Determination of the Maturity Stage and Most Proper Age for Harvesting the Fruit of Cherry Tomato (Solanum *lycopersicum* var. *cerasiforme*)

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ABSTRACT

This study was carried out on the hybrid F_1 "Katalina 522" which belongs to cherry tomato (Solanum *lycopersicum* var. *cerasiforme*) during the two seasons of 2018-2019 and 2019-2020 at a farm located in Zawyet Razeen village, Menoufia Governorate. The first step began with the labeling of flowers on the clusters starting at the full bloom to have nine fruit ages, namely 5, 10, 15, 20, 25, 30, 35, 40 and 45 days which were used to study the changes that occurred in the fruit physical and chemical characteristics in the collected developmental stages during cold storage to determine the maturity stage and the most suitable age for harvesting. The exerted figures showed that there was a rapid increase in the initial periods of the fruit fresh weight, size and diameter until the age of 20 days which was followed by a slow increase up to the age of 45 days, exhibiting statistically a curvilinear shape meanwhile the fruit firmness increased steadily till the age of 20 days after which a steady stable decline occurred till the last tested age of 45 days establishing in statistics a parabola shape. Moreover, the resulted data revealed a continuous quick gradual increase in T.S.S. and dry weight contents with the progress of age from the start of fruit formation up to the last examined age of 45 days that draw statistically a linear curve. However, the accumulation in the contents of ascorbic acid, lycopene and total sugars were increased gradually up to the age of 30 days, then followed by rapid increments up to the last age showing statistically a curvilinear shape. From another point of view, the characteristic of the pH reflects a gradual slow decrease with the progress of fruit age up to the age of 25 days followed by a steady gradual increase till the last age of 45 days. Storing these fruit developmental stages at 10ºC and 95% RH showed that the age of 35 days reflected the minimum loss in weight and the smallest unmarketable percentage during storage and at the same time contained the highest contents of T.S.S, ascorbic acid, lycopene, total sugars and dry weight. So, it is easy to show that the fruit maturity stage was attained at the age of 35 days, and the proper suitable age for harvesting was reached after 40 days.

Keywords: cherry tomato, maturity stage, proper age, harvesting

INTRODUCTION

Cherry tomato (Solanum *lycopersicum* var. *cerasiforme*) fruit is a rounded small shape which believed to be an intermediate genetic admixture between wild currant-type tomatoes and domesticated garden tomatoes (Kobryn and Hallmann, 2005). Cherry tomatoes formed a golf ball size that can range from being spherical to slightly oblong in shape. Although fruits are usually red but other varieties exist yellow, green or black in colour. This fruit contains four types of carotenoids: alpha-carotene, beta–carotene, lutein and lycopene. Cherry tomato contains lycopene (responsible for their vibrant red colour), a powerful antioxidant with the ability to help in repairing cells that are more susceptible to cancer and because of their higher tomato skin-to-tomato-flesh ratio over the other tomatoes which give them higher antioxidant content (Rosales et al., 2011).

The more objective approach to determine the maturity stage of cherry tomato fruit came from evidences of some research work done on this fruit and some related crops during its development. Thus, it was obvious that the fresh weight and diameter of cherry tomato fruit increased gradually during the different stages of growth, development and maturation (Abd El-Rahman et al., 1975). However, on tomato variety Strain B, it was observed that the fruit fresh weight, size and diameter increased during the period from blooming up to 35 days, then the increase was slowed down till the final examined age of 45 days (Abo El-Hamd, 1981). Furthermore, from the same family of tomato, it was found on fruit pepper that there were increments in firmness occurred till the age of 35 days then a decreasing trend took place up to the last examined age of 40 days (Mousa, 2004).

From the chemical point of view, the chemical contents reflected changes during the development of the fruit of tomato. Thus, on T.S.S. it was found that these contents increased with age advance in tomato fruit till it reached a peak correlated with the pink stage (Radwan et al., 1979). This view was noticed on the same contents, T.S.S., where it increased gradually in tomato fruit till the age of 35 days then a gradual decline was followed beyond this age (Abo El-Hamd, 1981). However, on the pH scale, it was found that the fruit of the cultivar Salomee of cherry tomato grown under the conditions of greenhouse produced fruits characterized with a gradual decrease in the pH values during development till the age 273 days from transplanting which turned to increases up to the last age of 315 (Franco et al., 2009). On ascorbic acid, the obtained data related to tomato fruit indicated clearly that this content increased continuously during the various developmental stages till the age of 35 days which was followed by a decreased tendency at the last period of growth at the age of 45 days (Abo El- Hamd, 1981). On lycopene, it was observed that the concentration of this content in tomato fruit increased with the proceed of the maturity stage till the last examined fruit age (Meredith and Purcell, 1966). On total sugars, the picture shed light on a steady and gradual increase in these contents with the proceed of age from 5 to 45 days (Abo El- Hamd, 1981). On dry weight, it was noticed that much greater increments happened during the development of tomato fruits (Hulme, 1970).

The chosen temperature degree was 10°C as postharvest recommendations indicate that cherry tomatoes should be stored at this degree or higher to avoid chilling injury (Jimenez et al., 1996; Roberts et al., 2002). However, some scientific reports presented the effect of cold storage duration on the changes that occurred in the physical and chemical characteristics in the various developmental stages in tomato. It is clear that the weight loss percentage occurred in mature green fruits of tomato cv. Roma VF was consistently higher during the whole storage periods. Thus, after 3 days of storage the immature green fruits lost 6.28 % and attained 13.31 % later at 12 days, whereas in full ripen fruits, the weight loss was lower as it reached 5.72 % and 11.96 % during the previous two storage periods, respectively (Moneruzzaman et al., 2009). On the same fruit, tomato, it was clear that the unmarketable fruits started to be shown under cold storage after 21 to 28 days in the various developmental stages where the age of 35 days showed the lesser percentage (Abo El-Hamd, 1981). However, the changes in the chemical constituents proved that the fruit T.S.S. of cherry tomato somewhat increased during storage and these contents are supposed to get more increments during storage with fruit development (Boe at al., 1967). On some other vegetables, such as pepper, there was a gradual increase in ascorbic acid content at the beginning of cold storage at 8°C in all the tested fruit ages, followed by a decline in the last storage periods. However, the fruits of age 30 days dominantly kept the higher concentrations of this vitamin during storage (Abd El- Rahman et al., 1990). Analogous results were obtained from tomato concerning the content of total sugars where it was found that it significantly varied in fruits of different maturity. However, it was found that the total sugars content was increased with the fruit ripening advancement. The highest quantity of total sugars during storage was recorded in full ripen tomatoes, while it was the lowest in mature green ones (Moneruzzaman et al., 2009).

The present work has involved studies on the models of plant physical and chemical attributes during development when stored under cold storage to provide knowledge and to have a complete understanding about the determination of the maturity stage and the proper age for harvesting of the hybrid F_1 "Katalina 522" of cherry tomato.

MATERIALS AND METHODS

The seeds of the hybrid "Katalina 522" F_1 of cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) were the material of this investigation which brought from GSI Syngenta company, Holland, imported by the Egyptian Technogreen company Cairo, Egypt. The established study was done at a private farm in the village of Zawyet Razeen, Menoufia Governorate during the two seasons of 2018-2019 and 2019-2020. This trial started on August 1st and 2nd in the first and second seasons, respectively. Seed sowing took place in seed bed and seedlings were shifted to the planting area under plastic greenhouses (40 x10 m) on September 10th of each season. The soil type was clay loam. The previous crop was sweet corn in the first season and cherry tomato in the second one. The design of the experiment was complete randomized blocks with three replicates. Each replicate consisted of three rows where every raw was three meter long and one meter wide and included 12 plants. Spacing in the plastic greenhouses took place at 80 cm between rows and 50 cm between plants in row. This study comprised two experiments where they were carried out to determine the fruit maturity age and the most suitable stage for harvesting by following the changes occurred in the physical and chemical features of the various fruit developmental stages besides the storage of these stages under cold conditions (10 °C and 95% RH).

The first experiment: Models of developmental stages:

This experiment began with labeling flowers on the clusters from the full-blown to record data of nine fruit ages, namely 5, 10, 15, 20, 25, 30, 35, 40 and 45 days. The fruits were harvested and immediately transferred to the laboratory of the Horticulture Department, Faculty of Agriculture, Al-Azhar University where the sound and healthy fruits were chosen to determine the physical characteristics which comprised the fresh weight, size, diameter and firmness beside the chemical ones that included total soluble solids (T.S.S.), pH, ascorbic acid, lycopene, total sugars and dry weight.

The second experiment: storage of the developmental stages:

In this experiment, the nine developmental ages were stored under cold storage at 10°C and 95% RH after being packed in plastic punnets provided with holes (5 mm in diameter) and placed in cardboard carton boxes (60x40x12cm). The experiment was done in the postharvest laboratory, Horticulture Research Institute, Agriculture Research Center, Ministry of Agriculture, Giza, A.R.E. The chosen samples of the different ages were taken from 3 punnets from each replicate during storage at 7 days intervals to check the changes that occurred in the physical and chemical characteristics. The fruit physical changes included loss in weight and unmarketable percentages; meanwhile, the chemical changes comprehended the contents of total soluble solids (T.S.S.), pH, ascorbic acid, lycopene and total sugars contents.

Determination procedures:

The fruit fresh weight was weighed in g by a digital balance. The fruit size was determined in cm^3 by immersing the fruit in a container filled with water and the displaced water was measured by a graduated jar. The fruit diameter was estimated in cm by vernier caliper. The fruit firmness was measured by using Magness and Ballauf pressure tester and was expressed as kg/cm^2. The percentage of fruits loss in weight was calculated by the following equation:

Loss in weight **%** = Loss in weight at sampling date / The initial weight of the fruits ×100.

The percentage of the unmarketable fruits was counted from the following equation:

Unmarketable fruits **(%)** = Total number of unmarketable fruits at sampling date / The initial number of fruits ×100.

The total soluble solids percentage (TSS) content was determined by Abbe refractometer as percentage described in A.O.A.C. (1990). The pH was determined by the method described by Rangana (1979). The ascorbic acid content was determined in mg/100g fresh weight as reported in A.O.A.C. (1990). Fruit lycopene content was determined by Minolta apparatus (Company, City, Country) as mg/100g fresh weight after Barrett and Anthon (2008). The total sugars content were determined in g/100g dry weight as reported by Smith et al. (1956). The dry weight was determined in g/100g fresh weight by drying 100 g fresh weight in an oven at 70 ^{o}C till constant weight was reached (A.O.A.C., 1990).

RESULTS AND DISCUSSION

Models of developmental stages:

The growth of cherry tomato fruits represented by hybrid "Katalina 522" F_1 had been followed by measuring a number of physical attributes such as fruit fresh weight, size, diameter and firmness as well as the chemical contents including total soluble solids (T.S.S.), pH, ascorbic acid, lycopene, sugars and dry weight.

Physical characteristics:

Presented data in Fig. (1) show the changes occurred in the fruit physical characteristics during development in the two seasons of 2018-2019 and 2019-2020. The obtained results exhibit rapid increments in the initial periods of fruit growth in the fresh weight, size and diameter during the different developmental stages till the age of 20 days then followed by a slow increase up to the last examined age of 45 days. From the statistical point of view, it is obvious that the development of these characteristics formed a curvilinear type with the advance of age in both seasons. The figures of fruit firmness show that this characteristic increased gradually till the age of 20 days, after which a steady stable decline occurred till the age of 45 days. The results in the statistical view revealed that a parabolic relationship was established between the fruit firmness and the various examined ages.

Chemical characteristics:

The obtained results on the changes in the fruit chemical contents during growth are exhibit in Fig. (2). The figures reflect a steady increase in the T.S.S. content with the progress of age from the start of fruit formation up to the last examined age of 45 days. The statistical relationship between the fruit T.S.S. content and the various developmental ages suggested a linear relationship. The behavior of the fruit pH content during development of the different ages performed a gradual slow decrease with the progress of fruit age up to the age of 25 days followed by a steady gradual increase till the last age of 45 days. The picture caught from the statistical analysis clarifies that the correlation between the various fruit developmental stages and its pH content formed a parabola shape. The existed figures of ascorbic acid indicate clearly that this content increased slowly and gradually from the first examined age of 5 days till the age of 30 days, then turned to be more rapid up to the last tested age of 45 days. The resulted values show statistically a curvilinear relationship between the content of ascorbic acid and the fruit developmental ages. Concerning the lycopene content, it is obvious that this content increased slowly and gradually from the first examined age of 5 days till the age of 25 days, then turned to be more rapid up to the last age of 45 days. The obtained results exist statistically a curvilinear shape. Concerning the total sugars content, it is clear that this content increased continuously in a gradual shape with the move forward in age days from the start of 5 till 30 days then turned to a slight increase up to the last tested age of 45 days. However, the correlation between these contents and the various developmental stages established statistically a curvilinear form. However, the results of fruit dry weight performed that the changes occurred in this content in the different developmental stages were accompanied by a gradual stable increase in this content from the beginning of development up to the end of the tested ages. The obtained results of fruit dry weight exhibit from the statistical point of view a linear shape.

To put the aforementioned results under discussion, it is obvious from the aforementioned studies in the two seasons on the fruit growth characteristics during development that the growth of cherry tomato fruit as other horticultural fruits is a complex process that led to greater enlargement in the fruit during development. Basic processes which plants and their parts depend on for growth are photosynthesis for food utilization, absorption for raw materials, transpiration for the upward flow of water and translocation for movement of manufactured food (Wien and Wurr, 1997). From the physiological point of view, the growth of any part of the plant such as the fruit could be divided into three fairly distinct phases, which are the formation of new cells, the enlargement of the newly formed cells and the differentiation or maturation of these enlarging cells into the mature tissue (Cite a reference).

The results of the physical characteristics during the growth of cherry tomato fruit followed two statistical curves, curvilinear or parabola. However, it was observed that the growth of the fruit fresh weight, size and diameter formed statistically a curvilinear shape while firmness established a parabola type. These characteristics, however, increased rapidly at the start of the fruit growth periods then turned to be slow in the fresh weight, size and diameter or drop in firmness till the last examined age. It is quite possible to say here that the increases in these physical characteristics may be ascribed to the considerable cell expansion after the early cessation of cell division (Abo- El Hamd, 1981). From another point of view, the rapid and slow increase in the physical characteristics during its cycle growth may be explained through the changes in the endogenous plant hormones (auxins, gibberellins and cytokinins). These growth substances increased progressively in the first stages of growth then tended to lessen in the later stages (Abd El- Rahman et al., 1975 and Mapelli et al., 1987 on tomato fruits).

From the chemical point of view, this study shed light on the most important chemical constituents during the development of cherry tomato fruit which gave awareness of the importance of this fruit as food. However, the accumulation of some important chemical contents was followed during the growth of this fruit. The obtained curves for these compounds showed characteristic forms. Thus, the resulted values revealed a continuous quick gradual increase in both T.S.S. and dry weight contents with the progress of age from the start of fruit formation up to the last examined age of 45 days. To explain the increasing trend of T.S.S., it may be clear to our knowledge that the changes in T.S.S. content during cherry tomato fruit are resultant of some aspects such as the movement of water and soluble solids to and from the fruit, the inversion of insoluble compounds to simpler soluble forms beside respiration which all these reasons may add or withdraw these chemicals. So, the prevalence of one or more of these factors during fruit development may accumulate or lessen these contents (Abu-Zinada, 1988; Emam, 1993). The increase in the fruit dry weight may be attributed chiefly to the increase mainly in sugars (Nilsson, 1988) beside the progressive accumulation of nutrients which moved from another plant parts to the fruit and the reduction in fruit moisture content (El-Sherbeiny, 1999). Further view on the trend of the fruit pH shows that this value gradually decreased slowly in the first stages of fruit development up to the age of 25 days then tended to increase gradually. This may be attributed to the exhaustion of organic acids during building the fruit cells and respiration in the first stage of development and the late increase of pH may be due to the continuous synthesis of organic acids (Abo-El Hamd, 1981).

In this experiment, the accumulation of some other chemical contents during fruit development such as ascorbic acid, lycopene and total sugars form statistically a curvilinear relationship. Thus, the results show that the content of ascorbic acid increased steadily till the age of 30 days then turned to be more rapid up to the last age of 45 days. This increase in ascorbic acid may be related to the high rate of hexose sugars synthesis from the precursor of these sugars, which depends on an adequate photosynthetic activity (Hulme, 1970; Davies et al., 1991). Concerning the lycopene content, it is obvious that this content increased slowly till the age of 25 days then turned to be rapid till the last examined age of 45 days. This may be attributed to the activity of chlorophyllase which is involved in the destruction of chlorophyll which is so characteristic during ripening of fruits (Hulme, 1970). Thus, the biochemistry action led to vanish the fruit green colour and gave a chance to the appearance of the red colour of lycopene. However, at the pink-red stage of cherry tomato fruit, the respiratory climacteric is at the maximum and the chromo blasts are formed (Harris and Spurr, 1969 a.). When the transition plastids in fresh material appeared in an optical microscope, red elongated or irregular crystal-like bodies could often be seen in one part of the plastid and green areas in other parts indicating that grana and pigment crystalloids occur together (Harris and Spurr, 1969 b.). As for total sugars, the formation of the curvilinear shape in statistics of these sugars increased continuously in intermediate steps till the fruit age of 30 days, then turned to slight increases up to the last age of 45 days. It is quite possible to say here that the main sugar transport from the leaves to the fruits during growth is sucrose. While part of these sugars is used to synthesize pectic substances and other cell-wall materials other parts are converted to the usual storage product starch (Bollard, 1970). So, it is easy here to suggest that in the early stages of fruit growth which was characterized with continuous gradual accumulation of these sugars, it was related to the high rate of increase in the fruit sugars than the rate of conversion to starch and cell-wall materials while in the late stages of growth which showed lower gathering and the opposite might be true (Nilsson, 1988).

Storage of developmental stages:

Determination of the proper picking stage of the fruits, in general, depends on the top quality for the market accompanied with the ability to be stored for long periods. Thus, this work was endeavors to describe the behavior of the different ages of cherry tomato fruit during storage which may facilitate and enable us to determine the fruit maturity stage and the most suitable age for harvest.

Physical characteristics:

The loss in weight percentage in the different fruit ages during the various cold storage periods (Table 1) demonstrates that a continuous gradual increase in this characteristic existed in all the examined ages with the extension of the storage periods in both seasons. When the results of these various ages were put in comparison, the first observed point is that the fruit age of 35 days exhibited the least loss in weight percentage during the various storage periods. On the other hand, the data of the fruit unmarketable percentage in the various developmental stages during cold storage (Table 2) show that the unmarketable fruits percentage increased gradually in all the stored ages till the end of the storage. On the whole, when the resulted values are compared, the age of 30 and 35 days show the least percentage of the unmarketable fruits during the various storage periods.

Chemical characteristics:

The obtained figures from the differences occurred in the T.S.S. fruit content in the various ages during cold storage in the two seasons of the experiment (Table 3) show that these contents in the different fruit ages increased gradually at the first storage periods.

while with the proceed of storage, gradual decreases happened in these contents. However, the fruit age of 35 days kept comparatively the highest contents of T.S.S. during the various storage periods. The behavior of the changes in the fruit pH during cold storage in all the examined ages (Table 4) exhibit a gradual increase at the start of the storage periods, which turned to a gradual decrease during the middle part of storage then ended by increases at the final storage periods. However, the highest pH content was noticed in both the ages of 45 and 40 days, respectively in the whole storage periods. Concerning the content of ascorbic acid (Table 5), the resulted data make it clear that a continuous gradual decrease in this content was seen in all the stored fruit ages. However, the fruit age of 35 and 40 days reserved the highest ascorbic acid content during the whole storage periods. Having a look to lycopene, the effect of cold storage periods on the fruit lycopene content in the various developmental stages (Table 6) reflects a gradual increase in the lycopene content in all the various ages with the elapse of cold storage periods. However, the highest lycopene content during the whole storage periods was found in both ages of 35 and 40 days. Regarding the content of total sugars (Table 7), it is obvious that the changes in these contents in the various fruit ages during cold storage exhibit that in all the stored fruit ages a gradual increase trend happened with the proceed of cold storage periods up to 14 days then decreased till the final storage periods. However, it is apparent that the age of 35 days is comparatively present to view the highest total sugars during the whole storage periods.

Further studies on the various stored fruit age were quite evident in indicating that the age of 35 days was the most favorable during storage as it reflected the least loss in weight and the minimum unmarketable percentage. However, the criterion of the loss in weight was expected due to the loss of water by transpiration plus the loss in dry matter by respiration (Cabezas et al., 2002; Simon and Dominyo, 2008). Therefore, weight loss adversely affects the appearance, texture, flavor, besides inducing wilting, shrinkage, loss of firmness and crispness, all factors that deteriorate the quality of vegetables (Kang et al., 2002; Manolopoulou and Varzakas, 2013). The existence of the unmarketable fruits in the stored developmental ages was also expected. This feature may be attributed to the continuous chemical and biochemical changes occurred in the fruits during storage which led to moisture condensation and transformation of complex compounds to simple forms of more liability to fungus and bacterial infection such as the changes from the solid protopectin to the soluble pectin form (Pilnik and Voragen, 1970, Gil et al., 2001, Villanueva et al., 2005; Guerra et al., 2011; Raja et al., 2011).

Following the chemical changes occurred in the various fruit ages during storage, it is evident that with the extension of storage periods a general trend of decrease took place in the contents of T.S.S., ascorbic acid and total sugars while the pH and lycopene content increased. In this concern, the decrease in T.S.S. contents may be accounted to the continuous loss through respiration (Hulme, 1970; Bauza et al., 1998; Roura et al., 2000; Raja et al., 2011; Jafri et al., 2013). On the other hand, the decrease in ascorbic acid content may be attributed to the oxidation of ascorbic acid into dehydro – ascorbic acid by the enzyme ascorbic acid oxidase in addition to the role of peroxidase which plays an important role in the enzymatic degradation of this compound (Barth et al., 1993). From another view, the gradual decrease in fruit total sugars contents during cold storage may result from its utilization and consumption in respiration (Whiting, 1970; Cabezas et al., 2002; Raccuia and Meilli, 2007). Nevertheless, the gradual increase in the fruit pH content during storage was observed in mature green fruit followed by lessen in the half ripe and ended with a rise in full ripen tomato (Botrel et al., 1993). Dealing with the increase in the fruit lycopene content in tomato, it was reported that lycopene is the pigment principally responsible for the characteristic of deep red colour in the ripe fruits and the most abundant carotenoid comprising approximately 80-90% of the total fruit pigments (Agarwal, 1998).

Determination of the maturity stage and the proper age for harvesting.

When the previous results of the various stored ages were put in comparison, the first demonstration observed is that the fruit age of 35 days exhibited the least loss in weight, the minimum percentage of unmarketable fruits and at the same time dominantly kept the highest concentrations of T.S.S, ascorbic acid, lycopene and total sugars during cold storage. Therefore, it can be concluded that the fruit age of 35 days coincided with the maturity stage of the hybrid F_1"katalina 522" of cherry tomato. This fruit age was characterized in the two seasons by an average of 12.13 g (13.12 and 11.15 g) fresh weight, 10.83 cm^3 (12.66 and 9.00 cm^3) size, 2.63 cm (2.69 and 2.58 cm) diameter, 3.00 g/cm[2] (2.77 and 3.23 g/cm[2]) firmness, 7.83 % (7.50 to 8.17 %) T.S.S, 3.92 % (3.84 to 4.00 %) pH, 19.26 mg/100g f.w. (18.82 to 19.70 mg/100g f.w.) ascorbic acid, 1.54 mg/100g f.w. (1.61 and 1.47 mg/100g f.w.) lycopene, 10.16 mg/100g d.w. (8.51 to 11.82 mg/100g d.w.) total sugars and 8.45 % (7.85 to 9.05 %) dry weight.

In seeking to follow and interpret the previous studies on the different fruit ages of cherry tomato, the obtained results showed that the fruit age of 40 days was the most favorable for the local market depending on its exerted characteristics that suit the common meetings for making purchases and sales of cherry tomato in A. R. Egypt. At the same time these characteristics as set together fulfill the requirements of export as published in the ministerial order No. 670, 2017, Ministry of Economic A. R. Egypt. This fruit age was characterized in the two combined seasons by an average of 13.19 g (14.23 to 12.16 g) fresh weight,11.88 cm^3 (9.66 to 14.11 cm^3) size, 2.66 cm (2.70 to 2.62 cm) diameter, 2.47 g/cm^3 (2.48 to 2.46 g/cm^3) firmness, 7.89 % (7.53 to 8.26 %) T.S.S., 3.92 % (3.80 to 4.05 %) pH, 25.73 mg/100g f.w. (25.29 to 26.17 mg/100g f.w.) ascorbic acid, 2.36 mg/100g f.w. (2.33 to 2.39 mg/100g f.w.) lycopene, 11.15 mg/100g d.w. (9.70 to 12.60 mg/100g d.w.) total sugars and 9.53% (9.52 to 9.54 %) dry weight.

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Table1: The changes in the fruit loss in weight percentage in the various developmental stages stored under cold storage (10ºC and R.H 95%)in 2018-2019 and 2019-2020 seasons.

Fruit age (days)	Storage periods (days)									
	2018-2019					2019-2020				
	7	14	21	28	35	7	14	21	28	35
5	3.76	6.93	9.41	10.79	11.11	3.28	6.68	9.17	10.73	11.02
10	2.51	3.97	5.95	7.70	9.85	2.29	4.01	5.89	7.64	9.34
15	1.34	2.70	4.45	5.57	9.15	2.55	4.83	6.97	9.84	11.36
20	3.16	4.26	4.83	7.49	9.63	3.11	4.79	5.49	7.80	9.80
25	0.91	2.53	5.30	7.57	10.83	3.71	6.74	9.42	10.56	12.31
30	1.64	3.56	5.64	7.05	9.36	3.59	4.23	9.26	11.17	14.39
35	1.28	2.81	4.63	5.76	8.01	2.28	3.97	6.53	8.86	9.05
40	1.66	3.48	5.54	6.84	8.06	2.62	5.06	6.97	9.78	10.85
45	1.85	5.31	8.24	10.30	11.80	3.41	5.83	6.93	10.22	11.46

Table2: The changes in the fruit unmarketable percentage in the various developmental stages stored under cold storage (10ºC and R.H 95%)in 2018-2019 and 2019-2020 seasons.

Fruit age (days)	Storage periods (days)									
	2018-2019					2019-2020				
	7	14	21	28	35	7	14	21	28	35
5	40.00	70.00	100.00	-	-	40.00	80.00	100.00	-	-
10	30.00	60.00	100.00	-	-	40.00	85.00	100.00	-	-
15	30.00	50.00	100.00	-	-	40.00	60.00	100.00	-	-
20	0	50.00	66.66	75.00	100.00	0	46.66	66.66	73.00	100.00
25	0	0	13.33	20.00	70.00	0	0	19.23	30.36	75.00
30	0	0	12.00	20.00	60.00	0	0	10.00	18.00	60.66
35	0	0		13.63	36.36	0	0	0	22.72	40.90
40	0	0	20.00	40.00	60.00	0	15.00	40.00	55.00	85.00
45	11.10	16.65	33.32	66.66	100.00	16.16	38.38	50.00	61.11	100.00

Table3: The changes in the fruit total soluble solids percentage in the various developmental stages stored under cold storage (10ºC and R.H 95%) in 2018-2019 and 2019-2020 seasons.

Fruit age (days)	Storage periods (days)											
	2018-2019						2019-2020					
	0	7	14	21	28	35	0	7	14	21	28	35
5	5.41	9.10	9.40	8.72	7.50	7.00	6.42	8.70	9.20	7.18	7.30	7.22
10	6.14	8.55	8.87	7.80	6.80	6.70	7.01	8.12	8.30	7.14	6.74	6.78
15	6.72	7.03	7.08	6.23	6.20	6.20	7.27	8.13	8.44	7.67	7.54	7.45
20	6.92	7.18	7.35	7.12	6.94	6.24	7.40	8.20	8.26	7.83	7.55	7.07
25	7.26	7.13	7.34	6.40	6.23	6.12	7.71	8.14	8.32	8.10	7.78	7.60
30	7.28	7.34	7.68	7.18	6.87	6.25	7.54	8.13	8.27	7.93	7.36	7.32
35	7.50	7.56	7.63	7.53	7.50	6.37	8.02	8.22	8.37	8.17	7.92	7.86
40	7.53	7.88	8.13	7.55	6.98	6.93	8.26	8.32	9.08	7.44	7.44	7.36
45	8.44	8.37	8.46	7.11	7.00	6.36	8.88	9.08	9.93	8.95	7.32	7.30

Table 4: The changes in the fruit pH percentage in the various developmental stages stored under cold storage (10ºC and R.H 95%) in 2018-2019 and 2019-2020 seasons.

Fruit age (days)	Storage periods (days)											
	2018-2019						2019-2020					
	0	7	14	21	28	35	0	7	14	21	28	35
5	4.44	4.03	4.12	4.31	3.93	3.96	4.19	4.03	4.18	4.30	4.17	3.95
10	4.31	4.02	4.12	4.16	3.84	3.79	4.11	3.98	4.15	4.21	3.79	3.83
15	3.70	3.85	3.74	3.69	3.74	3.88	4.08	4.02	4.14	4.18	3.74	3.82
20	3.59	3.94	3.72	3.77	3.78	3.93	3.99	4.06	4.16	4.20	3.81	3.81
25	3.59	3.99	3.90	3.82	3.88	3.98	3.98	3.95	4.06	4.13	3.77	3.84
30	3.66	3.60	3.94	3.96	3.96	4.09	4.17	3.82	3.83	3.97	4.03	4.21
35	3.84	4.01	4.04	4.15	4.16	4.11	4.00	4.05	4.17	4.18	4.24	4.39
40	3.80	4.11	4.17	4.19	4.23	4.30	4.05	4.13	4.29	4.32	4.36	4. 45
45	3.98	4.27	4.26	4.32	4.39	4.41	4.17	4.34	4.47	4.48	4.60	4.64

Table 5: The changes in the fruit ascorbic acid percentage in the various developmental stages stored under cold storage (10ºC and R.H 95%) in 2018-2019 and 2019-2020 seasons.

Fruit age (days)	Storage periods (days)											
	2018-2019						2019-2020					
	0	7	14	21	28	35	0	7	14	21	28	35
5	4.70	3. 85	3.07	2.95	2.50	2.57	7.35	6.64	6.28	5.07	4.57	3.85
10	6.47	5.50	4.78	5.85	5.21	4.78	9.11	9.08	8.05	7.21	7.14	6.50
15	8.82	8.57	8.21	7.78	7.50	7.21	10.88	9.92	9.50	9.07	8.21	8.57
20	10.58	9.57	9.35	9.21	8.50	8.21	12.64	10.85	10.57	10.28	9.32	8.35
25	13.52	13.28	12.50	12.42	11.42	11.42	15.58	14.71	13.14	12.28	11.64	11.92
30	15.88	15.00	14.14	14.07	13.35	13.57	16.17	15.71	15.00	14.50	13.71	13.78
35	18.82	17.85	17.71	16.42	16.35	15.92	19.70	15.71	15.35	15.35	14.78	14.28
40	25.29	24.64	24.64	20.85	15.78	14.07	26.17	22.85	21.42	21.12	18.11	13.64
45	31.17	28.21	24.10	19.85	18.92	13.92	29.70	23.03	21.42	19.71	18.35	14.02

Table 6: The changes in the fruit lycopene percentage in the various developmental stages stored under cold storage (10ºC and R.H 95%) in 2018-2019 and 2019-2020 seasons.

Fruit age (days)	Storage periods (days)											
	2018-2019						2019-2020					
	0	7	14	21	28	35	0	7	14	21	28	35
5	0.90	0.90	0.88	0.92	0.88	0.94	0.90	0.94	0.91	0.84	0.89	0.90
10	0.97	0.95	0.93	0.92	0.94	0.92	0.96	0.92	0.95	0.91	0.96	0.94
15	1.59	1.62	1.66	1.70	2.09	2.22	1.53	1.57	1.65	1.68	2.00	2.03
20	1.58	1.66	1.66	1.90	2.52	2.52	1.57	1.59	1.59	1.82	2.31	2.30
25	1.57	1.64	1.86	2.28	2.79	2.56	2.46	1.49	1.77	2.10	2.56	2.43
30	1.60	2.10	2.24	2.42	2.67	2.63	1.67	2.22	2.31	2.35	2.40	2.47
35	1.61	2.03	2.64	2.66	2.74	2.79	1.47	2.56	2.71	2.44	2.51	2.57
40	2.33	2.61	2.64	2.73	2.87	2.97	2.39	2.49	2.62	2.66	2.67	2.85
45	2.99	3.56	3.06	2.73	2.72	2.14	3.03	3.04	2.90	2.81	2.82	2.47

Table 7: The changes in the fruit total sugars percentage in the various developmental stages stored under cold storage (10ºC and R.H 95%) in 2018-2019 and 2019-2020 seasons.

Fruit age (days)	Storage periods (days)											
	2018-2019						2019-2020					
	0	7	14	21	28	35	0	7	14	21	28	35
5	3.61	3.77	3.85	2.18	2.49	2.62	1.85	2.92	3.89	3.42	3.67	3.75
10	4.41	5.35	5.98	4.49	4.82	4.37	4.16	5.36	6.95	2.14	4.71	4.70
15	5.76	7.62	9.72	9.10	9.28	8.86	7.31	7.77	7.24	5.39	6.71	6.98
20	6.18	8.64	9.54	8.05	7.91	7.26	8.92	9.34	10.27	8.94	8.16	8.91
25	6.61	8.69	9.82	9.05	9.94	9.22	9.45	9.87	9.94	8.20	8.59	9.45
30	7.23	9.87	10.11	8.20	9.84	9.14	9.90	11. 57	11. 84	10.36	9.77	9.59
35	8.51	10.34	11.68	10.90	10.27	10.86	11.82	11.88	12.52	9.95	11.80	12. 32
40	9.70	11.10	12.24	11.55	11.77	10.26	12.60	12.88	12.95	11.18	11.36	11.49
45	11.38	11.77	12.80	10.99	10.61	10.22	13.10	13.29	13.61	11.46	11.29	11. 12

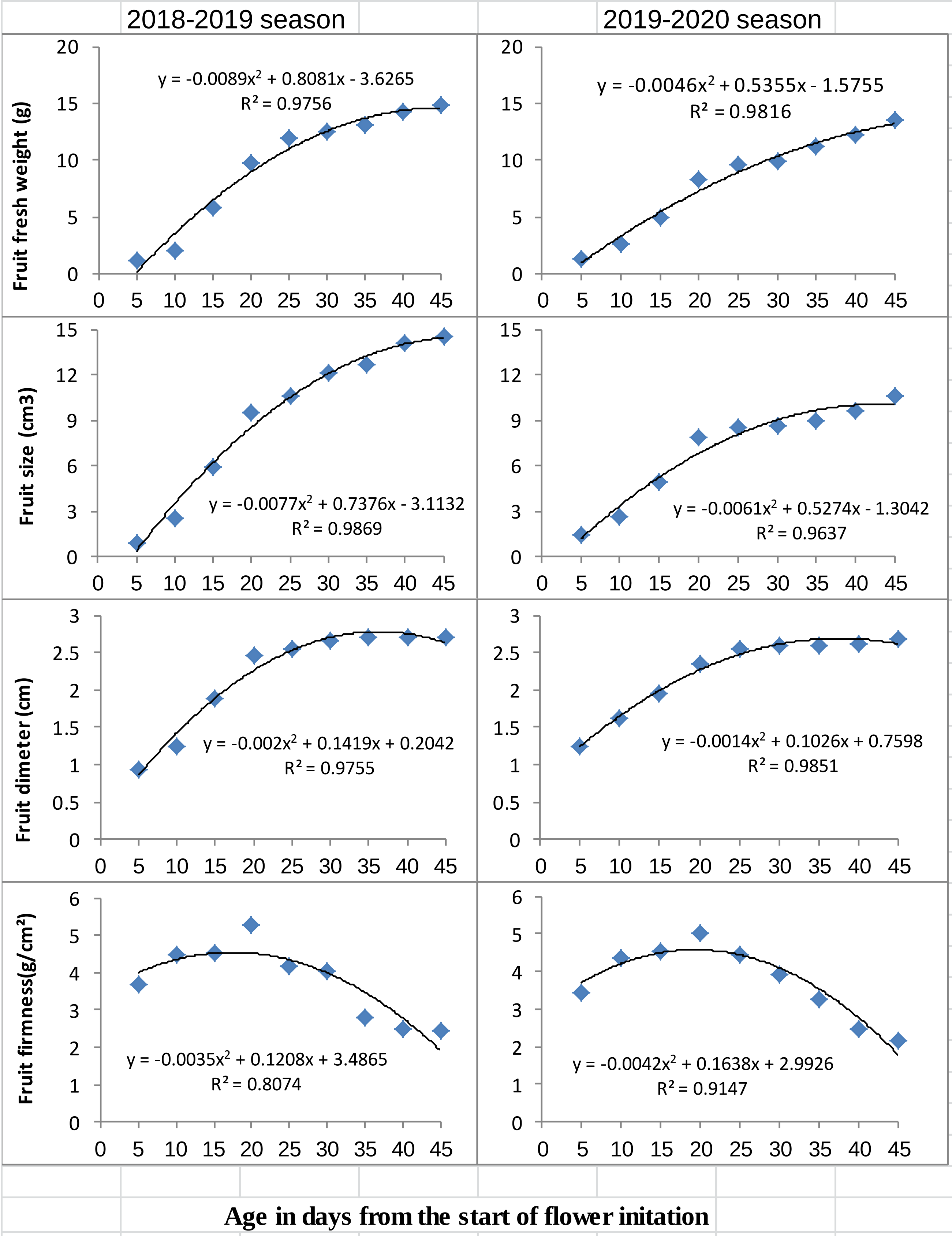

Fig. (1): The changes in the fruit physical characteristics during the various developmental stages in the two seasons of 2018-2019 and 2019-2020.

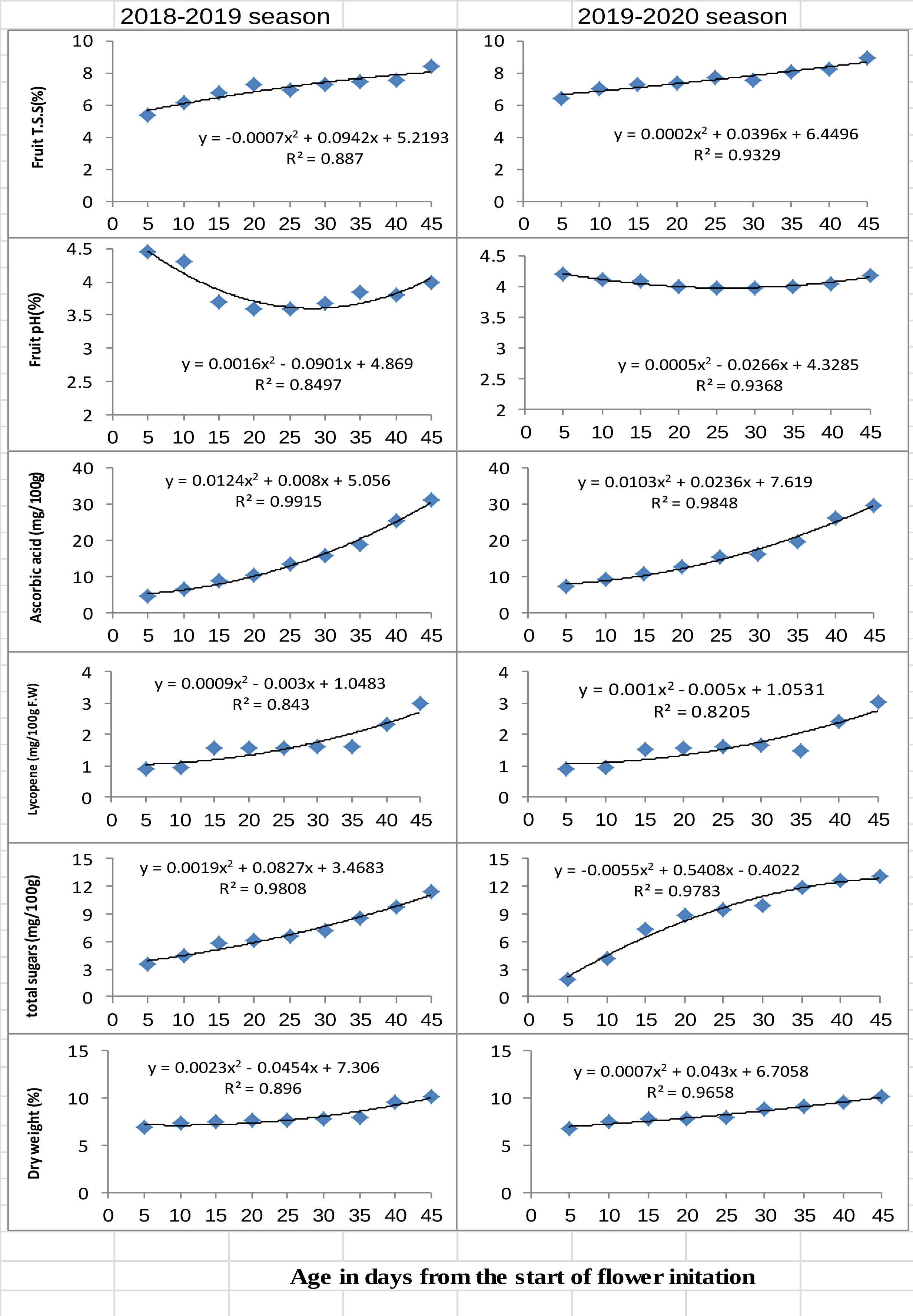

Fig.(2): The changes in the fruit chemical characteristics during the various developmental stages in the two seasons of 2018-2019 and 2019-2020.

تحديد مرحلة إكتمال النمو والعمر المناسب للحصاد لثمار الطماطم الشيرى

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الملخص العربي

أجريت تجربتين على ثمار الطماطم الشيرى للهجين كاتالينا 522 لدراسة التغيرات الطبيعية والكيماوية للثمار خلال مراحل تطورها المختلفة وتخزينها وذلك لتحديد درجة اكتمال النمو والعمر المناسب للحصاد خلال موسمى 2018-2019و 2019-2020 بمزرعة خاصه بقرية زاوية رزين- محافظة المنوفية, حيث تم تعليم الأزهار من بداية تكوينها عند ذروة التزهير كل خمسة أيام للحصول على ثمار ذات أعمار 5و10و 15و20و25و30 و35 و40 و45 يوما لدراسة الصفات الطبيعية والكيماوية عليها. وأشارت النتائج إلى زيادة سريعة فى الوزن الطازج والحجم وقطر الثمرة حتى عمر 20 يوما ثم تحولت تلك الزيادة لتكون بطيئه حتى عمر 45 يوم مكونة شكل curvilinear إحصائيا بينما زادت صلابة الثمار زياده منتظمة من بداية تكوينها حتى عمر 20 يوما أعقبها نقص تدريجى فى هذه الصلابة حتى عمر 45 يوما مكونة شكل parabola إحصائيا أما محتوى الثمار من المواد الصلبة الذائبة والوزن الجاف فكانت الزيادة مستمره من بداية تكون الثمرة حتى عمر 45 يوماً مكونة شكل linear إحصائيا وبالنسبة لحامض الأسكوربيك و الليكوبين والسكريات الكلية فقد زادت فى الثمار زيادة بطيئة من بداية تكوينها حتى عمر 25 إلا فى حالة الليكوبين فقد كانت الزيادة بطيئة حتى عمر 30 ثم تحولت تلك الزيادة فى هذه الصفات لتكون تدريجية حتى عمر 45 يوم مكونة شكل curvilinear إحصائيا. أما محتوى الثمار من pH فقد حدث له نقص بطيء حتى عمر 25 ثم زاد محتوى الثمار من pH زياده تدريجية حتى عمر 45 يوم مكونة شكل parabola إحصائيا. ولتحديد درجة اكتمال النمو والعمر المناسب للحصاد تم تخزين الثمار من الأعمار التى تم الحصول عليها على درجة حرارة 10 درجة مئوية ورطوبة نسبية 95% حيث تم تقدير التغيرات في بعض الصفات الطبيعية والكيماوية للثمار كل سبعة أيام. ولقد أوضحت النتائج أن أقل فقد فى وزن الثمار وفى نسبة الثمار غير الصالحة للتسويق كانت فى الثمار عمر 35 يوماً كما تميزت هذه الثمار بأقل فقد فى محتواها من المواد الصلبة الذائبة وحامض الأسكوربيك والليكوبين والسكريات. ومن هذه النتائج المتحصل عليها تبين أن ثمار نباتات الطماطم الشيرى (الكرزه) للهجين كاتالينا 522 وصلت إلى مرحلة اكتمال النمو عند عمر 35 يوماً من بداية تكوين الأزهار بينما العمر المناسب للحصاد كان عند عمر 40 يوما.

الكلمات الاسترشادية: الطماطم الشيرى, مرحلة اكتمال النمو، العمر المناسب، الحصاد.