الخصائص الطبيعية لثمار الطماطم

نبيل سعود البلوشى
قسم هندسة النظم الزراعية- كلية العلوم الزراعية والأغذية- جامعة الملك فيصل- المملكة العربية السعودية

الملخص العربي

تم تحديد الخصائص الطبيعية مثل الطول والعرض والسمك، ومتوسط القطر الهندسي، والكتلة والحجم الحقيقي، والحجم المحسوب، الكثافة الحقيقة، الكروية، مساحة السطح، ونسبة الارتفاع للطماطم للصنف التجاري. وهذه الخصائص ضرورية في تصميم المعدات اللازمة للفصل والحصاد والتصنيع والنقل والتعبئة والتغليف. وأظهرت النتائج أن الطول والعرض والسمك، ومتوسط القطر الهندسي ومعامل التكور للطماطم تراوحت من ٤٣,٣٦– ٨٠,٧٢مم، ٤٠,٣٨– ٨١,٥٢مم، ٣٧,٣٨– ٧٧,٥٢مم، ٤١,٠٠– ٧٨,٤٠مم و٠,٨٧– ١,٥١على التوالي. في حين كانت المساحة السطحية المحسوبة ومساحة السطح المقاسة تغيرت ٥٢,٧٥– ١٩٣.١٨سم٢و ٧٩,٤٤– ١٩١،٥٢سم٢ على التوالي. وكانت قيم حجم الثمرة المقاس والمحسوب والكثافة والثقل النوعي تتراوح ما بين ٥٠– ٢٥٠ سم٣، ٣٦,٠٣– ٢٥٢,٥٤ سم٣، ٠,٧٠– ١,٧٦ جرام/سم٣ و١,٠٠– ١,١١ على التوالي. وعلاوة على ذلك تراوحت كتلة ثمرة الطماطم ٤٤,٣٦– ٢٥٤,٩٦ جرام.

PHYSICAL CHARACTERISTICS OF TOMATO FRUITS

N. S. Albaloushi
Department of Agriculture Systems Engineering, College of Agricultural and Food Sciences, King Faisal University, P.O. Box 420, Al-Hassa 31982, Saudi Arabia.

(Received: Mar. 4, 2012)

ABSTRACT: *In this paper, the physical properties such as length, width, thickness, geometric mean diameter, mass, true volume, apparent volume, particle density, sphericity, surface area, aspect ratio were determined for tomato of the commercial variety. These properties are necessary in the design of the equipment for harvesting, processing and transportation, separating and packing. The results showed that the length, width, thickness, geometric mean diameter and coefficient of spherical shape of tomato varied from 43.36 to 80.72 mm, 40.38 to 81.52 mm, 37.38 to 77.52 mm, 41.00 to 78.40 mm and 0.87 to 1.51, respectively. While the surface area determined by Mohsenin. formula, and surface area measured by experimental method changed from 52.75 to 193.18cm^2, and 79.44 to 191.52 cm^2, respectively. The values of the fruit's true volume, determined volume, particle density and specific gravity were between 50-250 cm^3, 36.03-252.54 cm^3, 0.70 to 1.76 g/cm^3 and 1.00 to 1.11, respectively. Furthermore, the unit mass of tomato ranged from 44.36 to 254.96 g.*

Key words*: *Tomato, Geometrical properties, physical properties

INTRODUCTION

It is known that the quality of tomatoes can be described in terms of internal and external properties. There are many reports about qualitative evaluation of agricultural products (Arana, Jare´n, & Arazuri, 2004; Jare´n & Garcı´a, 2002; Peris, 1983). Although a clear definition of quality for agricultural products does not exist, it could be described as the group of characteristics that consumers wish to find in the product. The processing industries demand concrete specifications from its providers (Calvo, 1996) which affects the demanded quality. Quality is not only related to flavour, external aspect and texture, but also to other features such as the aptitude of the product for harvesting, transport and transformation. Since most quality factors are related to physical properties, it is possible to develop quality evaluation methods based on these properties, in most of the cases (Ruiz & Chen, 1990).

Data on physical properties of agro-food materials are valuable because they are needed as input to models predicting the quality and behaviour of products in pre-harvest, harvest and post-harvest (Nesvadba *et al.,* 2004).

Physical properties of food materials also affect on handling, conveying characteristics and estimating the cooling and heating loads (Mohsenin, 1986). Physical attributes such as size, shape, bulk density and porosity are major consideration in designing of hopper, drying and aeration systems, as these properties affect on the resistance to airflow of the stored mass.

To design and optimization a machine for handling, cleaning, conveying, and storing, the physical attributes and their relationships must be known (Mirzaee *et al.,* 2008). The physical properties of tomato are important to design the equipment for processing, transportation, sorting, separation and storing. Designing such equipment without consideration of these properties may yield poor results. Therefore the determination and consideration of these properties have an important role (Taheri-Garavand *et al.,* 2009). Among these physical properties, length, width, thickness, mass, volume, projected areas and center of gravity are the most important factors in sizing systems (Mohsenin, 1986). There are some situations in which it is desirable to determine relationships among physical attributes; for example, vegetables are often graded by size, but it may be more economical to develop a machine which grades by weight. Therefore, the relationship between weight and the major, minor and intermediate diameters is needed (Stroshine and Hamann, 1995).

Determining relationships between mass and dimensions and projected areas may be useful and applicable (Stroshine and Hamann, 1995). In weight sizer machines, individual vegetables are carried by cups or trays that linked together in a conveyor and are individually supported by spring loaded mechanism. As the cups travel along the conveyor, the supports are engaged by triggering mechanisms, which allow the tray to dump if there is sufficient weight.

Successive triggering mechanisms are set to dump the tray at lower weight. If the density of the vegetable is constant, the weight sizer sorts by volume. The sizing error will depend upon the correlation between weight and volume (Khoshnam *et al.,* 2007). Beside, consumers prefer bright color vegetables with even weight and uniform shape. Mass grading of vegetable and fruit can reduce packaging and transportation costs, and also may provide an optimum packaging configuration (Peleg *et al.,* 1985). Tabatabaeefar *et al.* (2000) achieved models for predicting mass of Iranian orange for its dimensions, volumes and projected areas. These researchers stated that among the systems that stored oranges based on one dimension, the system that applies intermediate diameter is suitable with nonlinear relationship. Al-Maiman and Ahmad (2001) had analyzed pomegranate physical properties and obtained models to predict fruit weight from dimension, volume and surface pictures. Topuz *et al.* (2005) studied physical and nutritional properties of four mandarin genotypes of orange varieties. They reported dimension, volume, weight, surface picture, friction coefficient, porosity, and mass and fruit density in four mandarin genotypes. Among these physical characteristics, mass, volume, projected area are the most important factors in determining sizing systems (Mirzaee et al., 2009). Tabatabaeefar and Rajabipour (2005) recommended 11 models for predicting mass of apples based on geometrical attributes. Several models for predicting mass of kiwi based on physical attributes were determined and reported by Lorestani and Tabatabaeefar (2006). Also, Khoshnam *et al.* (2007) used this method for predicting the mass of pomegranate fruits. They suggested that there is a very good relationship between mass and measured volume for all varieties of kiwi. This information provides useful insights into design of harvesting, processing, sorting, separating and packing equipments for tomato.

Other physical parameters are size and shape. Different shape tomatoes are used in the canning industry, with the exception of canned whole tomatoes, which require oblong fruits (Rodrı´guez, 1992). Depending on their industrial use, tomato varieties are classified into two groups: peeled and concentrated varieties (Arazuri & Jare´n, 2004).

With respect to economical and processing importance of tomato, overcoming the world market and decreasing product losses, investigation and development in the field of selection or designing of the most suitable machine for it is necessary. But, limited study concerning physical and mechanical properties of tomato has been performed up to now.

The aim of this research was to investigate the physical properties of tomato in order to achieve a complete profile of these attributes. The physical characteristics studied were length, width, thickness, unit mass, apparent and true volumes, geometric mean diameters, aspect ratio, surface area, sphericity, true and bulk densities.

MATERIALS AND METHODS

1. Material

Mature fresh tomato were used for all experiments. Samples were obtained from the commerical farm, and kept in a refrigerator until laboratory measurements were performed. Physical properties of tomato randomly selected for all experiments. All the measurements were carried out at room temperature.

2. Physical Properties Determination

Linear dimensions, i.e. length (L), width (W) and thickness (T) were measured using a micrometer with an accuracy of 0.01 mm. The arithmetic mean diameter (D_a) and the geometric mean diameter (D_g) were then calculated by the following relationships, respectively (Mohsenin, 1986):

$$D_a = \frac{(LWT)}{3} \quad (1)$$

$$D_g = (LWT)^{1/3} \quad (2)$$

The aspect ratio (R_a) in percent is used in classification of tomato shape and it was obtained using following relationship as recommended by Razavi and Parvar (2007):

$$R_a = (\frac{W}{L}) \times 100 \quad (3)$$

The criteria used to describe the shape of the tomato were sphericity. Thus, the sphericity (Φ) of samples was found according the relationship given by Mohsenin (1986) as:

$$\Phi = \frac{(LWT)^{1/3}}{L} \quad (4)$$

Surface area is defined as the total area over the outside of the tomato. Surface area (S) was theoretically calculated as apparent surface area by Mohsenin, 1986):

$$S = \pi D_g^2 \quad (5)$$

True volume and true density were determined by the liquid displacement method (Mohsenin, 1986). Water was used for this purpose. The true volume (V_t) calculated by the following equation:

$$V_t = \frac{M_a - M_w}{\rho_w} \quad (6)$$

Where, M_w is mass of sample in water; M_a , mass of sample in air and ρ_w ,density of water. Then, the true density of Tomato obtained by the following relationship:

$$\rho_t = \frac{M_a}{V_t} \quad (7)$$

Apparent volume (V_a) calculated theoretically by the following equation used a for volume of ellipsoid materials:

$$V_a = \frac{4\pi}{3} LWT \quad (8)$$

The error of apparent volume to true volume in percent was obtained by following relationship:

$$e_V = \frac{V_a - V_t}{V_t} \times 100 \quad (9)$$

Unit mass (M_f) of tomato was measured by using a digital balance with sensitivity of 0.001 g.

In order to obtain the bulk density of tomato, a container with known mass and volume was filled with the samples to the top. The fruits were poured to the container in similar way and with a constant rate. After filling the container, it was weighted and bulk density (ρ_b) was calculated from the ratio of fruit mass in the container to its volume.

The porosity of bulk fruits in percent was computed from the values of true and bulk density using the relationship as follow (Mohsenin, 1986):

$$\varepsilon = (1 - \frac{\rho_b}{\rho_t}) \times 100 \quad (10)$$

2.3 Data Analyses

All properties were measured at least in five replications, unless stated otherwise. Maximum, minimum, range, mean, standard deviation, regression equations and coefficient of determination were obtained by spread sheet software program namely Microsoft Excel (2007).

RESULTS AND DISCUSSION

1. Physical Characteristics:

Determinations of the main dimensions of tomatoes are very important for describing their technological characteristics in many respects. The measured dimensions of tomato such as; Length (L), Width (W), and Thickness (T) affect the harvesting, curing during storage period and sorting devices.Typical mean values obtained from large number of observations for the investigated tomato are given in Table (1), with the arithmetic means of all samples, range of values, and other statistical indices for the main dimensions of the studied varieties such as standard deviation (σn-1), standard error (S.E), and coefficient of variance (C.V.,%) to show the dispersion of the measured values around the mean value.

1.1. Linear Dimensions:

The variations of length (L), width (W), thickness (T) and geometric diameter (Dg) of the tomatoes with tomatoes storage time are displayed in Fig (1). All dimensions decreased with increasing storage period.

Very high correlation was observed between these dimensions and storage time of tomatoes. This indicates that, on storage time, the tomatoes decreased in length, width, thickness and geometric diameter within the increasing in storage time. The linear dimensions of tomato decrease with increase of storage time, but in a liner manner and these returned to during storage tubers lose dry matter, mainly carbohydrates, which are converted into carbon dioxide and water (Smith, 1977). At the same time, transpiration of tomatoes causes loss of water which is often the most serious cause of weight loss during storage (Burton, 1989). Therefore, changes in physical properties of tomatoes over time must be related to both transpiration and respiration.

The total average decreasing from storage time of tomatoes was largest along the tomatoes length and least along its width and thickness. The (*L/W, L/T, T/W* and L/D_g) ratio variations with storage time are shown in Fig (2). *(L/T)* exhibits the highest ratios, followed by *L/W* then L/D_g in descending order. This means that the values of D_g are generally the highest, followed by *W* then *T*. The relationships between the linear dimensions (*L*, *W*, and *T*) and geometric mean diameter (D_g) with tomatoes storage time (*S.T.*) may be represented linear regression on one or more tomato dimensions as follows:

$$L = 84.665 - 1.961\ S.T. \quad (R^2 = 0.97) \quad (11)$$
$$W = 66.865 - 1.435\ S.T. \quad (R^2 = 0.99) \quad (12)$$
$$T = 64.60 - 0.973\ S.T. \quad (R^2 = 0.96) \quad (13)$$
$$Dg = 77.51 - 1.098\ S.T. \quad (R^2 = 0.98) \quad (14)$$

Based on the data of tomatoes measurements for the three main tomato dimensions the frequency distribution curves for tomato for length, width and thickness are shown in Fig (3). The frequency distribution curves show the trend towards normal distribution. The overlapping between the frequency distribution curves plays important role for separating the tomatoes based on its dimensions (L, W and T).

Fig.(1). Indicate the changes in tomatoes dimensions during storage periods. It was grading decreased by increased storage time for all the tomatoes.The small changes in tomatoes length were 6.78 %, while the small changes in tomatoes width were 6.70 %, while in tomatoes thickness were 4.48 %, but were in tomatoes geometric diameter 4.45 %.

1.2. Coefficient of Spherical Shape:

The coefficient of spherical shape was calculated for each individual tomato by using the ratio between the length and square root (multiplication width and thickness), the frequency distribution curve and the averages were represented graphically in Fig (3). The results in table (1) showed that tomato ranged from 0.87 to 1.51. Meanwhile most of the tomato may be considered as round to oblong group according to the classification of (Ismail, 1988).

Table (2) shows that the percentages of the classes of tomato shape were (79%) spherical shape and (21%) oval shape for tomato.

The relationship between the coefficients of spherical shape for tomato with storage time (*S.T.*) may be represented mathematically as follows:

$$I = 1.38 - 0.018\ S.T \quad (R^2 = 0.95) \quad (15)$$

Fig (4) indicates the changes in tomato coefficient of spherical shape during storage periods. It was grading decreased by increased storage time for all tomato.The small changes in tomato coefficient of spherical shape when stored were 3.68 %.

Table (1): Statistical index of some physical properties for the investigated of tomato.

Items	No	Average	Range, Max - Min	S.D.	S.E.	C.V. %
Length, mm	90	61.15	80.72 – 43.36	8.35	0.88	13.66
Width, mm	90	52.11	81.52 – 40.38	6.88	0.73	13.20
Thickness, mm	90	49.17	77.52 – 37.38	6.83	0.72	13.89
Coefficient of spherical shape	90	1.21	1.51 – 0.87	0.13	0.01	10.69
Geometric diameter	90	53.80	78.40- 41.00	6.80	0.70	12.54

Table (2): Distribution of the obtained data within the two main classes of tomato coefficient of spherical shape.

Varieties	Classes of shape	
	Spherical ≤ 1.5	Oval shape >1.5
Tomato	79 %	21 %

Fig. (1).Linear dimensions vs storage time.

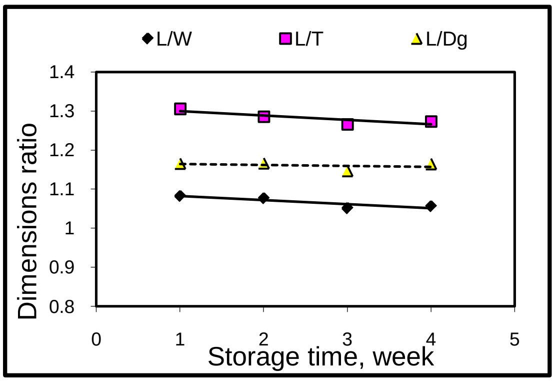


Fig.(2). Effect of storage time on dimensions ratio for tomatoes

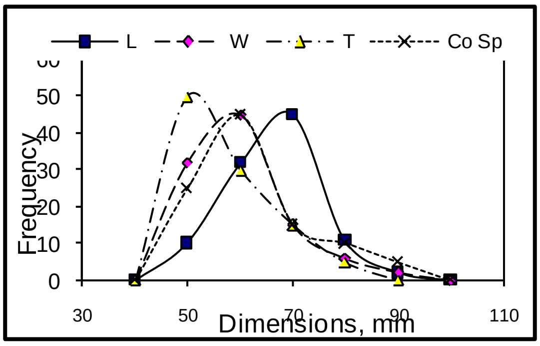


Fig.(3). Frequency of dimensions for tomatoes

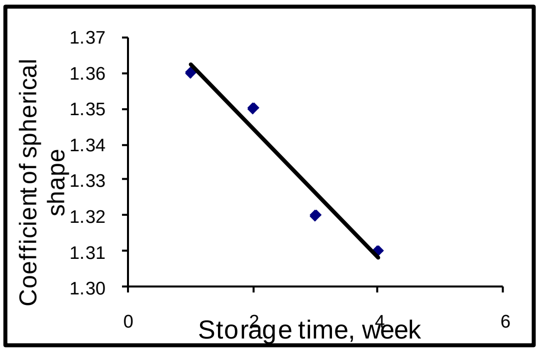


Fig.(4).Coefficient of spherical shape vs storage time

1.3. Mass of Tomato:

The variation of mass tomatoes, (M_g) with tomato storage time is displayed in Fig (5). Mass of tomato was decreased with tomato storage time. The decreasing rate of tomato was 12.17 %. The relationship between mass of tomato (M_g.) and tomato storage time can be represented by the following equation:

M_g= 171.23 – 6.613 *S.T.* (R^2=0.98) (16)

Where: M_g = is mass of tomato, g & S.T = is the storage time, week.

Fresh tomato mass was measured, statistically analyzed. On the other hand, it can be seen from Table (3) that tomato varied greatly in tomato mass as it ranged from (44.36 – 254.96, g). The mass of the tomato was closely related to geometric mean diameter, but less associated with major diameter. Thus, the best dimension to estimate the mass of the tomato is geometric mean diameter (Fig. 6), this findings agreement with (Khazaei. J: D.D. Mann (2004).

M_g = 5.4863 G_d –*197.39* (R^2 = 0.957) (17)

1.4. Volume (measured- calculated):

The variation of volume of tomato (measured and calculated), (V) with storage time is displayed in Fig (7). volume of tomato was decreased with tomato storage time. The relationship between volume and tomato storage time can be represented by the following equations:

V_{Mea} =125.13 - 9.325 *S.T.* (R^2 = 0.92) (18)

V_{Cal} =106.63 - 8.138 *S.T.* (R^2 =0.92) (19)

Frequency distribution curves for both the measured and calculated volume of the tomatoes were graphically presented in Fig (8). Generally, the statistical analysis showed that there are significant differences between the calculated and measured volumes of each tomato during storage period. Consequently liner regressions analysis for the calculated volume as independent variable and the measured volume as dependent variable were carried out for each storage period. Fig (9) shows regression equation between calculated and measured volumes of tomato, which were fitted to the following linear function equation.

V_{Mea}=0.9714 $V_{Ca.l}$ +17.615 (R^2 =0.85) (20)

1.5. Particle Density:

The results of particl density of tomato showed that the values of there observed characteristics were widely varied as shown in Fig (10).These variation depend greatly on the difference in tomato sizes, volumes.

The experimental results of the particle density for tomato at different storage time are presented in Fig (11). The particle density decreased at increasing storage time. The relationship between particle density was found to be linear with the storage time and can be expressed as follows:

P_d = 1.015 – 0.029 S.T. (R^2 = 0.98) (21)

This decrease indicates that, there is a small decrease in tomato weight in comparison to its decrease in volume as its storage time increases.

1.6. Surface Area:

Tomatoes surface area (both measured and calculated) was calculated for each tomato, and the results were statistically analyzed and given in Table (3), while the mean values and the frequency distribution curves were showed in Figs (12&13). Which show the variation of the calculated and measured surface area ($S_{a.c}$, $S_{a.m.}$) with tomato storage time. The figure indicates that the surface area decreases linearly with increase in tomato storage time for tomatoes. The relationship between storage time and calculated, measured surface area can be expressed mathematically as follows:

$S_{a.c.}$= 108.39 - 5.2756 S.T. (R^2 = 0.97) (22)

$S_{a.m.}$= 135.70 - 5.424 S.T. (R^2 = 0.96) (23)

Fig (14) shows the variation of the measured surface area ($S_{a.m.}$) with calculated surface area (S_{ac}) for all tomatoes. The relationship between measured and calculated surface area may given by the following expression:

$S_{a.m}$ = 1.6014+1.328 S_{ac} (R^2= 0.95) (24)

1.7. Sphericity:

The sphericity (Φ) variation with tomato storage time is shown in Fig (15). The sphericity graph given by equation.(3. 4). The linear relationship between sphericity and tomato storage time may be given by:

$\Phi = 88.795 - 0.919$ S.T. $(R^2 = 0.98)$ (25)

1.8. Specific Gravity:

The obtained mean value of tomato samples specific gravity were (1.01). The statistical analysis of this property was showen in Table (4).

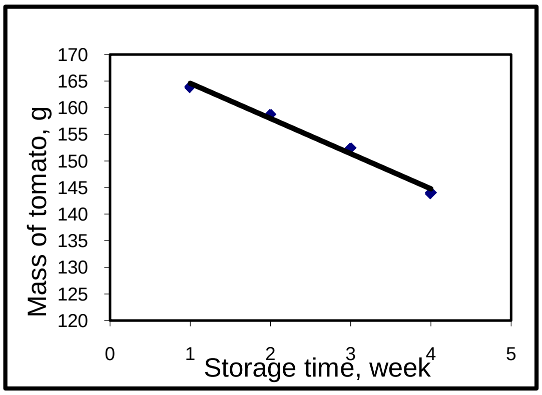


Fig. (5). Effect of storage time on mass of tomato.

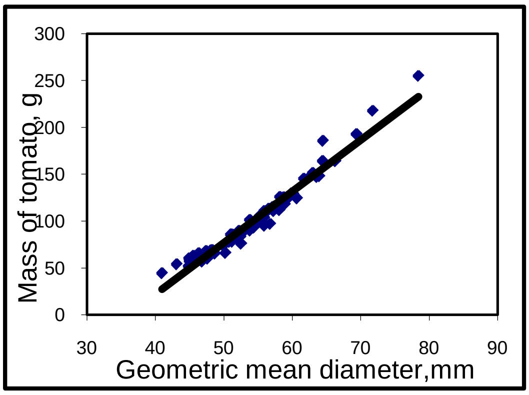


Fig.(6). Relationship between geometric mean diameter and tomato mass

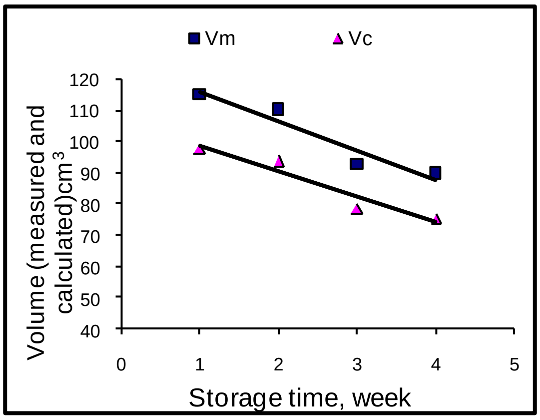


Fig.(7). Volume of tomato (measured and calculated) vs storage time.

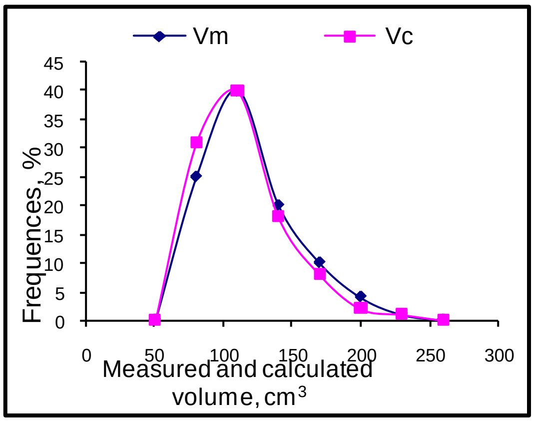


Fig.(8). Frequency of measured and calculated volume for tomato.

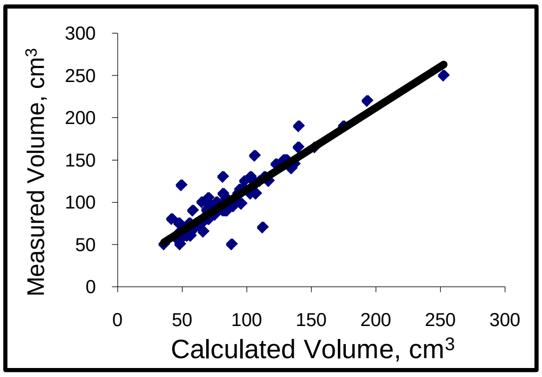


Fig.(9). Relationship between measured and calculated volumes for tomato.

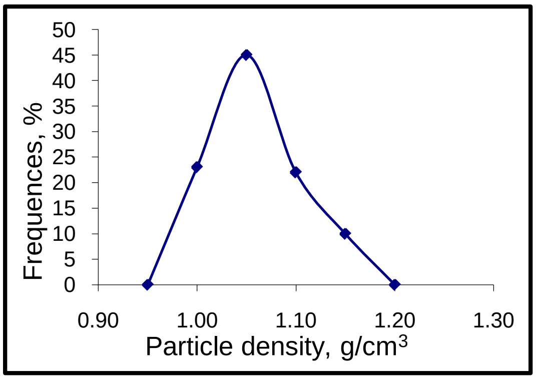


Fig.(10). Frequency of particle density for tomato.

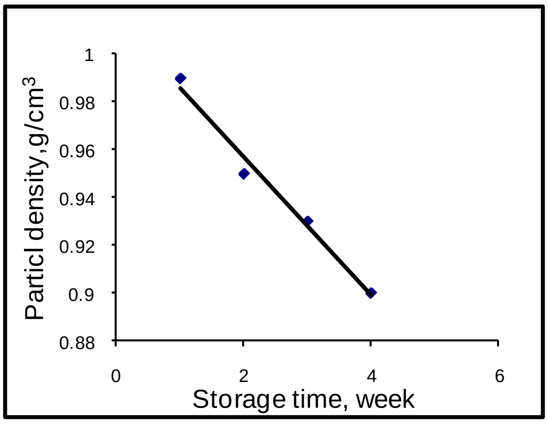


Fig. (11). Effect of storage time on particle density for tomato.

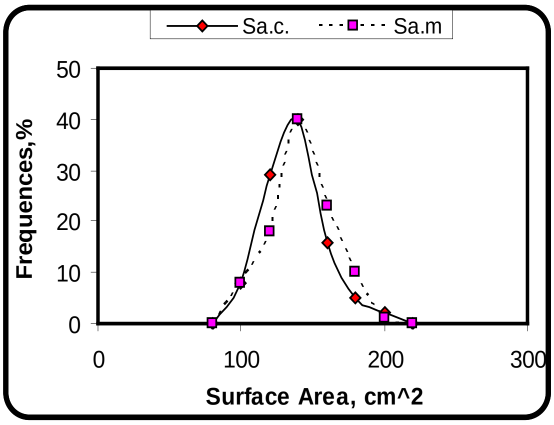


Fig. (12). Frequency of measured and calculated surface area for tomato.

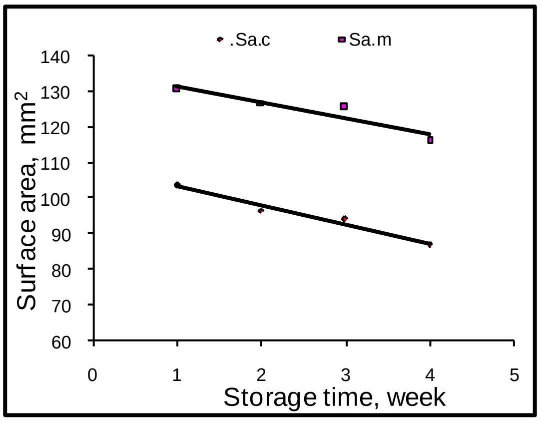


Fig. (13). Effect of storage time on measured and calculated surface area for tomato.

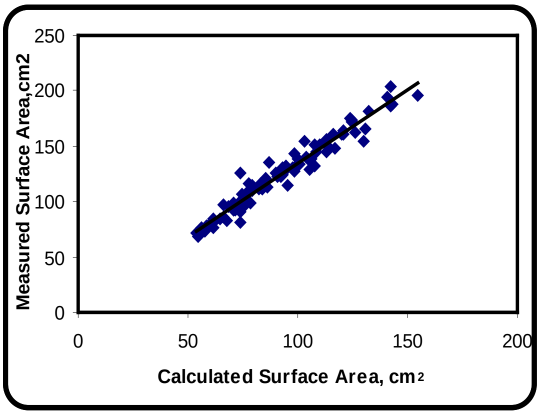


Fig. (14). Relationship between calculated and measured surface area for tomato.

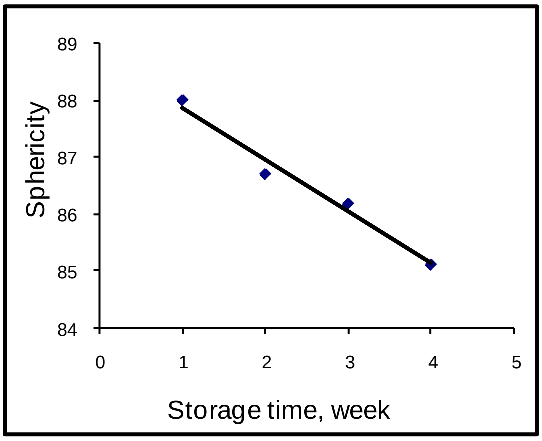


Fig.(15). Effect of storage time on sphericity of tomato.

Table (3): Physical properties for the investigated of Statistical index of some tomato.

Items	Average	Range, Max - Min	S.D.	S.E.	C.V. %
Mass, g	97.99	254.96 – 44.36	37.87	3.99	38.64
Measured volume, cm^3	100.78	250 – 50	36.88	3.89	36.60
Calculated volume, cm^3	85.61	252.54 – 36.03	34.98	3.69	40.86
Partical Density, g/cm^3	0.97	1.76 – 0.70	0.12	0.01	12.15
Mea. Surface area, cm^2	128.56	191.52 - 79.44	24.79	2.61	19.29
Cal. Surface area, cm^2	92.43	193.18 – 52.75	24.04	2.53	26.01

Table (4): Statistical index of specific gravity for tomato samples

Varieties	Average	Range, Max - min	S.D.	S.E.	C.V. %
Tomato	1.01	1.11 – 1.00	0.01	0.001	0.099

The physical properties of the tomato samples were described in order to better design specific machines for harvesting and post-harvesting operations. In this study many properties were determined to be significantly different. Therefore, the differences between the physical properties of tomato must be considered in optimising product and post-product mechanization and food processing.

Conclusion

It can be point out those physical attributes of the studied tomato can be a subject of interest to agricultural scientist for farm machinery engineers for efficiently equipment design for tomato postharvest operations. Also, the best models obtained are important information in sorting and sizing the tested tomato based on their weight. The results can be summarized as follows:

1. The structural and geometrical properties such as length, width, thickness, Coefficient of spherical shape, geometric mean diameter, volume (measured and calculated), mass, surface area (measured and calculated) of tomato fruits ranged in between 43.36 to 80.72 mm, 40.38 to 81.52 mm, 37.38 to 77.52 mm, 0.87 to 1.51, 41.00 to 78.40 mm, (50 to 250) (36.03 to 252.54) cm^3, 44.36 to 254.96 g, (79.44 to 191.52) (52.75 to 193.18) mm^2, respectively. These parameters are necessary for the proper mechanism design of tomato harvesting robot.
2. The coefficient of determination R^2 showed that the mass was most closely related to geometric mean diameter of tomato fruit. The result suggests that the mass of the tomato fruits can be predicted by the geometric mean diameter.

REFERENCES

Al-Maiman, S. and D. Ahmad (2001). Changes in Physical and Chemical Properties During Pomegranate Fruit Maturation. Department of Food Science and Nutrition, King Saud University.

Arana, I., C. Jare´n and S. Arazuri (2004). Apple mealiness detection by nondestructive mechanical impact. Journal of Food Engineering, 62, 399–408.

Arazuri, S. and C. Jare´n (2004). Caracterizacio´n de la Resistencia Meca´nica de Variedades de Tomate de Uso Industrial. In IX Jornadas Grupo Horticultura de la Sociedad Espan˜ola de Ciencias Hortı´colas (SECH), Derio, Spain.

Burton, W. G. (1989). The potato Longman Scientific & Technical, co-published in the United States with John Wiley& Sons, Inc. New York.

Calvo, M. (1996). Calidad de la produccio´n agraria. Agricultura Sostenible,577–588.

De Ketelaere, B., M.S. Howarth, L. Crezee, J. Lammertyn, K. Viaene, I. Bulens and J. De Baerdemaeker (2006). Postharvest firmness changes as measured by acoustic and low-mass impact devices: a comparison of techniques. Postharvest Biology and Technology 41, 275–284.

Ismail, Z. E. (1988). Some of the physio-mechanical properties for potato planters. J. Agric. Sci. Mansoura Uni., 13 (4), 2259- 2270.

Jare´n, C. and E. Garcı´a (2002). Using non destructive impact testing for sorting fruits. Journal of Food Engineering, 52, 89–95.

Khazaei, J. and D.D. Mann (2004). Effects of Temperature and Loading Characteristics on Mechanical and Stress-Relaxation Behavior of Sea Buckthorn Berries.Part 3. Relaxation Behavior. Agricultural Engineering International: the CIGR Journal of Scientific Research and Development. Manuscript FP 03 014. Vol. VI.

Khoshnam, F, Tabatabaeefar A, Ghasemi-Varnamkhasti M, Borghei AM (2007) Mass modeling of pomegranate (Punica granatum L) fruit with some physical characteristics. Sci Hortic 114: 21–26

Khoshnam F, Tabatabaeefar A, Ghasemi-Varnamkhasti M, Borghei AM (2007) Mass modeling of pomegranate (Punica granatum L) fruit with some physical characteristics. Sci Hortic 114: 21–26

Lorestani AN, Tabatabaeefar A (2006) Modeling the mass of Kiwi fruit by geometrical attributes. Int Agrophy 20: 135– 139

Mirzaee E, Rafiee S, Keyhani A, Emam Djom-eh Z, Kheiralipour K (2008) Mass modeling of two varieties of apricot (prunus armenaica L.) with some physical characteristics. Plant Omics J 1: 37-43

Mirzaee E, Rafiee S, Keyhani A, Emam Djom-eh Z (2009) Physical properties of apricot to characterize best post harvesting options. Aust J Crop Sci 3(2): 95-100.

Mohsenin, N.N., 1986. Physical properties of plant and animal materials, second ed. Gordon and Breach, Science Publishers Inc., U.K.

Nesvadba, P., Houska, M., Wolf, W., Gekas, V., Jarvis, D., Sadd, P. A., et al. (2004). Database of physical properties of agro-food materials. Journal of Food Engineering, 61, 497–503.

Peleg K (1985) Produce Handling, Packaging and Distribution. The AVI Publishing Company. Inc., Westport, Connecticut, pp 20–90

Peris, J. (1983). La calidad de las frutas y hortalizas. La textura como factor de calidad. Me´todos e instrumentos para su medida. Agrı´cola Vergel, 2, 59–64.

Rodrı´guez, A. (1992). Carga y transporte a granel del tomate para la elaboracio´n de concentrados: factores que influyen sobre las pe´rdidas de producto y de calidad y modelos para su estimacio´n. PhD thesis. Polytechnic University of Madrid, Spain.

Ruiz, M. and P. Chen (1990). Los productos agrı´colas. Evaluacio´n cualitativa y clasificacio´n. Ma´ quinas y Tractores, 2, 82–87.

Smith, O. (1977). Potatoes: production, storing, processing. The AVI publishing company, INC. Westport, Connecticut.

Stroshine, R. and D. Hamann (1995). Physical properties of agricultural materials and food products. Copy Cat, West Lafayette, IN.

Tabatabaeefar, A., A. Vefagh-Nematolaheeand and A. Rajabipour (2000). Modeling of orange mass based on dimensions. Agric Sci Tech 2: 299–305 (in Persian)

Tabatabaeefar, A. and A. Rajabipour (2005). Modeling the mass of apples by geometrical attributes. Sci Hortic 105: 373–382

Taheri-Garavand, A., H. Ahmadi and S.M.T Gharibzahedi (2009) Investigation of moisture-dependent physical and chemical properties of red lentil cultivated in Iran. International Agricultural Engineering Conference (IAEC). Bangkok, Thailand, 7 – 10.

Topuz, A., M. Topakci, M. Canakci, I. Akinci and F. Ozdemir (2005). Physical and nutritional properties of four orange varieties. J. Food Eng 66: 519–523.

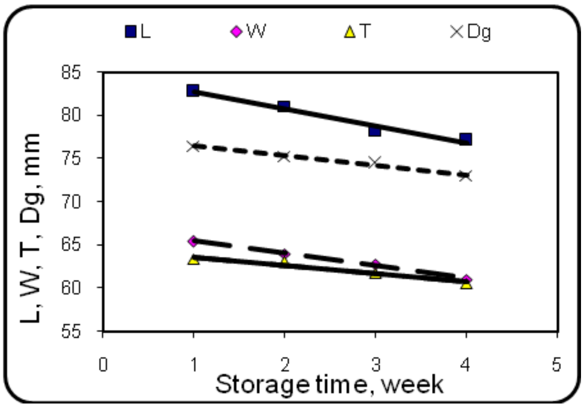
الخصائص الطبيعية لثمار الطماطم

نبيل سعود البلوشى

قسم هندسة النظم الزراعية– كلية العلوم الزراعية والأغذية– جامعة الملك فيصل– المملكة العربية السعودية

الملخص العربي

تم تحديد الخصائص الطبيعية مثل الطول والعرض والسمك، ومتوسط القطر الهندسي، والكتلة والحجم الحقيقي، والحجم المحسوب، الكثافة الحقيقة، الكروية، مساحة السطح، ونسبة الارتفاع للطماطم للصنف التجاري. وهذه الخصائص ضرورية في تصميم المعدات اللازمة للفصل والحصاد والتصنيع والنقل والتعبئة والتغليف. وأظهرت النتائج أن الطول والعرض والسمك، ومتوسط القطر الهندسي ومعامل التكور للطماطم تراوحت من ٤٣,٣٦– ٨٠,٧٢مم، ٤٠,٣٨– ٨١,٥٢مم، ٣٧,٣٨– ٧٧,٥٢مم، ٤١,٠٠– ٧٨,٤٠مم و٠,٨٧– ١,٥١على التوالي. في حين كانت المساحة السطحية المحسوبة ومساحة السطح المقاسة تغيرت ٥٢,٧٥– ١٩٣.١٨سم٢و ٧٩,٤٤– ١٩١،٥٢سم٢ على التوالي. وكانت قيم حجم الثمرة المقاس والمحسوب والكثافة والثقل النوعي تتراوح ما بين ٥٠– ٢٥٠ سم٣، ٣٦,٠٣– ٢٥٢,٥٤ سم٣، ٠,٧٠– ١,٧٦ جرام/سم٣ و١,٠٠– ١,١١ على التوالي. وعلاوة على ذلك تراوحت كتلة ثمرة الطماطم ٤٤,٣٦– ٢٥٤,٩٦ جرام.


L
W
T
Dg
L, W, T, Dg, mm
85
80
75
70
65
60
55
0
1
2
3
4
5
Storage time, week