

PHYSICAL AND MECHANICAL PROPERTIES OF TOMATO PLANT TO DESIGNA HARVEST MACHINE

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ABSTRACT

This study was carried out during the summer seasons from 2008 to 2009 at Kaha Horticultural Research Station, Kalubia Governorate the investigat physical and mechanical properties of tomato crop. The characteristics used were length, width, weight, volume, surface area, density rigidity force, angle of repose and angle of friction of three different varieties of tomato (Florada, Super B and Castle Royal) and three hybrids (Bregenith, Fanfare and Heinz).

The obtained results can be applied to design and develop of tomato harvester functional units summarized in the following points: Plant characteristics for cultivars and hybrids: Angle of inclination of the main branches on the vertical plane was averaged 25° , the highest percentage of the fruits (95 %) was found in circumference the inter plant.

Physical properties of tomato fruit: Heights for cultivars were averaged 62.23, 55.92, 54.12 mm, respectively, for hybrids averaged 63.07, 52.69, 53.14 mm, respectively. Width for cultivars were averaged 58.26, 47.53 and 49.62 mm, respectively, and for hybrids were averaged 58.19, 62.72 and 61.44 mm, respectively. Sphericity for cultivars averaged (1.06, 1.18 and 1.09), respectively and the fruit sphericity for hybrids were (1.09, 1.17 and 0.78), respectively. Mass for cultivars were averaged (131, 87.5 and 76 g), respectively, and for hybrids averaged (128.5, 106.5 and 123.5 g), respectively. Volume for cultivars averaged (129, 85 and 69.5 cm³), respectively, and for hybrids averaged (126.5, 105.5 and 121.75 cm³), respectively. The deformation range increased from 0.85- 2.6 to 6.5 – 7.9 mm by increasing loading from 1 to 6 N. Meanwhile, the deformation range increased from 0.85 - 6.5 to 2.6 – 7.9 by increasing loading time from 20 to 60 s. The maximum impact heights, which caused damage was 1.0 m.

While, the corresponding impact height which caused bruise was 0.75 m.

The present work aimed at studying the harvest machine design using the physical and mechanical properties of tomato plant.

Key words: *cultivars, hybrids, physical and mechanical properties, tomato.*

1. INTRODUCTION

Tomato is one of the most important vegetable crops in Egypt for fresh consumption and processing.

The objectives of this study were to investigate the physical and mechanical properties of tomato plant. This knowledge is useful in selecting machine-harvest, for establishing design and developing specifications for fruit tomato-harvesting machines .

The physical property determinations are useful to build up data base for standardizing each crop that will be required for the international marketing (El-Raie *et al.*, 1996). Hojat *et al.* (2008) studied some physical and mechanical properties such as dimensions, geometric mean diameter, sphericity, surface area, bulk density,

real density, porosity, volume, mass, 1000- unit mass, coefficient of static friction on various surface and rupture force in 3 axes of apricot fruits. Abd-Allah (1995) found highly significant differences for plant height among the tested genotypes of tomato; Marmande was the tallest plant while Peto 86 was the shortest one.

Mouhamed and Hewedy (1994) found that plant height of determinate tomato cultivars differed from 29 cm to more than 85 cm. However.Hanna *et al.* (1993) stated that, the angle of the repose is very important in the determination of the inclination angle of the machine hopper tank.

Bishop and Maunder (1990) stated that there are four basic causes of damage: pressure, impact, cutting, and friction. Damage by pressure is not

typical on a grading line. Cutting should also not be a problem, as if cut wounds are found it is normally a relatively easy task to protect shape edges. Impact and friction are the two most important causes of damage.

Balls (1986) reported that there is an inherent damage capability in hand-harvesting system, as well as in mechanical harvesting; however, the latter is often more severe and likely to have less chance of being observed and corrected. Damage exists in two forms; external, caused by cutting, gouging or abrasion; while internal bruising caused by pressure or impact forces. The former is more easily detected, but more obvious in fresh market produce. Bruising often has a delayed visual effect, and consequently cannot be detected and rectified at source bruising might be enhanced by certain conditions.

Peterson and colario (1990) found that fruit-fruit impacts were a major cause of damage in the mechanical harvesting of peaches, and established bruising levels for a 400 mm drop onto other fruit as 11% bruised for Red Globe, 3% bruised for Loring, 3% bruised for Red Skin and 0% bruised for Bounty; and for a 800 mm drop, 64% bruised for Red Skin.

Haydar *et al.* (2007) mentioned that properties are necessary for the design of equipments for harvesting, processing, and transportation, separating and packing. Technological properties are length and diameter of fruits, mass, volume of fruits, geometric mean-diameter, sphericity, bulk density, fruits density, porosity, projected area,

static and dynamic coefficient of friction.

Huang *et al.* (2000) stated that the basic physical properties (shapes, sizes and mass, slanting and rolling angles, coefficients of friction and size attribution ratio) of the grading machine used to sort *Ziziphus mauritiana* were investigated and indexes of physical properties were established to provide information for the design and development of a grading machine suitable for postharvest processes such as cleaning, grading, packing, and preservation.

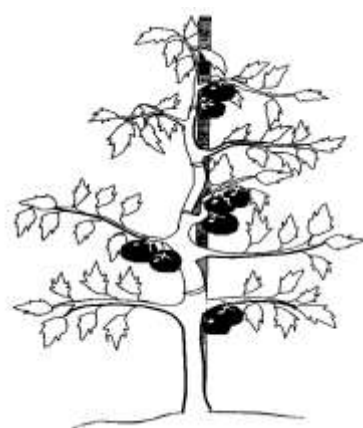
2. MATERIAL AND METHODS

This work was carried out to determine some physical and mechanical properties of six tomato varieties commonly cultivated in Egypt. These varieties are: Cultivars (Florada, Super Strain B and Castle Royal) and Hybrids (Bregenith, Fanfare and Heinz). The physical and mechanical studies may help in choosing, altering or design of a suitable machine for harvesting tomato.

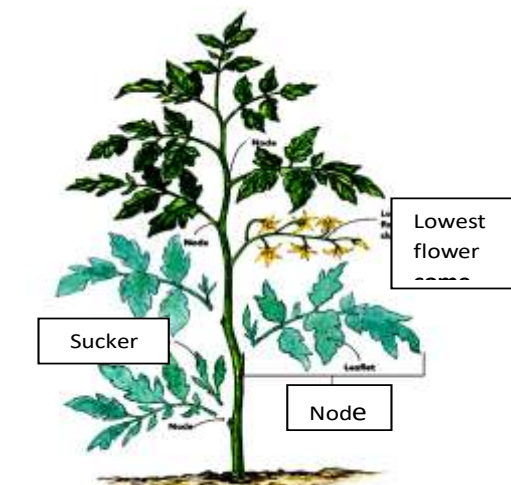
2.1.Characteristics of tomato plant

The dimension characteristics of the tomato plant are important in estimating the amount of tomato yield, its plant.

The positions of plant parts above the soil surface were studied and measured on the selected tomato plants. The angle of inclination of each main branch with respect to the vertical plane axis was measured with a protractor with accuracy of 5. Fig. (1) shows the divisions of a tomato plant determination of plant size. It was counted for each plant and the average was calculated.



(A)



(B)

Fig.(1): Division of a tomato plant.

A: The distribution of the tomato fruits on the plant

B: The positions of parts above the soil.

2.2.Physical and mechanical properties of tomato fruits

2.2.1.Physical properties of tomato fruits

In order to determine the mean weight and the dimensions of tomato fruits, a sample of 100 fruits was selected randomly for both groups. Each fruit of the average sample was weighed using an electric balance with an accuracy of 0.01 g and using a caliper.

2.2.2.Mechanical properties of tomato fruits

2.2.2.1. Static compression force of tomato fruit

The fruit strength is defined by the pericarp hardness, by the magnitude of the static crushing force and by crushing of fruit due to impact (Buyanov and Voronyuk, 1985). The fruits were crushed in two directions, along a major axis (D_2) and a minor axis (D_1) in (Fig., 2). The fruit was put on the flat plastic surface along the axis.

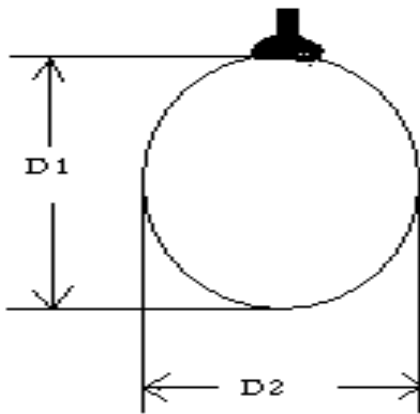


Fig. (2): Tomato fruit dimensions D_1 and D_2

The weight was put on the fruit and increased gradually to the maximum point at which cracks begin to appear then compression stopped. Before the test, the fruit dimensions and their weights were recorded. After removing the loads the dimensions D_1 and D_2 were measured again and the fruit deformation was calculated as follows:

Deformation along D_1 axis = $D_{11} - D_{12}$

Where: D_{11} = the dimension before the test

D_{12} = the dimension after the test

Deformation along D_2 axis = $D_{22} - D_{21}$

Where: D_{22} = the dimension before the test

D_{21} = the dimension after the test

2.2.2.2. Detachment force of tomato fruit (F)

Tomato fruits are attached to their supporting twig through a small button (calyx). Tomato fruit detachment force is an indicator for the degree of fruit maturity (Ghonim, 1986) and the magnitude of twig torsion shear stress. Tomato fruit detachment force was measured to estimate the

variation of fruit detachment force. The detachment force was measured for the tomato fruits exist by using the detachment force meter (Fig. 3). After tomato fruit separation from the twig, fruit dimensions; D_1 , D_2 and twig diameter were measured with a caliper and then the fruit was weighed. During the harvesting time, the ripe cohort of fruit, calyx and twig is attached to the branches of the tree, to attenuate that attachment at any location (1) or (2) or (3) of (Fig. 4) the fruit will be separated with its own twig.



Fig. (3): The detachment force meter.

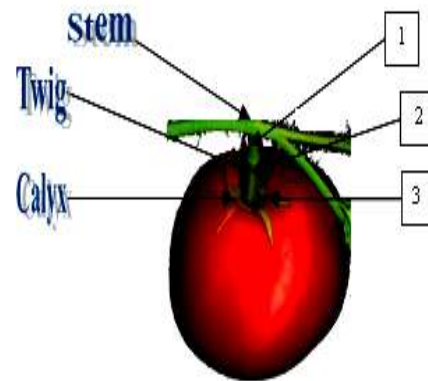


Fig. (4): Major diameters of a tomato fruit

2.3. Design-idea of the tomato harvester the pull-type

A design-idea of the tomato harvester the pull-type in (Fig. 5) allows the growers who purchase the machines a great degree of adaptability for harvesting in different environments.

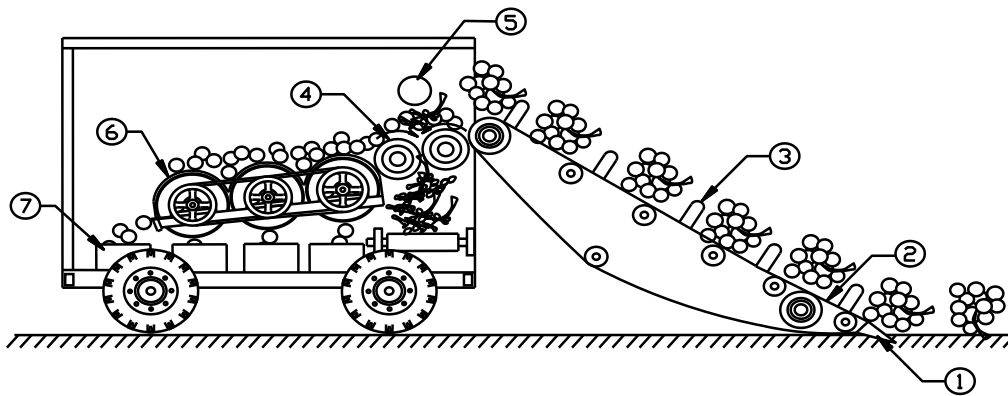


Fig. (5): Schematic design-idea of the tomato harvester the pull-type.

- 1- Width cutting bar more than the spacing between the rows of plants and positioned perpendicular to the plant row, as the tractor moves forward. Tomato plants are thus uprooted from below the ground surface to harvesting.
- 2- Conveyor belt for plant matter and shaker are for fruit cleaning from vine mass and debris the vines, leaves slide back down the concave.
- 3- Rigid fingers are arranged on the parallel rods of the elevator for lifting plants and prevent movement of loose fruit. The leading end of the elevator is raised or lowered hydraulically by the tractor operator. Speed of the elevator is adjusted to conform to the forward speed of the tractor.
- 4- Fruit-laden plants are carried up the 45° incline to a height of about 160 cm from bed surface, and are discharged to two cylinders for detaching the fruits from The plant stems, leaves and vine are severed. The cylinders was tending to dislodge the fruit for grading
- 5- Two workers standing on opposite sides of two cylinders inclined 30° for trash removal and green fruits, (the number depending primarily upon the harvest rate and the maturity and condition of the fruit.).
- 6- The grading machine is conveyed directly behind the harvester for grading fruits into shallow boxes to reduce pressure bruising on the trailer.
- 7- Medium and smallest fruit anticipated diameter of fruit to be harvested into boxes, while the largest fruit plants are discharged at the rear of the machine.

3.RESULTS AND DISCUSSION

3.1. Plant characteristics

The characteristics of tomato plant as the dimensions of main branches and inclination angle of the main branches on the vertical plane were measured for six different varieties and hybrids of tomato.

3.1.1. Dimensions of tomato plant components

The dimension characteristics of the tomato plant and distribution percentage on the plant are important in determining harvesting methods. Table (1) shows the average dimensions of a tomato plant components and Table (2) shows plant height and No. of branches in the two seasons (2008 & 2009). The main branches in the two seasons for the cultivars averaged (9.01, 8.87, 12.2cm), and for the hybrids were (13.9, 17.1, 16.1cm), respectively.

3.1.2. Fruit distribution cluster on the plant

Fruits spatial position (fruits distribution) and percentage are illustrated in Fig. (1-A). The results

showed that, the highest percentage of the fruits (95 %) was found in circumference the inter plant.

3.2. Physical and mechanical properties of tomato fruits

The physical and mechanical properties of the tested tomato fruits were evaluated. The obtained results are used to design-idea of the tomato harvester the pull-type .

3.2.1. Physical properties of tomato fruits

Tables 3 and 4 show the dimensions, sphericity, mass, volume and real density. These parameters were measured on 100 fruit sample for each variety, according to the standards set in (Mohsenin,1986) (Fig. 6 and 7).

3.2.1.1. Dimensions of fruit

Tables 3 and 4 and Fig. (6) indicate that the fruit height ranges for the cultivars (52.72 -71.73, 53.97 -57.87, 50.97 - 57.26 mm) and (average 62.23, 55.92, 54.12 mm), respectively. The fruit height ranges of the sample for the hybrids were (56.7 - 69.44, 48.83 - 56.55, 49.83 - 56.44 mm)

Table (1): Average dimensions of the tomato plant components for six tomato cultivars and hybrids.

Plant height, cm	Main branches						Angle of inclination of the main branches on the vertical plane, degree		
	Length			Diameter					
	cm			mm			degree		
	Max	Min.	Mean	Max	Min.	Mean	Max	Min.	Mean
170	50	35	42.5	10	6	8	35	15	25

Table (2): Average performance of the six tomato cultivars and hybrids for plant height and no. of branches in the two seasons (2008 & 2009).

Cultivars		Plant height (cm)			No. of branches		
		Season 2008	Season 2009	Avg.	Season 2008	Season 2009	Avg.
Cultivars	Florada	46.35	48.27	47.3	8.25	9.76	9.01
	Super Strain B	41.7	42.95	42.33	9.65	8.08	8.87
	Castle Royal	45.8	50.12	48	11.85	12.55	12.2
Hybrids	Bregenith	80.6	77.65	79.13	14.5	13.37	13.9
	Fanfare	65.7	61.25	63.48	16.67	17.5	17.1
	Heinz	75.8	70.45	73.13	15.85	16.33	16.1

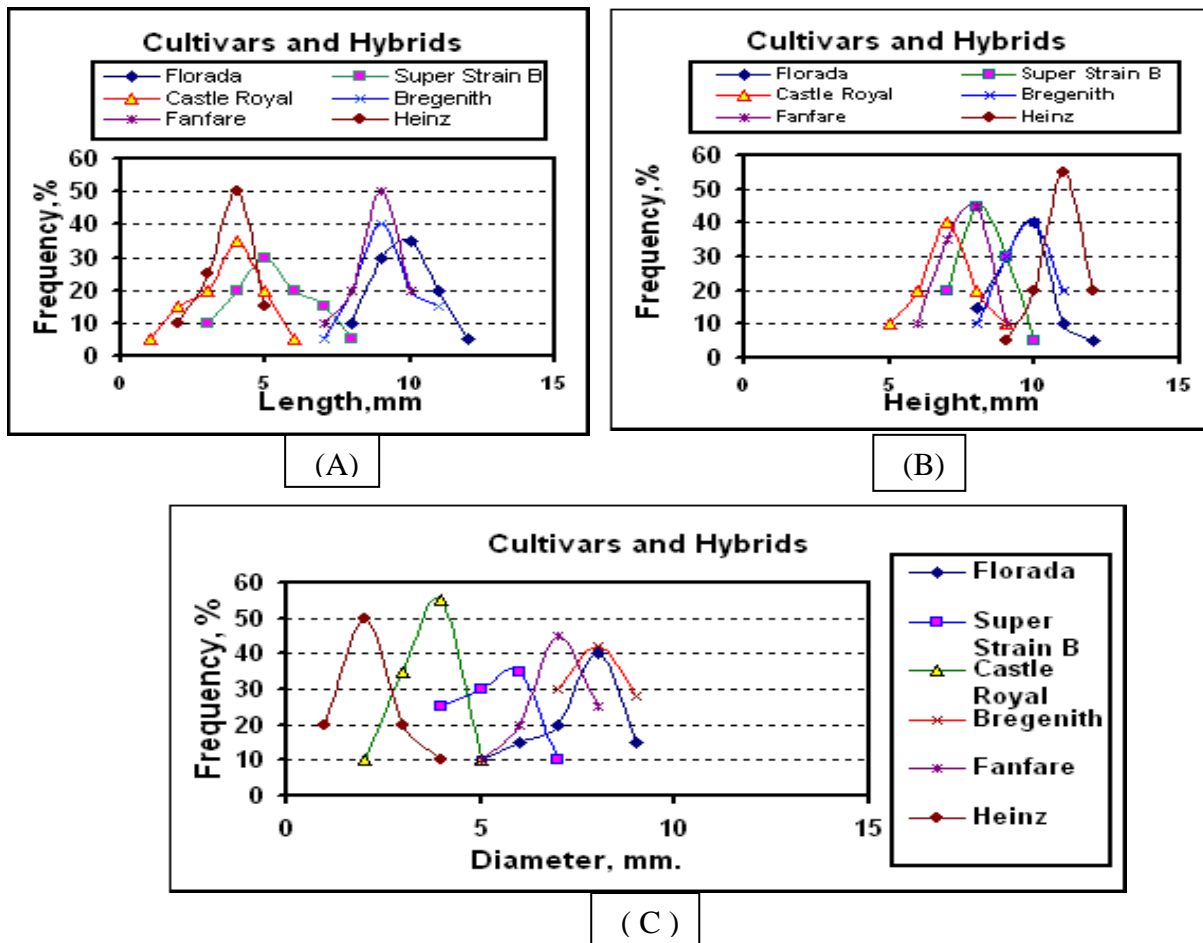


Fig. (6): Frequency distribution of fruit dimensions of tomato fruits, A,B,C.

and (average 53.07, 52.69, 53.14 mm), respectively. The most frequent percentages more than 90 % of tomato fruits in the sample for the cultivars were (55 – 60, 60-65, 65-70) mm height and for the hybrids (55 – 60, 60-65, 65-70) mm height.

The fruit width for the cultivars were (53.75 – 62.77, 46.24 – 48.82 and 49.34 – 49.90 mm) and (average 58.26, 47.53 and 49.62 mm), respectively. The fruit width ranges of the sample for the hybrids were (54.2 – 62.17, 57.68 – 67.75 and 57.68 – 65.20 mm) and (average 58.19, 62.72 and 61.44 mm), respectively. The most frequent percentages more than 90 % of tomato fruits in the sample for cultivars were (55 – 60, 60-65, 65-70) mm width and for the hybrids (55 – 60, 60-65, 65-70) mm width .

3.2.1.2. Shape and size of the fruit

The fruit mass and volume affect the required amount of kinetic energy of the fruit during harvesting operation .

If sphericity is less than 0.9, the fruit belongs to oblate group; if sphericity is greater than 1.1, it belongs to the oblong group. The remaining fruits with intermediate index values are considered to be round (Buyanov and Voronyuk, 1985).

Tables 3 and 4 and Fig. 7 indicate that the fruit sphericity ranged in the sample for the cultivars were (0.87, 1.08 and 1.05), respectively and the fruit sphericity ranges in the sample for the hybrids were (1.41, 1.26 and 1.45), respectively. The most frequent percentage (85.8 %) of tomato fruits in the sample was round (sphericity 0.9 - 1.2) and (14.2 %) of tomato fruits in the sample were oblong (sphericity 1.2 - 1.4).

3.2.1.3. Mass and volume of fruit

Tables 3 and 4 indicate that the fruit mass ranges of the sample for the cultivars were (102-160, 76-99 and 66-86 g) with an average (131, 78.5 and 76 g), respectively. The fruit mass ranges for the hybrids were (99- 158, 98-115 and 108-139 g) with an average (128.5, 106.5 and 123.5 g), respectively. The most frequent percentage (93.15 %) of tomato fruits in the sample was 90 - 75 g mass.

The fruit volume ranges of the sample for the cultivars were (101-152, 70-100 and 60-79 cm³) with an average (126.5, 85 and 69.5 cm³), respectively. The fruit volume ranges of the sample for the hybrids were (102.5-150.5, 101-112 and 106-137.5 cm³) with average of (126.5, 106.5 and 121.75 cm³), respectively. The most frequent percentage (90.45 %) of tomato fruits in the sample was 95 - 70 cm³. Fig. 7 indicates presents the best fitted curves of the relations

between fruit volume and mass.

3.2.1.4. Real density of the fruit

The fruit real density ranges of the sample for the cultivars were (0.85, 0.87, 0.83 – 0.97, 0.93, 0.91 g/cm³) with an average (0.91, 0.90, 0.86), respectively. The fruit real density ranges of the sample for the hybrids were (0.92, 0.88, 0.89 – 0.99, 0.95, 0.93 g/cm³) with an average (0.96, 0.92, 0.91), respectively. The most frequent percentage (76.2%) of tomato fruits in the sample was 0.95 - 0.98 g/cm³ real density.

3.2.2 Mechanical properties of tomato fruits

3.2.2.1. Fruit detachment force

The detachment force depends on the twig diameter. The relationship between detachment force and twig diameter is plotted in Fig. 8. It can be seen that the detachment force increased as the twig diameter increased.

3.2.2.2. Friction, rolling and repose angles of tomato fruits

Friction, rolling and repose angle play an important role in the design must be found such that the relative value of frictional resistance is as low as possible.

The suitable surface, which gives a low value of friction coefficient between the machine surfaces and tomato fruit surface, must be found to satisfy the design requirements. Table 5 shows friction and rolling angles of tomato fruits. The maximum friction angle 11-19 degree and rolling angle ranges 17 - 40 degree were obtained with wood surface. Whereas, the minimum ranges of friction and rolling angles 7 - 15 degrees and 12 – 19 degrees respectively, were obtained with aluminum surface.

3.2.2.3. Deformation of fruits

Fig. 9 shows the average deformation of tomato fruits at different loading weights and times. The deformation range increased from 0.85- 2.6 to 6.5 – 7.9 mm by increasing loading from 1 to 6 N.

Meanwhile, the deformation range increased from 0.85 - 6.5 to 2.6 – 7.9 mm by increasing loading time from 20 to 60 s.

3.2.2.4. Impact height

Impact height must be studied as one of the important factors for determining the height, which causes the fruit damage and the corresponding potential energy of fruit to avoid damage. The obtained results from the present study from impacting the tomato fruits was plotted in Fig. 10. The maximum impact heights, which caused damage for tomato fruit, are 1.0 m. While, the corresponded impact height which caused bruising of tomato was 0.75 m.

3.3. Application of tomato harvester design-theory

3.3.1. Some parameters required for harvest machine design have been investigated as follows

- The cutting bar width should be more than the spacing between the rows of plants.

- Conveyor belt is plant matter and shaker for fruit cleaning.

- Clearance is between rigid fingers must be smaller than 46.24 mm fruit diameter and covered with plastic tube for minimizing the friction.

-The cylinders tangential angle must be more

Table (3) : Main dimensions and some properties of the tomato three cultivars : Florada, Super Strain B and Castle Royal.

Cultivars		Physical properties	Max.	Min.	Average	S. D.	C. V.
Cultivars	Florada	Height, mm	71.73	52.72	62.23	9.51	15.28
		Width, mm	62.77	53.75	58.26	4.51	7.74
		Length, mm	69.53	58.91	64.22	5.31	8.27
		Sphericity	1.14	0.98	1.06	0.08	7.55
		Mass, g	160	102	131	29	22.14
		Volume, cm ³	153	105	129	24	18.60
		Bulk density, g/cm ³	0.58	0.74	0.66	0.08	12.12
		Real density, g/cm ³	0.97	0.85	0.91	0.06	6.59
	Super Strain B	Height, mm	57.87	53.97	55.92	1.95	3.49
		Width, mm	48.82	46.24	47.53	1.29	2.71
		Length, mm	59.2	50.85	55.92	4.21	7.52
		Sphericity	1.19	1.17	1.18	0.01	0.85
		Mass, g	99	76	87.50	11.50	13.14
		Volume, cm ³	100	70	85.0	15.00	17.65
		Bulk density, g/cm ³	0.96	0.72	0.84	0.12	14.29
		Real density, g/cm ³	0.93	0.87	0.90	0.03	3.33
	Castle Royal	Height, mm	57.26	50.97	54.12	3.15	5.81
		Width, mm	49.9	49.34	49.62	0.28	0.56
		Length, mm	51.89	48.5	54.12	2.83	5.23
		Sphericity	1.15	1.03	1.09	0.06	5.50
		Mass, g	86	66	76.00	10.00	13.16
		Volume, cm ³	79	60	69.50	9.50	13.67
		Bulk density, g/cm ³	0.92	0.73	0.83	0.10	11.52
		Real density, g/cm ³	0.91	0.83	0.87	0.04	4.60

S.D. : standard deviation.

C.V. : coefficient of variation.

Table (4) : Main dimensions and some properties of the tomato three hybrids: Bregenith, Fanfare and Heinz .

Cultivars		Physical properties	Max.	Min.	Average	S. D.	C. V.
Hybrids	Bregenith	Height, mm	69.44	56.7	63.07	6.37	10.10
		Width, mm	62.17	54.2	58.19	3.98	6.85
		Length, mm	65.81	58.3	62.06	3.76	6.05
		Sphericity	1.12	1.05	1.09	0.04	3.23
		Mass, g	158	99	128.5	29.5	22.96
		Volume, cm ³	150.5	102.5	126.5	24	18.97
		Bulk density, g/cm ³	1.1	1.01	1.06	0.045	4.27
		Real density, g/cm ³	0.99	0.92	0.96	0.04	3.66
	Fanfare	Height, mm	56.55	48.83	52.69	3.86	7.33
		Width, mm	67.75	57.68	62.72	5.03	8.03
		Length, mm	69.85	58.7	52.69	8.71	16.53
		Sphericity	1.18	1.16	1.17	0.01	0.85
		Mass, g	115	98	106.5	8.50	7.98
		Volume, cm ³	110	101	105.5	4.50	4.27
		Bulk density, g/cm ³	1.02	1.01	1.02	0.01	0.49
		Real density, g/cm ³	0.95	0.88	0.92	0.03	3.83
	Heinz	Height, mm	56.44	49.83	53.14	3.31	6.22
		Width, mm	65.2	57.68	61.44	3.76	6.12
		Length, mm	71.3	58.76	53.14	9.30	17.50
		Sphericity	0.87	0.86	0.87	0.01	0.58
		Mass, g	139	108	123.5	15.50	12.55
		Volume, cm ³	137.5	106	121.75	15.75	12.94
		Bulk density, g/cm ³	1.11	1.06	1.09	0.03	2.30
		Real density, g/cm ³	0.93	0.89	0.91	0.02	2.20

S.D. : standard deviation.

C.V. : coefficient of variation.

Table (5): Friction and rolling angles for tomato fruits with different surface types.

Surface type	Friction angle, degree			Rolling angle, degree					
				Maximum			Minimum		
	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
Wood	19	11	15	40	28	35	28	17	25
Glass	17	10	13.5	26	22	25	20	13	17
Galv. I.	15	8	11.5	25	23	24	19	12	16
Alum.	15	7	11.5	25	21	23	19	12	16
SS.	15	7	11	25	22	24	20	12	17

Galv. I.: Galvanized iron; Alum.: Aluminum; and SS.: Stainless steel. The average repose-angle was about 35.5 degree.

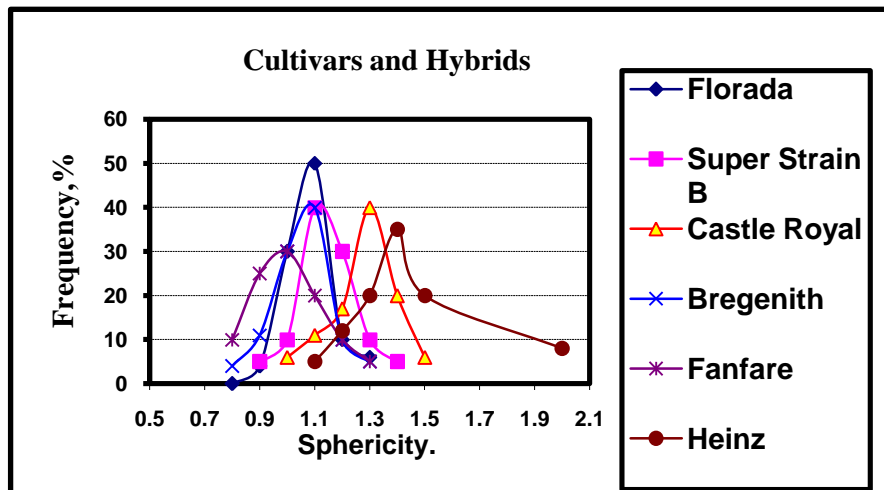


Fig. (7): Frequency distribution of fruit sphericity of tomato fruits.

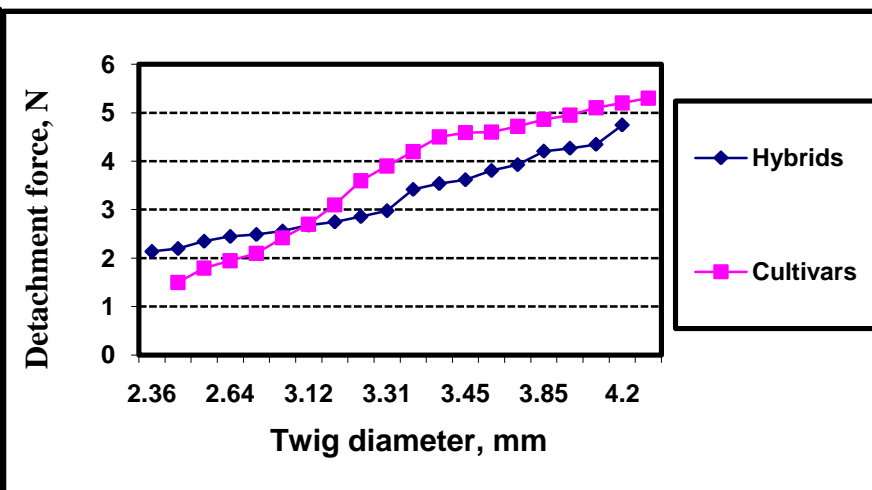


Fig. (8): The relationship between twig diameter and detachment force for cultivars and hybrids

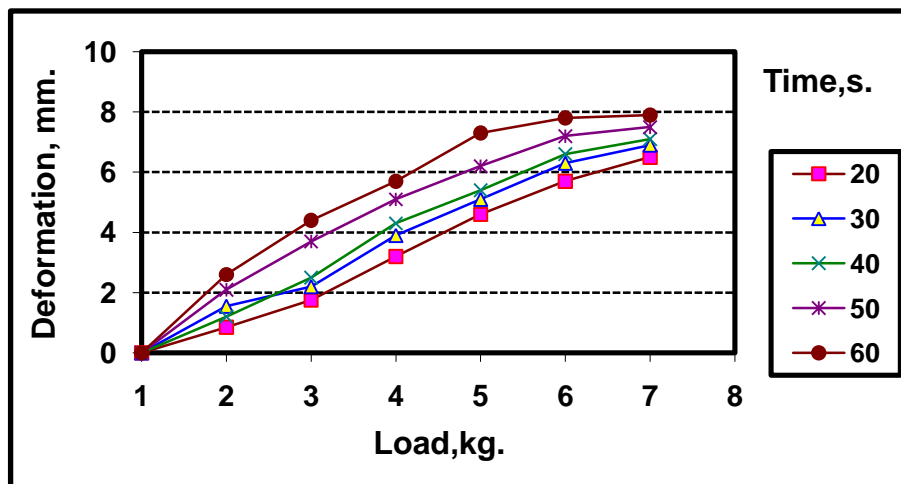


Fig. (9): The maximum impact heights, which caused damage for tomato fruit

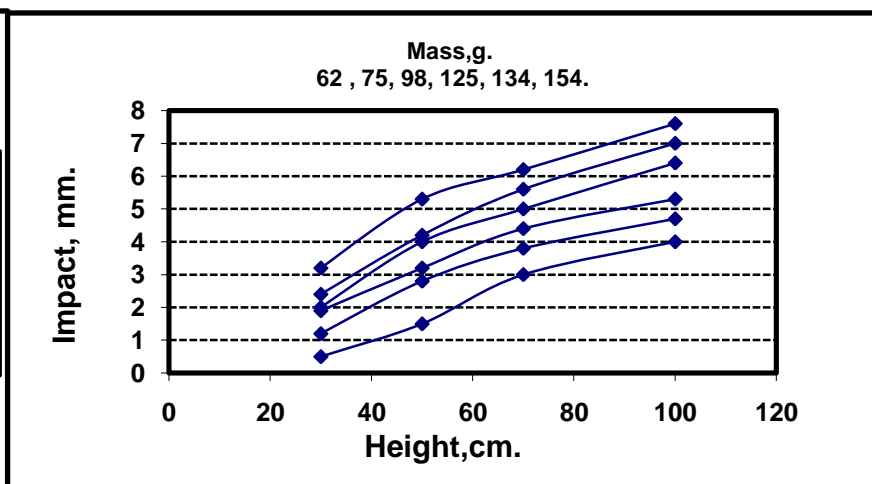


Fig. (10): The maximum impact heights, which caused damage for tomato fruit

than 25° rolling angles.

- The clearance between the two cylinders must be smaller than 46.24 mm fruit diameter for the six tomato cultivars and hybrids.
- Feeding rate specified relating to the plants density and machine forward speed.
- The grading machine is conveyed directly behind the harvester for grading fruit into shallow boxes to reduce pressure bruising on the trailer

3.3.2. Grading drums

- Three drums used to grade tomato fruit .
- Rotating drums holes used to grade 4 size fruit. Drum hole diameters are 30, 40 and 50 mm, while the largest fruit plants are discharged at the rear of the machine.
- Drums tangential angle more than maximum 25° rolling angle between tomato fruits and stainless steel surface.
- Machine out put should be more than maximum 17° friction angle between tomato fruits and stainless steel surface to minimize friction.

3.3.3. Grading fruit into boxes

- Space between grading fruits and boxes should be smaller than minimum 75 cm impact heights to minimize mechanical damage.
- Fruit boxes : The obtained results relieved that the fruit boxes depth should be smaller than 40 cm, to minimize the fruit mechanical damage.

Conclusion

The main results in this study can be summarized as follows:

Physical properties of tomato fruits for cultivars: Height = 71.73, 57.87, 57.26- 52.72, 53.97, 50.97 mm, Width = 62.77, 48.82, 49.9- 53.75, 49.9, 49.34 mm, Length = 69.53, 59.2, 51.89 - 58.91, 50.85, 48.5 mm, Mass = 160, 99, 86 – 102, 76, 66 g, volume = 153, 100, 79 – 105, 70, 60 cm³,

Physical properties of tomato fruits for hybrids were: Height = 69.44, 56.55, 56.44- 56.7, 48.83, 49.83 mm, Width = 62.17, 67.75, 65.2 - 54.2, 57.68, 57.68 mm, Length = 69.81, 69.85, 71.3 - 65.3, 58.7, 61.76 mm, Mass = 160 – 102 g, volume = 150.5, 110, 137.5 - 102.5, 101, 106 cm³.

Mechanical properties of tomato: The deformation range increased from 10.85- 2.6 to 6.5–7.9 by increasing loading from 1 to 6 N., and increasing time from 20 to 60s.

Using physical and mechanical properties of tomato in the design of the harvest machine for different cultivars and hybrids of tomato are summarized as follows :

Harvest unit : The cutting bar width should be more than the spacing between the rows of plants. Conveyor belt is plant matter and shaker for fruit

cleaning. Clearance between rigid fingers is smaller than 46.24 mm with plastic tube covered. Fruit-laden plants are carried up the 45° incline to a height of about 160 cm from bed surface. Two cylinders are tending with angle of 25°, with 46.24 mm clearance between them. Feeding rate specified relating to the plants density and machine forward speed.

Grading drums : Rotating drums used be 3 hole size diameters 50, 55 and 60 mm, while the largest fruit plants are discharged at the rear of the machine. Drums tangential angle should be more than 25°. Machine out put should be more than 17°. Space between grading fruit and boxes should be smaller than 75 cm.

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الخصائص الطبيعية والميكانيكية لنباتات وثمار الطماطم وإستخدامها فى تصميم آلة حصاد

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ملخص

تعد الطماطم من أهم محاصيل الخضر وتأتى فى المرتبة الأولى من حيث المساحة المنزرعة سنويا والانتاج والاستهلاك. وتأتى مصر فى المرتبة الرابعة على مستوى دول العالم من حيث إنتاجية وحدة المساحة. ويعتبر محصول الطماطم من المحاصيل التى ليست لها آلات متخصصة محلها لميكنة بعض عمليات إنتاجها ونظرا لانتشار زراعة الطماطم على ست عروات فإن ذلك يشجع على التفكير فى ميكنة العمليات الخاصة بإنتاجها. ولتصميم هذه الآلات فلا بد من معرفة الخ صائص الطبيعية والميكانيكية لمحصول الطماطم كقاعدة بيانات أساسية لتصميم هذه الآلات خاصة آلات الزراعة والحصاد والتداول. لذلك فمن الضروري دراسة الخصائص الطبيعية الخاصة بالنباتات (الخصائص الطبيعية للنبات – التوزيع الطبيعى للثمار) والخصائص الطبيعية الخاصة بثمار الطماطم وهى أبعاد الثمرة (طول – عرض – قطر) معامل شكل الثمرة (طول الثمرة/عرضها)-وزن الثمرة-حجم الثمرة . وكذلك الخصائص الميكانيكية للثمار وهى قوة صلابة الثمرة - زاوية الاحتكاك – زاوية مكوث الثمرة - قوة فصل الثمرة لبعض أصناف الطماطم، وإستخدامها فى تصميم آلة لحصاد وتدرج ثمار الطماطم.

وقد أوضحت النتائج ما يلى الخصائص الطبيعية

- 1- أبعاد الثمرة : وجد ان متوسط ارتفاع ثمار الطماطم للأصناف يتراوح ما بين 62.23، 55.92، 54.12 م م على التوالي، وكان للهجن 63.07، 52.69، 53.14 مم، وكان متوسط الأقطار للأصناف يتراوح ما بين 58.26 و 47.53 و 49.62 م م على التوالي أما للهجن فكان 58.19 و 62.72 و 61.44 م م على التوالي.
- 2- الشكل والحجم : كان متوسط الشكل الكروى لأصناف ثمار الطماطم (1,06 و 1,18 و 1,09) على التوالي ، ومتوسط الهجن كان (1,09 و 1,17 و 0,78) على التوالي. كان متوسط الكتلة لأصناف ثمار الطماطم (131 و 87,5 و 76 جم) على التوالي، ومتوسط كتلة الهجن كان (128,5 و 106,5 و 123,5 جم) على التوالي. كان متوسط حجم الأصناف لثمار الطماطم (129 و 85 و 76 سم³) على التوالي، وكان متوسط حجم الهجن لثمار الطماطم (126,5 و 105,5 و 121,75 سم³) على التوالي ووجد أن 85.8 % من الثمار الموجودة فى العينة تأخذ الشكل الكروى، 14.2 % تأخذ الشكل المفلطح.

الخصائص الميكانيكية

- 1-زاوية الاحتكاك والتدرج والتكويم : وجد أن متوسط زاوية الاحتكاك القصى لثمار الطماطم (11-19 درجة) وزاوية التدرج تتراوح (17 - 40 درجة)حصلت عليها بسطح الخشب، بينما المجاميع الدنيا للإحتكاك والزوايا المتكحرجة (7 - 15 و 12 - 19 على التوالي) حصلوا عليه بسطح الألومنيوم.
- 2-تشوه الثمار تحت أحمال وأزمنة تحمل مختلفة: وجد أن متوسط التشوه زاد 0.85- 2.6 إلى 6.5 - 7.9 مم بزيادة التحميل من 1 إلى 6 نيوتن فى هذه الأثناء، مدى التشويه زاد من 0.85 - 6.5 إلى 2.6 - 7.9 مم بالتحميل المتزايد لزمان التعرض للحمل من 20 إلى 60 ث.
- 3-أعلى ارتفاعات التأثير القصى، التى تسببت فى الضرر كان 1.0 م. بينما إرتفاع التأثير الذى سبب فى حدوث الكدمة كانت 0.75م.

* توصيف لبعض الخصائص الطبيعية والميكانيكية لتصميم آلة الحصاد ووحدة التدرج لمحصول الطماطم.

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