still increasing all over the world and it belongs to the Solanaceae family, which includes other types of vegetables also known as potatoes, eggplant and peppers. The global production of tomatoes in 2018 amounted to about 182 million tons of fresh fruits, according to the statistical database issued by the Food and Agriculture Organization of the United Nations.

The area planted with this crop in Iraq during 2018 was estimated at 69.686 Dunams, with a total production rate of 467.579 tons, which constitutes 33.9% of the total vegetable production in Iraq (Central Statistics Organization 2018). Tomatoes are rich in minerals, vitamins, essential amino acids, sugars, and dietary fibers (Ayandiji *et al*., 2011), and tomatoes also contain ascorbic acid (Rashid and Shammari, 2014). The shape of the fruit varies according to the variety. The color of the ripe fruits ranges from yellow to red (Akishin *et al*., 2021).

In view of meeting the needs and requirements of the consumer, studies were directed to improve the quality of tomato fruits in terms of the size, color, firmness of the fruits, and their content of soluble solids and antioxidants, and this is done through the management of agricultural operations such as choosing the appropriate variety, securing environmental conditions and applying some modern agricultural operations (Morshid and Najla, 2013).

The companies improve these varieties in order to give them the ability to adapt to different climatic conditions and to entice farmers to grow these varieties (Saifudin, 2016). These varieties were produced in terms of their suitability to the prevailing environmental conditions in the region or their resistance to diseases, their productivity and the quality of their fruits (Ta'in *et al.*, 2007).

The different tomato cultivars show clear differences in the acidity ratio after the end of the storage periods, as well as the reduction in the level of vitamin C for the studied cultivars (Younis and Abu Turabi, 2004). The amount of vitamin C decreases when the storage period for five tomato cultivars increases, and the cultivars did not differ significantly. among them in its vitamin C content at the end of the 30-day storage period (Gerry *et al.*, 2007).

The degree of ripeness depends on the mechanical strength of the fruits, the juice of the pulp, the content of sugars, organic acids, dry matter, the speed of respiration and other physiological, physical, mechanical and biochemical indicators (Shamshin, 2019). Also, the degree of ripeness of tomato fruits depends on the optimum temperature and relative humidity during storage, as well as on post-harvest operations of tomato fruit ripening, quality preservation, transportation or storage (Akishin, 2021).

The methods of determining the degree of ripeness are different, and one of these methods, which depends on wide ranges, is to determine the degree of ripeness visually through the change in the color of the skin and pulp (Al-Shamri and Al-Jbawi, 2020). The most successful method for determining the degree of ripeness of tomato fruit is based on an 8-point color scale, for each 8 degree of ripeness, certain values have been set for weight, density, content of sugars, acids, dry matter, respiration of fruits and ethylene release rate. (Akishin, 2021).

Also, monitoring the level of chlorophyll in tomato fruits is an important qualitative characteristic of their maturity, as the degree of ripeness can be inferred from it (Sudnik, 2020). The minimum validity stage for harvesting the fruits of ordinary tomatoes is determined on the basis of the internal structure of the fruit (Al-Shammari, 2017).

Materials and methods:

Two cultivars of tomatoes grown in greenhouses were prepared in Khan Bani Saad farms in the spring planting season 2021. These cultivars are Newton hybrid tomato an unlimited-growing hybrid, produced by Holland (S&G/Syngenta Seeds B.V/Enkhuizen). It is suitable for cultivation in greenhouses and plastic, and is characterized by high productivity and distinctive and desirable fruits in shape, and its fruits are circular in shape, and weighing (170-190 g) with high hardness, excellent quality, attractive red color, abundant production and length of season. This variety is suitable for cultivation in various conditions, even relatively cold. (Hussein *et al*., 2009).

The Siemens tomato fruits variety are medium-sized, with high specific weight, high hardness, bright red color, and a high content of soluble solids (T.S.S). Moreover, their storage capacity is high, and they tolerate cold environmental conditions well. Two levels of ripeness for each of the mentioned cultivars, where the first level was the red coloration of 50% of the surface of the fruit and the second ripeness level was the light red stage, where the area colored in pink-red for the fruit reaches from 60-

90% of the surface of the fruit (Al-Ali, 2011; Al-Shammari and Al-Jbawi, 2020), then a sorting process was carried out on the fruits by excluding the infected and damaged fruits during harvesting and the fruits are irregular in shape. The fruits were selected as homogeneous as possible, and the rest of the fruits were washed for the purpose of removing dust and other suspended materials and then exposed to air for drying and stored at a temperature of 5 °C for a month (Al-Shammari and Fadhil, 2021).

Studied traits:

1. **Total Soluble Solids (TSS):**
   Estimated by using a hand refractometer.
2. **Total acidity percentage:**
   It was calculated by smearing a certain volume of fruit juice with the base NaOH with a titer ratio (0.1N) and using phenolphthalein, given that citric acid is the predominant acid, and then the total acid percentage was calculated according to the method of Ranganna, (1977).
3. **Vitamin C content of fruits:**
   Calculated by smearing a certain volume of fruit juice with a dye (Indo Phenol-Dichloro Phenol 2.6) and on the basis of a mg unit of vitamin C per 100 ml of juice, according to the method of Ranganna, (1977).
4. **Respiratory rate:**
   The respiratory rate in fruits was measured using the Closed System method and at room temperature, and the results were calculated according to what was mentioned (Al-Ani, 1985) and according to the following equation:

$$\text{mg } CO^2\text{/kg/hr.} = \frac{\textit{The number of equivalent weights of the reactant base} \times 22}{\text{kg xhr}}$$

$$\text{mg } CO^2\text{/kg/hr.} = \frac{\textit{HCL Acid X its caliber} - \textit{Base (used NaOH x its caliber} \times 22)}{\text{kg.(At the beginning of storage) xhr}}$$

Studied Traits	Cultivar	Degree of ripening	Before storage	After storage
Fruit Hardness	Newton	Half-ripe	4.3	3.867
		Ripe	3.6	3.723
	Siemens	Half-ripe	4.5	3.833
		Ripe	3.8	2.8
Weight Loss	Newton	Half-ripe	1 kg	%10.66
		Ripe	1 kg	%11.50
	Siemens	Half-ripe	1 kg	%10.30
		Ripe	1 kg	%12.00
Percentage of physiological spoilage	Newton	Half-ripe	-	15.70
		Ripe	-	17.30
	Siemens	Half-ripe	-	15.35
		Ripe	-	16.69
Percentage of biological spoilage	Newton	Half-ripe	-	14.20
		Ripe	-	16.89
	Siemens	Half-ripe	-	14.12
		Ripe	-	15.89
Sensory evaluation of fruits	Newton	Half-ripe	2	5.000
		Ripe	3	5.000

	Siemens	Half-ripe	2	5.000
		Ripe	3	5.000
% Total soluble Solids TSS	Newton	Half-ripe	6.9	7.067
		Ripe	7.9	8.167
	Siemens	Half-ripe	8.1	9.033
		Ripe	8.7	9.200
Total acidity percentage	Newton	Half-ripe	0.52	0.337
		Ripe	0.31	0.313
	Siemens	Half-ripe	0.21	0.317
		Ripe	0.44	0.413
Vitamin C content of fruits	Newton	Half-ripe	9.9	8.55
		Ripe	9.5	8.123
	Siemens	Half-ripe	12.3	7.830
		Ripe	11.5	7.537
Beta-carotene pigment	Newton	Half-ripe	90	105.0
		Ripe	118	87.93
	Siemens	Half-ripe	108	93.14
		Ripe	93	98.73
Lycopene pigment	Newton	Half-ripe	9.74	8.051
		Ripe	8.9	8.057
	Siemens	Half-ripe	8.5	7.929
		Ripe	8.23	7.845
Fruit respiration rate	Newton	Half-ripe	3.21	3.110
		Ripe	4.2	3.267
	Siemens	Half-ripe	4	3.333
		Ripe	4.3	3.233

Results and discussion:

Percentage of Total Soluble Solids (T.S.S):

It is noticed from Table (1) that the effect of the variety and the degree of ripeness on the characteristic of total soluble solids (TSS) were not significant between the two tomato cultivars Newton and Siemens, as well as no significant differences were noticed in the degree of ripeness of the fruits on this trait.

As for the interactions between the treatments, the results indicate that there are no significant differences as a result of the interaction between the treatments of the variety (A) and the degree of ripeness (M). The results obtained from analyzing the percentage of total soluble solids in the tomato fruits used in the experiment show that the substances total soluble solids increase relatively at the end of the storage period.

It appeared with the highest percentage in both the study varieties and the two degrees of ripeness, and that this increase may be due to the decrease in the moisture content of the fruits with the progression of the storage periods (Burton, 1982). Although there is a process of consuming a quantity of soluble solids through the respiratory process, the amount of what is consumed is less than the amount of water lost by fruits during storage.

Table 1. Effect of variety and degree of ripeness and the interaction between them on the character of total dissolved solids (TSS)

Cultivars (A)	Degree of Ripeness (M)	MxA	Cultivar Effect	Effect of Degree of Ripeness	
Newton	half-ripe	3.500	4.995	Half-ripe	3.539
	Ripe	6.489			
Seminis	Half-ripe	3.578	5.039	Ripe	6.495
	Ripe	6.500			
LSD 5%	A	M	A x M		
	NS	NS	NS		

Total acidity percentage:

The results presented in Table (2) indicate the effect of the variety and the degree of ripeness of the fruits on the overall acidity of the experimental fruits. These results showed that there were no significant differences between the two tomato varieties, Newton and Siemens. The results showed that there were significant differences between the two levels of ripeness. In terms of the half-ripe fruits, the acidity level was higher and amounted to 0.464%. While the acidity level of the fully-ripened fruits was 0.418%, as for the interactions between the treatments, the results indicate that there are significant differences as a result of an interaction between the treatments of the variety with the degree of ripeness.

The half-ripe fruits of Newton variety outperformed the other treatments by giving the highest acidity of 0.546% and the lowest acidity with the ripe fruits of the same variety, which amounted to 0.351%.

The reason for the increase in the total acidity of the unripe fruits and its decrease in the fully ripened fruits is that storing the fruits leads to the consumption of organic acids by the respiration process (Al-Shammari, 2017) and that the fully ripened fruits have reached the aging stage before the immature fruits in which the fruits are in the final ripening stage. This result was in agreement with Islam *et al*., (1996) where they all affirmed that the total acidity of the fruits increases with the progression in the stages of ripening.

Table 2. Effect of variety and degree of ripeness and the interaction between them on the percentage of total acidity

Cultivars (A)	Degree of Ripeness (M)	MxA	Cultivar Effect	Effect of Degree of Ripeness	
Newton	half-ripe	0.546	0.448	Half-ripe	0.464
	Ripe	0.351			
Seminis	Half-ripe	0.382	0.433	Ripe	0.418
	Ripe	0.484			
LSD 5%	A	M	A x M		
	NS	0.026	0.037		

Vitamin C content of fruits (mg.100ml^{-1} juice):

The results in Table (3) show the effect of the variety and degree of ripeness on the content of vitamin C in tomato fruits, as no significant differences appeared between the two tomato varieties, Newton and Siemens in the content of vitamin C, while these results showed significant differences between the two degrees of ripeness used in the experiment.

The half-ripe fruits were superior by giving the highest content of vitamin C, which reached 10.30 mg.100 ml^{-1} juice, with a significant difference than the ripe fruits, which gave a proportion of 9.356 mg.100 ml^{-1} juice. As for the interaction effect between the treatments, there was a significant effect between the interaction of both varieties and degree of ripeness, where the highest percentage of fruit content of vitamin C was recorded for Newton cultivar with a degree of ripeness of 50%, where the percentage was 10.70 mg. 100ml^{-1} juice, and a significant difference from Siemens cultivar at 100% ripeness, which recorded the lowest percentage of fruits content of vitamin C 9.185 mg.100 ml^{-1} juice.

The conclusion of the study for this characteristic shows that the treatment of the half-ripe fruits gave the highest content of vitamin C compared to the treatment of the ripe fruits, and the reason for this may be due to the fact that the respiratory rate in the half-ripe fruits is low compared to the ripe fruits, and then the consumption of amino acids is low (Muthuselvi *et al*., 2020).

Table (3) Effect of cultivar and degree of ripeness and the interaction between them on the content of vitamin C in tomato juice.

Cultivars (A)	Degree of Ripeness (M)	MxA	Cultivar Effect	Effect of Degree of Ripeness	
Newton	half-ripe	10.70	10.113	Half-ripe	10.30
	Ripe	9.526			
Seminis	Half-ripe	9.900	9.543	Ripe	9.356
	Ripe	9.185			
LSD 5%	A	M	A x M		
	NS	0.078	0.110		

Fruits respiration rate (mg CO^2/kg/hour):

Table (4) shows the effect of the variety and degree of maturity on the rate of respiration of tomato fruits, which were significant between the two cultivars of tomato Newton and Siemens, where the lowest rate of respiration was recorded (3.091 mg CO^2/kg/hour in the fruits of the cultivar Siemens and the highest rate of respiratory was recorded for Newton variety (3.127 mg CO^2/kg/hour), and the degree of maturity did not show a significant effect on respiration rate of the fruits.

As for the interactions between the treatments, there was a significant interaction between the cultivar and the degree of ripeness, where Siemens variety for half-fruits ripeness excelled with the lowest value of respiratory rate, which reached (3.069 mg CO^2/kg/hour) and the highest rate of respiration rate of fruits was with the interaction of the half-ripened fruits for Newton cultivar, which amounted to (3.149 mg CO^2/kg/hour).

From the foregoing, it is clear to us that the rate of respiration in ripe fruits is less than in half-ripened fruits. The reason for the high rate of respiration in tomato fruits after storage is due to the fact that the beginning of the increase in respiration rate in climacteric fruits begins immediately after harvest and in the first days of storage, and this is what was indicated by Kopeliovitch *et al*., (1980), and here it

should be noted that tomato fruits reach the best validity for eating after reaching the peak of breathing a little (Al-Ani, 1985).

Table (4) Effect of variety and degree of ripeness and the interaction between them on the rate of respiration rate of tomato fruits.

Cultivars (A)	Degree of Ripeness (M)	MxA	Cultivar Effect	Effect of Degree of Ripeness	
Newton	half-ripe	3.149	3.127	Half-ripe	3.109
	Ripe	3.104			
Seminis	Half-ripe	3.069	3.091	Ripe	3.109
	Ripe	3.113			
LSD 5%	A	M	A x M		
	0.027	NS	0.066		

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